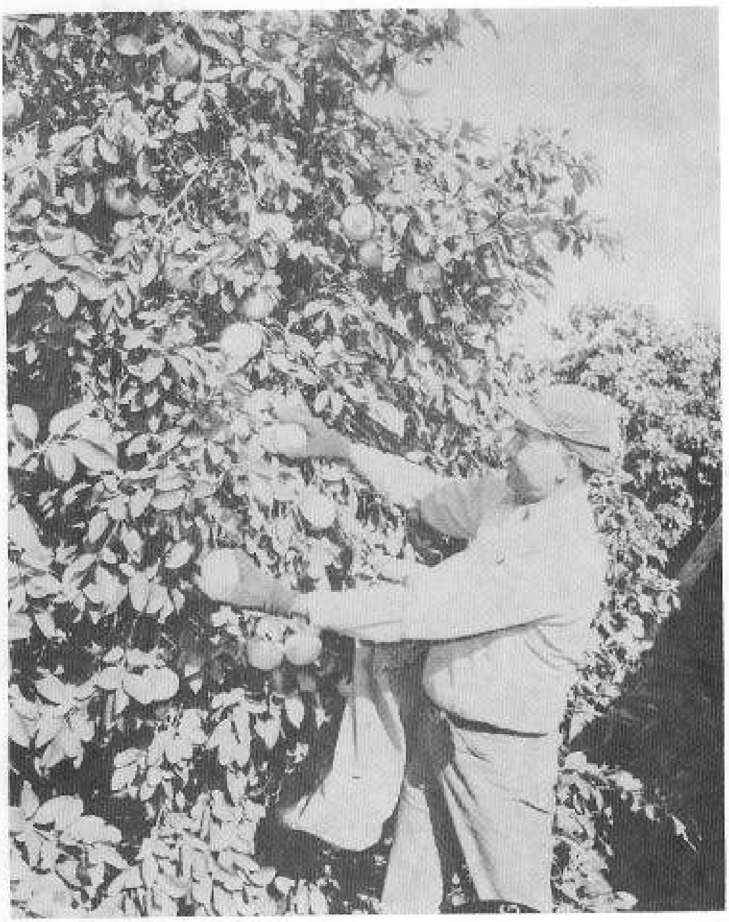
JOURNAL

OF THE

RIO GRANDE VALLEY HORTICULTURAL SOCIETY

Volume 24, 1970



COVER: A hold-out in the age of mechanization — no practical way has been devised to harvest fresh fruit by machines. (Photo by Harry Foehner)

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

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 24 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 1970

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FRANK JOHN SCHUSTER

Recipient of the Arthur T. Potts Award 1970

Frank John Schuster is one of the Rio Grande Valley's largest farmers, both physically and economically. He is a man ever preoccupied with improvement of the industry and his adopted country. He is a civic as well as business leader and a cooperator in all his affairs.

Frank Schuster was born in Yugoslavia but was reared in Austria and considered himself an Austrian until he came to the United States in 1935 at the age of 15.

He has been farming here ever since. Most of his land is located along U. S. 281 south of San Juan. Schuster raises a wide variety of vegetables, palm trees and livestock.

Schuster has conducted many vegetable trials on his extensive farms in cooperation with Texas A&M University and the U. S. Department of Agriculture. He has been a member of the National Vegetable Advisory Committee for six years and is past president of the Rio Grande Valley and Hidalgo County Farm Bureau. Schuster has been a leader in promotion of the All-Valley Winter Vegetable Show at Pharr.

Schuster pioneered in vegetable mechanization through system approach. He is an active member of the Texas Fruit & Vegetable Growers & Shippers, and chairman of the Marketing Advisory Subcommittee to the Rio Grande Valley Research & Extension Center, and chairman of the agriculture committee of the Valley Chamber of Commerce.

The Schuster Farms has been a showplace for many tours and demonstrations of ideal growing and harvesting techniques. He was one of the first to undertake land levelling and drainage of heavy clay soil.

He is a leader in the Santa Gertrudis Cattle Breeders Association.

Schuster's enthusiasm for all he undertakes is contagious and his participation in any project adds substantially to its prospects for success.

Schuster's family includes his wife, a son Frank Jr., and two daughters, Kathy, a senior, and Becky a Junior at Trinity University.

Program of the Twenty-fourth Annual Institute of the Society January 27, 1970

MORNING PROGRAM

Charles Rankin – Chairman

Addres sof Welcome .... T. D. Longbrake, President
Rio Grande Valley Horticultural Society

Cooperative Packing of Citrus .... Joe Rawls, Manager
Edinburg Citrus Assn., Edinburg

Citrus Processing, Future Needs in Texas .... Harold Bryant, Manager
Texas Citrus Exchange, Edinburg

Economics of Cold Protection
in Citrus .... Dr. Chan Connolly, Assoc. Professor
Texas A&M University, Weslaco

Impact of Imports and Exports
of Fruits and Vegetables on
South Texas .... Dr. A. Clinton Cook, Chief
Fruit and Vegetable Branch
Foreigh Agricultural Service, USDA, Washington, D.C.

Farmers and the Legislature .... Raul Longoria, State Representative
15th District, Edinburg

Citrus Crop Forecasting .... Douglas Murfield, Mathematical Statistician
Texas Crop & Livestock Reporting Service
USDA, Austin, Texas

Presentation of Arthur T. Potts Award .... President Tom Longbrake

AFTERNOON PROGRAM

Dr. R. M. Menges – Chairman

Special Award by USDA
Growers Organization .... Frank Schuster, Farmer
San Juan, Texas

New Techniques in Harvesting
South Texas Onions .... Wayne LePori, Agricultural Engineer
Texas A&M University, College Station

Effect of Amistad Dam on Water Supply
to Lower Rio Grande Valley .... Tate Dalrymple
Court Appointed Special Watermaster
McAllen, Texas

The Valley Master Drainage System .... Roy Ussery
Agricultural Engineer
Weslaco, Texas

Questions and Answers

EVENING PROGRAM

Dr. John Fucik — Chairman

Palms and Native Trees for
South Texas .... George Pletcher, Past President
Texas Nurserymen's Association
Harlingen, Texas

Demonstrations on Floral Arrangements .... Mrs. G. Browning Smith
Vice President
Texas Garden Clubs, Harlingen, Texas

ADDRESS OF WELCOME

24th Annual Horticultural Institute

MR. T. D. LONGBRAKE
President
Rio Grande Valley Horticultural Society

On behalf of the Rio Grande Valley Horticultural Society, I want to open this 24th Annual Institute with a warm and hearty welcome to all of you. We hope that this day will be fruitful and rewarding to those who have come to share knowledge, and for those who have worked so hard to make this meeting possible.

All the speakers on our program are experts in their field. The subjects to be discussed include: legislation, fruit and vegetable imports and exports, farm organizations, mechanization developments, irrigation water reserves, drainage plans, citrus marketing and processing, crop forecasting. The evening program will emphasize the ornamental nursery industry and demonstrations on floral arrangements.

Over the past years the farm vote has been decreasing, and wants and needs of labor and urban population has received more emphasis. It is evident then, that the agricultural population must become more market oriented, while continuing to adapt new techniques in production. Competition from other production areas and especially imports and exports are continuing to narrow the margin of profit. As producers of food products, we must become familiar with the needs and desires of the housewife, the ultimate consumer, so that our products reach the market at the right place at the right time of the right quality and the right volume at the right price.

To those here today who are not members of the Horticultural Society, we urge you to join. The annual dues are only $4.00 per year. This entitles one to receive the monthly newsletters and a copy of the annual horticultural journal. Those who wish to join or renew memberships, please see the ladies at the desk near the entrance.

I would like to express my appreciation to the speakers on the program; to the morning, afternoon and evening chairmen; to the lady registrars; to the various committee chairmen and members who have made this meeting possible. Also to the Texas A&I Citrus Center for providing the use of their facilities.

I now turn the morning program over to Mr. Charles Rankin, Mr. RFD of radio and television in South Texas.

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Nucellar and Old-line Red Grapefruit: Yield and Growth[1]

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Abstract: Fruit yield, size, and tree growth of 12 nucellar red grapefruit selections, originating from 7 old-line varieties, were compared in a planting with one old-line. At 5 years of age there was no significant difference in yield between the old-line and 2 of the nucellar selections. By the 9th year all 12 nucellar selections significantly outyielded the old-line. The nucellar slowest to come into bearing was the one most recently derived from seed. There was a wide spread in yield between the highest and lowest producing trees in each selection every year. Nucellar and old-line selections produced the same proportion of fruit of marketable size for fresh shipment. Nucellar trees grew taller, wider, and had greater trunk diameters than the old-line trees.

INTRODUCTION

The term "nucellar citrus trees" describes a unique character of some citrus varieties. Most of the embryos in the seeds of commercial orange and grapefruit varieties develop wholly from tissue of the mother tree (5, 7). They are genetically identical to the mother tree, having acquired no genes or characters from pollination and subsequent fertilization. These embryos are formed from the nucellus and are termed nucellar embryos and the seedlings from them are called nucellar seedlings. Trees propagated with buds from nucellar seedlings are called nucellar trees, to distinguish them from trees propagated with buds from the mother or old-line trees. Nucellar and old-line will be used herein to identify trees with these separate modes of origin.

Although genetically identical with the old-line, the nucellar trees express a pronounced juvenile growth in their early years which decreases as the trees mature (3, 4, 5, 6). The more obvious juvenile characters associated with the newly developed nucellar trees are: a rapid growth rate, upright habit of growth, thorniness, slowness to fruit, and alternate bearing in the early years. In older nucellar trees, especially after repeated propagation and repropagation, these characteristics are modified (1, 3). The quality, size, and shape of the fruit on older nucellar trees is comparable to that grown on the old-line trees of the same variety (2, 10).

Most citrus viruses are not transmitted through the seed to the seedling. Thus nucellar trees are generally free from the virus diseases that are inherent in many old-lines. This is valuable when varieties must be grown on rootstocks that are not tolerant of these viruses.

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Besides their freedom from virus diseases the most valuable attributes of nucellar trees are their exceptional tree vigor and high fruit yields (1, 2).

Nucellar selections are rapidly displacing old-lines in many citrus areas (7). In 1968 California nurserymen were propagating most of the orange and lemon trees and many of the grapefruit and mandarins from trees of known nucellar origin (1).

The Texas A&I University Citrus Center has a program to test nucellar citrus trees for use in the Lower Rio Grande Valley. This report covers a part of that work.

MATERIALS AND METHODS

In Texas the term red grapefruit covers an assemblage of varieties that originated in the late 1920's and early 1930's as bud mutations (7,9). These varieties, no longer distinguishable from one another by quality, generally share the two names Redblush and Ruby Red (7, 8). Twelve nucellar red grapefruit selections grown from seed of seven of the old-line varieties, along with one old-line red grapefruit, were planted in a performance test at the Texas A&I Citrus Center, Weslaco, Texas, in June, 1960. These selections, with the approximate year of seedling origin for the nucellar clones, are listed below.

	Selection		*Approximate Year Seed Planted*
A.	Nucellar	California Red No. 3	1945
B.	"	Redblush (RFR13T3)	1950
C.	"	Redblush (CCR24T2)	1953
D.	"	Redblush (CCR23T2)	1953
E.	"	Redblush (CCR22T5)	1953
F.	"	Redblush (CCR20T3)	1953
G.	"	Riddle Redgold	1950
H.	"	Fawcett Red	1958
I.	"	Shary Red	1952
J.	"	Langford Red No. 1	1949
K.	"	Curry Red Radiance	1950
L.	"	Ruby Red	1949
M.	Old-line	Ruby Red	N/A

Selection A is a nucellar Redblush clone that originated from seed planted in California (3). All other nucellar clones are from seed planted in Texas. Selections B, G, J, K, and L were obtained from Dr. E. O. Olson, USDA, ARS, Weslaco. Seeds for selections B. J, and L were planted by the Texas Agricultural Experiment Station, Weslaco. Selections C, D, E, F, and H were grown from seed at the Texas A&I Citrus Center, Weslaco. Selection F was grown from seed at the Law nursery at McAllen and the old-line Ruby Red was obtained from the Hughes nursery, Elsa.

The trees were propagated on sour orange rootstock and planted in Hidalgo sandy clay loam. The test planting was grown under sod culture during the first four years, and then converted to chemical weed control with no tillage. The trees were frozen to their insulating wraps in January, 1962, at 18 months of age. Only nitrogen fertilizer has been applied at the rate of 1 to 1½ lb of N per tree per year from age three to the present date.

The rows in the planting run from east to west. The tree spacing is 22 x 20 ft, or 100 trees per acre. When the trees were 7½ years old, February, 1968, the branches were touching across the 22 ft rows and they were hedge-pruned on the north and south sides to 7 ft from the trunk. By February, 1970, it was necessary to hedge them again and this time they were cut back to 6 ft from the trunk.

Thirteen trees of each selection were planted in a 13 x 13 Latin Square. Where applicable the data were subjected to analysis of variance and the means were ranked by Duncan's multiple range test. The fruit was harvested each year in December.

RESULTS AND DISCUSSION

The average yield in pounds per tree for each test selection is shown in Table 1. They are arranged in order of rank for each year. The first

Table 1. Ranking of average yields of one old-line and twelve nucellar selections of red grapefruit through six seasons. Trees planted in 1960.[1]

Selection - Yield in lb/tree[x]											
1964		*1965*		*1966*		*1967*		*1968*		*1969*	
M	6	M	99 a	M	221 a	A	314 a	A	356 a	F	654 a
A	1	A	69 ab	A	173 ab	F	295 a	G	336 a	L	651 a
B	0	B	55 ab	G	147 bc	L	280 ab	D	334 a	G	650 a
C	0	E	32 b	J	126 bcd	I	280 ab	I	312 ab	E	646 a
D	0	D	27 b	B	104 cd	B	274 ab	B	310 ab	C	631 a
E	0	F	27 b	C	103 cd	G	267 ab	K	310 ab	J	619 a
F	0	G	27 b	E	94 cd	J	260 ab	L	304 ab	B	607 a
G	0	J	27 b	D	93 cd	C	259 ab	J	303 ab	D	600 a
H	0	C	24 b	F	87 d	D	247 ab	M	302 ab	K	591 a
I	0	L	24 b	I	68 d	E	245 ab	E	298 ab	I	584 a
J	0	K	7 c	L	67 d	M	240 ab	C	285 ab	H	574 a
K	0	I	6 c	K	67 d	K	206 b	F	244 bc	A	563 a
L	0	H	0 c	H	10 e	H	123 c	H	195 c	M	352 b

[x] Numbers in each column followed by the same letter are not significantly different at the 1% level according to Duncan's multiple range test.

[1] A Nuc. Calif. Red No. 3
B Nuc. Redblush (RFR13T3)
C Nuc. Redblush (CCR24T2
D Nuc. Redblush (CCR23T2)
E Nuc. Redblush (CCR22T5)
F Nuc. Redblush (CCR20T3)
G Nuc. Riddle Redgold
H Nuc. Fawcett Red
I Nuc. Shary Red
J Nuc. Langford Red No. 1
K Nuc. Curry Red Radiance
L Nuc. Ruby Red
M Old-line Ruby Red

harvest was in December 1964, when the trees were four years old. The growth lost because of the 1962 freeze and less than ideal growing conditions under sod culture the first four years could have contributed to the slow start in fruit production. The old-line Ruby Red was the only producer the first year with an average of 7 lb of fruit per tree.

In 1965 there was no statistical difference between the yields of the nucellar California Red No. 3, the nucellar Redblush (RFR13T3), and the old-line Ruby Red. The nucellar Fawcett Red had no yield. The nucellar clone from the earliest planted seed had the highest ranking of the average yields and the clone from the latest planted seed was not yet bearing. The yield of the old-line would equal 5 tons per acre at this spacing.

In 1966 the difference between the yield of the old-line Ruby Red and the nucellar California Red No. 3 was not significant. The nucellar Fawcett Red still showed a slowness to come into bearing and produced the least amount of fruit.

In 1967 the crop was severely reduced because of a hurricane in September. The total crop loss could not be determined because of the rain and standing water that followed, but it was estimated to have been 25 to 35 percent. The remaining crop was harvested and, despite the hurricane loss, all selections had increased yields over the previous year. The differences in yields between the first eleven ranked selections were not statistically significant. In looking only at the ranking of yield averages the old-line dropped to eleventh place.

By February 1968, before the trees bloomed, the branches of the nucellar trees were touching across the rows and it was necessary to open a passageway for equipment. The trees were pruned to seven feet from the trunk to open an eight-foot middle. Most branches cut from the trees were typical fruiting wood and would have borne some fruit. Pruning of the old-line Ruby Red trees was minimal because the canopies were smaller than the nucellars. Thus, pruning was expected to favor the old-line in comparison with the other varieties.

In the 1968 harvest all but one selection increased in average yield from the previous year. There was no significant difference between the yield of the old-line and 10 of the nucellars. Again the nucellar Fawcett Red had the lowest ranked average and the nucellar California Red No. 3 the highest. Nucellar Redblush (CCR20T3) dropped to 12th from second the previous year.

In the ninth year, 1969, all nucellar selections had significantly higher yields than the old-line. The differences among the nucellars were not significant. Nucellar Redblush (CCR20T3), which had dropped to 12th in 1968, was first ranked this year. The nucellar California Red No. 3, which had ranked first the previous two years, was lowest of the nucellars. All showed a substanital increase in production over the previous year. The nucellar Fawcett Red, which was now eleven years from seed, no longer had the lowest yield.

The yields reported here are for a 22 x 20 ft tree spacing. At other spacing these yields could be altered by the amount of pruning required, competition for space above and below the ground, and other factors.

The yield in tons per acre for the ninth year, 1969, was calculated from the tree averages, and is shown in Table 2. The highest ranked, nucellar Redblush (CCR20T3), produced 32.7 tons, the lowest ranked nucellar, California Red No. 3, produced 28.1 tons, and the old-line Ruby Red produced 17.6 tons per acre and ranked the lowest of all the selections.

The cumulative yield in tons per acre for all years is also shown in Table 2. The nucellar California Red No. 3 ranked first with 73.8 tons. In 13th place nucellar Fawcett Red had 45.1 tons. In 11th place the old-line Ruby Red had 61.0 tons per acre.

Every year each selection had a wide range of yields between the lowest and highest producing trees, (Table 3). The range was greater in the early years but even in the ninth year the highest yielding trees generally had double the amount of fruit of the lowest. Such variation makes it difficult to make definite statements about citrus production at an early tree age and when only a limited number of trees are used for a test or observation.

The distribution of fruit sizes for 1968 and 1969 are shown in Table 2. Percentages were calculated on a weight basis. In 1968 the size separation used was the commercial size per box of 96 and larger. In 1969 we lowered the size separation to 112 and larger. Although marketing restrictions usually limit minimum sizes to 96's, because of our December harvest, a measurement of size 112 and larger would give us a better indication of marketable size fruit for January and February. These differences were not subjected to statistical analysis but the data indicate that in these two seasons there was little difference in fruit size among all selections. Fruit sizes were generally small in commercial groves in 1968, but not in 1969.

The average trunk diameters four inches above the bud union, measured 10 years after planting, are shown in Table 2. The average diameter of each of the 12 nucellars was within a range of 1.7 inches and statistical analysis showed all were significantly larger than the old-line.

Tree height was measured 10 years after planting. The nucellars averaged 17 ft, with a range of 16 to 18 ft. The old-line ranged from 12.5 to 16.5 ft and averaged 14 ft. Width of the trees was not measured because of pruning.

On the basis of data presented for the nine years of this study some conclusions can be drawn.

The greater the span of time between planting a seed and the growth and propagation and repropagation of a nucellar red grapefruit clone, the shorter the time for young trees to equal or exceed the old-line in production.

Table 2. Yields in tons/acre at 9 years of age, cumulative yields through 9 years, distribution of fruit size at harvest time, and tree growth at 10 years for one old-line and twelve nucellar selections of red grapefruit.

SELECTION	*YIELD*[1] *Tons/Acre 9th Year*	*CUMULATIVE YIELD*[1] *Tons/Acre All Years*	*FRUIT SIZE*[2] *1968 % Size 96+*	*FRUIT SIZE*[2] *1969 % Size 112+*	*TREE GROWTH*[3] *1970 Trunk Dia. (Inches)*
A. Nuc. Calif. Red No. 3	28.1	73.8	42	94	9.2
B. Nuc. Redblush (RFR13T3)	30.3	67.5	60	95	9.6
C. Nuc. Redblush (CCR24T2)	31.5	65.1	69	96	9.6
D. Nuc. Redblush (CCR23T2)	30.0	65.0	65	96	10.1
E. Nuc. Redblush (CCR22T5)	32.3	65.7	59	98	9.2
F. Nuc. Redblush (CCR20T3)	32.7	65.3	68	96	9.5
G. Nuc. Riddle Redgold	32.5	71.3	64	94	9.8
H. Nuc. Fawcett Red	28.7	45.1	69	93	10.5
I. Nuc. Shary Red	29.2	62.5	68	97	8.8
J. Nuc. Langford Red No. 1	30.9	66.7	65	95	9.6
K. Nuc. Curry Red Radiance	29.5	59.5	66	96	9.6
L. Nuc. Ruby Red	32.5	66.3	70	95	9.4
M. Old-line Ruby Red	17.6	61.0	55	99	6.7

[1] Based on 100 trees/acre, 22 x 20 ft spacing.
[2] Percent by weight of commercial fruit sizes at December harvest.
[3] Truck diameters measured four inches above bud union, June 1970.

Table 3. Range of individual tree yields for one old-line and twelve nucellar selections of red grapefruit through five seasons. Thirteen trees of each selection were planted in 1960.

Selection	*Range of Tree Yields in lb/Tree*				
	1969 Low-High	*1965 Low-High*	*1966 Low-High*	*1967 Low-High*	*1968 Low-High*
A. Nuc. Calif. Red No. 3	0 – 157	42 – 247	82 – 485	151 – 534	336 – 755
B. Nuc. Redblush (RFR13T3)	0 – 206	39 – 177	115 – 428	101 – 515	423 – 743
C. Nuc. Redblush (CCR24T2)	0 – 154	26 – 375	91 – 388	163 – 515	415 – 720
D. Nuc. Redblush (CCR23T2)	0 – 154	24 – 225	105 – 409	242 – 450	465 – 902
E. Nuc. Redblush (CCR22T5)	0 – 166	32 – 234	84 – 373	121 – 479	438 – 771
F. Nuc. Redblush (CCR20T3)	0 – 240	40 – 191	188 – 396	143 – 366	512 – 897
G. Nuc. Riddle Redgold	0 – 76	38 – 294	150 – 374	121 – 490	523 – 787
H. Nuc. Fawcett Red	0 – 2	0 – 23	24 – 349	40 – 266	416 – 741
I. Nuc. Shary Red	0 – 54	6 – 115	102 – 460	183 – 446	445 – 699
J. Nuc. Langford Red No. 1	0 – 99	28 – 388	101 – 417	221 – 520	436 – 809
K. Nuc. Curry Red Radiance	0 – 37	18 – 158	71 – 441	163 – 515	410 – 775
L. Nuc. Ruby Red	0 – 139	19 – 172	185 – 393	201 – 575	332 – 834
M. Old-line Ruby Red	10 – 236	79 – 291	166 – 317	221 – 373	240 – 478

Differences in yield between nucellar clones originating from seven different old-line red grapefruit varieties could not be attributed to varietal differences.

Differences in yield between nucellar clones of red grapefruit could be attributed to the length of time since the trees were derived from seed. These differences disappeared with age of the trees.

Trees of the same age and origin varied widely in fruit production in any year through nine years of age but these differences were more pronounced in the early years. Care should be taken in drawing conclusions on yield when a small number of trees make up a test population.

Nucellar and old-line red grapefruit trees of the same age and in the same planting produced the same proportion of fruit of marketable size for shipment.

Nucellar red grapefruit trees grew faster than the old-line in trunk diameter, tree height, and tree width. This should be taken into consideration when tree spacings for nucellar plantings are planned.

LITERATURE CITED

1. Cameron, J. W., and H. B. Frost. 1968. Genetics, breeding, and nucellar embryony, p. 325-370. *In* Walter Reuther, Leon Dexter Batchelor, and Herbert John Webber, [ed.], The Citrus Industry. Vol. II. Univ. California, Berkeley.

2. Cameron, J. W., and R. K. Soost. 1952. Size, yield, and fruit characters of orchard trees of citrus propagated from young nucellar-seedling lines and parental old lines. Proc. Amer. Soc. Hort. Sci. 60:255-264.

3. Frost, H. B. 1938. Nucellar embryony and juvenile characters in clonal varieties of *citrus*. J. Heredity 29:423-432.

4. Frost, H. B. 1952. Characteristics in the nursery of citrus budlings of young nucellar-seedling lines and parental old lines. Proc. Amer. Soc. Hort. Sci. 60:247-254.

5. Frost, H. B., and R. G. Soost. 1968. Seed reproduction: Development of gametes and embryos, p. 290-324. *In* Walter Reuther, Leon Dexter Batchelor, and Herbert John Webber, [ed.], The Citrus Industry. Vol. II. Univ. California, Berkeley.

6. Hodgson, R. W. 1938. Effects of reproduction by nucellar embryony on clonal characteristics in *citrus*. J. Heredity 29:417-419.

7. Hodgson, R. W. 1967. Horticultural varieties of citrus, p. 431-591. *In* Walter Reuther, Leon Dexter Batchelor, and

Herbert John Webber, [ed.], The Citrus Industry. Vol. I. Univ. California, Berkeley.

8. Krezdorn, A. H., and N. P. Maxwell. 1959. Fruit quality studies of eight strains of red fleshed grapefruit on two rootstocks. J. Rio Grande Valley Hort. Soc. 13:54-58.

9. Waibel, Carl. 1953. Varieties and strains of citrus originating in the Lower Rio Grande Valley of Texas. J. Rio Grande Valley Hort. Soc. 7:18-24.

10. Young, Roger, E. O. Olson, and Art Shull. 1968. Comparative performance of juvenile and old-line Redblush grapefruit. J. Rio Grande Valley Hort. Soc. 22:16 25.

The Performance of Old-Line and Young-Line Valencia Orange Trees on Five Tristeza-Tolerant Rootstocks in the Rio Grande Valley[1]

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Abstract: A comparison of 13-year-old old-line and young-line Valencia orange trees on Morton, Troyer, Cleopatra, Natsu Mikan, and Ponkan rootstocks with trees on sour orange showed that Morton and Troyer citranges could replace sour orange without decreasing yield or fruit quality. Old-line trees on Morton outproduced trees on sour orange rootstock by 26%. Old-line trees had 15-30% smaller canopies than nucellar trees but produced from 26-60% more fruit over a 5-year period.

INTRODUCTION

The presence of tristeza virus in several citrus varieties (6) is a constant threat to the Texas citrus industry, with 99% of its trees budded on sour orange, a rootstock susceptible to the tristeza disease. The most efficient vector of this virus, the brown citrus aphid (*Aphis citricidus*), has not been found in Texas so far. Natural spread of the disease has not yet become a problem, but less efficient aphid vectors, such as *Aphis gossypii*, are already present and may eventually bring about widespread infection, particularly among sweet oranges.

The best defense against tristeza is to plant trees on rootstocks which tolerate the virus. Since 1945 the USDA, in cooperation with the Texas Agricultural Experiment Station and Rio Farms, Inc., has conducted tests to find tristeza-tolerant rootstocks equal or better than sour orange for yield and fruit quality. Seven of 16 rootstocks screened in prior tests appeared immune or at least tolerant to the disease (8). The subject of the present report is performance of old-line and young-line Valencia orange trees on five of these rootstocks and on sour orange in a field trial.

MATERIALS AND METHODS

Seedlings of six rootstock varieties, sour orange, *Citrus aurantium* L.; 'Morton' and 'Troyer' citranges, *Poncirus trifoliata* (L.) Raf. x *C. sinensis* (L.); 'Natsu Mikan', *C. natsudaidai* Hayata, a pummelo-like chance hybrid from Japan; 'Ponkan' and 'Cleopatra' mandarins, *C. reticulata* Blanco, were budded with old-line and young-line Valencia orange in 1957.

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[1] Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, the Texas Agricultural Experiment Station, and Rio Farms, Inc., Weslaco, and Monte Alto, Texas.

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The bud sources were registered trees thought to be free of exocortis, xyloporosis, and psorosis viruses (7). Later indexing, using the newer, more sensitive citron method, showed, however, that the old-line bud source carried a mild strain of exocortis. The trees were planted at Monte Alto, Texas, in April 1958. The experiment contained three two-tree plots of each rootstock-scion combination in a randomized block design. The trees were frozen back to the main scaffold limbs during the 1962 freeze. Grove care included applications of 70 lbs/acre of N, four or five flood irrigations with Rio Grande river water (700-1500 ppm total salts) per year, and insecticide sprays as needed. Yield records were kept over the 5-year period, 1966-70. Fruit quality measurements were made in March 1969 and 1970. Fruit size, peel color and thickness were determined on 15-fruit samples from each plot; fruit weight and juice data are based on 60-fruit samples from each plot. A prototype commercial juice extractor[3] (FMC Corporation, Winterhaven, Florida) was used. The width and height of the trees were measured in March 1970 and their canopy volume was calculated by the formula width^2 x height ÷ 4.

RESULTS

Both old-line and young-line Valencia trees on Morton and Troyer citrange rootstock produced as much or more fruit than trees on sour orange (Table 1). Fruit quality was also comparable (Table 2). Of the fruit-quality factors, only size and total acids were influenced by the rootstock. Trees on Morton citrange produced the largest fruit, but the differences in fruit diameter were small. Morton and Natsu Mikan rootstocks lowered the total-acids level but not enough to cause significant differences in the Brix/acid ratios.

Fruits from nucellar trees were heavier, but only slightly larger. They had thinner rinds and tended to be less acid (Table 2). The old-line trees outyielded the nucellar trees on all rootstocks tested although their canopy volume was 23% smaller (Table 1). The size differences between nucellar and old-line trees varied from 36% on Natsu Mikan rootstock to 15% on sour orange.

DISCUSSION AND CONCLUSIONS

The results show that Troyer and Morton citranges could possibly replace sour orange as a rootstock for Valencia orange in South Texas without lowering yield and fruit quality. Valencia trees on these citrange rootstocks have also been reported to produce well in Florida (4). Their main advantage is tristeza-tolerance, but they are apparently not completely immune to severe strains of this virus (1). They cannot be used with tops infected with severe strains of exocortis virus, but the mild strain present in the old-line scions in the present test did not produce any specific symptoms. Trees on citrange rootstocks, when irrigated with

[3] Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

Table 1. Five-year cumulative yield and size of 13-year-old old-line and nucellar Valencia orange trees on six rootstocks.

Rootstock	*Old-line*		*Nucellar*	
	Cumulative yield/tree 1966-70 in 70-lb field boxes	*Volume of canopy (m^3)*	*Cumulative yield/tree 1966-70 in 70-lb field boxes*	*Volume of canopy (m^3)*
Sour orange	6.8ab	10.9ab	4.3bc	12.8a
Morton citrange	8.6a	11.5ab	6.8a	14.5a
Cleopatra mandarin	4.4b	12.0a	2.8cd	14.9a
Troyer citrange	6.2ab	12.8a	4.9b	15.1a
Natsu Mikan	4.0bc	9.8b	2.5d	15.2a
Ponkan mandarin	2.4c	8.9c	1.7d	12.7a
Total mean	5.4a	11.0b	3.8b	14.2a

* Mean followed by letter "a" is significantly different (at the 5% level) from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

Table 2. Means of fruit quality in crop years 1969 and 1970 of old-line and nucellar Valencia oranges grown on six rootstocks.*

Rootstock	*Scion type*	*Fruit dia. (cm)*	*Fruit weight (g)*	*Peel color*	*Rind thickness (mm)*	*Juice/Fruit (ml)*	*% Juice*	*Total soluble solids %*	*Total acids %*	*Brix/Acid ratio*
Sour orange	Old-line	6.8	163.1	J***	3.3	84.7	53.8	12.7	.95	13.1
	Nucellar	7.0	182.8	J	3.2	94.1	53.6	12.9	.91	14.1
Mean**		6.9abc	173.0a	J	3.3a	89.4a	53.7a	12.8a	.93ab	13.9a
Morton citrange	Old-line	7.0	177.4	J	3.6	91.3	52.3	12.6	.88	14.4
	Nucellar	7.0	179.1	I	3.3	89.3	54.1	12.7	.89	14.5
Mean		7.0a	178.3a	J-I	3.5a	90.3a	53.2a	12.7a	.88b	14.5a
Cleopatra mandarin	Old-line	6.7	163.1	J	3.3	84.6	51.4	12.5	.96	13.1
	Nucellar	6.9	177.9	J	3.3	86.3	51.9	12.4	.84	14.9
Mean		6.8bc	170.5a	J	3.3a	85.5a	51.7a	12.5a	.90b	14.0a
Troyer citrange	Old-line	6.8	170.1	J	3.4	82.4	50.6	13.0	.93	14.0
	Nucellar	7.0	184.7	J	3.3	90.9	51.1	12.5	.92	13.7
Mean		6.9ab	177.4a	J	3.4a	86.7a	50.9a	12.8a	.93ab	13.9a
Natsu Mikan	Old-line	6.6	161.2	I	3.4	81.8	53.0	12.4	.91	13.8
	Nucellar	6.7	168.1	I	3.0	87.4	53.7	12.2	.85	14.4
Mean		6.7c	164.7a	I	3.2a	84.6a	53.4a	12.3a	.88b	14.1a
Ponkan mandarin	Old-line	6.8	169.8	J	3.4	87.8	54.0	12.7	.96	13.5
	Nucellar	6.7	164.7	I	3.3	81.9	51.9	12.8	.97	13.3
Mean		6.8bc	167.3a	J-I	3.4a	84.9a	53.0a	12.8a	.97a	13.4a
Scion means——Old-line		6.8a	167.5b	J	3.39a	85.4a	52.5a	12.6a	.93a	13.7a
Scion means——Nucellar		6.9a	176.7a	J	3.24b	88.4a	52.7a	12.6a	.90b	14.2a

* Each value based on three samples, one from each of three two-tree plots.

** Mean followed by letter "a" is significantly different (at the 5% level) from those means not having "a"; those followed by "b" are significantly different from those not having "b", etc.

*** Peel color ratings according to Harding, et al. (5).

brackish water, tend to accumulate high levels of sodium and chloride in their leaves (3). On calcareous soils they are somewhat susceptible to iron-deficiency chlorosis (2). Morton fruits sometimes contain very few seeds which might make large-scale propagation difficult.

In view of these drawbacks, it would be unwise to suggest widespread substitution of sour orange by Morton and Troyer citrange rootstocks at this time. The 26% higher yields on Morton roostock, however, warrant further trial plantings on this rootstock. Should there be an outbreak of tristeza, sour orange can be replaced with Morton and Troyer without causing a decline in yield and fruit quality of Valencia orange.

Trees on Cleopatra, Ponkan, and Natsu Mikan rootstocks were less productive than trees on sour orange, and these varieties are apparently not suited as rootstocks for Valencia orange in South Texas. It appears that the mild strain of exocortis virus present in the old-line trops caused stunting on Natsu Mikan and Ponkan rootstocks.

The greater productiveness of the old-line trees as compared to the nucellar Valencia trees could be further increased on a per acre basis because their smaller size permits closer planting. Reducing the planting distance within the row to 12 ft. from the commonly used 15 ft. would raise the number of trees to 145 per acre, 29 more than the usual 116 with current planting practices.

ACKNOWLEDGEMENT

The authors are grateful to Dr. H. Delvar Petersen, Biometrical Services Staff, USDA, ARS, Colorado State University, Fort Collins, Colorado, for statistical analysis of the data.

LITERATURE CITED

1. Calavan, E. C., R. M. Pratt, B. W. Lee, and J. P. Hill. 1968. Tristeza related decline of orange trees on citrange rootstock. Calif. Citrograph 53(3):75-90.

2. Cooper, W. C., and Ascension Peynado. 1954. Screening citrus rootstock seedlings for tolerance to calcareous soils. Jour. Rio Grande Valley Hort. Soc. 8:100-105.

3. ―――――― and ――――――, 1961. Toxicity and accumulation of salts in citrus trees on various rootstocks in Texas. Proc. Florida State Hort. Soc. 74:95-104.

4. Gardner, F. E., and G. E. Horanic. 1967. *Poncirus trifoliata* and some of its hybrids as rootstocks for Valencia sweet orange. Proc. Florida State Hort. Soc. 80:85-88.

5. Harding, P. L., J. R. Winston, and D. F. Fisher. 1940. Seasonal changes in Florida orange. USDA Technical Bulletin No. 753, pp. 10.

6. Olson, E. O. 1955. A survey for tristeza virus in Texas Citrus. Jour. Rio Grande Valley Hort. Soc. 9:51-60.

7. ——————, W. C. Cooper, and A. V. Shull. 1959. Virus-free seedlings-line and old-line selections of citrus varieties in Texas. Jour. Rio Grande Valley Hort. Soc. 13:22-26.

8. ——————. 1960. Evaluation of rootstocks for Valencia orange trees following inoculation under screenhouse conditions with a severe strain of tristeza virus. Jour. Rio Grande Valley Hort. Soc. 14:29-32.

Cultural Revolution in the Orchard[1,2]

R. F. Leyden[3]

Abstract: Orchards, in the past, have been maintained chiefly under the traditional cultural system of clean cultivation. The literature dealing with orchard cultural practices indicates that soil physical conditions are best maintained under a non-tillage program. The only justification for cultivation in an orchard is to control weeds. Modern herbicides have made weed control without tillage a practicality. Properly used, herbicides have no detrimental effect on fruit quality or quantity. Under chemical weed control with no tillage newly planted trees grow faster and have higher yields in the early years than under any other cultural system. A change in orchard cultural practices from the traditional clean cultivation to chemical weed control with no tillage is taking place.

INTRODUCTION

Cultural revolution in the orchard implies a complete change in orchard cultural practices. In the past orchards were maintained under the traditional practice of clean cultivation. Over the years tillage and cultivation have been the subject of numerous scientific investigations, results of which have been too long overlooked.

Cole, in 1939 (3) discussing soil structure and cultural practices states that the number of tillage operations performed is more often based on habitual practice than on a consideration of the soil physical conditions to be obtained. He considered many tillage operations to be entirely unnecessary. Russell in 1938 (12) pointed out that suitable cultivation, when soil moisture is in the optimum range, can, in some soils, increase the amount and stability of aggregates. But, more often than not, soil moisture is not in the optimum range at the time of tillage. The result is a reduction in aggregation. Baver (1) has said that soil physical condition tends to deteriorate under usual tillage operations.

With regard to cultivation as it applies specifically to orchards, Hilgard (4) in 1906 reported that excessive cultivation, as then being practiced in California orchards, resulted in serious losses of organic matter and nitrogen during the hot, dry summers. He held these losses responsible for the small fruit sizes growers were then complaining about. That sounds familiar. Here, 60 years later we still have growers complaining about small sizes.

In 1930 Veihmer and Hendrickson (18) stated that the only purpose of tillage in an orchard was to control weeds. About this time California workers began recommending reduced tillage for orchards.

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1 Presented at the Twenty-third Annual Horticultural Institute, Rio Grande Valley Horticultural Society, Weslaco, Texas, January 21, 1969.

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

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In deciduous orchards much of the same picture was developing (15, 16). Workers in New York demonstrated in 1935 that soil structure, porosity, and organic matter were better maintained under non-tillage than under clean cultivation. Pennsylvania workers reported similar findings. From West Virginia in 1940 came a report dealing with 63 orchards. Under clean cultivation as opposed to non-tillage, organic matter was reduced, non-capillary porosity was reduced, and soil bulk density was increased. Michigan workers reporting on a 25 year orchard study indicated that there was a gradual reduction in permeability and loss of soil structure under clean cultivation as compared to non-tillage.

Tillage and traffic in the orchard greatly increased soil bulk density and reduced permeability according to California reports (10,14,17). Compaction was much greater in the cultivated middles than in the tree row. The long-term effect of tillage in many orchards was the formation of a compacted layer. In the Lower Rio Grande Valley, Pickett (11) in 1946 was recommending shallow cultivation for orchards.

As I have tried to indicate, between 1900 and 1950 a great deal of literature was published pointing out the desireability of reducing or eliminating tillage in orchards. Apparently not many people were convinced by the early work. Since 1950 the volume of published work dealing with orchard cultural practices has not let up.

In California citrus the earlier finds did make an impression. By the 1930's non-tillage was beginning to take hold. At first diesel oil or heater oil was used to control weeds. This was later fortified with dinitrophenol or pentachlorophenol. Eventually a separate petroleum fraction, now known as weed oil, came into use. By 1949 about 50,000 acres, out of 330,000 acres of citrus in California were under the system of weed oil and no tillage (5).

The real impetus to non-tillage in citrus came in the early 1950's with the advent of the substituted urea and the triazine herbicides, karmex and simazine. Here were broad spectrum herbicides which, at rates tolerated by citrus trees, could provide virtually year-long weed control. With these materials, and others which have since been added to the list of approved herbicides, citrus growers can successfully establish and maintain chemical weed control with no tillage in their orchards. Currently about two-thirds of the citrus acreage in California uses the system of herbicides and no tillage.

Widespread use of the newer herbicides naturally raised the question to fruit quality McCarthy et al (8) compared karmex-no tillage, weed oil-no tillage, and clean cultivation in a lemon orchard. Over a five year period there were no significant differences in lemon fruit quality. Jones et al (6) reporting on the long-time fertilizer experiment with navel oranges at Riverside, state that by 1954 water intake had become a problem on certain plots. These plots were split; one portion receiving chemical weed control with no tillage, the other remaining under conventional tillage. Over a four year period water intake improved measurably on chemical weed control-no tillage plots. The better moisture relations were apparently reflected in fruit quality. Fruit from plots under herbicides with no tillage had thinner peel, higher percent juice, and a higher ratio than did fruit from cultivated plots.

Regarding yield, a recent Australian report (2) concerning a citrus experiment established in 1941 indicates that the highest yields and the best quality fruit came from plots under chemical weed control with no tillage.

In Florida (13) more rapid growth of young orange trees and greater yield in the early years was found where herbicides and no tillage was used as compared to clean cultivation. Improved growth of young trees has also been reported for deciduous fruits. In Oregon (9) significant differences were found in the growth of apple trees from planting through four years-of-age under various cultural systems. Greatest total growth over the four years and greatest annual increment occurred on plots under herbicides with no tillage. Maximum differences occurred in the first two years, emphasizing the need for adequate weed control in new plantings. Continued significant differences in the third and fourth year indicate the need for continued weed control if maximum growth is to be realized.

Karmex was registered for use in California citrus in 1953 following about five years of research. There now exists in California some 15 years of commercial experience and about 20 years of research experience. In the Lower Rio Grande Valley we have five years of commercial experience and ten years of research experience. When used as recommended, herbicides are in no way detrimental to citrus trees or fruit.

EXPERIMENTAL RESULTS

The first cultural practice experiment at the Citrus Center, set out in 1953, compares the systems: chemical weed control with no tillage, sod culture with no tillage, and clean cultivation. In the latter practice cultivation is performed only when necessary to facilitate other operations. In practice this has varied from five to eight times a year. In 1960 a second trial, involving the three cultural systems in four replications, was set out on the South Research Farm.

Following the freeze of January 1962 we found, in line with our experience in earlier, less severe freezes, that the amount of freeze injury varied with cultural practice: the greatest damage occurred under sod culture, the least under chemical weed control with no tillage, and an intermediate amount under clean cultivation. With a bare soil-no tillage system a small but real temperature difference is found on nights when temperatures critical to citrus are reached. The bare, undisturbed soil serves as a heat sink, absorbing radiant energy during the hours of sunlight, and releasing the energy as heat when radiation conditions prevail at night. Chemical weed control with no tillage is a means of gaining some cold protection.

Tree growth under the three cultural systems is presented in Table 1. Significant differences in trunk diameter were found at four, five, and six years-of-age. Trees from plots under chemical weed control with no tillage were the largest in each instance. Yield at five and six years-of-age, for the same trees, is presented in Table 2. In both years the greatest yield was found under chemical weed control with no tillage. Yield difference in these early years is directly related to the difference in tree size: the larger trees simply have more bearing surface and accordingly carry a larger crop (7).

Yield from the older experimental block for the period 1959-69 is presented in Table 3. The major freeze of January 1962, which drastically reduced yields for at least two seasons, and hurricane Beulah, September 1967, which resulted in a large and variable loss of that year's crop, are of course included in the ten year period being considered. With these setbacks chemical weed control with no tillage produced an annual average for the ten years of 15.4 tons an acre; one-half ton more than clean cultivation and two and a half tons more than sod culture.

Differences in freeze injury and in rate of recovery are apparent from the yield records. In 1962-63, the first season following the freeze, all

Table 1. Growth of young Redblush grapefruit trees under three cultural systems at 4, 5, and 6 years from planting.

CULTURAL SYSTEM	*TRUNK DIAMETER (inches)*[x]		
	4 yrs.	*5 yrs.*	*6 yrs.*
Chemical Weed Control	3.4 a	5.4 a	7.1 a
Clean Cultivation	2.4 b	4.1 b	6.1 b
Sod Culture	1.9 b	3.0 b	4.8 c

[x]Reading down, entries having the same subscript do not differ significantly at 5% level.

Table 2. Yield of young Redblush grapefruit trees under three cultural systems at 5 and 6 years from planting. Tree spacing 16 x 22 ft., giving 123 trees/A.

CULTURAL SYSTEM	*YIELD*[x]			
	5 yrs.		*6 yrs.*	
	lb/Tree	*Tons/Acre*	*lb/Tree*	*Tons/Acre*
Chemical Weed Control	210 a	12.5 a	236 a	13.9 a
Clean Cultivation	22 b	1.3 b	163 b	9.2 b
Sod Culture	9 b	0.5 b	29 c	3.6 c

[x]Reading down, entries having the same subscript do not differ significantly at the 5% level.

30 test trees on chemical weed control plots contributed to the yield while only a few trees on clean cultivated or sod culture plots contributed. The differences persisted into the second and third seasons. By 1965-66, the fourth season after the freeze, all trees had recovered to at least pre-freeze levels.

Following a severe freeze prices are likely to remain relatively high for a few seasons. The average on-tree price to the grower for the 1962-63 season was $100 a ton. At this rate chemical weed control grossed $50 an acre. Clean cultivation and sod culture, with about 100 lb. an acre, probably would not have been harvested commercially. The next season the average price was $76 a ton. Returns were $184, 86, 35 for chemical weed control, clean cultivation, and sod culture respectively. In 1964-65 with the average price at $51 returns were $871 an acre for chemical weed control, $564 for clean cultivation, and $456 for sod culture. That such differences in gross returns are important to the grower scarcely needs to be pointed out.

The cultural revolution in the orchard is taking us from the stage of extreme soil manipulation, as under clean cultivation, to the stage where soil manipulation is virtually eliminated. The new system gives us faster growth of newly-planted trees and with it greater yields in the early years. The new system offers some measure of cold protection in that the amount of freeze damage is reduced and full production is restored sooner. Grower experience in the Lower Rio Grande Valley since 1963 has shown that, with proper management, chemical weed control with no tillage can be a more desirable and a more economical orchard cultural practice than clean cultivation or sod culture.

Table 3. Yield of Redblush grapefruit on sour orange rootstock under three cultural systems. Trees planted in 1953 spaced 20 x 22 ft, giving 100 trees/A.

SEASON	*YIELD*					
	CWC		*CULT*		*SOD*	
	lb/Tree	*Ton/acre*	*lb/Tree*	*Ton/acre*	*lb/Tree*	*Ton/acre*
1959-60	434	21.6	372	18.6	282	14.1
1960-61	443	22.3	370	18.5	366	18.3
1961-62	397	19.9	408	20.4	430	21.5
1962-63	11	0.5	1	0.05	1	0.05
1963-64	49	2.4	22	1.1	10	0.5
1964-65	340	17.0	220	11.0	178	8.9
1965-66	434	21.7	488	24.4	390	19.5
1966-67	377	18.8	368	18.4	214	10.7
1967-68	150	7.5	228	11.4	252	12.6
1968-69	450	22.5	492	24.6	454	22.7
Ten yr avg	309	15.4	297	14.8	258	12.8

LITERATURE CITED

1. Baver, L. D. 1940. Soil Physics. J. Wiley, New York. 313 p.
2. Cary, P. R. 1968. Effects of Tillage, Non-Tillage, and Nitrogen on Yield and Fruit Composition of Citrus. J. Hort. Sci. 43:299-315.
3. Cole, R. C. 1939. Soil Mascrostructure As Affected By Cultural Treatments. Hilgardia. 12(6):429-472.
4. Hilgard, E. W. 1906. Soils. Macmillan, New York. 131 p.
5. Johnston, J. C. and W. Sullivan. 1949. Eliminating Tillage In Citrus Soil Management. California Agr. Ext. Ser. Circ. 150. 16 p.
6. Jones, W. W., C. B. Cree, and T. W. Embleton. 1958. Effect of Non-Tillage on Navels. California Agriculture 12:5,10.
7. Leyden, R. F. 1969. Development of the Herbicide Program in Texas. Proc. 1st International Citrus Sympo. 1:473-478.
8. McCarthy, C. D., B. E. Day, and R. C. Russell. 1960. Effect of Monuron on Lemon Fruit Quality. California Citrograph 45:174.
9. Mellenthin, W. M., C. Crabtree, and F. D. Rauch. 1966. Effect of Herbicides and Weed Competition on Growth of Orchard Trees. Amer. Soc. Hort. Sci., Proc., 88:121-126.
10. Parker, E. R. and H. Jenny. 1945. Water Infiltration and Related Soil Properties As Affected By Cultivation and Organic Fertilization. Soil Sci. 60:353-376.
11. Pickett, B. S. 1946. Management of Soils In The Lower Rio Grande Valley. Texas Agr. Exp. Sta. Circ. 110. 13 p.
12. Russell, E. W. 1938. Soil Structure. Imp. Bur. Soil Sci. Tech. Commu. 37.
13. Ryan, G. F. 1965. Effect of Herbicides on Growth and Yield Of Orange Trees. Cit. & Veg. Mag. 28(10):22,23,25.
14. Salter ,R. M. 1940. Some Soil Factors Affecting Tree Growth. Science 91:391-398.
15. Shaulis, N. J. and F. G. Merkle. 1939. Orchard Soil Management. Pennsylvania Agr. Exp. Sta. Bull. 373.
16. Sudds, R. H. and G. M. Browning. 1941. Effect of Soil Management Methods on Physical and Chemical Properties in Relation to Infiltration Rates In West Virginia Orchards. Amer. Soc. Hort. Sci., Proc., 39:38-46.

17. Taylor, O. D., L. H. Stolzy, and R. B. Harding. 1959. Effect of Management Practices On Production and Soil Physical Properties. California Citrograph 44:285-288.

18. Veihmeyer, F. J. and A. H. Hendrickson. 1930. Essentials of Irrigation and Cultivation of Orchards. California Agri. Ext. Serv. Circ. 50. 24 p.

Evaluation of Spray Equipment for Pesticide Application to Citrus[1]

Rex B. Reinking[2]

Abstract: A five year experiment testing eight types of orchard sprayers was conducted in a grapefruit orchard at Texas A&I University Citrus Center. Two sprayers spraying dilute – a Hardie with hand guns and a Hardie with oscillating boom, and six sprayers spraying concentrated mixtures – the 29" and 36" fan Econ-O-Mist, the R.S.M., the Lachazette, the John Bean 200 TR, and the John Bean 757 were evaluated. All sprayers effectively controlled Texas citrus mites and brown soft scale. Although armored scale infestations showed considerable yearly variation, the John Bean, Hardie, and R.S.M. sprayers consistently gave good control of this pest. The Econ-O-Mist performed erratically on armored scale and the Lachazette gave significantly poorer control than the other sprayers the one year it was tested. Concentrate sprayers offer the grower an economical method of pest contol.

INTRODUCTION

The application of pesticides to control insects and mites is necessary for successful citrus production. These applications are usually made three or four times during the year. In recent seasons a diminishing labor supply has forced the abandonment of most hand spray operations and growers have had to obtain spray coverage by mechanical means.

Mechanical spray applications may be grouped according to their means of distributing the pesticide to the tree and fruit. In general these would be:

1. Hydraulic dilute – pesticide carried in a dilute mixture, high gallonage, under high liquid pressure.
2. Air blast dilute – pesticide carried in a dilute mixture, high gallonage, under high air volume.
3. Air blast concentrate – pesticide carried in a concentrated mixture (2X to 90X), low gallonage, under high air volume.
4. Aerial concentrate – pesticide carried in a very highly concentrated mixture, very low gallonage, distributed by airplane or helicopter flying at low levels over the tree tops.

In Texas, two principal pests, the Texas citrus mite, *Eutetranychus banksi* (McGregor), and the rust mite, *Phyllocoptruta oleivora* (Ashmead), are not difficult to control by spray application. Their active

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movement can carry them to the site of spray deposit and there are a number of effective miticides (acaracides) available. Less than complete wetting of the tree can provide a measurable and often satsifactory level of control for mites. Brown soft scale, *Coccus hesperidum* (Linnaeus), are easily killed with one of several effective insecticides and are not as difficult to control as the armored scale.

Because of their feeding habits and their protective cover, armored scale insects, primarily California red scale, *Aonidiella aurantii* (Maskell), are the most difficult pests to control. Once past the crawler stage the female scale settles in one location on a leaf, fruit, or branch and proceeds to feed and rear young without moving from that spot. Since the scale do not roam to feed chemicals applied for control must be deposited on or at the site of the scale. For armored scale in Texas, control is based primarily on the suffocating effect of petroleum spray oils. To assure good armored scale control it is necessary that all the fruit, leaves, and branches be thoroughly covered with spray material.

Years ago it was found necessary to thoroughly spray citrus trees to control scale insects and this had to be done with dilute sprays using hand guns (5). As mechanical sprayers came into use it was found that better oil deposits resulted when air blast dilute sprayers were driven at forward speeds under 1.2 mph than when higher gallonage was applied at higher forward speeds (4). Several models of air blast concentrate sprayers were reported to give satisfactory coverage with parathion sprays (6). Recently helicopter applications were found to control citrus rust mite but were not effective in controlling armored scale (1). Two air blast concentrate sprayers were reported as effective as dilute sprayers in controlling scales and mites in Florida (2). In Texas another concentrate sprayer was found as effective as hand gun dilute spraying for the control of rust mites, Texas citrus mites, and brown soft scale, but not as effective for controlling California red scale (3).

In 1964 the Texas A&I University Citrus Center established a program for evaluating sprayers for citrus. Special emphasis was given to concentrate spraying because of its saving of labor.

MATERIALS AND METHODS

Sprayers were tested in a grapefruit orchard that had been planted at the Citrus Center in 1953. Individual plots for each treatment and non-sprayed check were three tree rows with 25 trees each in 1965 and 1966, and two tree rows with 12 trees each in the years thereafter. The test block design was completely randomized with three replications of each sprayer treatment.

Leaf samples were examined at various dates after treatment for rust mites, Texas citrus mites, and brown soft scale. Because the complete spray program followed in each test provided control of these pests with all types of sprayers used this data is not included. To produce clean fruit a sprayer must control armored scale. This was the basis for these tests. Armored scale populations were determined in December by counting the number of clean fruit (5 scales or less) in a 50 fruit sample taken at the 5-6 foot level from the outside to the center of the tree from random trees in each plot.

The sprayers[3] tested were:

Hardie hydraulic sprayer using hand guns operated at 500 psi
Hardie hydraulic sprayer equipped with a Randell oscillating boom operated at 500 psi
Econ-O-Mist air blast concentrate sprayer with a 29 inch fan
Econ-O-Mist air blast concentrate sprayer with a 36 inch fan
John Bean 757 air blast sprayer
John Bean 200 TR air blast sprayer
R.S.M. air blast sprayer
Lachazette air blast sprayer

RESULTS

1965 and 1966 Tests

Two sprayers were tested: a Hardie hydraulic dilute sprayer with a hand gun application operated at 500 psi and an Econ-O-Mist air blast concentrate sprayer with a 29 inch fan set to spray at 40X concentration.

Four applications were made each year as follows:

Time	*Material per Acre*
April:	10 gal spray oil, 10 lb Zineb, 14 lb Tribasic Copper
June:	15 gal spray oil, 1 gal Ethion
August:	2 gal Guthion
October:	5 gal spray oil, 19 lb Sevin, 1 gal Ethion

The same amount of material per acre was applied with each machine each year but in different amounts of water.

As seen in Table 1 both the Hardie hand gun application and the Econ-O-Mist with 29 inch fan at 40X concentration gave significant control of armored scale over the untreated check in both years of the test. In 1966 the performance of the Econ-O-Mist did not match the previous year, producing only 15% scale-free fruit, and was less effective than the hand gun spray.

1967 Tests

In 1967 the Hardie sprayer was equipped with a Randell oscillating

[3] The author wishes to express his appreciation to Tide Chemical Co., Edinburg; Don Lindsley Spraying Service, Monte Alto; Jimmy Hill, Inc., McAllen; Herman S. Mayeaux, Harlingen; and Edge-Rite Corp., Brownwood for the loan of the spraying equipment used in these experiments.

boom. A John Bean 757 air blast sprayer with nozzle adjustment to spray a 6X concentration and an R.S.M. air blast sprayer set to spray a 14X concentration were included in the test. The Econ-O-Mist with 29 inch fan set to spray at 40X concentration was included in the test for the third year.

Only three applications were made due to Hurricane Beulah and the excessive rainfall afterward. The applications were as follows:

Time	*Material per Acre*
April:	12 gal spray, 12 lb Zineb, 17 lb Tribastic Copper
June:	18 gal spray oil, 1¼ gal Ethion
August:	2 gal Guthion

The same amount of material per acre was applied with each machine but in different amount of water, thus the difference was only in the type of sprayer and the spray concentration.

Table 2 shows the Hardie with oscillating boom dilute and the John Bean 757 air blast sprayer at 6X concentration gave significantly better control of armored scale than the Econ-O-Mist concentrate sprayer and the check. The R.S.M. concentrate sprayer at 14X concentration was statistically as good as the Hardie and the John Bean 757 but not significantly better than the Econ-O-Mist. The Econ-O-Mist was statistically no better than the check.

Table 1. Armored scale control with different sprayers in 1965 and 1966.

Sprayer	*Concentration*	*Forward Speed*	*Gal/Acre*	*% Scale-free Fruit*[x] 1965	1966
Hardie hand gun	1X	N/	1000	90 a	81 a
Econ-O-Mist 29" fan	40X	1.1 mph	25	60 a	15 b
Check				<1 b	<1 c

Means in a column bounded by the same letter do not differ significantly at the 1% level according to Duncan's Multiple Range Test.

Table 2. Armored scale control with different sprayers in 1967.

Sprayer	*Concentration*	*Forward Speed*	*Gal/Acre*	*% Scale-free Fruit*[x]
Hardie Boom	1X	1.1 mph	1200	82 a
John Bean 757	6X	1.2 mph	200	82 a
R.S.M.	14X	1.1 mph	85	66 ab
Econ-O-Mist 29" fan	40X	1.1 mph	30	52 bc
Check				15 c

[x] Means bounded by the same letter do not differ significantly at the 1% level according to Duncan's Multiple Range Test.

It is interesting to note that the Hardie sprayer equipped with a mechanical oscillating boom performed as well as in previous years when the sprayer was equipped with hand guns. The hand gun operation was with three men while the sprayer equipped with oscillating boom required only one man.

1968 Test

A Lachazette air blast sprayer, manufactured in France, was made available for testing in 1968. It applied a 22X concentration spray mix. The John Bean 200 TR air blast sprayer was used in the 1968 experiment instead of the John Bean 757 but with the same 6X concentration. The R.S.M. was in the test but this year at 10X concentration. The Econ-O-Mist was not available for testing. The Hardie with oscillating boom was again used spraying dilute.

Material applied per acre and dates of application were as follows:

Time	*Material per Acre*
April:	15 gal spray oil, 15 lb Zineb, 21 lb. Tribasic Copper
June:	22 gal spray oil, 1 gal Trithion
August:	4 lb Guthion W.P.
December:	1½ gal Kelthane, 10 lb Sevin

Note in Table 3 that the only significant difference among the sprayers was between the John Bean 200 TR at 250 gallons per acre and the Lachazette. All sprayers provided better control than the check. Except as noted, there were no differences between the other sprayers.

1969 Test

In 1969 an Econ-O-Mist was again available for testing, but this time it was a machine with a 36 inch blower fan. It was set to spray at 60X concentration. The Lachazette sprayer was withdrawn from the tests. The Hardie, John Bean 200 TR, and R.S.M. sprayers were the same as in the 1968 test.

Table 3. Armored scale control with different sprayers in 1968.

Sprayer	*Concentration*	*Forward Speed*	*Gal/Acre*	*% Scale-free Fruit*[x]
John Bean 200 TR	6X	1 mph	250	99 a
Hardie Boom	1X	1 mph	1500	94 ab
R.S.M.	10X	1 mph	150	77 ab
Lachazette	22X	1 mph	67	59 b
Check				10 c

[x] Means bounded by the same letter do not differ significantly at the 1% level according to Duncan's Multiple Range Test.

Material applied per acre and dates of application were as follows:

Time	*Material per Acre*
April:	15 gal spray oil, 15 lb Zineb, 21 lb Tribasic Copper
June:	22 gal spray oil, 1 gal Trithion
August:	4 lb Guthion 50% W.P. + 4 pts Acaraben
October:	10 lb Sevin, 1½ gal Ethion

This was a year of low armored scale infestation as seen in the high percentage of scale-free fruit in the check (Table 4). There were no significant differences between sprayers, but all sprayers differed significantly from the unsprayed check.

DISCUSSION

In all of these experiments Texas citrus mites and brown soft scale were controlled with comparatively small amounts of water in the spray mixture. The Econ-O-Mist at 60X and 40X concentration, the R.S.M. at 14X and 10X, and the Lachazette at 22X, achieved control of Texas citrus mites and brown soft scale using only 25 to 150 gallons of complete spray mix per acre.

It was apparent that the magnitude of infestation of armored scale varied considerably from year to year. In 1969 49% of the fruit in the check plot was classed as scale free fruit while in 1965 and 1966 less than 1% of the fruit in the check plot was scale free. The results suggest that in years of relatively light infestations applications of high concentrate spray mixtures would achieve better armored scale control than in years of heavy infestation. Whether the low scale infestation or the 36" fan accounts for the improved performance of the Econ-O-Mist in 1969 over previous years can only be determined by further testing. These tests indicate that overall satisfactory pest control can be achieved with concentrate sprayers in most years. Because they use less water and labor, concentrate sprayers offer the grower a means of lowering the cost of his spraying operation without sacraficing effective pest control.

In addition to cost and effectiveness several other factors will influence the growers selection of spraying equipment. A major considera-

Table 4. Armored scale control with different sprayers in 1969.

Sprayer	*Concentration*	*Forward Speed*	*Gal/Acre*	*% Scale-free Fruit*[x]
Hardie Boom	1X	1 mph	1500	100 a
John Bean 200 TR	6X	1 mph	250	99 a
Econ-O-Mist 36" fan	60X	1 mph	25	97 a
R.S.M.	10X	1 mph	150	95 a
Check				49 b

[x] Means bounded by the same letter do not differ significantly at the 1% level according to Duncan's Multiple Range Test.

tion is the number of acres he will be spraying. A one-sided machine takes nearly twice the time to cover a given acreage as a two-sided sprayer. A rule of thumb used in other citrus areas is to have a two-sided sprayer for each 500 acres of trees. The age and size of the trees and row spacing will affect the choice of spray pattern and height and the size of the sprayer. Finally the variety and the quality of the fruit demanded by the market the grower is supplying may limit his selection of spray equipment. If he intends to market his fruit through gift shippers the most effective sprayer will be needed to produce large crops of high quality fruit. For less extensive operations smaller sprayers than the ones described are available for any size orchard. Usually though these smaller units tend to increase labor requirements. For some orchard owners the best solution may be to hire their spraying done. There are many custom operators in the Valley who will do this work.

LITERATURE CITED

1. Brooks, R. F. 1965. Comparison of a helicopter with a conventional air-blast sprayer in the application of a citrus spray program. Proc. Florida State Hort. Soc. 78:69-73.
2. Brooks, R. F. 1968. Developing pesticide application equipment for citrus. Proc. 1st International Citrus Sympo. 2:923-932.
3. Reinking, R. B. 1965. Concentrate spraying of citrus under test. Texas Farming and Citriculture 42(2):7,22.
4. Stearns, C. R. Jr., W. L. Thompson, and J. T. Griffiths. 1949. Effect of methods of application on copper, sulfur and oil deposits obtained by spraying and dusting. Citrus Industry 30(3):9,11-12,14.
5. Thompson, W. L. 1938. Results of different methods of oil application for the control of scale insects on citrus. Proc. Florida State Hort. Soc. 51:109-114.
6. Thompson, W. L., C. R. Stearns, Jr., and W. A. Simanton. 1954. Combined control of scale insects and mites on citrus. p. 160. Florida Agr. Exp. Sta. Annu. Rep. 1954.

Distribution and Control of the Citrus Nematode in the Lower Rio Grande Valley of Texas[1]

C. M. HEALD[2]

Abstract: The citrus nematode (*Tylenchulus semipenetrans Cobb*) was found in 90% of the orchards sampled in the Lower Rio Grande Valley. Nematicides applied in irrigation water or disked into the soil around Valencia orange trees resulted in significant yield increases ranging from 25.8 to 41.2%. Nematode counts indicated that after 14 months good control persisted.

INTRODUCTION

The citrus nematode (*Tylenchulus semipenetrans* Cobb) occurs in most citrus production areas of the world. Several workers (1, 4, 5) have shown increases in quality and quantity of citrus by control of the citrus nematode. In 1950 Godfrey and Waibel (2) reported the first occurrence of the citrus nematode in the Lower Rio Grande Valley. They stated that this confirmed a long-time suspicion that the nematode was present in the Valley. Sleeth (6) demonstrated that orange and grapefruit trees planted in fumigated soil showed an increase in growth from 3.2 percent for Valencia orange to 40.6 percent for red grapefruit when compared with trees planted in non-fumigated soil. This paper reports the extent of the citrus nematode in the Lower Rio Grande Valley, its control with nematicides, and the yield increase as a result of nematode control.

MATERIALS AND METHODS

Soil and root samples were collected at 100 locations throughout the Lower Rio Grande Valley to study the distribution of the citrus nematode. Roots were stained with lactophenol and acid fuchsin for identification of citrus nematode females. Soil for nematode analysis was processed by a centrifuge technique (3). Chemicals applied were 1.2 dibromo-3-chloropropane (Nemagon EC-2)[3], *O,O*-diethyl *O,O* (methylsulfinyl)phenyl phosphorothioate (Dasanit)[3], ethyl 4-(methylthio)-m-tolyl isopropyl-phosphoromidate (Bay 68138)[3], and 2-methyl 1-2(methylthio)propionaldehyde-O(methyl carbamoyl)oxime (Temik)[3]. Each material, with the exception of Temik, was applied in the irrigation water with a Carter-o-matic[3] insecticide applicator in May 1968. Temik

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[1] Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, the Texas Agricultural Experiment Station, and Rio Farms, Inc., Weslaco, and Monte Alto, Texas.

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

was applied to the surface with a Gandy[3] fertilizer applicator, disked-in to a depth of 4 inches, and watered with an equal amount of water as with the liquid materials. The experiment was a randomized complete block design in which treatments consisted of an irrigation block of 20 trees per row spaced 15 feet apart, replicated three times. At time of treatment the Valencia orange trees (*Citrus sinensis* (L.) were 8 years old, planted on sour orange (*C. aurantium* L.) rootstock. Each year's data were taken on the number of boxes per treatment (20 trees), average size and weight of the fruit, and nematode population during the year.

RESULTS AND DISCUSSION

The citrus nematode was found in all citrus growing areas of the Lower Rio Grande Valley from Mission to Bay View, Texas. In 10 of the 100 orchards sampled, the citrus nematode was not detected. Effect of the various nematicide treatments are shown in Table 1. All chemicals and rates used significantly (.05 level) increased the yield of oranges in this test on the second crop after application. These increases ranged from 41.2% with Bay 68138 at 20 lb/A to 25.8% with Dasanit at 20 lb/A. Of the chemicals tested, DBCP (Nemagon EC-2)[4] is the only material

Table 1. Increase in yields of Valencia oranges due to applications of nematicides.

	Fruit		
Nemcticide and rate	*Boxes (20 trees)*	*Weight (G)*	*Circumference (cm)*
Bay 68138 — 20 lb/A	53.8 b[a]	172.5	22.1
Nemagon — 5 gal/A	49.6 b	183.4	22.4
Dasanit — 10 lb/A	45.0 b	175.0	22.0
Dasanit — 20 lb/A	42.6 b	171.8	21.9
Temik — 10 lb/A	44.1 b	176.3	22.1
Temik — 20 lb/A	46.6 b	177.2	22.2
Check	31.6 a	169.4	21.7

[a] Means with a letter in common do not differ at P = .05 according to Duncan's Multiple Range Test.

[3] Experimental quantities of Nemagon EC-2, Dasanit and Bay 68138, and Temik were supplied by Shell Chemical Co., Chemagro Corp., and Union Carbide Corp., respectively. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

[4] This is a report on the current status of research involving use of certain chemicals that require registration under the Federal Insecticide, Fungicide, and Rodenticide Act. It does not contain recommendations for the use of such chemicals, nor does it imply that the uses discussed have been registered. All uses of these chemicals must be registered by the appropriate State and Federal Agencies before they can be recommended.

registered by the USDA for use on citrus. An increase in fruit weight and size was also noted with each chemical, but these differences were not significant. In Arizona, O'Bannon and Reynolds (4, 5) have shown increased yields in Navel oranges (C. *sinensis* (L.) Osbeck) when infected trees were treated with DBCP. Baines et al. (1) in California increased yields in Valencia oranges and two lemon varieties, using various methods of DBCP application.

Control of the citrus nematode with the nematicides tested is shown in Table 2. Nemagon and Bay 68138 reduced the initial population by the largest percent, and these two treatments were still showing the best control at the last sampling date. Annual yields from these sites will be taken until no differences are found. Other workers (4, 5) have found that single applications of DBCP increased citrus yields in nematode-infected citrus for as long as 5 years.

Table 2. Control of the citrus nematode with nematicides.

	Sampling Date			
Nematicide and Rate	*7-16-68*	*1-13-69*	*4-1-69*	*8-7-69*
Bay 68138 — 20 lb/A	833[a]	1,013	4,012	867
Dasanit — 10 lb/A	7,566	2,300	10,160	1,567
Dasanit — 20 lb/A	2,333	6,616	9,643	2,683
Nemagon — 5 gal/A	1,033	766	2,200	233
Temik — 10 lb/A	4,800	4,033	5,860	4,212
Temik — 20 lb/A	1,466	3,100	5,068	2,167
Check	8,033	16,843	13,879	2,450

[a] Average number of nematodes/100 g soil + 3 g root (3 reps.).

LITERATURE CITED

1. Baines, R. C., L. H. Stolzy, R. H. Small, S. B. Boswell, and G. E. Goodall. 1960. Controlling citrus nematodes in established orchards. The Calif. Citrograph 45:389, 400, 402, 404-406.

2. Godfrey, G. H., and C. W. Waibel. 1950. The citrus nematode in the Lower Rio Grande Valley of Texas. Texas Farming and Citriculture 2(10):11.

3. Jenkins, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. Plant Dis. Reptr. 48:692.

4. O'Bannon, John H., and Harold W. Reynolds. 1963. Response of Navel orange trees to a postplanting application of DBCP for control of the citrus nematode. Plant Dis. Reptr. 47:401-404.

5. ——————, and ——————. 1967. The effect of chemical treatment on *Tylenchulus semipenetrans* and citrus tree response during 8 years. Nematologica 13:131-136.

6. Sleeth, Bailey. 1958. Soil fumigation increases growth of citrus replants. Jour. Rio Grande Valley Hort. Soc. 12:53-56.

Detection of Foot Rot Disease of Grapefruit Trees with Infrared Color Film[1]

H. W. GAUSMAN, W. A. ALLEN, R. CARDENAS, and R. L. BOWEN[2]

Abstract: Spectrophotometric measurements of individual leaves of grapefruit trees revealed that foot rot affected light reflectance, transmittance, and absorptance in the visable range of the spectrum, 400 to 750 nm. On photographs taken with Kodak Ektachrome Infrared Aero Film, Type 8443, and a light-orange filter (approximately 100% absorption edge at 500 nm), foot-rot-infected trees appeared as white images compared with red images for healthy trees.

INTRODUCTION

Citrus foot rot is a fungal disease caused by *Phytophthora citrophthora* (Sm. & Sm.) Leonian and *Phytophthora parasitica* Dast.(1). These fungi produce a gummy exudate at or near the graft union on citrus trees; wood rots underneath, leaves lose color, and decline sets in.

Phytophthora parasitica is the primary causal agent of foot rot in Florida(2). This is also apparently true in the Rio Grande Valley of Texas[3].

This paper relates foot-rot-induced changes in grapefruit leaves with: (A) infrared color film sensing of reflectance from overflights of a grapefruit orchard and (B) spectrophotometric measurements on individual leaves.

MATERIALS AND METHODS

An overflight of a grapefruit citrus orchard, *Citrus paradise* Macf., Nucellar – CES-3 selection of Red Blush on *Citrus aurantium* Linn. Sour Orange rootstock, near Monte Alto, Texas was made at an altitude of 2,000 ft., with clear to moderate haze, at 11:29 a.m., central standard time, December 5, 1968, in the easterly direction. Photographs were

[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. This study was supported in part by the National Aeronautics and Space Administration under Contract No. 160-75-01-07-10.

[2] Research Plant Physiologist, Physicist, Plant Physiologist, and Photographer, respectively, USDA, Weslaco, Texas 78596.

[3] Private communiques with Dr. C. G. Lyons, Jr. and N. P. Maxwell, Texas Agricultural Experiment Station, and Dr. H. K. Wutscher, U. S. Fruit, Vegetable, Soil and Water Research Laboratory, Weslaco, Texas.

taken with a Zeiss, 6-in. focal length camera, using 9½-in. Kodak Ektachrome Infrared Aero Film (EIR), Type 8443[4], and a Zeiss D light-orange filter, approximate 100% absorption edge at 500 nanometers (nm)[5].

EIR color film has three image layers sensitized to green, red, and infrared radiation(3). A light-orange filter, Zeiss D, Kodak Wratten No. 12 or 15 or equivalent, is used over the camera lens to absorb approximately 100 % of the blue radiation to which all three layers are sensitive. Upon processing, process E-3, yellow, magenta (purplish-red), and cyan (greenish-blue) positive images appear in the green-, red-, and infrared-sensitive layers, respectively. The relative exposure produced in each film layer determines the many possible colors or tonal responses. Healthy plant leaves reflect "brightly" in infrared which produces a light-toned cyan image allowing the red formed in the other layers to predominate.

Fifteen leaves each of approximately the same size and age were collected from a foot-rot-infected tree and a healthy tree (normal appearance by visual observation) five days after the overflight. The foot-rot-infected tree had sparse foliage and was blooming profusely; its leaves were yellowish-white, and its trunk was partially girdled by a foot rot lesion. Spectra were determined on five leaves randomly selected from each group of 15 leaves.

Spectral diffuse reflectance on upper (adaxial) surfaces of single leaves and transmittance were measured over the wavelength interval 500 to 2500 nm with a Beckman Model DK-2A spectrophotometer equipped with a reflectance attachment. Data have been corrected for decay of the MgO reference(5) to obtain absolute radiometric values.

The data were analyzed statistically.

RESULTS AND DISCUSSION

Spectrum colors can be combined to give nonspectrum colors. A proper mixture of blue and red produces magenta, and a proper combination of red, blue, and green gives white light. Reflectance of radiation from aerial photographs of foot-rot-infected trees produced white images, compared with red images for healthy trees, on processed EIR color film used with a Zeiss D, light-orange filter having an approximate 100% absorption edge at 500 nm. Exposure of the yellow, magenta, and cyan dye layers on the film to green, red, and infrared radiations, respectively, gave the proper combination of blue, green, and red colors to produce white light or a white-appearing image on the processed film.

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[4] Trade names and company names are included for the benefit of the reader and do not imply an endorsement or preferential treatment of the product listed by the U. S. Department of Agriculture.

[5] 1.0 nanometer = 1.0 millimicron (mu) = 0.001 micron (u).

Figure 1 is a negative print from an EIR color positive from an overflight of a grapefruit orchard, showing images of dark-appearing (white on EIR color film) foot-rot-infected trees, center, and white-appearing (red on EIR color film) healthy trees. Various degrees of white-

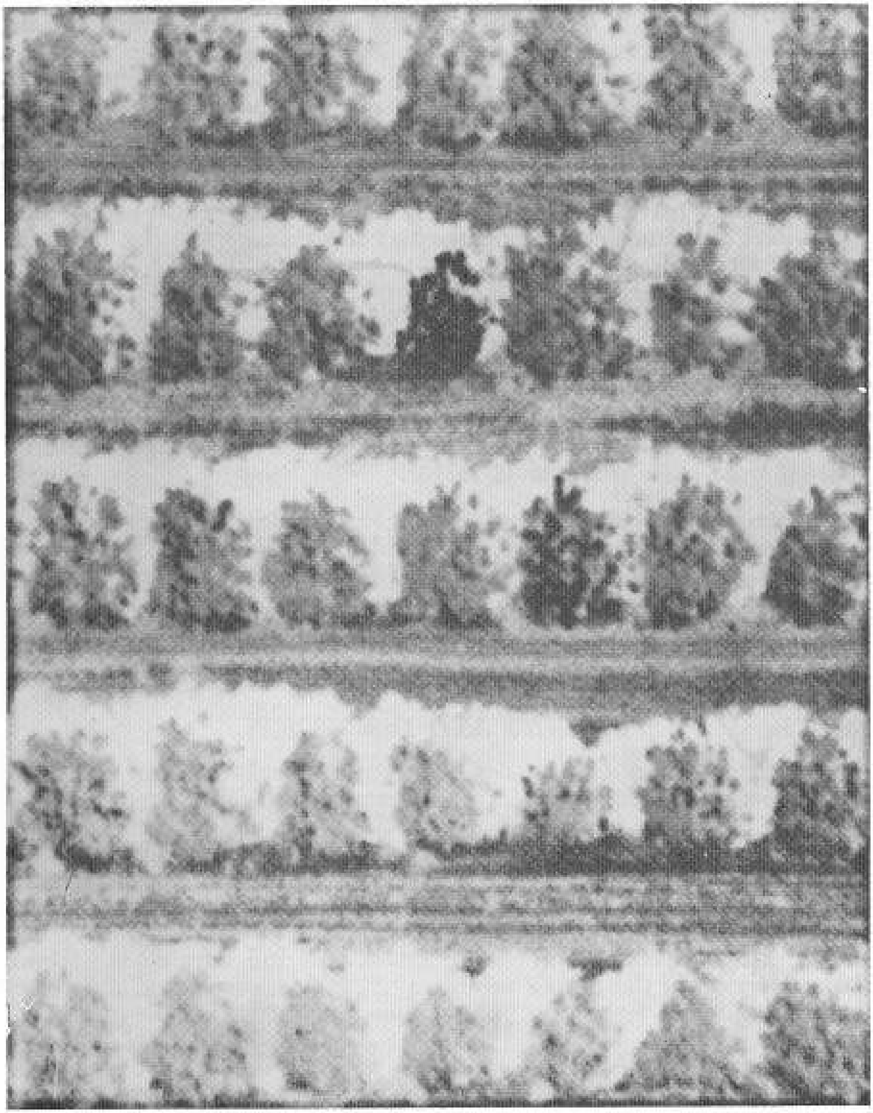

Figure 1. Kodak Ektaprint from a Kodak EIR positive from an overflight of a grapefruit orchard showing images of dark-appearing (white on EIR positive), foot-rot-infected trees, center, and white appearing (red on EIR positive) healthy trees.

appearing trees were detected among the expected red-appearing trees on the EIR color film. An outstanding example of a very white-appearing tree found on the color film is represented by the dark tree in the upper center of the black and white negative print. Investigation revealed that this tree and others like it had foot rot. Their leaves were chlorotic (yellowish-white) in contrast to the dark-green foliage of healthy trees, Fig. 2. None of the trees investigated were completely girdled by foot rot, and as is characteristic for foot-rot-infected trees [1], only part of their foliage was chlorotic.

Other disturbances to citrus trees may also cause chlorotic leaves[4]. Their distribution or location in the canopy, however, appears to be different in comparison with chlorotic leaves on foot-rot-infected trees.

Leaves of approximately the same age and size were sampled from the infected tree and from the healthy tree above and next to the affected tree in the same row, Fig. 1. Spectrophotometric measurements over the wavelength interval 500 to 2500 nm on individual leaves indicated that main differences in response, statistically significant, p = .01, were in the visible region. Accordingly, reflectance and transmittance spectra were obtained over the wavelength interval 400 to 750 nm. Data, mean values for five leaves for each spectrum, are presented in Table 1. The leaves of the foot-rot-infected tree, compared with leaves

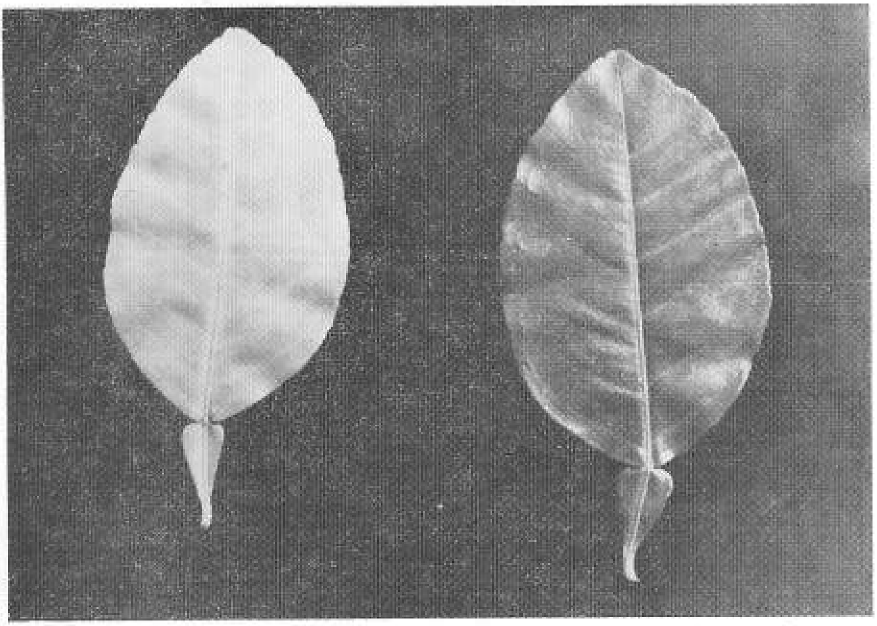

Figure 2. Negative print of Ektachrome color (film type B) photographic comparison of white grapefruit leaf on left (yellowish-white on color film) from foot-rot-infected tree with dark leaf on right (dark-green on color film) from healthy tree.

Table 1. The spectra over wavelength interval 400 to 750 nm of foot-rot-infected, yellowish-white grapefruit leaves, compared with healthy, dark-green leaves. Each spectrum is the mean for five leaves.

Leaves	*Wavelength, nm* 400	450	500	550	600	650	700	750
				Reflectance (Percent)				
Infected	4.56	8.14	18.56	44.68	41.16	28.64	56.06	60.88
Healthy	4.44	4.88	5.56	13.30	7.42	4.72	27.38	60.92
Difference	.12	3.26	13.00	31.38	33.74	23.92	28.68	−.04
				Transmittance (Percent)				
Infected	0	0	2.98	16.70	15.06	8.26	24.34	28.24
Healthy	0	0	0	.18	0	0	4.94	25.62
Difference	0	0	2.98	16.52	15.06	8.26	19.40	2.62
				Absorptance (Percent)[a]				
Infected	95.44	91.86	78.46	38.62	43.78	63.10	19.60	10.88
Healthy	95.56	95.12	94.44	86.52	92.58	95.28	67.68	13.46
Difference	−.12	−3.26	−15.98	−47.90	−48.80	−32.18	−48.08	−2.58

[a] Absorptance = 100 − (% transmittance + ´ reflectance).

of the healthy tree, had higher mean values of 3.3, 31.4, and 23.9% for reflectance; 0.0 and higher mean values of 16.5 and 8.3% for transmittance; and lower mean values of 3.3, 47.9, and 32.2% for absorptance, at 450 (blue), 550 (green), and 650 (red) nm wavelengths, respectively.

SUMMARY

Remote sensing with EIR color film may be useful for determining the amount of foot rot damage in citrus orchards in the Lower Rio Grande Valley. On photographs taken with Kodak Ektachrome Infrared Aero Film (EIR color), Type 8443, and a Zeiss D light-orange filter (approximate 100% absorption edge at 500 nm), foot-rot-infected trees appeared as white images compared with red images for healthy trees.

Leaves of grapefruit trees infected with foot rot were yellowish-white in contrast to the dark-green leaves of healthy plants. Spectrophotometric measurements of the reflectance, transmittance, and absorptance of individual leaves showed differences in the visible range of the spectrum (400 to 750 nm). At the 450 (blue), 550 (green), and 650 (red) nm wavelengths, respectively, reflectance was 3.3, 31.4, and 23.9% higher; transmittance was 0.0, 16.5, and 8.3% higher; and absorptance was 3.3, 47.9, and 32.2% lower for the foot-rot-infected than for the healthy leaves.

CONCLUSION

Foot rot disease of citrus can be detected with aerial photography using EIR color film and a light orange filter. The chlorotic foliage of an infected citrus tree gives a white image on the developed film in contrast to a red image for the foliage of a healthy tree.

ACKNOWLEDGMENTS

The authors acknowledge the helpful commentaries of Drs. Craig L. Wiegand and H. K. Wutscher, and the stenographic assistance by Jean Ryan.

LITERATURE CITED

1. Brandes, G. A., T. M. Cordero, and R. L. Skiles, Editorial Committee. 1959. *Compendium of Plant Diseases.* Rohm & Haas Co., Philadelphia, Pa. pp. 126-127.

2. Cohen, M., G. R. Grimm, and F. W. Bistline. 1964. Foot rot in young groves. *Proc. Florida Hort. Soc.* 77:45-52.

3. Fritz, N. L. 1967. Optimum methods for using infrared-sensitive color film. *Photogram. Eng.* 33:1128-1138.

4. Lundegordh, H. 1966. *Plant Physiology.* American Elsevier Publishing Co., New York, pp. 310-311.

5. Sanders, C. L. and E. E. K. Middleton. 1953. The absolute spectral diffuse reflectance of magnesium oxide in the near infrared. *J. Opt. Soc. Am.* 43:58.

6. Steel, R. G. D. and J. H. Torrie. 1960. *Principles and Procedures of Statistics.* McGraw-Hill Book Co., New York. 481 pp.

7. Strandberg, C. H. 1968. The language of color. In: *Manual of Color Aerial Photography*, Smith, J. T. and A. Anson, editors. Am. Soc. of Photogrammetry, Falls Church, Virginia, pp. 3-24.

The Control of Mature Grapefruit Droppage with 2,4-D[1]

John E. Fucik[2]

Abstract: For three seasons the effect of 2,4-Dichlorophenoxyacetic acid (2,4-D) on drop of mature grapefruit was studied. Sprays of 5 to 16 ppm 2,4-D plus Foli-gard or Multi-film Buffer X adjuvants were applied on two dates. One season the growth retardant Alar-85 was also included. Results showed fruit droppage varies considerably from year to year, is inversely related to number of fruit on the tree, but does not increase as fruit size increases. In two of the three years the 2,4-D significantly lowered the percent of fruit drop over the whole harvest period. However, for any single counting date, with one exception, no significant differences between treatments and no meaningful effects of the adjuvants or dates of application were detected. The results suggest further testing using more trees and higher concentrations of 2,4-D.

INTRODUCTION

Trees on which citrus is stored for late harvesting often lose much fruit. Losses range from 15 to 30% in Florida and California, while in Texas grapefruit droppage through March may exceed 25% (2, 4, 5, 13). Sprays containing 2,4-Dichlorophenoxyacetic acid (2,4-D) or 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) have effectively reduced droppage of oranges and lemons in California, Florida, and Japan, and of grapefruit in California but not in Florida (5, 7, 9, 11, 13, 14). Since much of Texas grapefruit is harvested late, the effect of 2,4-D on fruit drop would be of interest to Valley citrus growers.

MATERIALS AND METHODS

1966-67

The 14 year-old Redblush trees used were in two adjacent east-west rows under sod culture. The test variables were 8 and 16 ppm of 2,4-D; two adjuvants, 2.5% Foli-gard[3], an isopropanolic amine anti-transpirant, and 0.05% Multi-film Buffer X[4], a non-ionic wetting agent; and two application dates, November 15 and December 9, 1966. There were eight treatments plus the control and four replicates of each. Treatments and replications were randomly assigned. Since the trees had been frozen in 1962 and had only four years top growth, 6 liters of solution per tree were sufficient to wet the foliage.

A lithium salt of 2,4-D[5] was used in the first application and a low

[1] Cooperative citrus research of Texas A&I University Citrus Center and Texas Agricultural Experiment Station, Weslaco.
[2] Associate Professor of Agriculture, Texas A&I University Citrus Center, Weslaco.
[3] Supplied by E-Z-Flow Chemical Company, Lexington, Kentucky.
[4] Supplied by Colloidal Products Corp., Sausalito, California.
[5] Supplied by Valley Solvent Company, Combes, Texas.

volatile butyl ether ester[6] for the second application. These were the only forms of 2,4-D available at the time.

Fifteen fruit on the lower half of each tree were tagged at random for drop counts. This system was necessary because of the heavy sod cover which made recovery of dropped fruit difficult. Later the number of the original 15 fruit remaining was used to calculate percent drop.

The November application was made from 9 to 11 AM, the temperature was 70-75 F, the relative humidity (R.H.) was 85%, the wind was S.E. at less than 3 mph and the sky was clear. In December the 2,4-D was applied at the same time of day, temperature was 68-69 F, R.H. 85%, and the sky clear. By late afternoon December 9 a cold front moved into the Valley. Temperatures fell to 50 F and the R.H. to 25%.

1968-69

The test was done in a block of 18 year-old Redblush trees on the Citrus Center's South Research Farm. A water solution of the butyl ether ester of 2,4-D was used at 5 and 10 ppm. The first application was December 10, 1968, from 4-5 PM. The temperature was 72 F, the R.H. 76%, and the sky cloudy. Ten liters of solution were used per tree. The second application was made on January 8, 1969, from 4-5 PM; the temperature was 70 F, R.H. 70%, and the sky overcast. A 2000 ppm Alar-85[7] spray with 1 ppm Multi-film Buffer X surfactant[4] was included in the second treatments. The single-tree replications for each treatment were randomly assigned within the test block.

When the initial 2,4-D application was made the dropped fruit under each tree was counted and removed; and this was repeated for each counting date. In July 1969, a final count was made and the fruit was harvested. Both the number and weight of fruit was recorded. The initial fruit load was obtained by adding the accumulated fruit drop to the number of fruit harvested. Drop percentages were based on the initial fruit load.

1969-70

The 1969-1970 tests were conducted at the same location as the previous year. A water solution of 10 ppm of the butyl ether ester of 2,4-D was applied on December 12, 1969 and January 20, 1970. Four single-tree replications were used for the controls and for each 2-4-D treatment. On January 20, 0.1% Multi-film Spray Modifier[4], a non-ionic surfactant, was added to the 2,4-D solution sprayed on two of the four trees treated. Twenty liters of solution were used per tree.

At the time of application, 4-5 PM December 12, the temperature was 72 F, the R.H. 54%, the wind S.E. at 2-3 mph, and the sky sunny

[6] Trade name, "Esteron", mfg. by Dow Chemical Company. Sample supplied by Redbarn Chemicals, Inc., Elsa, Texas.
[7] Mfg. and supplied by United State Rubber Company, Naugatuck, Conn.

with scattered clouds. The trees were sprayed at 4-5 PM on January 20; the temperature was 70 F, R.H. 71%, the wind S.E. at 8-10 mph and the sky cloudy with intermittent sun.

An initial count of dropped fruit was made on all trees when the first 2,4-D spray was applied and counts were made approximately every two weeks thereafter as in 1968-69.

For all tests a portable 3 hp piston sprayer was used to apply the sprays. The 400 psi pressure developed by the sprayer was adequate to obtain good coverage of the trees.

Data for each counting date were subjected to analysis of variance to determine treatment effects. Differences between treated and control trees over all dates were analyzed by the "t" test (10). Other comparisons were made by standard regression or correlation techniques (18). When percentages ranged from below 10 to more than 30% the values were transformed as described by Snedecor (12).

RESULTS AND DISCUSSION

Characteristics of Fruit Drop

The solid lines in Fig. 1 represent the normal seasonal fruit drop for 1966-67, 1968-69, and 1969-70. Data from another experiment were used for the 1966-67 curve since the control trees for the 2,4-D test did not have a typical drop for the season (4). The curves are similar in that the drop rate during the winter months increases slowly then accelerates with warm weather. The coincidence of this increased rate of drop with the maximum spring growth and blossoming, indicated by the arrows, is consistent for all seasons. The major differences between the curves are the initial percent drop and the time when the drop rate accelerates.

The relationships between yield, fruit size, and drop are shown in Table 1. A significant negative regression of number of fruit on average fruit size reported by others was substantiated in 1968-69, but not in 1969-70. The lack of significance in 1969-70 was probably an effect on the young fruit of not harvesting the 1968 crop until July, 1969. A significant negative correlation of −.458 between the 1968-69 and 1969-70 individual tree yields supports the premise that the late harvest reduced the next season's yields.

The negative regression of number of fruit on percent drop in 1968-69 suggests that trees with a small crop lose proportionately more fruit than trees with a heavy crop. This relationship was not repeated in 1969-70, again, a probable result of late harvesting on the new crop.

The relationship between average fruit weight and percent drop in 1968-69 should be significant since it is derived from the regressions of number of fruit vs percent drop and number of fruit vs average fruit weight both of which were significant. Another interpretation of this relationship is that the larger the fruit the greater its chance of drop-

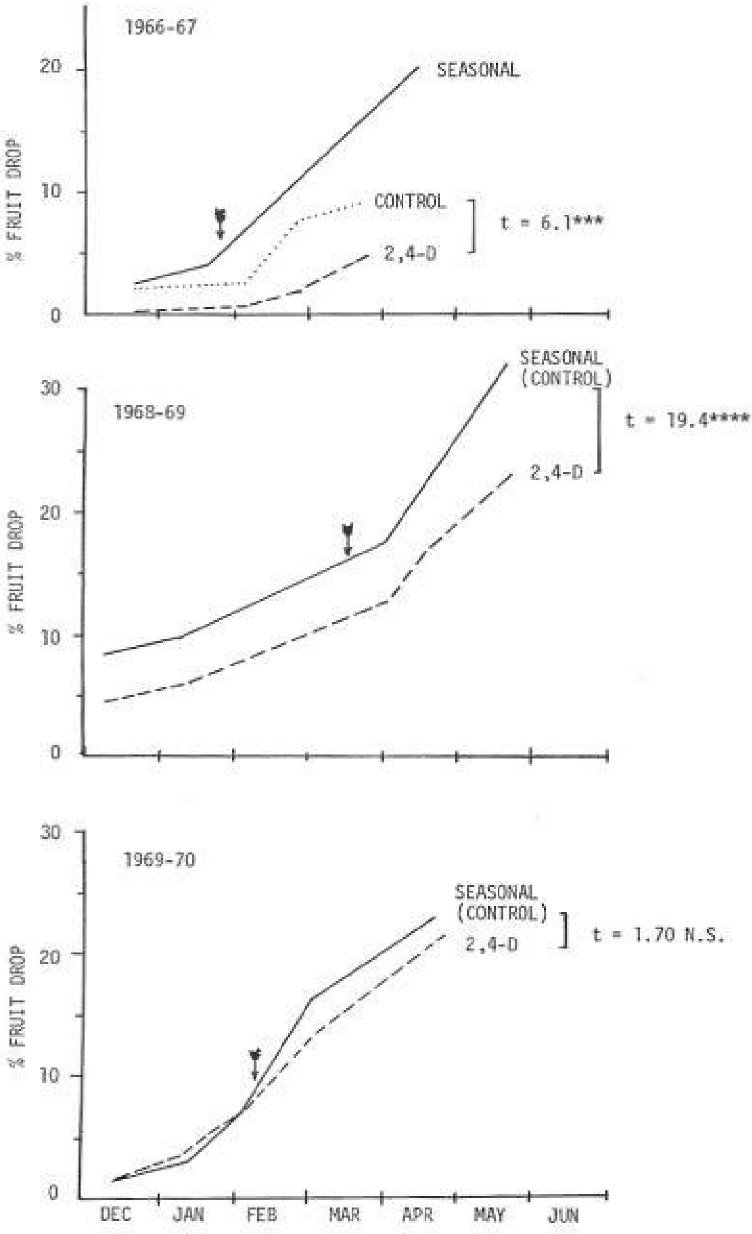

Figure 1. The effect of 2,4-D on seasonal drop of mature grapefruit in Texas for 1966-67, 1968-69, and 1969-70.

ping. My data cannot test this hypothesis, but such a relationship has not been proposed by others (8). Furthermore, if this were true, the percent drop in 1968-69 (Table 1) should have exceeded that for 1969-70.

The Effect of 2,4-D Sprays

1966-67

The effects of 2,4-D and other variables on the percent of grapefruit dropped on the six counting dates is shown in Table 2. The average percent drop from the 2,4-D treated trees was significantly less than the control trees, but there was no difference between the 8 and 16 ppm sprays. Neither the date of the 2,4-D application nor the adjuvants significantly affected drop over the test period. When the percent drop for each counting date was analyzed, no significant differences were observed between any of these variables except between Foli-gard and Multi-film Buffer X on March 21. This 3.3% difference was significant at the 10% level.

While comparisons among the treated trees in this test are acceptable, it was noted above that the percent drop on the control trees was atypical, probably because the method employed for evaluating drop did not provide a fair sample. Also the test trees were inadvertently harvested early which precluded an assessment of the treatments on final yields. Based on reports from California (14) reductions in grapefruit drop of this magnitude could be expected from the 2,4-D concentrations applied.

In the fall of 1967 I noticed an unusual number of off-bloom fruit on several trees sprayed with 16 ppm 2,4-D. While this might have been partly a consequence of Hurricane Beulah in September, it could also have been caused by a low volatile form of 2,4-D[8]. Therefore, concentrations of this formulation of 2,4-D were reduced in subsequent experiments.

1968-69

The 2,4-D treated trees had consistently less drop than the control trees (Fig. 1). Over the period covered this difference was very highly significant. The average reduction in fruit drop due to 2,4-D ranged from 44% in January to 22% in May. There were no significant differences between 5 and 10 ppm 2,4-D nor between the two dates of application. Over the same period the Alar-85 treated trees also showed significantly less fruit drop than the controls but not less than the 2,4-D treated trees.

There was no significant difference in the percent drop for each counting date between any treatments. This inconsistency with the sea-

[8] Personal conversation with C. W. Coggins, Jr., UCR, at the International Citrus Symposium, March, 1968.

Table 1. The relationships between yield, average fruit weight and percent drop of mature Redblush grapefruit.

					Regression of:		
Season	*Average No. Fruit (Initial)*	*Yield/Tree lbs (Final)*	*Average Fruit Wt.*	*Average % Drop (Apr. 20)*	*No. of Fruit on Avg. Fr. Wt.*	*No. of Fruit on % Drop*	*Avg. Frt. Wt. on % Drop*
1968-69	407	319	1.19	17.0	—.759***	—.633*	.490*
1969-70	658	593	1.13	21.4	—.469[N.S.]	—.346[N.S.]	.056[N.S.]

*** Significant at .1% level.
* Significant at 10% level.
N.S. Not Significant.

sonal results suggested that the control and treated trees were not random selections from the same population. My calculations showed initially less fruit on the control trees than on the treated trees. The inverse relation between fruit load and percent drop could account for the heavier fruit drop from the control and the lighter drop from the treated trees. A statistical analysis of the initial number of fruit, however, revealed no significant difference between trees. From this the among trees variation in percent drop for each date was assumed to be sufficient to make differences between treatment means undetectable. To overcome this, future tests should include more trees per treatment.

1969-70

Although the 2,4-D treated trees, Fig. 1, had a lower percent drop than the control trees, this difference over the season was not significant. Analysis of the percent drop for each counting date, however, showed a slight effect (significant at 10%) for the second application of 2,4-D. This reflects a change in the rate of drop rather than differences in total drop on that date. From January 20 to February 2 the average weekly drop for the control and the first application 2,4-D trees went from .66 to 1.43% and .76 to .95% respectively while for the second application 2,4-D trees the rate increased from .96 to only 1.10%. At this point the curve for the 2,4-D treated trees crosses and remains beneath the curve for the control trees. Thus under certain conditions, low concentrations of 2,4-D may have only a short residual effect on fruit drop. The 2,4-D may have to be applied early in the harvesting season before fruit drop

Table 2. The effect of date of application and adjuvants on 2,4-D sprays applied to control mature grapefruit droppage, 1966-67.

	Percent Fruit Drop on						
Variable	*Dec 20*	*Jan 6*	*Jan 20*	*Feb 3*	*Feb 24*	*Mar 21*	*Statistical Difference*
2,4-D Concentration							
None	2.2	2.7	2.7	2.7	7.1	8.9	***
Average: 8+16 ppm	0	0.2	0.4	0.4	2.0	4.6	
8 ppm	0	0.4	0.8	0.8	2.6	4.8	N.S.
16 ppm	0	0	0	0	1.3	4.4	
Dates of Application							
Nov 15	0	0.4	0.4	0.4	1.7	3.0	N.S.
Dec 9	0	0	0.4	0.4	2.2	6.2	
Adjuvant							
Foli-gard	0	0.4	0.4	0.4	1.3	6.0	N.S.
Multi-film Buffer X	0	0	0.4	0.4	2.6	7.6	

begins to accelerate as reported by Iwasaki (9). Fig. 1 indicates that this may be most important in years when droppage has reached 4-6% by late November.

In California 2,4-D is applied to oranges and grapefruit trees in the spring to increase fruit size (15, 17). Since they were applied in winter, the 2,4-D sprays in my tests should not have affected size. Nevertheless, the average weight of the fruit from the trees treated with 2,4-D and Altar in 1968-69 was analyzed in 1970. No significant size or yield differences accreditable to the previous year's treatments were found.

CONCLUSIONS

The pattern and extent of grapefruit droppage varies considerably from year to year. During the winter months the droppage rate increases slightly and usually accelerates with warm weather. The increased rate of drop coincides closely with spring growth initiation and flowering. The percent of the total fruit that fall decreases as the number of fruit per tree increases. The percent drop is not directly related to the size of the individual fruit. In two of the three years 2,4-D sprays significantly reduced fruit drop. This affect appeared greatest in years of naturally heavy drop, and when the 2,4-D was applied before the period of accelerated drop began. Under certain conditions the spray seems to have a short residual effect.

Neither the experience of California nor Florida researchers regarding the use of 2,4-D to prevent mature grapefruit droppage seems to apply to Texas. My 2,4-D sprays were more effective than those in Florida, but not as good or consistent as those in California (5, 14). While I suspect climate is the major factor affecting response, varietal differences have been noted by other workers (9, 11). The concentrations of 2,4-D used are in the range of the California recommendations (17). Although high concentrations of 2,4-D and 2,4,5-T produce adverse affects in citrus, 15-30 ppm 2,4-D would likely reduce drop without causing harmful side effects (2, 6, 16).

Significant decreases in fruit drop on individual counting dates might be detected by using more trees per treatment.

Before 2,4-D can be used commercially on citrus in Texas, approval of U. S. Food and Drug Administration is necessary. Whether 2,4-D is compatible with pesticides used in Texas as is true in California needs to be investigated (18).

LITERATURE CITED

1. Coggins, C. W., Jr., and H. Z. Hield. 1968. Plant growth regulators, p. 371-389. *In* Walter Reuther, Leon Dexter Batchelor and Herbert John Webber, [ed.], The Citrus Industry. Univ. California, Berkeley.

2. Erickson, L. C. 1951. Overtreatment with 2,4-D. California Citrograph 36:268.

3. Erickson, L. C. 1951. Effects of 2,4-D on drop of sound and unsound Washington Navel oranges. Proc. Amer. Soc. Hort. Sci. 58:46-52.

4. Fucik, John E. 1967. Some aspects of growth and sizing of Redblush grapefruit. J. Rio Grande Valley Hort. Soc. 21:58-67.

5. Gardner, F. E., P. Reece, and G. Horanic. 1950. The effect of 2,4-D on pre-harvest drop of citrus fruit under Florida conditions. Proc. Florida State Hort. Soc. 63:7-11.

6. Hensz, R. A., and R. F. Leyden. 1961. Some effects of gibberellic acid and 2,4,5-Trichlorophenoxyacetic acid on navel orange production. J. Rio Grande Valley Hort. Soc. 15:75-77.

7. Hield, H. S., R. M. Burns, and C. W. Coggins, Jr. 1964. Pre-harvest use of 2,4-D on citrus. California Agr. Exp. Sta. Ext. Ser., Circ. 528. 10 p.

8. Iwasaki, T. 1956. Observations on the dropping of fruits in some citrus varieties. [in Japanese, English summary]. National Tokai-kinki Agr. Exp. Sta. Bull. 3.

9. Iwasaki, T., M. Nishiura, and R. Shichijo. 1956. Effects of 2,4-D and 2,4-5-T on fruit drop and abscission of stem buttons in some citrus varieties.]in Japanese, English summary]. National Tokai-kinki Agr. Exp. Sta. Bull. 3.

10. Leclerg, E., W. Leonard, and A. Clark. 1962. Field Plot Technique. 2nd ed., Burgess Publishing Co., Minneapolis, Minnesota. 373 p.

11. Reece, P. C., and G. Horanic. 1952. Some varietal responses of Florida oranges to pre-harvest sprays. Proc. Florida State Hort. Soc. 65:88-91.

12. Snedecor, George W. 1946. Statistical Methods. 4th ed., Iowa State College Press, Ames, Iowa.

13. Stewart, W. S., and E. R. Parker. 1947. Preliminary studies on the effects of 2,4-D sprays on preharvest drop, yield, and quality of grapefruit. Proc. Amer. Soc. Hort. Sci. 50:187-194.

14. Stewart, W. S., and E. R. Parker. 1954. Effects of 2,4-D and related substances on fruit drop, yield, size and quality of grapefruit. Hilgardia 22:623-641.

15. Stewart, W. S., and H. Z. Hield. 1950. The use of 2,4-D to increase sizes of oranges and grapefruit. California Citrograph 35:320-327.

16. Stewart, W. S., and H. Z. Hield. 1950. Effects of 2,4-dichlorophenoxyacetic acid and 2,4,5-trichlorophenoxyacetic acid on fruit drop, fruit production and leaf drop of lemon trees. Proc. Amer. Soc. Hort. Sci. 55:163-171.

17. California Agricultural Experiment Station. 1970-71. Treatment Guide for California Citrus Crops. California Agri. Exp. Sta., Univ. California. 53 p.

18. California Agricultural Extension Service. 1966. Experimental Methods for Extension Workers. California Agri. Ext. Ser., Univ. California. 33 p.

Retail Sales Responses Related to Grade Changes for Fresh Texas Grapefruit

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Abstract: An important aspect of marketing fresh Texas grapefruit is the system of grades used to determine a marketable product. The purpose of this study was to examine the sales response at retail to a change of grade marketed from a Combination grade to U.S. No. 1 grade. It was observed that the relationship between grade and per customer sales depends on the nature of the market and degree of competition from other grapefruit supply areas. A significant increase in sales per customer of Texas grapefruit, related to a change in grade from Combination to U.S. No. 1, was observed under conditions of strong competition from other supply areas. Where no such competition existed, no significant change in sales was found. This is of major importance to the Texas citrus industry as it develops a marketing program geared to the requirements of a rapidly expanding production potential.

INTRODUCTION

Grapefruit produced in the Rio Grande Valley area of Texas has traditionally been marketed fresh in Southwest markets with some movement into the Midwest, Eastern, and Northwestern areas. Since 1960 the grades under which Texas fresh grapefruit could be shipped have been regulated by a Federal Market Order. This order establishes the specifications for the grades shipped. In addition to U.S. No. 1, U.S. No. 2 and U.S. No. 3 grades, a Combination grade has been permitted consisting of a mixture of U.S. No. 1 and U.S. No. 2 grade fruit with a specified minimum percentage of U.S. No. 1.

While it was thought to be beneficial during short crop years to market a Combination grade thus spreading the value of the No. 1 grade fruit, the changing marketing environment created by rapidly expanding production required a different approach with regard to grade standards. Thus beginning with the 1968-69 season, the Combination grade was discontinued and all fresh grapefruit were marketed in conformance with specifications for U.S. No. 1, U.S. No. 2, and U.S. No. 3 grades. It was the purpose of this study to evaluate this change in permissable grading systems and determine its effect on retail sales of fresh Texas grapefruit.

METHODOLOGY

An experiment was designed to test sales responses to the two different grade systems at the retail level. Two test markets were selected each providing a different marketing environment. Dallas, Texas was selected as a market where Texas grapefruit has in the recent past com-

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posed much of the total supply of grapefruit (Table 1). Kansas City was selected as a test market in which Texas grapefruit has represented a relatively small share of the market.

Twelve stores were selected in each market representing a cross-section of all income levels and geographic areas. The experiment was conducted in these stores over a ten week period in late Winter and early Spring of 1969. Two grade systems were employed in supplying Texas grapefruit to the stores (See Figure 1). Grade system I provided U.S. Combination grade grapefruit in bulk and U.S. No. 2 grade grapefruit in 20 pound sacks.[2] Grade system II provided U.S. No. 1 grade grapefruit in bulk and U.S. No. 2 grapefruit in 20 pound sacks. The marketing of other grapefruit was continued as normal for all stores.

A continuous eight week period was divided into two four week sub-periods. The twelve stores were divided into two equal groups. The two grade systems were then assigned to the store groups and sub-periods as shown in Figure 1. The systems were rotated so that each store was exposed to each system for a period of four weeks. The same pattern was employed in both market areas.

Weekly records were kept of prices and shelf space allocation for all grapefruit items. Data were also collected weekly on volume sold by each store of all grapefruit items as well as competing fresh fruit (apples, oranges, and bananas). The standard audit method of relating inventory change to deliveries and spoilage was used to derive sales.[3] The number of customer transactions for each store was recorded on a weekly basis. Newspaper advertising for grapefruit and competing pro-

Table 1. Unloads of fresh grapefruit for two selected markets, by state of origin, 1965-1969.

	Dallas		*Kansas City*	
Year	*Texas*	*Florida and other*	*Texas*	*Florida and other*
1965	53.2	46.8	6.5	93.5
1966	74.8	25.2	23.8	76.2
1967	88.6	11.4	25.5	74.5
1968	77.4	22.6	20.1	79.9
1969	89.1	10.9	35.0	65.0
Average	78.6	21.4	23.2	76.8

Source: Fresh Fruit and Vegetable Unload Totals for 41 Cities. U.S.D.A. Consumer Marketing Service. Fruit and Vegetable Division. Washington, D. C. 1965-1969.

[2] The combination grade was comprised of a minimum of 60 percent U.S. No. 1 fruit and the rest U.S. No. 2.

[3] Sales = Beginning inventory + Deliveries — Ending Inventory — Spoilage.

ducts was observed and the amount recorded weekly for both the test stores and competing stores.

Observation of the effect of grade on retail sales of grapefruit required analysis of the data in a manner which removed the influence of other related variables. Both quantitative and qualitative variables were involved thus requiring the use of an analysis of covariance model.[4] This model allows an examination of the relationship between two variables while holding the others constant. The data collected provided weekly observations for each store on each of the variables noted above. Thus there were 96 observations available for analysis for each market. Separate analyses were run for each city so that the influence of differences in type of market could be examined.

RESULTS

The differing historical supply source for the two markets is indicated in Table 1. An analysis of the sales of the cooperating stores during the test period revealed a different situation (Table 2). In the Dallas test stores, Texas grapefruit represented a very high proportion of the grapefruit purchased while in the Kansas City stores a smaller proportion, though still a majority, was Texas grapefruit.

The deviation from historical averages for each market which was observed in the test stores may be explained in two ways. First examination of the trend in Table 1 reveals that during the test year, 1969, unloads of Texas grapefruit in both cities represented the largest proportion in the recent past. Thus while sales of Texas grapefruit in the Kansas City test stores indicated a Texas share of unloads much larger than the average in the past, part of this was due to a basic trend which shows Texas' share of the unloads increasing in that market.

Figure 1. Design of experiment for the evaluation of two grade systems: Application of treatment between store groups and over time.[1]

	Time Period 1	Time Period 2
Store Group A	Grade System I	Grade System II
Store Group B	Grade System II	Grade System I

[1] Grade System I = U.S. Combination grade and U.S. No. 2 grade.
Grade System II = U.S. No. 1 grade and U.S. No. 2 grade.

[4] For a discussion of covariance analysis see W. G. Tomek, "Using Zero - one Variables with Time Series Data in Regression Equations," *Journal of Farm Economics*, Vol. XLV, No. 4, November, 1963, pp. 814-822.

Beyond this, however, is an additional cause. The stores included in the market test were required to carry certain Texas grapefruit items in order to complete the experiment. Some of these items had not been carried by these stores in the past and were not being carried by other non-participating stores. In effect, due to the nature of the experiment itself, the test stores were "forced" to carry additional Texas grapefruit items. This resulted in an observed share of sales for Texas grapefruit which was much greater than the historical averages for the market as a whole.

Convariance analysis. The final equations developed for each market for examination of the effect of grade on retail sales of grapefruit are shown in Table 3. The regression coefficients and an indication of their statistical significance are given for each variable. A "t" test was used to examine the significance of most variables. Because grade and income variables are specially constructed "dummy" variables, a "F" test was employed in examining their statistical significance.

The dependent variable for each equation is termed "test grapefruit." This term refers to the Texas grapefruit items in each store which were actually involved in the experiment and were, depending on the store and period, either of U.S. No. 1 or U.S. Combination grade. This variable was measured in terms of pounds sold per customer per unit of time.

Variables significant at least at the 5 percent level of significance in the Dallas equation were price, income, and the sales volume of Florida grapefruit, apples, and oranges. In the Kansas City equation price, shelf space, grade, income and the sales volume of Florida grapefruit were significant at least at the same level.

The variable of primary interest in this analysis is the "dummy" variable for grade. This variable was constructed so that a value of one was used in association with the U.S. No. 1 grade and a value of zero in association with the U.S. Combination grade. Thus a positive sign of the coefficient indicates an increase in sales of "test" grapefruit" is associated with the U.S. No. 1 grapefruit relative to the Combination grade. This variable was not significant in the Dallas equation but was

Table 2. Grapefruit sales in test stores by market and state of origin, January 25, 1969-April 15, 1969.

Source	*Market*	
	Dallas	*Kansas City*
	—percent—	
Texas	98.5	60
Florida	1.5	40

Source: Computed from audits of 24 Test Supermarkets.

highly significant in the Kansas City analysis. The magnitude of the coefficient indicates that the volume sold per customer was 0.01178 pounds greater on a weekly basis with the No. 1 grade than with the Combination grade. This represents a 28.5 percent increase when compared with average weekly sales per customer of 0.0414 pounds of "test grapefruit."

The coefficient for the price variable was observed to be highly significant in both equations. These coefficients when related to average volume sold per customer yield price elasticities of demand of –1.25 in Dallas and –1.27 in Kansas City. Thus, the demand for these "test grapefruit" items was somewhat elastic at the retail level.

An analysis of the effect of the grade change on sales of other grapefruit in the Kansas City market was conducted in view of the significant relationship observed between grade and "test grapefruit." The sales of U.S. No. 2 grapefruit packaged in 20 pound sacks was examined first to determine if any substitution had occurred when the sales of "test grapefruit" increased as a result of the grade change. An equation similar to those in Table 3 was estimated which revealed a coefficient for the grade variable which was not significant. In other words the analysis

Table 3. Results of analysis of co-variance for "test grapefruit," by city.

	Regression Coefficients	
Variable	*Dallas*[1]	*Kansas City*[2]
Intercept Value (lbs./customer/week)	0.1009	0.0746
Price (cents/lb.)	—0.0068**	—0.00584**
Shelf Space (ft.^{2})	0.0074	0.00208**
Grade	0.0023	0.01178**
Income (high)	0.0176 } *	0.01939 } **
Income (low)	—0.0295 } *	0.00104 } **
Sales of Apples (lbs./customer/week)	0.03087**	—0.0443
Sales of Oranges (lbs./customer/week)	0.0981*	0.0424
Sales of Bananas (lbs./customer/week)	—0.0654	0.0059
Sales of Florida Grapefruit (lbs./customer/week)	—1.492**	—0.1009*

[1] $R^2 = .55$
[2] $R^2 = .37$
* Significant at the 5 percent level
** Significant at the 1 percent level

showed no significant relationship between the grade of "test grapefruit" and the volume of No. 2 grapefruit sold per customer.

An additional equation was estimated to examine the relationship between grade and the volume sold of all Texas grapefruit in the Kansas City test stores. This included both the "test grapefruit" and all of the U.S. No. 2 grapefruit. The coefficient for grade in this equation was significant at the 10 percent level indicating that the increase in "test grapefruit" sales per customer resulting from the change to U.S. No. 1 grade actually shows up in total Texas grapefruit sales per customer as well. The magnitude of this coefficient relative to average per customer sales of Texas grapefruit indicates about a 14 percent increase in total Texas grapefruit sales in the Kansas City test stores associated with the change to U.S. No. 1 grade.

CONCLUSIONS AND IMPLICATIONS

The key factor in evaluating the results discussed above, lies in relating the effect of grade on grapefruit sales to the differences in market areas examined. It was observed that the change in grade system had a highly significant effect on per customer sales not only of the directly affected grapefruit item, but also of total Texas grapefruit in the test stores in the Kansas City market. At the same time no significant effect was observed in Dallas. The primary difference in the nature of the two markets lies in the fact that Dallas has long been dominated by Texas grapefruit whereas Kansas City has been predominately supplied with Florida grapefruit.

On the basis of the results, it is concluded that the effect of grade on sales of Texas grapefruit is related to the type of market and competition from other grapefruit supply areas. In a market where strong competition exists from supply areas with established standards of quality, the sales of Texas grapefruit can be increased by supplying a U.S. No. 1 grade instead of a Combination grade. In a market where Texas grapefruit has long been accepted and has no competition from other supply areas, the sales are not affected by a change in grade from Combination to U.S. No. 1.

The major implication of these conclusions becomes apparent when the rapidly exanding Texas grapefruit production is considered.[5] The Texas citrus industry has recovered from the short supply years of the early 1960's. It is moving toward a situation where a large supply of grapefruit will require that new markets be carved out in areas that in recent years have not been users of Texas citrus. Strong preferences and supplier arrangements have developed for grapefruit from other areas. It is apparent from the findings of this study that development of these

[5] See Chan Connolly, "Projected Citrus Supply for Rio Grande Valley, Texas: 7 Year Period 1968-69 to 1974-75." *Journal of the Rio Grande Valley Horticultural Society*, Vol. 23, 1969, pp. 18-23.

new markets will be facilitated by the change from the shipment of the Combination grade to the shipment of the U.S. No. 1 grade grapefruit.

LITERATURE CITED

1. Connolly, Chan. "Projected Citrus Supply for Rio Grande Valley Texas: 7 Year Period 1968-69 to 1974-75." *Journal of the Rio Grande Valley Horticultural Society.* Vol. 23. 1969. pp. 18-23.

2. Tomek, W. G. "Using Zero-One Variables with Time Series Data in Regression Equations," *Journal of Farm Economics.* Vol. XLV, No. 4. November 1963. pp. 814-822.

3. United States Department of Agriculture. *Fresh Fruit and Vegetable Unload Totals for 41 Cities.* Consumer Marketing Service. Fruit and Vegetable Division, Washington, D. C. 1965-1969.

Citrus Supply Variation

CHAN C. CONNOLY[1]

Abstract: The annual supply of Texas oranges and grapefruit has more variation than any other U.S. citrus supply state. Since supply continuity is a necessary condition for generating maximum economic returns in a market oriented economy, the lack of supply continuity in the Texas citrus industry creates unique challenges to Texas citrus marketing firms.

INTRODUCTION

Supply continuity, though not a sufficient condition, has become a necessary condition for the succesful marketing of fruit and vegetables in a market oriented economy which now exists in the United States.

Texas now has over a half century of commercial citrus marketing experience. The purpose of this inquiry was to measure Texas' citrus supply continuity with that of other competing production areas.

The major current supply of United States citrus is produced in the states of Florida, California, Arizona, and Texas. Florida is the dominant supply state producing almost 76% of the total U.S. orange supply and a little more than 72% of the U.S. grapefruit supply for the 1969-70 marketing season. Texas produced about 2.5% of the total U.S. orange supply and almost 16% of the total grapefruit supply. (6)

METHODOLOGY

The degree of supply continuity by citrus supply areas was measured by the utilization of a less squares linear regression equation. Data was obtained from the Crop Reporting Board, Statistical Reporting Service of the U.S. Department of Agriculture.

The mathematical model was as follows:

(1) $Y = a + bx + u$

Y = Supply in tons

a = Level of linear regression line

b = Slope of linear regression line

x = Time in seasons

u = Stochastic disturbance term

Two sets of coefficient of variations (CV's) were computed for two different time periods. The 51 year time period 1919-20 to 1969-70 covered the entire time period during which the Texas citrus industry had commercially marketed citrus. During this period, three (3) severe

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freezes were experienced.[2] The second time period was a 20 year period 1929-30 to 1948-49 during which no severe freeze occurred.

As the CV's are a relative measure of dispersion, the magnitude of each supply area's CV is directly comparable with the CV of any other supply area.

RESULTS

The annual supply of oranges and grapefruit from Arizona, California, Florida, and Texas for the 51 year period 1919-20 to 1969-70 are graphically presented in Figures 1 and 2. It is observed that all supply states lack some annual supply continuity.

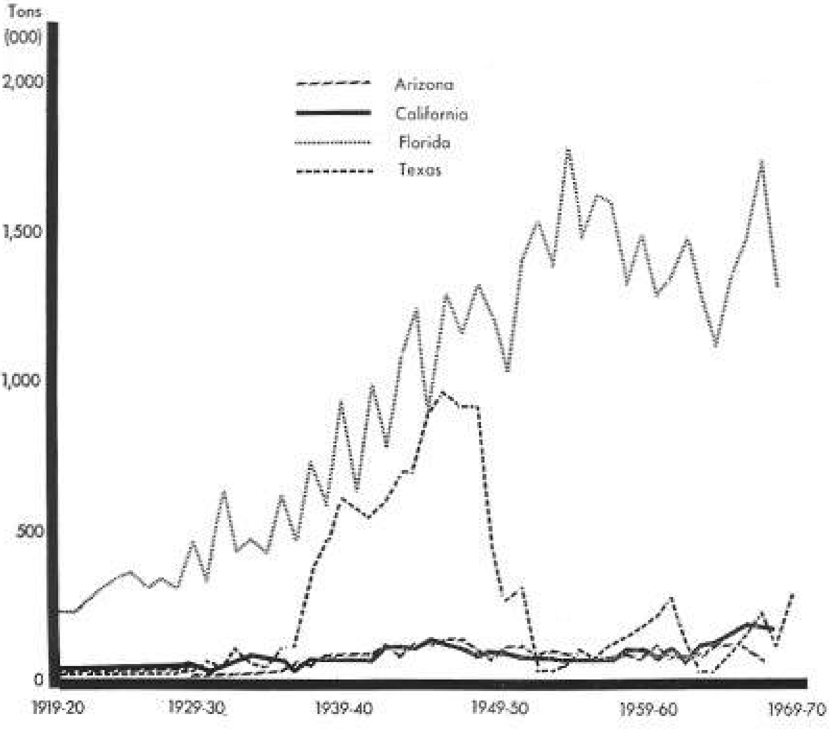

Figure 1. Variation in Orange Supply By Major States, 51 Year Period 1919-20 to 1969-70.

Source: U.S. Department of Agriculture, Citrus Fruits, SRS, Statistical Bulletin No. 380, January 1967 and subsequent supplements, Washington, D.C.

[2] A severe freeze is defined as a temperature of 21°F. or lower for a period of four hours or more.

The computed statistics for mathematical model (1) are tabulated in Tables 1 and 2 for the 51 and 20 year periods, respectively. The CV's for both periods are presented in Table 3. (1, 2, 3, 4, 5, 6)

Texas as a citrus supply area had the largest CV for the 51 year period 1920-21 to 1969-70. Texas orange supply variation was about five times greater than that of California, and a little more than double that of Arizona. Texas grapefruit supply variation was almost six times greater than that of Florida, more than four times greater than that of California, and more than double that of Arizona, Table 3.

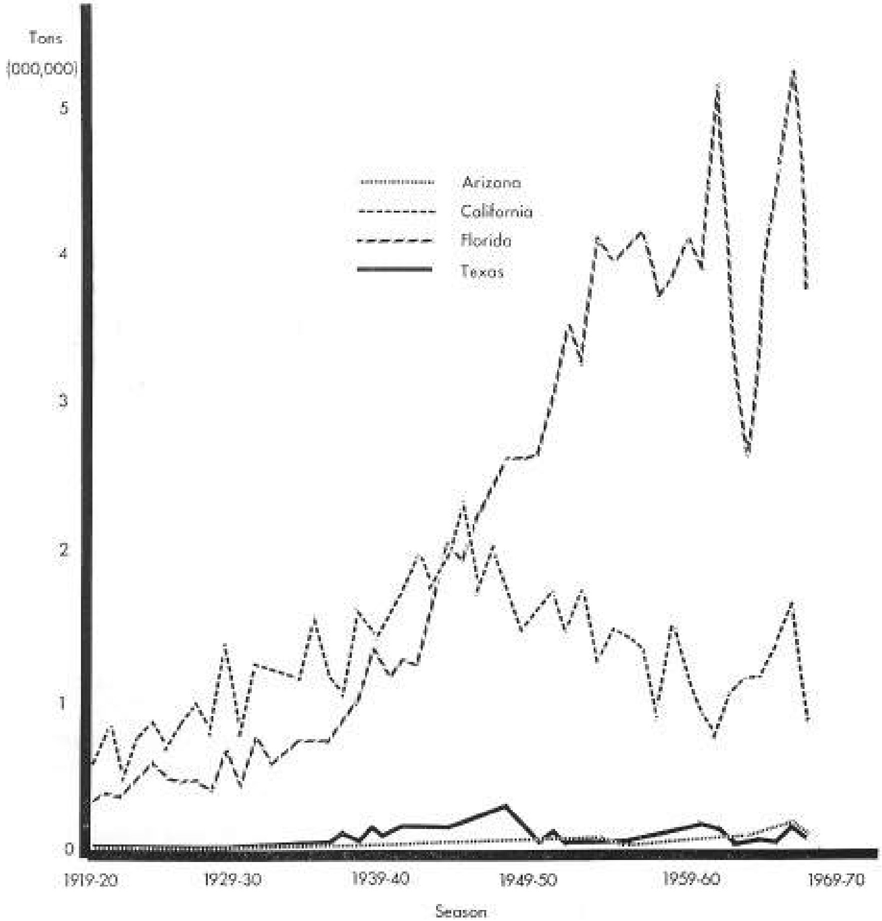

Figure 2. Variation in Grapefruit Supply By Major States, 51 Year Period 1919-20 to 1969-70.

Source: U.S. Department of Agriculture, Citrus Fruits, SRS, Statistical Bulletin No. 380, January 1967 and subsequent supplements, Washington, D.C.

When the citrus supply variations were measured by supply areas for the 20 year period 1929-30 to 1948-49, during which no severe freezes occurred. Texas citrus supply variation was also greater than that of other supply areas.[3] However, the magnitude of the Texas grapefruit supply CV was considerably less than the Texas orange supply CV, Table 3. During the 20 year no severe freeze period, Texas orange supply variation was almost seven times greater than that of California, and a little less than three times that of Arizona. However, the Texas grapefruit supply variation was about double that of Florida, a little greater than either that of California and Arizona.

Table 1. Computed statistics for linear regression trends, 51 year period 1919-20 to 1969-70.

Supply Area and Kind of Citrus	*a*	*b*	$\overline{Y}$	$S_{y.x}$	R^2
United States	*Tons*	*Tons*	*Tons*	*Tons*	
Oranges	550,507	121,739	3,654,851	657,817	.88
Grapefruit	367,466	37,810	1,331,628	431,564	.62
Arizona					
Oranges	— 20,775	2,207	35,511	23,477	.66
Grapefruit	9,381	2,105	63,069	29,494	.53
California					
Oranges	1,081,820	8,516	1,298,985	409,219	.09
Grapefruit	8,100	2,565	73,517	20,910	.77
Florida					
Oranges	—517,591	108,219	2,241,992	580,577	.88
Grapefruit	167,290	31,155	961,743	196,172	.85
Texas					
Oranges	39,093	1,807	85,177	106,804	.05
Grapefruit	179,854	2,354	239,891	288,577	.01

Note: Model $Y = a + bx + u$

When: Y = Supply in tons

a = Level of linear regression trend line in tons

b = Slope of linear regression trend line in tons

x = Time in season

u = Stochastic disturbance term

R^2 = Coefficient of determination

$\overline{Y}$ = Mean in tons

$S_{y.x}$ = Standard error of estimate in tons

Source: U.S. Department of Agriculture, Statistical Reporting Service, Statistical Bulletin No. 380, January 1967 and subsequent supplements, Washington, D. C.

[3] Non severe freezes did occur that damaged fruit.

With severe freezes removed from the model, Texas annual grapefruit supply variation declined. This indicates that severe freezes and degree of grapefruit supply variations are associated. However, by removing the severe freezes in the model for oranges, annual supply variation did no tdecline to the same magnitude. This suggests that Texas annual orange supply variation was associated with other variables than severe freezes.[4]

Table 2. Computed statistics for linear regression trends, 20 year period 1929-30 to 1948-49.

Supply Area and Kind of Citrus	*a*	*b*	$\bar{Y}$	$S_{y.x}$	R^2
United States	*Tons*	*Tons*	*Tons*	*Tons*	
Oranges	1,081,327	184,415	3,017,685	324,519	.92
Grapefruit	264,308	109,747	1,416,650	249,364	.88
Arizona					
Oranges	— 3,609	2,269	20,212	7,430	.77
Grapefruit	6,228	6,150	70,803	23,177	.72
California					
Oranges	1,081,128	45,340	1,557,197	288,473	.48
Grapefruit	31,190	3,868	71,806	18,198	.63
Florida					
Oranges	108,898	118,317	1,351,225	213,928	.92
Grapefruit	286,526	49,759	809,000	139,673	.82
Texas					
Oranges	26,081	10,077	131,888	139,727	.16
Grapefruit	—59,638	49,969	465,040	155,790	.79

Note: Model $Y = a + bx + u$

When: Y = Supply in tons

a = Level of linear regression trend line in tons

b = Slope of linear regression trend line in tons

x = Time in season

u = Stochastic disturbance term

R^2 = Coefficient of determination

$\bar{Y}$ = Mean in tons

$S_{y.x}$ = Standard error of estimate in tons

Source: U.S. Department of Agriculture, Statistical Reporting Service, Statistical Bulletin No. 380, January 1967 and subsequent supplements, Washington, D. C.

[4] Individuals that were associated with the Texas citrus industry during the 20 year period 1929-30 to 1948-49 are unable to explain the relatively high variation in the annual supply of oranges. Some of the variation in orange supply may be caused by the orange being more sensitive to non-severe freezes than grapfruit. The annual rate orange grove plantings may be another variable. Neither of the variables can be quantified.

CONCLUSION

Texas supply of citrus has more annual supply variation than any other U.S. supply area. This lack of supply continuity places a greater marketing task on Texas citrus marketing firms.

Since supply continuity is a necessary condition in generating maximum economic returns, the Texas citrus industry is faced with the development of market strategy that will minimize the effect of this constraint. Processing a larger portion of the Texas supply and storing it provides one alternative in market strategy. Marketing the Texas citrus processed supply through a national marketing firm offers another alternative for market strategy.

The development of marketing strategy for Texas citrus in the future to minimize the lack of annual supply continuity presents unique challenges to marketers.

Table 3. Annual supply variation by four major U.S. orange and grapefruit states and aggregate U.S. for a 51 year and a 20 year period.

(51 year period = 1920-21 to 1969-70)
(20 year period = 1929-30 to 1948-49)

Supply Area and Kind of Citrus	*51 Year Variation CV*[1]	*20 Year Variation CV*[1]
United States	*Percent*	*Percent*
Oranges	17.99	10.75
Grapefruit	32.40	17.60
Arizona		
Oranges	66.11	36.76
Grapefruit	46.47	32.73
California		
Oranges	31.50	18.54
Grapefruit	28.44	25.34
Florida		
Oranges	25.89	15.83
Grapefruit	20.39	17.26
Texas		
Oranges	125.39	105.94
Grapefruit	120.29	33.50

Note: 51 year period 1920-21 to 1969-70 is a long run time period during which three severe freezes occurred.
20 year period 1929-30 to 1948-49 is a long run time period during which no severe freezes occurred.

[1] CV = Coefficient of variation = $S_{y \cdot x} \div \bar{y}$

Source: Tables 1 and 2

LITERATURE CITED

1. U. S. Department of Agriculture, Citrus Fruits by States 1909-10 to 1964-65, Statistical Reporting Service, Statistical Bulletin 380, January 1967, Washington, D. C.
2. U. S. Department of Agriculture, Citrus Fruits by States, 1964-65 and 1965-66, Statistical Reporting Service, October 1966, Washington, D. C.
3. U. S. Department of Agriculture, Citrus Fruits by States 1965-66 and 1966-67, Statistical Reporting Service, October 1967, Washington, D. C.
4. U. S. Department of Agriculture, Citrus Fruits by States 1966-67 and 1967-68, Statistical Reporting Service, October 1968, Washington, D. C.
5. U. S. Department of Agriculture, Citrus Fruits by States 1967-68 and 1968-69, Statistical Reporting Service, October 1969, Washington, D. C.
6. U. S. Department of Agriculture and Texas Department of Agriculture, Texas Citrus, Statistical Reporting Service, May 1, 1970, Austin, Texas.

Share of U.S. Orange and Grapefruit Supply Contributed by Four Major States

CHAN C. CONNOLY[1]

Abstract: During the 51 year period 1919-20 to 1969-70 Florida was the dominate orange and grapefruit U.S. supply state. Florida's orange share of 61.34 percent and California's share of 35.54 percent together represented almost 97 percent of the aggregate U.S. orange supply with Texas and Arizona representing less than 3 percent.

Florida's share of the aggregate U.S. grapefruit supply of 72.22 percent and Texas' share of 18.01 percent together contributed more than 90 percent of the U.S. supply with California and Arizona representing the balance. The recent three year period 1967-68 to 1969-70 indicated very little change in the relative position of each of the four major citrus supply states for oranges and grapefruit. There is no indication that these relative positions will change in the near future.

INTRODUCTION

The share of the aggregate U.S. supply of oranges and grapefruit produced by each of the four major citrus supply states is a major variable that is considered in the development of market strategy by each supply state. A major citrus supply state is in a strong position to develop an image for its orange and grapefruit products and to allocate resources for advertising and promotion of its product. A minor supply state is not in a position to compete with the allocation of resources of the magnitude of the major supply state for advertising and promotion and as a consequence, alternative market strategies need be employed.

This paper quantifies the orange and grapefruit supply share that each of the four major citrus supply states contribute to the aggregate U.S. supply during a long run period compared to a recent three year period. The findings may then be utilized in the future market strategy by each of the major supply states.

METHODOLOGY

The share of the aggregate U.S. orange and grapefruit supply produced by each of the four major citrus supply states was measured by the utilization of a simple linear regression equation. Annual orange and grapefruit production data published by the U.S. Deprtment of Agriculture, Statistical Reporting Board, Washington, D. C. was used. (1, 2, 3, 4, 5, 6) The mathematical model was as follows:

(1) $Y = a + bx + u$

where:

Y = Annual supply in tons

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a = Intercept of linear regression line
b = Slope of linear regression line
x = Time in seasons
u = Stochastic disturbance term

The earliest season for which citrus supply data is available for Texas is 1919-20. Starting with this season and continuing through 1969-70 represents a long run period of 51 years for Texas. The orange and grapefruit annual supply data for the three other major supply states were analyzed for the same period.

RESULTS

The statistics for equation 1 are presented in Table 1 for all four

Table 1. Computed statistics for orange and grapefruit linear regression trends for aggregate U.S. and four major supply states, 51 year period 1919-20 to 1969-70.

Supply area and Kind of Citrus	*a*	*b*	$\bar{y}$	$S_{y.x}$	R^2
United States	*Tons*	*Tons*	*Tons*	*Tons*	
Oranges	550,507	121,739	3,654,851	657,817	.88
Grapefruit	367,466	37,810	1,331,628	431,564	.62
Arizona					
Oranges	— 20,775	2,207	35,511	23,477	.66
Grapefruit	9,381	2,105	63,069	29,494	.53
California					
Oranges	1,081,820	8,516	1,298,985	409,219	.09
Grapefruit	8,100	2,565	73,517	20,910	.77
Florida					
Oranges	—517,591	108,219	2,241,992	580,577	.88
Grapefruit	167,290	31,155	961,743	196,172	.85
Texas					
Oranges	39,093	1,807	85,177	106,804	.05
Grapefruit	179,854	2,354	239,891	288,577	.01

Note: Model $Y = a + b x + u$
When: Y = Supply in tons
a = Level of Linear regression trend line in tons
b = Slope of Linear regression trend line in tons
x = Time in season
R^2 = Coefficient of determination
$\bar{y}$ = Mean in tons
$S_{y.x}$ = Standard error of estimate in tons

Source: Computed from data published by United States Department of Agriculture, Crop Reporting Board, Statistical Reporting Service, Statistical Bulletin No. 280 and subsequent supplements, Washington, D.C.

major citrus supply states and aggregate U.S. for both oranges and grapefruit. Florida had more annual growth as an orange and grapefruit supply state than any one of the other major supply states. During the 51 year period 1919-20 to 1969-70, Florida had an average annual increase of 108,219 tons of oranges and 31, 155 tons of grapefruit. Florida's average annual orange and grapefruit supply was 2,241,992 and 961,743 tons, respectively. Florida was the dominate orange supply state during this 51 year long run period contributing 61.34 percent of the aggregate U.S. orange supply and 72.22 percent of the aggregate U.S. grapefruit supply. Florida and California together supplied almost 97 percent of the aggregate supply of oranges, Table 2.

Texas' share of the aggregate U.S. orange and grapefruit supply was 2.33 and 18.01 percent, respectively, Table 2. Arizona represented the smallest supply state for both oranges and grapefruit. During this 51 year long run period both Arizona and Texas were minor supply states for oranges.

Florida and Texas together supplied more than 90 percent of the aggregate U.S. grapefruit supply.

For the most recent three year period 1967-68 to 1969-70 Florida and California continue as dominant supply states for oranges and Flor-

Table 2. Annual average U.S. orange and grapefruit supply by four major states, 51 year period 1919-20 to 1969-70.

Supply States	*Average Annual Supply*	*Percent of U.S. Total Supply*
United States	*Tons*	
Orange	3,654,851	100.00
Grapefruit	1,331,628	100.00
Arizona		
Orange	35,511	0.09
Grapefruit	63,069	4.74
California		
Orange	1,298,985	35.54
Grapefruit	73,517	5.52
Florida		
Orange	2,241,992	61.34
Grapefruit	961,743	72.22
Texas		
Orange	85,177	2.33
Grapefruit	239,891	18.01

Source: Computed from data published by U. S. Department of Agriculture, Statistical Reporting Service, Statistical Bulletin No. 380 and subsequent supplements, Washington, D. C.

ida and Texas as the major supply states for grapefruit. The relative position of each state as an orange and grapefruit supply state for the 3 year period 1967-68 to 1969-70 is similar to position as a supply state during the 51 year period, Tables 2 and 3.

CONCLUSIONS

For the 51 year period 1919-20 to 1969-70, Florida was the dominant orange supply state with California following in second place. Florida's share of the aggregate U.S. orange supply of 61 percent, and California's share of 36 percent, together provided almost 97 percent of the aggregate U.S. orange supply. Arizona and Texas together supplied less than 3 percent.

Florida's grapefruit supply for the same long run period contributed more than 72 percent to the aggregate U.S. grapefruit supply followed by Texas supply of about 18 percent. Florida and Texas together provided more than 90 perecent of the aggregate U.S. grapefruit supply.

The relative share of each orange and grapefruit supply state for the recent three year period 1967-68 to 1969-70 made very little change compared to the 51 year period. For the three year period, Florida and California's share of the aggregate U.S. orange supply was a little more than 95 percent, and Florida's and Texas' share of the aggregate U.S. grapefruit supply was a little more than 87 percent.

Table 3. Annual average U.S. orange and grapefruit supply by four major states, 3 year period 1967-68 to 1969-70.

Supply States	*Average Annual Supply*	*Percent of U.S. Total Supply*
United States	*Tons*	
Orange	7,100,933	100.00
Grapefruit	2,057,267	100.00
Arizona		
Orange	169,933	2,39
Grapefruit	99,833	4.85
California		
Orange	1,306,000	18.39
Grapefruit	161,767	7.86
Florida		
Orange	5,463,000	76,93
Grapefruit	1,555,667	75.61
Texas		
Orange	162,000	2.28
Grapefruit	240,000	11.66

Source: Texas Department of Agriculture and U. S. Department of Agriculture, Texas Citrus May 1, 1970.

LITERATURE CITED

1. U. S. Department of Agriculture, Citrus Fruits by States 1909-10 to 1964-65, Statistical Reporting Service, Statistical Bulletin 380, January 1967, Washington, D. C.

2. U. S. Department of Agriculture, Citrus Fruits by States, 1964-65 and 1965-66, Statistical Reporting Service, October 1966, Washington, D. C.

3. U. S. Department of Agriculture, Citrus Fruits by States 1965-66 and 1966-67, Statistical Reporting Service, October 1967, Washington, D. C.

4. U. S. Department of Agriculture, Citrus Fruits by States 1966-67 and 1967-68, Statistical Reporting Service, October 1968, Washington, D. C.

5. U. S. Department of Agriculture, Citrus Fruits by States 1967-68 and 1968-69, Statistical Reporting Service, October 1969, Washington, D. C.

6. U. S. Department of Agriculture and Texas Department of Agriculture, Texas Citrus, Statistical Reporting Service, May 1, 1970, Austin, Texas.

Effect of Heater Placement on Temperature Rise Inside Citrus Trees in the Lower Rio Grande Valley

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and ART SHULL[1]

Abstract: A pressurized pipeline heater, burning diesel fuel, was tested in the 1970 winter to determine its effectiveness for increasing temperatures inside the canopy of grapefruit trees under radiant low temperature conditions. With proper heater placement, using one heater burning 1.2 gallons and producing 162,000 B.T.U. per hour for every two trees, the mean temperature was increased 5-7°F within a 12-foot diameter area inside of trees in a hedge-row citrus planting of 116 trees per acre.

INTRODUCTION

Protection against severe freezes is one of the primary problems of the Texas citrus industry. Only trees whose large limbs and trunks remain undamaged during a severe freeze can be brought back into commercial production. Therefore development of orchard heating systems which give protection to the framework of the trees is important.

Earlier research in the Rio Grande Valley has shown that the most effective spot to place heat sources is under the canopy 3 to 4 feet north and northwest of the trunk (1). Two heaters placed at this location with a 0-5 miles per wind, producing 40,000 B.T.U. per hour gave a mean temperature rise under the tree of 5-7°F throughout a 12-foot diameter.

During January and February 1970, personnel of the Texas A&M University Agricultural Research and Extension Center at Weslaco, the USDA, Crops Research Division and Rio Farms, Inc. tested the "Spot Heater"[2], a pressurized pipeline heater system that burns diesel oil. The performance of the system under climatic conditions similar to radiation freezes in the Rio Grande Valley, the number of heaters per acre needed, and their placement in relation to the trees were the objectives of the present investigation.

METHODS

The orchard heater system used in the test (Spot Heaters, Inc., Sunnyside, Washington) consisted of cone-shaped stack heaters 3 feet

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[2] Mention of a trademark name or a proprietary product does not constitute a guarantee or warranty of the product by the USDA, and does not imply its approval to the exclusion of other products that may also be suitable.

high, pressure-fed through polyvinylchloride pipelines from a central bulk tank. The heaters burned diesel oil and heat output was regulated by changing the pressure.

The test was conducted on 2½ acres of close-planted (15 x 25 feet) red grapefruit orchard. The interlocking 14-year-old tree canopies were 12-15 feet in diameter and about 10 feet high. Chemical weed control maintained the orchard relatively weed free.

Four trees in the heated area had thermometers with an accuracy of ±½°F suspended at the 5-foot level in the center of the tree and 3 and 6 feet from the center in all four quadrants of the tree. One tree in an unheated part of the orchard had three thermometers at the 5-foot level, in the center of the tree, and 6 feet north and south from the center.

A Beckman and Whitley recording anemometer on the north side of the heated area recorded horizontal wind speed and wind direction 10 feet above the top of the canopy.

Heaters were placed at several locations in relation to the trees. On the west side of the heated area, one heater was placed 4 feet outside the dripline at the southwest corner of the test tree and another 4 feet from the dripline at the northwest corner of the tree north of the test tree (Figure 1).

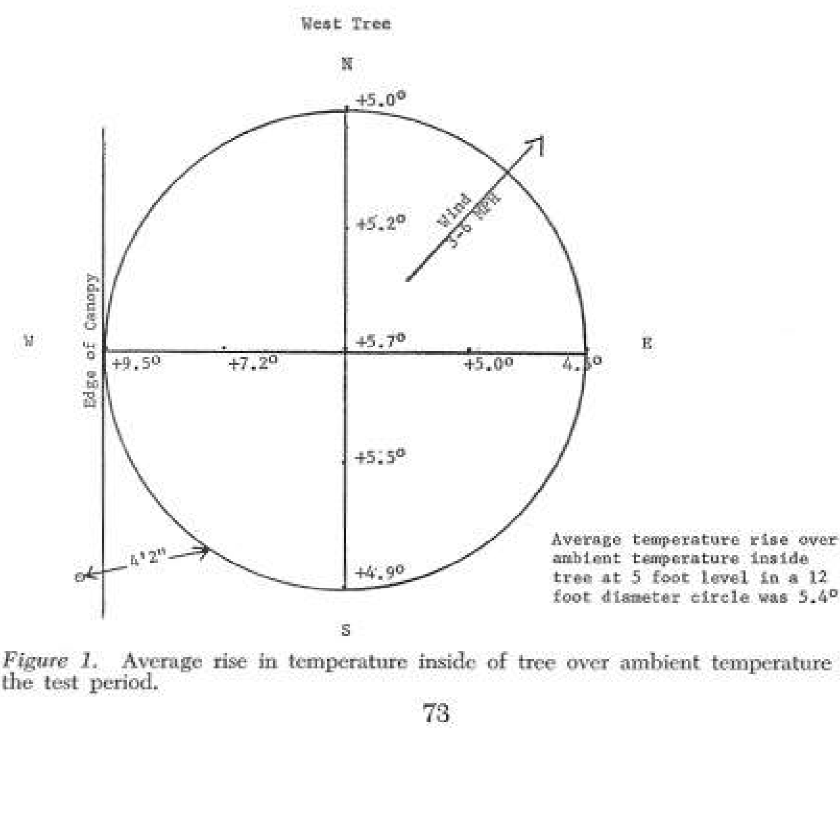

Figure 1. Average rise in temperature inside of tree over ambient temperature for the test period.

In the center of the heated area two heaters were placed about 4 feet from the foliage borderline at the southwest and northwest corners of two test trees. These heaters, however, were placed near the dripline and in a niche between two trees instead of in the space between the tree rows (Figure 2).

On the east side of the heated area, one heater was set 3.5 feet from the dripline at the northeast corner of the test tree and another was placed 3.5 feet from the dripline at the southeast corner of the tree south of the test tree (Figure 3).

The heaters were lit at 4:15 A.M. on the morning of February 17, when the ambient temperature fell to 40°F. After 45 minutes, sufficient time to bring the heat output of the heaters to its maximum, the first

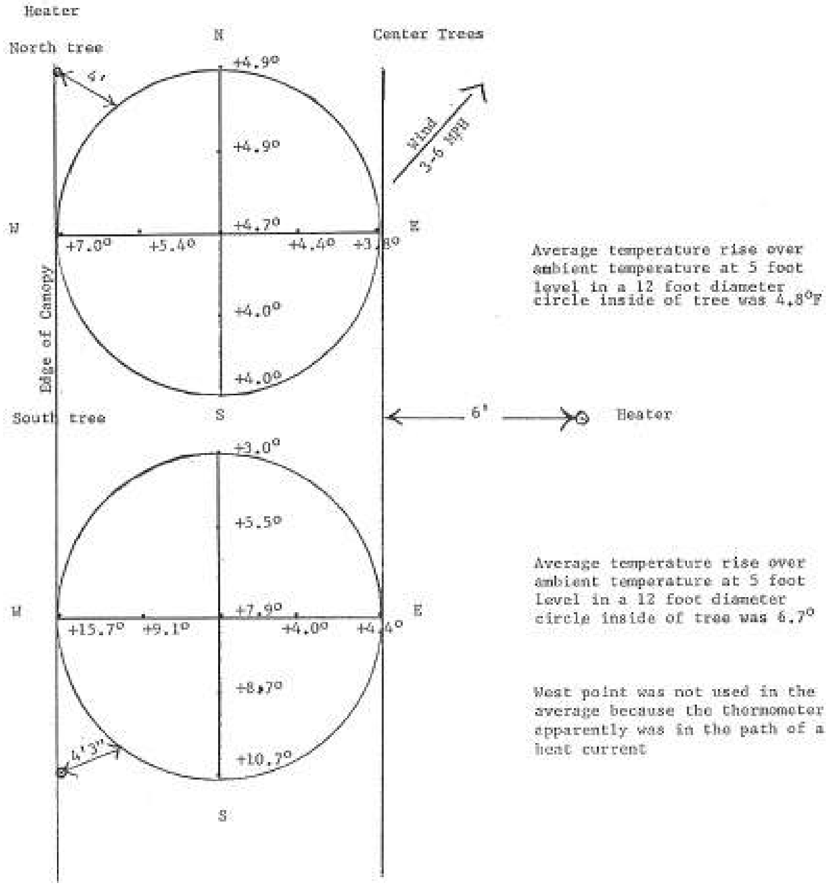

Figure 2. Average rise in temperature inside of tree over ambient temperature for the test period.

thermometer readings were taken. Temperatures were also recorded at 5:30 and 6:00 A.M., 75 and 105 minutes after lighting the heaters. The test was terminated at 6:15 A.M.

The heaters were operated at a 180 psi pressure, which gave a burning rate of 1.2 gallons of oil per heater per hour which produced 162,000 B.T.U's. The 61 heaters per acre provided one heater for every two trees.

During the test period the sky was clear and the ambient temperature averaged 38.3°F. The recording anemometer showed a variable windspeed of 3-6 miles per hour coming from the southwest. Although the test was conducted at air temperatures above the freezing point, it was shown by Haddock (2) that the heat necessary for a given increase in air temperature varies little when initial air temperatures are in the 20-40°F range.

RESULTS AND DISCUSSION

Figures 1, 2 and 3 give the means of results obtained during the

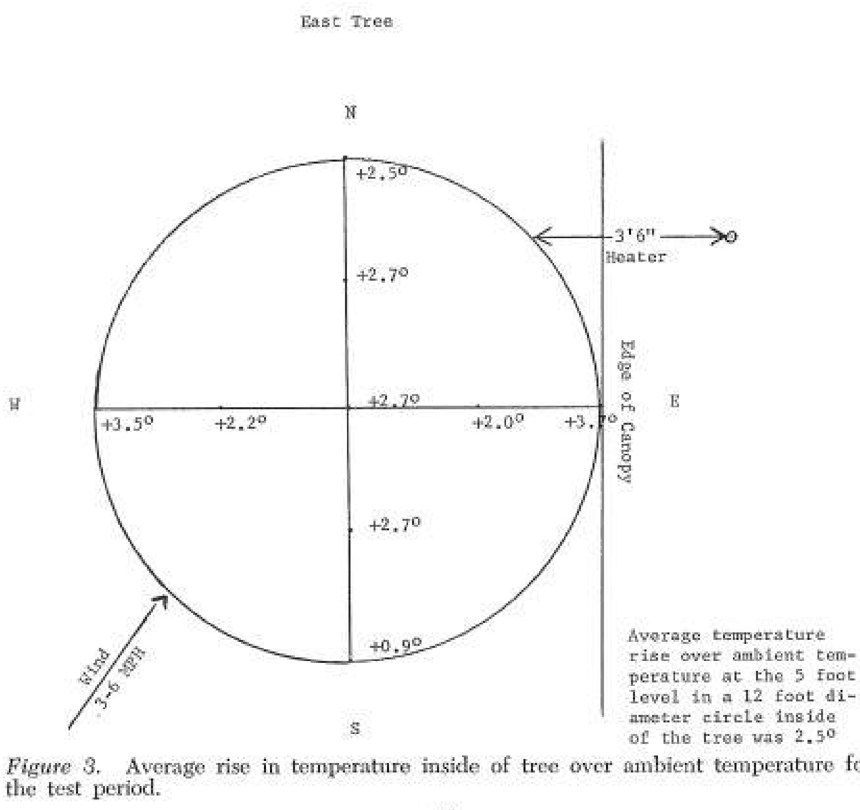

Figure 3. Average rise in temperature inside of tree over ambient temperature for the test period.

heating test. The results in Figure 1 and Figure 2 show that, even though the heaters were placed approximately the same distance from the edge of the canopy, the heater in the tree row as shown in Figure 2 caused a greater temperature increase inside the tree. When the heaters were placed on the leeward side of the tree, as shown in Figure 3, very little heat reached the interior of the canopy. Part of the temperature rise in the east tree was probably due to convected heat from the row west of the test tree where the heaters were also on the east side of the trees.

CONCLUSIONS

The data in Figure 2 show that in a citrus orchard spaced 15 x 25 feet, one heater, burning diesel fuel in excess of one gallon per hour, will be required for every two trees to obtain the 5-7°F temperature rise needed to prevent major wood damage during severe freezes. Although the oil-burning heaters used in the test cannot be placed under the canopy where they would be most effective, they should be placed as close as possible to the trees and not in the middle between the rows. The angle between two tree canopies appears to be the heater location which gives maximum temperature increases under the canopy.

ACKNOWLEDGMENT

The orchard heaters used in the test were Spot Heaters supplied at no charge by Spot Heaters, Inc. of Sunnyside, Washington.

The grove, labor, supervisory personnel and fuel for conducting the tests were furnished by Rio Farms, Inc.

LITERATURE CITED

1. Bailey, M. and N. P. Maxwell. 1965. Citrus tree cold protection utilizing solid petroleum fuel blocks as under-the-tree heaters. Jour. Rio Grande Valley Hort. Soc. 19:66-75.

2. Haddock, D. J. 1965. Heating air when initial temperatures are either 20° or 40°F and its relation to citrus grove heating research in Texas. Jour. Rio Grande Valley Hort. Soc. 19:51-53.

Low Temperature Risk Associated with Citrus and Fall Tomato Production, Weslaco, Texas

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Abstract: Knowledge of the probability of low temperature occurrence in a geographic area is an aid in formulating some subjective expectation with respect to potential crop damage or loss from a freeze. This paper presents low temperature probabilities and other associated statistics for Weslaco, Texas. The within year periods of analysis are November through March and November only. The former is appropriate for citrus production, the latter is appropriate for fall tomato production.

INTRODUCTION

Ability to deliver consistent quality and quantity of product over time is one of the more challenging and important aspects of the successful firm engaged in marketing and/or production of fruits and vegetables. Historically, some supply (quantity) variability and quality variability in these commodities in Texas can be attributed to freezes.[2] The purpose of this paper is to provide additional information concerning the risk associated with the occurrence of low temperatures.[3] Although the occurrence of *freeze damage* to a particular crop is an uncertainty because freeze damage is a function of factors other than temperature, temperature probabilities are indicative of the potential for crop loss due to freeze.[4]

SCOPE AND METHODOLOGY

This paper presents low temperature probabilities estimated from monthly extreme minimum temperature data recorded at Weslaco, Texas for the 50-year period November through March 1920-21 to November through March 1969-70. Two types of probability are presented. One type is the probability, P, that some particular temperature, x, will occur in any one year. Another type is the probability, W(v), that some particular temperature, x, will occur at least once within v years. Also presented is a complementary statistic computed from P and called a "return period." The return period, denoted T(x), is the number of years that will elapse, on the average, before a temperature will occur which is less than or equal to some particular temperature x_0. The statistics of extremes are utilized to analyze the monthly extreme minimum temperature data. The Fisher-Tippet Type I extreme value function is the ap-

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[2] For documentation, see (1).
[3] Some information is already available. For example, see (2,4).
[4] For other factors affecting freeze damage, see (4, p. 19).

propriate statistical distribution for minimum temperatures. The parameters of the distribution were estimated by Lieblein's fitting procedure.[5]

PROBABILITIES FOR NOVEMBER THROUGH MARCH

The probability of a particular low temperature occurring and the associated return period for that temperature at Weslaco, Texas is presented in Table 1. The range of the monthly extreme minimum temperatures for Weslaco from November through March 1920-21 to November through March 1969-70 was from 35 to 16. Accordingly, the probability of occurrence of each temperature in the range of the actual data is presented (Table 1), along with the return period in years for each temperature.

Haddock has comupted the probability of occurrence of certain low temperatures for Weslaco using data for November through March 1933-34 to 1962-63 (2, 4). Haddock's probabilities of temperature occurrence are generally higher than the ones presented in Tables 1 and 3. Haddock's estimates are accurate but differ from those presented here for two

Table 1. Probability and return period for selected minimum temperatures, Weslaco, Texas, November through March.

Temperature	*Probability of temperature occurring*	*Return period T(x)*
35	.993	1.0
34	.971	1.0
33	.921	1.1
32	.837	1.2
31	.728	1.4
30	.606	1.6
29	.487	2.1
28	.380	2.6
27	.290	3.4
26	.218	4.6
25	.161	6.2
24	.118	8.5
23	.086	11.6
22	.063	16.0
21	.045	22.1
20	.033	30.7
19	.023	42.6
18	.017	59.3
17	.012	82.6
16	.009	115.1

Source: Computed from minimum extreme monthly temperatures for the 50-year period 1920-21 to 1969-70, Texas Agricultural Experiment Station, Weslaco, Texas.

[5] A computer program was devised to calculate these parameters and associated statistics. The program and a more detailed explanation of calculations are contained in (5).

reasons. First, Haddock used data spanning a 30-year time period contrasted to the 50-year time period used for calculation of the probabilities presented in this article. Second, the Lieblein weights utilized in the calculation of the probabilities presented here differ from those utilized by Haddock. The weights utilized here are more accurate but were not available when Haddock computed his probabilities.

The probability that a particular temperature will occur within a certain time period for Weslaco is presented in Table 2. Again, these probabilities are computed for each temperature in the range of the data. Interpretation of these two types of probability (Table 1 and 2) is illustrated in the following example. Suppose a firm engaged in production and/or marketing citrus in Weslaco, Texas is interested in the likelihood of crop loss from a freeze. Suppose the manager of the operation decides that 21° F. is the relevant critical temperature to consider given the unique aspects of the operation (variety, age of the grove, etc.).[6] That is, 21° F. represents the critical temperature which, in his judgment, may extensively damage the crop.

From Table 1 the probability that a temperature of 21° F. or below

Table 2. Probability of selected low temperatures occurring at least once within a certain time period, Weslaco, Texas, November through March.

Temperature	*Probability of Temperature Occurring At Least Once Within*				
	1 Year	*3 Years*	*5 Years*	*8 Years*	*10 Years*
35	.99	1.0	1.0	1.0	1.0
34	.97	1.0	1.0	1.0	1.0
33	.92	1.0	1.0	1.0	1.0
32	.84	1.0	1.0	1.0	1.0
31	.73	.98	1.0	1.0	1.0
30	.61	.94	.99	1.0	1.0
29	.49	.87	.97	1.0	1.0
28	.38	.76	.91	.98	.99
27	.29	.64	.82	.94	.97
26	.22	.52	.71	.86	.91
25	.16	.41	.59	.76	.83
24	.12	.32	.47	.64	.72
23	.09	.24	.36	.51	.59
22	.06	.18	.28	.40	.48
21	.05	.13	.21	.31	.37
20	.03	.10	.15	.23	.28
19	.02	.07	.11	.17	.21
18	.02	.05	.08	.13	.16
17	.01	.04	.06	.09	.12
16	.01	.03	.04	.07	.08

Source: Computed from minimum extreme monthly temperatures for the 50-year period 1920-21 to 1969-70, Texas Agricultural Experiment Station, Weslaco, Texas.

[6] Generally, 21° F. is considered the relevant critical temperature for severe freeze damage in citrus in the Rio Grande Valley (4, p. 19).

will occur during the citrus season is .05. Of course, the probability that a temperature of 21° F. or below will not occur is .95. The return period for 21° F. is 22.1 years (Table 1). This means that about 22 years will elapse, *on the average*, before a temperature equal to or below 21° F. will occur. Thus, the manager might anticipate crop loss due to low temperatures about once every 22 years.

The W(v) statistic for v = 1, 3, 5, 8, 10, 15, 20, 25, 30, and 35 years is given in Table 2. Note than when v = 1 then W(v) equals the probability of that temperature occurring. As an interpretive example, the W(v) statistic for v = 5 is .21. This means that there is about a 20 percent chance of 21° F. or below occurring at least once within 5 years during the citrus season in Weslaco.[7]

PROBABILITIES FOR NOVEMBER

The probability of a particular low temperature occurring at Weslaco, Texas and the associated return period for that temperature for November only is presented in Table 3. The range of November extreme minimum temperature for Weslaco from 1920 through 1969 was from 51

Table 2. (continued) Probability of selected temperatures occurring at least once within a certain time period, Weslaco, Texas, November through March.

Temperature	*Probability of Temperature Occurring At Least Once Within*				
	15 Years	*20 Years*	*25 Years*	*30 Years*	*35 Years*
35	1.0	1.0	1.0	1.0	1.0
34	1.0	1.0	1.0	1.0	1.0
33	1.0	1.0	1.0	1.0	1.0
32	1.0	1.0	1.0	1.0	1.0
31	1.0	1.0	1.0	1.0	1.0
30	1.0	1.0	1.0	1.0	1.0
29	1.0	1.0	1.0	1.0	1.0
28	1.0	1.0	1.0	1.0	1.0
27	.99	1.0	1.0	1.0	1.0
26	.98	.99	1.0	1.0	1.0
25	.93	.97	.99	1.0	1.0
24	.85	.92	.96	.98	.99
23	.74	.84	.90	.93	.96
22	.62	.73	.80	.86	.90
21	.50	.60	.69	.75	.80
20	.39	.49	.56	.62	.69
19	.30	.38	.45	.51	.56
18	.23	.29	.35	.40	.45
17	.17	.22	.26	.31	.35
16	.12	.16	.20	.23	.26

Source: Computed from minimum extreme monthly temperatures for the 50-year period 1920-21 to 1969-70, Texas Agricultural Experiment Station, Weslaco, Texas.

[7] Caution must be exercised in comparing the W(v) statistic with the return period since the underlying distribution is asymmetric. See (6, p. 3 or 5, p. 11).

to 30. In addition to the probability of occurrence of each temperature in the range of the actual data, probabilities were computed for the extrapolated values of 29°, 26°, and 23° (Table 3). The probabilities and return periods for these values should not be considered as precise as the comparable statistics for temperatures within the range. Of course, the interpretation of the statistics in Table 3 is similar to those in Table 1.

The probability of a particular temperature occurring at least once within v years for November is presented in Table 4. For example, the probability of 32° F. occurring at least once in November within 5 years ies .44, 10 years is .69, and 15 years is .83. Again, interpretation of probabilities in Table 4 is similar to interpretation of Table 2.

The probabilities for November are useful for firms engaged in the production and/or marketing of fresh fall tomatoes.

Table 3. Probability and return period for selected low temperature occurring in November, Weslaco, Texas.

Temperature	*Probability of temperature occurring*	*Return period*
51	1.0	1.0
50	1.0	1.0
49	1.0	1.0
48	.993	1.0
47	.980	1.0
46	.955	1.0
45	.914	1.1
44	.856	1.2
43	.784	1.3
42	.703	1.4
41	.617	1.6
40	.532	1.9
39	.451	2.2
38	.378	2.6
37	.313	3.2
36	.257	3.9
35	.209	4.8
34	.169	5.9
33	.137	7.3
32	.110	9.1
31	.088	11.4
30	.070	14.3
29*	.06*	16.7*
26*	.03*	33.3*
23*	.01*	100.0*

* These are extrapolated values and should not be considered precise.

Source: Computed from minimum extreme monthly temperatures for the 50-year period 1920-21 to 1969-70, Texas Agricultural Experiment Station, Weslaco, Texas.

CONCLUSIONS

Although an analysis of extreme minimum temperatures does provide objective information concerning the occurrence of low temperature in a geographic area, subjective judgment must still enter into expectations about future crop damage or loss from freezes. There is no exact way to predict where or when a damaging freeze will occur. At best, analysis of historical data provides a means of indicating the potential frequency of occurrence of future events.

LITERATURE CITED

1. Connolly, C. C., *Citrus Supply Variation*, Journal of Lower Rio Grande Valley Horticultural Society, 1970.
2. Haddock, D. J., *Agricultural Meteorology for Citrus Production Guide for Citrus Production in the Lower Rio Grande Valley*, B-1002, Texas A&M University, College Station, Texas, pp. 26-28.
3. Lieblein, J., "A New Method of Analyzing Extreme-value Data," Technical Note 3053, National Advisory Committee for Aeronautics, Washington, D. C., 1954.

Table 4. Probability of selected low temperatures occurring at least once within v years, Wesalco, Texas, November.

	Probability of Temperature Occurring At Least Once Within					
	1 Year	*3 Years*	*5 Years*	*8 Years*	*10 Years*	*15 Years*
51	1.0	1.0	1.0	1.0	1.0	1.0
51	1.0	1.0	1.0	1.0	1.0	1.0
49	1.0	1.0	1.0	1.0	1.0	1.0
48	.99	1.0	1.0	1.0	1.0	1.0
47	.98	1.0	1.0	1.0	1.0	1.0
46	.96	1.0	1.0	1.0	1.0	1.0
45	.91	1.0	1.0	1.0	1.0	1.0
44	.86	1.0	1.0	1.0	1.0	1.0
43	.78	.99	1.0	1.0	1.0	1.0
42	.70	.97	1.0	1.0	1.0	1.0
41	.62	.94	.99	1.0	1.0	1.0
40	.53	.90	.98	1.0	1.0	1.0
39	.45	.84	.95	.99	1.0	1.0
38	.38	.76	.91	.98	.99	1.0
37	.31	.68	.85	.95	.98	1.0
36	.26	.59	.77	.91	.95	.99
35	.21	.51	.69	.85	.91	.97
34	.17	.43	.61	.77	.84	.94
33	.14	.36	.52	.69	.77	.89
32	.11	.29	.44	.61	.69	.83
31	.09	.24	.37	.52	.60	.75
30	.07	.20	.31	.44	.52	.66

Source: Computed from minimum extreme monthly temperatures for the 50-year period 1920-21 to 1969-70, Texas Agricultural Experiment Station, Weslaco, Texas.

4. Orton, Robert, et. al., *Climatic Guide, The Lower Rio Grande Valley of Texas,* MP-841, Texas A&M University, College Station, Texas, September, 1967.

5. Sporleder, Thomas L., *TEMPROB: A Fortran IV Program for Calculating Temperature Probabilities from Extreme Minimum Temperature Data,* Texas Agricultural Market Research and Development Center Technical Report No. MRC-70-3, Texas A&M University, College Station, Texas, July, 1970.

6. Vestal, C. K., "Fitting of Climatological Extreme Value Data," Climatological Services Memorandum Number 89, U.S. Weather Bureau, August, 1961.

Temperature Inversions in the Lower Rio Grande Valley[1]

Robert F. Leyden and Richard A. Hensz[2]

Abstract: Temperatures were measured at various heights above ground on all cold nights from 1958 to 1970 at Weslaco and from 1966 to 1970 at Adams Gardens and Sharyland. Data are separated into hours in the 34 to 30 F range and hours below 30 F at the 5 ft level. Most cold nights in the Lower Rio Grande Valley were in the 34 to 30 F range. These are of particular concern to vegetable growers. Temperatures critical for citrus, these below 30 F, were a small percentage of the total cold hours. The frequency of temperature inversions, their strengths, and their distribution through the night are shown.

INTRODUCTION

Temperature inversions are important in any attempt to protect crops from damaging cold. They occur at night as a result of the cooling of the earth's surface through the loss of heat by radiation to the open sky and the subsequent cooling of the air that comes in contact with this surface. The air at lower levels becomes colder than the air above, up to 100-200 ft. Such a condition is the inverse of natural adiabatic cooling, the gradual decrease in temperature that normally occurs with height.

Conditions favoring the formation of temperature inversions are: clear sky, low wind velocities, low relative humidity, and high pressure. Any change in conditions causing an inversion will affect the strength of that inversion.

The strength of an inversion is the difference in air temperature between ground level and the height where normal adiabatic cooling resumes. For crop protection purposes, inversions are measured from some height near the ground, e.g. 5 ft, to a height usually not more than 50 ft above the surface. For low growing crops temperatures between the surface and 5 ft are important. The citrus grower is more interested in the inversion measured between 5 and 50 ft. Inversions may form when temperatures are not low enough to freeze vegetation, but it is when there is strong radiative cooling and frost damage is a threat that temperature inversions become important.

Even high, thin cirrus clouds can intercept and reflect heat lost by radiation. The formation or passage of clouds has a modifying influence on temperature that is decreasing because of radiative cooling. Air move-

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ment causes turbulence which mixes the warm air aloft with the cold air below. While this does not stop radiation cooling, it modifies the rate of temperature drop at the lower levels.

An understanding of the inversion characteristics of an area is helpful in planning and using cold protection systems. Temperatures 1, 5, and 28 ft above ground have been reported for all nights from 1958 to 1963 when 32 F or less was registered at the 5 ft level at Weslaco, Texas (3). On the coldest night of the major freeze of January 1962, Young found that when the wind subsided, air temperature 20 and 40 ft above ground was 5 to 8.5 F warmer than at the 7 ft level in an orchard at Monte Alto, Texas (5). On a night of variable windspeed and direction: the inversion diminished during periods of higher windspeed and reformed during periods of lower windspeed; air temperature at tree height increased during periods of high windspeed (1). The greater turbulence at higher windspeeds mixed the warm air from the upper layers with the cold air below. The breaking up of an inversion by natural wind movement provides the same beneficial effect as a wind machine. Other workers have measured and reported inversions present during particular tests of cold protection systems in the Lower Rio Grande Valley (2, 4, 6, 7).

PROCEDURE

At the Citrus Center we have measured air temperature at various heights since 1958 when a 30 ft windmill tower was erected near an orchard. Minimum registering thermometers in inverted L-shelters were secured to the tower 1, 5, 10, 15, 20, and 28 ft above ground. In 1959, U. S. Weather Bureau Cotton Region Instrument Shelters were installed on the tower 5 and 28 ft above ground. Recording thermographs provided continuous temperature records. Since 1966, towers fashioned from three utility poles, with shelters 5 and 45 ft above ground, equipped with recording thermographs, have been in operation during the winter months. The towers are located at: Adams Gardens, south of Highway 83, between Harlingen and La Feria; Citrus Center South Research Farm, south of Highway 83 on Farm Road 1015, between Weslaco and Mercedes; Sharyland Orchards, four miles north of Highway 83 on Farm Road 494, between Mission and McAllen.

The area under and around the inversion towers is maintained in a sod or short turf condition.

Whenever the temperature at 5 ft was 34 F or below at any inversion tower, regardless of wind or sky condition, the inversion was measured and the total number of hours of inversion was recorded. Nights are included when these temperatures were reached for only one or two hours. The data are divided into hours when temperatures were between 34 and 30 F and when they were below 30 F and further divided into early night, 8 PM - 1 AM, and late night, 1 AM - 7 AM. The presentation gives the frequency of inversions, their strengths, and their distribution through the night. Records for Weslaco are from 1958 to 1970, and for Adams Gardens and Sharyland from 1966 to 1970.

RESULTS

At Weslaco, the 34 - 30 F range occurred in 11 of the 12 winters, below 30 F in 6. At the other locations, 34 - 30 F occurred in all 4 winters, below 30 F in 2 at Adams Gardens and 3 at Sharyland.

Inversions between 5 and 28 ft at Weslaco, 1958 to 1966. Inversions at Weslaco from 1958 to 1966, measured between 5 and 28 ft, are shown in Fig. 1. Involved were 7 winters with 24 nights, including those that were windy and overcast as well as nights of radiation cooling. The solid part of the bar in the figure represents hours when the temperature at the 5 ft level was less than 30 F; the cross-hatched portion, hours in the 34 to 30 F range.

In the early night there were 51 hr in the 34 - 30 F range. Sixteen hours with no inversion were recorded on 3 windy, overcast nights, one of them the first night of the major freeze of January 1962. In the late night there were 73 hr in the 34 - 30 F range with 21 hr of no inversion. These 21 hr were accumulated on 7 nights, the second night of the 1962 freeze and 6 others when clouds appeared and windspeed increased resulting in a complete disruption of the inversion.

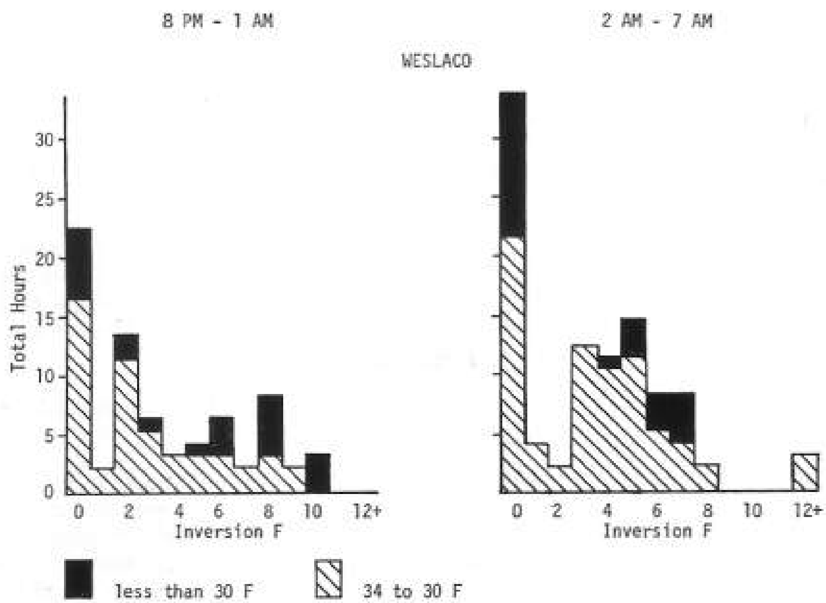

Figure 1. Total hours of inversions of different strengths, measured between 5 and 28 ft whenever 5 ft temperatures were 34 - 30 F and below 30 F. Left: early night, 8 PM - 1 AM. Right: late night, 2 AM - 7 AM. At Weslaco, 1958 to 1966.

The total number of hours when temperatures were 34 - 30 F and less than 30 F and the percentage of these hours with inversions of 5 F or more, 1 - 4 F, and less than 1 F are presented in Table 1. Inversions of 5 F or more are strong inversions and of value when cold protection systems are used. Inversions in the range 1 - 4 F represent mostly transitional stages during which the inversion is either building or breaking. Inversions of less than 1 F are essentially no inversion, and were generally associated with windy or cloudy conditions.

With a total of 124 hr in the 34 - 30 F range strong inversions were present 31% of the time, the transition stage 39%, and no inversion 30%. While most of the cold hours occurred in late night, the distribution of inversion strengths was similar in both parts of the night. Temperatures less than 30 F occurred for 44 hr; strong inversions were present 48%, and no inversion 43% of the time. Strong inversions were present 55% of the hours early in the night. No inversions were present 54% of the hours late in the night.

Inversions between 5 and 45 ft at Weslaco, Adams Gardens, and Sharyland, 1966 to 1970. From 1966 to 1970 the 45 ft towers were used at three locations. At Weslaco temperatures 34 to 30 F occurred in every winter for a total of 13 nights; below 30 F in two of the winters for a total of 4 nights. At Sharyland 34 to 30 F occurred in each winter for a total of 9 nights; below 30 F in three winters on 4 nights. At Adams Gardens 34 to 30 F occurred in each winter for a total of 13 nights; below 30 F in two winters on 2 nights.

While no extreme cold of long duration occurred between 1966 and 1970 the rate of accumulation of cold hours was similar to that in the period 1958 to 1966. At Weslaco there were 168 hr below 34 F during eight winters from 1958 to 1966 and 97 hr during four winters in the 1966 to 1970 period.

Table 1. Total hours when temperatures at the 5 ft level were 34-30 F and less than 30 F and the percent of these hours when inversions were 5 F or more, 1-4 F, or less than 1 F. Weslaco, Texas, 1958 to 1966.

Time	*Total Hours*	*Strength of Inversion F**		
		5 or more	*1 to 4*	*less than 1*
		(percent of total hours)		
	34 to 30 F			
8 PM - 1 AM	51	27	42	31
2 AM - 7 AM	73	33	38	29
	less than 30 F			
8 PM - 1 AM	20	55	15	30
2 AM - 7 AM	24	42	4	54

* Measured between 5 and 28 ft.

In Fig. 2 the inversion strength between 5 and 45 ft and the total hours when the temperature was less than 34 F are presented for each location, and for early and late night. The solid portion of the bar represents hours when temperatures were less than 30 F; the cross-hatched, hours in the 34 - 30 F range.

Most of the cold hours occurred in the late night. No hours below 30 F occurred in the early night. Only at Sharyland were there any cold hours with no inversion in the early night. On virtually all cold nights inversions were building during the early hours. The number of hours with strong inversions in the second half of the night indicated that the inversions tended to persist.

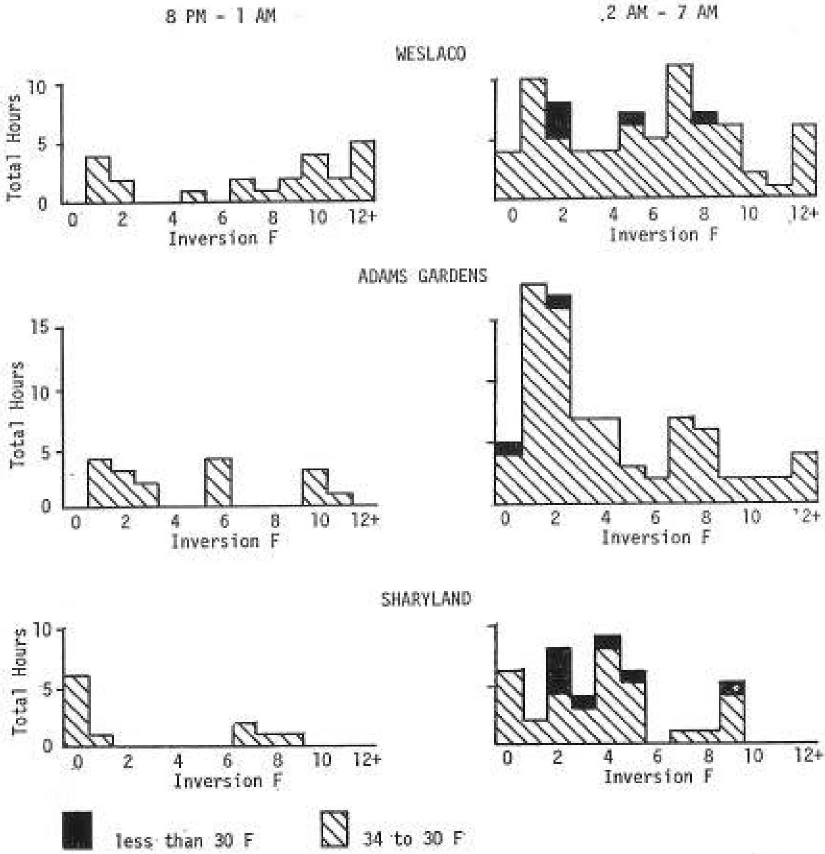

Figure 2. Total hours of inversions of different strengths, measured between 5 and 45 ft whenever 5 ft temperatures were 34 - 30 F and below 30 F. Left: early night, 8 PM - 1 AM. Right: late night, 2 AM - 7 AM. At Weslaco, Adams Gardens, and Sharyland, 1966 to 1970.

Temperatures below 30 F occurred for only 10 hr at Sharyland, 5 hr at Weslaco, and 2 hr at Adams Gardens. These have been included with the hours in the 34 - 30 F range and are presented in Table 2 as hours below 34 F. At Weslaco, with a total of 97 hr, strong inversions were present 63% of the time, the transitional stage 33%, and no inversion 4%. At Adams Gardens, with 98 hr, strong inversions were present 36% of the time, the transitional stage 59%, and no inversion 5%. At Sharyland, with 55 hr, 35% had strong inversions, 44% transitional, and 21% no inversion. The distribution between early and late night was similar at Weslaco and Adams Gardens. At Sharyland inversions were absent a greater percent of the time in the early night than in the late night.

DISCUSSION

At Weslaco, during the 12 winters from 1958 to 1970, there were 42 nights with a total of 265 hr when temperatures 34 F and below were recorded. Strong inversions were present 46% of these hours and no inversion 22% of the hours. There were 13 nights with a total of 55 hr of temperatures below 30 F. Strong inversions were present 36% of the time and no inversion 42%.

At Adams Gardens the inversion pattern was similar and of about the same frequency as at Weslaco.

Sharyland had the least number of hours below 34 F. The inversion pattern differed somewhat from that at the other locations in that inversions formed later in the night and did not have strengths over 10 F. The difference can be partially accounted for by changes in land use in the vicinity of the tower. At the time of installation, when the Sharyland tower bordered on a pasture and a fallow field, the inversion pattern was similar to that of the other locations where the towers were

Table 2. Total hours when temperatures at the 5 ft level were 34 F or less and the percent of these hours when inversions were 5 F or more, 1-4 F, or less than 1 F. At Weslaco, Adams Gardens, and Sharyland, 1966 to 1970.

Location	*Time*	*Total Hours*	*Strength of Inversion F**		
			5 or more	*1 to 4*	*less than 1*
			(Percent of total hours)		
Weslaco	8 PM - 1 AM	23	74	26	0
	2 AM - 7 AM	74	60	35	5
Adams Gardens	8 PM - 1 AM	16	44	56	0
	2 AM - 7 AM	82	34	60	6
Sharyland	8 PM - 1 AM	11	36	9	55
	2 AM - 7 AM	44	34	52	14

* Measured between 5 and 45 ft.

in areas having a short weed and grass cover during the winter months. The following spring an orchard was planted on three sides of the tower and chemical weed control with no tillage was established. The next winter the inversion pattern changed. The bare, undisturbed soil in the orchard absorbed heat well during the hours of sunlight and radiated the stored heat on nights of radiation cooling. Since such a soil stored more heat than a less efficient absorber the surface did not become as cold under radiation cooling as would a recently cultivated or sodded soil. With the lower air layers cooled more slowly inversions did not develop as early and were not as strong as they were over other surfaces. At the Citrus Center when a tower was moved into an orchard under chemical weed control with no tillage the inversion pattern changed radically. The temperature at the 5 ft level over the undisturbed orchard soil on nights of radiation cooling was from 1 to 5 F warmer than the 5 ft temperature over an open, sodded area.

When temperatures at the 5 ft level are 34 F or lower and typical frost or radiation conditions exist, temperature inversions frequently develop. Inversions exist because of rapid cooling of the lower air layers and, since this is where the plants are, the need for cold protection increases in the presence of strong inversions. Fortunately, any cold protection system is more efficient when inversions are present. The natural disruption of an inversion during the night by turbulence usually modifies temperatures and is to the grower's advantage.

Temperatures from 34 to 30 F are important to vegetable growers with tender crops since under radiation conditions temperatures at the 1 ft level are typically several degrees colder than those at the 5 ft level. At Weslaco, between 1958 and 1970, there were 29 nights in the 34 - 34 F range. Ten had strong inversions during all the cold hours; another seven had strong inversions during some of the cold hours. This suggests considerable potential for protecting low growing crops from frost damage.

Temperatures below 30 F are critical for citrus. In the Lower Rio Grande Valley only a small portion of the total cold hours and total cold nights are in this range. In 12 winters there were 55 hr below 30 F as compared to 210 hr in the 34 - 30 F range. Widespread damage to citrus occurred on one occasion during the period of record, the January 1962 freeze. The coldest and most damaging night of that freeze had strong inversions and properly used cold protection systems afforded some protection even under these extreme conditions. On several other occasions between 1958 and 1970, minor cold injury to citrus was reported in scattered locations in the Lower Rio Grande Valley. These occurred on nights of radiation cooling when cold protection systems would likely have prevented or reduced the damage sustained.

The authors wish to acknowledge the assistance provided by the following: Sharyland Nurseries and Crockett Groves, Inc. for providing sites for towers, Mr. W. T. Ellis and Mr. Blaine H. Holcomb for purchasing a recording instrument to replace one stolen from a tower, and

Central Power and Light Company for supplying and erecting utility poles for the inversion towers.

LITERATURE CITED

1. Bartholic, J. F., and C. L. Weigand. 1969. The environment in a citrus grove with and without heater blocks during cold conditions. Proc. 1st International Citrus Sympo. 2:583-592.

2. Hensz, R. A. 1969. Petroleum coke fuel blocks: Alone and with wind machines. Proc. 1st International Citrus Sympo. 2:529-534.

3. Leyden, R., and P. W. Rohrbaugh. 1963. Protection of citrus trees from cold damage. Proc. Amer. Soc. Hort. Sci. 83:344-351.

4. Leyden, R., R. A. Hensz, and J. E. Fucik. 1965. Under-the-tree heating tests in citrus orchards using petroleum coke fuel blocks. J. Rio Grande Valley Hort. Soc. 19:54-60.

5. Peynado, A. R., R. Young, and W. C. Cooper. 1963. A comparison of three major Texas freezes and a description of tissue temperature of Valencia orange tree parts during the January 1962 freeze. J. Rio Grande Valley Hort. Soc. 17:15-23.

6. Young, R., and A. Peynado. 1964. Frost formation on "Redblush" grapefruit trees during a mild radiation freeze as affected by heaters and windmachines. J. Rio Grande Valley Hort. Soc. 18:9-14.

7. Young, R., N. Maxwell, M. Bailey, and W. R. Cowley. 1964. Temperature in and around grapefruit trees as affected by under-the-tree heat sources. J. Rio Grande Valley Hort. Soc. 18:15-20.

A Field Test of Several Freeze Protectant Sprays on Young Grapefruit Trees[1]

John E. Fucik

Abstract: Solutions of Foli-gard, an anti-transpirant; TD 692, experimental growth regulator; L-cysteine and L-glutamic acids; decenylsuccinic acid and FXT-X, a fermentation process by-product, were sprayed on young grapefruit trees prior to a forecasted freeze. After three weeks of alternating warm and cool weather freezing temperatures did occur. None of these materials provided any real significant reduction in freeze injury to young shoots nor did they influence subsequent tree growth. Because of certain consistent effects four of the materials might be worthy of further testing.

INTRODUCTION

The search for methods of protecting citrus from freeze injury has occupied citrus scientists throughout much of the world.

The conventional approach to citrus freeze protection is to modify the weather by heating, sprinkling, using wind machines, windbreaks and other devices. A second approach is to desensitize the trees to low temperature effects by inducing dormancy, preventing intracellular water from freezing, or preserving cell structure and function. Under the second approach some growth regulators, particularly maleic hydrazide, have shown promise in inducing dormancy (2, 5, 20). The use of decenylsuccinic acid (DSA) to protect cell membranes from disruption by freezing has been unsuccessful in limited trials with citrus (11, 22). Preventing tissue dessication, which usually accompanies or follows freezing, by anti-transpirant sprays has protected some plants from winter injury (6). Anti-transpirants can reduce water loss from citrus, but they have not been effective in freeze protection (7).

Much research has been done on the changes a plant undergoes with the onset and perpetuation of dormancy, on a plant's response to freezing, and on the nature of freeze injury (14, 16, 23). Generally increases in cold hardiness are accompanied by increases in cell sugars, conductivity of the cell sap, membrane permeability to polar substances, and decreases in the "unbound" water within the tissues (13). Russian workers have found that a decrease in free amino acids accompanies increased cold hardiness in apple buds (15). In citrus, increases in

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sugars, electrical conductivity, and "bound" water accompany increased cold hardiness (10, 24). While most of these phenomena are apparently responses to weather changes, the possibility of blocking or enhancing these natural plant responses remains a plausible and attractive challenge to plant scientists (8, 9, 17). This paper reports the effectiveness of several materials in protecting the young shoots of grapefruit trees from freeze injury under field conditions.

MATERIALS AND METHODS

The trees used in this test were 10-month-old nucellar Redblush grapefruit planted 4 ft apart in a hedgerow in the South Research Farm of Texas A&I University Citrus Center, Weslaco. The hedgerow ran north and south between an open field and a blacktop highway. Within the row 11 plots of four consecutive trees each were selected. Each plot was separated by one or two guard trees. Replications were randomly assigned to the four trees in each plot and treatments were randomly assigned to the plots.

The materials tested for freeze protection are listed in Table 1. According to the manufacturer TD 692 had shown growth regulator and frost protection effects in preliminary tests on deciduous trees. An increase in tissue sugar content was noted on treated plants. Foli-gard is an isopropanolic amine anti-transpirant which has proven effective on certain ornamentals (18). L-cysteine and L-glutamic acid are two of the basic amino acids found in proteins and were included because of evidence linking proteins with cell hydration-dehydration processes and because of the role lipo-proteins play in membrane function. DSA was included because it increased freeze resistance of apple and peach blooms (11). FXT-X is apparently a by-product of a fermentation process. Its formulation and nature were not supplied by the manufacturer who only noted that it seemed to impart frost resistance to St. Augustine turf. Multi-film Buffer X is a non-ionic surfactant commonly used in pesticide sprays. Evidence that DMSO facilitates movement of substances through plant and animal tissues is well-documented (1).

On January 16, 1967 freezing temperatures were forecast for the mid-Rio Grande Valley for the evening or early morning of January 18-19. In view of this forecast the test materials were prepared and applied to the trees with a 2 gal garden sprayer between 4 and 5 PM, January 16. The trees in treatments 1A and 1B each received 1 liter of solution while the rest of the trees received 0.5 liter each. The temperature was 62 F, the R.H. 60% and the wind was S.E. at 8-10 mph. There was a bright sun and scattered clouds.

The cold weather forecast for January 18-19 did not materialize. Typical alternating warm and cold periods prevailed until a cold front with freezing temperatures moved into the area on February 6. Minimum temperatures of 24-26 F were registered on the morning of February 8 by sheltered thermometers near the treated hedgerow. A tempera-

Table 1. Description, concentration and source of experimental freeze protectant sprays applied to Redblush grapefruit trees.

Treatment	*MATERIAL*[x]	*Concentration*	*Additives*[x]	*Source of Material*
1A	TD 692	100 ppm	None	Pennsalt Chem. Corp., Bryan, Texas.
1B	TD 692	1000 ppm	None	Same as above
2A	Foli-gard	20%	None	E-Z-Flow Chem. Co., Lexington, Kentucky.
2B	Foli-gard	40%	None	Same as above
3A	L-cysteine	2000 ppm	10% Dimethyl-sulfoxide (DMSO)	Amino acid: Pfanstiehl Labs., Inc., Waukegan, Illinois. DMSO: Crown-Zellerbach Lumber Co., Chem. Div., Camas, Washington.
3B	L-cysteine	2000 ppm	0.5% Multi-film Buffer X	Multi-film Buffer X: Colloidal Prod. Corp., Sausalito, California.
4	Decenylsuccinic acid (DSA)	0.5%	0.5% Multi-film Buffer X	DSA: Humphrey Chem. Corp., No. Haven, Connecticut.
5A	L-glutamic acid	200 ppm	0.5% Multi-film Buffer X	Amino acid: Pfanstiehl Labs., Inc., Waukegan, Illinois.
5B	L-glutamic acid	1000 ppm	10% DMSO	Same as above
6	FXT-X	25%	0.5% Multi-film Buffer X	FXT-X: Conservation Products Corp., San Antonio, Texas.

[x] All solutions were made up with tap water to the final concentrations indicated.

ture resumé of January 16 through February 8 follows:

	Daytime Temp Range (F)	*Nightime Temp Range (F)*
January 16-26	60 - 80	50 - 60
January 27-29	55 - 75	38 - 55
January 30 - February 5	60 - 80	50 - 60
February 6-8	45 - 65	24 - 45

Freeze damage was assessed by determining the percentage of dead and injured shoots on each of four randomly selected branches on each tree. Injured shoots were those whose tips or leaf margins were killed by freezing. The average length of new shoots was also determined by measuring 10-20 live shoots on each of these branches. The above data were collected on February 16 and 17. In July, 1968, the height of each tree and its trunk diameter one inch above the bud union were measured to determine if any of the treatments had influenced subsequent growth of the trees.

For statistical analysis the percent values for the dead and damaged shoots were transformed to angles by the equation, angle = Arc sin $\sqrt{\text{percent value}}$ (19). All the data were subjected to analysis of variance to evaluate treatment differences (3). Where appropriate, Duncan's Multiple Range Test was employed to separate differences between treatment means (12).

RESULTS

The amount of freeze injury sustained by the treated trees and the subsequent shoot growth are shown in Table 2. With such a wide range in the number of shoots killed or damaged on individual trees significant differences would not be anticipated. Consequently the statistically significant difference in the percentage of shoots damaged between the 40% Foli-gard treated trees and the 100 ppm TD 692 and FXT-X treatments is difficult to interpret, especially since there were no significant differences in the number of shoots killed or in shoot length. Considering, however, the total dead and damaged shoots the ten treatments except for glutamic acid with DMSO and TD 692 (100 ppm) seem to segregate into two groups, those showing considerably less and those showing somewhat more injury than the controls. The sharp increase in damage between DSA and the controls emphasizes this break. It appears some treatments may have increased while others decreased the trees susceptibility to this particular freeze, but only further testing can determine the accuracy of this observation.

The average shoot length showed no evidence of being affected by the treatments. An examination of the trees 10 days after being sprayed showed no obvious growth effects from the treatments.

The assessment of growth in the year succeeding treatment was made because there appeared to be marked differences between the groups of trees in the hedgerow. This observation was not supported by differences in tree height and trunk diameter (Table 2).

To test the possibility that freeze injury might be related to the tree's vigor or overall growth capacity the multiple correlation between percent dead and damaged shoots, shoot length and trunk diameter was examined. If the tree's vigor influenced freeze injury or conversely if freeze damage affected subsequent growth it should be reflected in significant correlations between these factors. This multiple correlation was calculated and the results indicated no significant relationships between any of the factors mentioned.

DISCUSSION

Although many factors have been implicated in a plant's ability to resist freezing recent reviews suggest that no single factor is responsible but several act in concert and all are affected by macro and micro climatic effects (14). Also the behavior of cell water at freezing temperatures is not well understood (4, 16, 25). Though Levitt indicated that artifically increasing the sugar concentration in plant tissues seldom increased freeze resistance, the induction of this process in the plant still remains plausible (13, 21). Field testing of any methods that could affect these processes remains a valid adjunct to basic studies in plant hardiness.

While this experiment was intended to test the short term value of these materials for freeze protection, the change in weather dictated it be a study of residual effectiveness. None of the sprays displayed any unusual long-lasting freeze protecting qualities since there was no consistant treatment response between the percent dead and damaged shoots.

The treated trees did tend to fall into two distinct groups relative to the controls, those showing less freeze injury, shorter new shoot growth, and greater tree growth and those having more freeze injury, longer new shoots, and less tree growth. Further testing would be necessary to determine whether these materials might offer short term freeze protection or consistently influence citrus trees' response to low temperatures. On the basis of these results Foli-gard, L-cysteine, DSA, and perhaps L-glutamic acid would seem the most promising materials to use again.

LITERATURE CITED

1. The Academy. 1967. Biological actions of dimethylsulfoxide. Ann. New York Acad. of Sci. 141(Art.1):1-671.

2. Anonymous. 1970. Frostproofing for trees? Citrograph 55(5):179-182.

3. California Agricultural Extension Service. 1966. Experimental Methods for Extension Workers. Univ. California Agr. Ext. Ser., 33 p.

Table 2. The effects of experimental freeze protectant sprays on freeze injury, new shoot length and growth of Redblush grapefruit trees.

Treatment No.	Treatment Description	% Shoots Damaged[w]	% Shoots Dead	Total Dead + Damaged Shoots	Avg. Shoot Length (Cm.)	Avg. Trunk Diameter[x] (Cm.)	Avg. Tree Height[x] (Ft.)
2B	40% Foli-gard	0.0 a	5.3	5.3	2.9	7.1	7.7
5A	L-glutamic acid (200 ppm + Multi-film)	0.2 ab	7.1	7.6	2.3	6.1	6.6
3A	L-cysteine (2000 ppm + DMSO)	4.8 ab	0.7	6.4	1.0	7.1	7.6
5B	L-glutamic acid (1000 ppm + DMSO)	5.4 ab	11.6	19.9	3.4	6.8	7.6
3B	L-cysteine (2000 ppm + Multi-film)	5.8 ab	0.5	7.1	2.6	7.0	7.7
2A	20% Foli-gard	6.0 ab	1.6	8.3	1.0	7.4	8.3
4	Decenylsuccinic acid	6.6 ab	1.1	9.0	3.0	6.8	7.1
7	Control	6.6 ab	7.0	16.2	2.7	6.4	7.2
1B	TD 692 (1000 ppm)	10.0 ab	12.7	26.6	2.6	6.5	6.9
1A	TD 692 (100 ppm)	11.8 b	2.1	14.7	2.6	7.1	7.3
6	FXT-X	14.0 c	7.1	24.2	3.2	6.6	7.0
		**[y]	N.S.[z]	N.S.[z]	N.S.[z]	N.S.[z]	N.S.[z]

[w] Values followed by a common letter are not statistically different at the 1% level using Duncan's Multiple Range Test.
[x] Tree height and diameters were measured in July, 1968, ca. 18 months after treatment.
[y] ** = significantly different at 1% level.
[z] N.S. = no significant difference.

4. Cary, J. W., M. E. Jensen, and H. D. Fisher. 1968. Physical state of water in xylem vessels. Agron. J. 60(2):167-169.

5. Cooper, W. C. 1959. Cold hardiness in citrus as related to dormancy. Proc. Florida State Hort. Soc. 72:61-66.

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

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

8. Irving, R. Mac. 1967. The long day leaf as a source of cold hardiness inhibitors. Plant Physiol. 42(10):1384-1388.

9. Jones, W. W. and M. L. Steinacker. 1951. Seasonal changes in concentrations of sugar and starch in leaves and twigs of citrus trees. Proc. Amer. Soc. Hort. Sci. 58:1-4.

10. Ketchie, D. O. 1969. Methods of determining cold hardiness and cold injury in citrus. Proc. 1st International Citrus Symp. 2:559-563.

11. Kuiper, P. J. C. 1954. Inducing resistance to freezing and desiccation in plants by decenylsuccinic acid. Science 146:544-546.

12. Leclerg, E., W. Leonard, and A. Clark. 1962. Field Plot Technique. 2nd ed., Burgess Publishing Co., Minneapolis, Minnesota. 373 p.

13. Levitt, J. 1956. The Hardiness of Plants. Academic Press, Inc., New York. 278 p.

14. Mazur, P. 1969. Freezing injury in plants. Ann. Rev. Plant Physiol. 20:419-448.

15. Oknina, E. Z. and T. N. Pustovoitova. 1967. The relation of the concentration of free amino acids and the amino acids of hydrolysates of the buds of fruit trees as a function of the depth of dormancy. (Ways and methods for increasing the hardiness of acclimatized plants). Nauk. dumka: Kiev. 39-50.

16. Olien, C. R. 1967. Freezing stresses and survival. Ann. Rev. Plant Physiol. 18:387-408.

17. Sharples, G. C. and L. Burkhart. 1954. Seasonal changes in carbohydrates in the Marsh grapefruit tree in Arizona. Proc. Amer. Soc. Hort. Sci. 63:74-80.

18. Smith, E., L. C. Chadwick, 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.

19. Snedecor, G. W. 1946. Statistical Methods. 4th ed. Iowa State College Press, Ames, Iowa. 485 p.

20. Stewart, Ivan and C. D. Leonard. 1960. Increased winter hardiness in citrus from maleic hydrazide sprays. Proc. Amer. Soc. Hort. Sci. 75:253-256.

21. Wardlaw, Ian F. 1968. The control and pattern of movement of carbohydrates in plants. Bot. Rev. 34:79-105.

22. Yelenosky, G. 1967. Effects of decenylsuccinic acid and subfreezing conditions on germination of citrus seed. Proc. Amer. Soc. Hort. Sci. 91:169-172.

23. Young, Roger. 1969. Effect of freezing on the photosynthetic system in citrus. Proc. 1st International Citrus Symp. 2:553-558.

24. Young, R. and A. Peynado. 1965. Changes in cold hardiness and certain physiological factors of Red Blush grapefruit seedlings as affected by exposure to artificial hardening temperatures. Proc. Amer. Soc. Hort. Sci. 86:244-252.

25. Young, R. and A. Peynado. 1967. Freezing and water-soaking in citrus leaves. Proc. Amer. Soc. Hort. Sci. 91:157-162.

VEGETABLE SECTION

Association of Tobacco Ringspot Virus with Blossom End Rot of Watermelon[1]

Claude E. Thomas[2]

Abstract: A small field of "Charleston Grey" watermelon (*Citrullus lanatus* [Thunb.] Mansf.), in which there were both blossom end rot and TRSV was studied. Of 694 melons harvested, 21% were pimpled, 18% had blossom end rot, 9% had visible symptoms of both pimples and blossom end rot, and 52% showed no symptoms of either disease. Watermelon fruits infected with TRSV may be more susceptible to blossom end rot than are fruits that are free of the virus.

INTRODUCTION

In the Lower Rio Grande Valley, where blossom end rot of watermelon (*Citrullus lanatus* [Thunb.] Mansf.) is prevalent, there is also a high incidence of tobacco ringspot virus (TRSV) infection. This investigation was conducted to determine what association might exist between blossom end rot and TRSV infection.

MATERIALS AND METHODS

A small field of "Charleston Grey" watermelon, in which there were both blossom end rot and TRSV was chosen for study. Counts were made of the total number of fruits harvested, the number with blossom end rot, and the number with visible symptoms of TRSV, or pimples (1). Pieces cut from melons served as the inoculum source for local lesion assay hosts of TRSV in the greenhouse.

RESULTS AND DISCUSSION

Of 694 melons harvested, 21% were pimpled, 18% had blossom end rot, 9% had visible symptoms of both pimples and blossom end rot, and 52% showed no symptoms of either disease. Inoculations from these four categories of fruits from this field had the following results:

Category of melon	*Percent recovery of TRSV*
Healthy	13
"Pimpled"	46
"Blossom end rot"	45
"Pimples" and "blossom end rot"	25

Obviously, visual appraisals do not detect all virus-infected fruits,

[1] Cooperative investigations of the Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, and the Texas Agricultural Experiment Station, Weslaco, Texas.

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since 13% of those categorized as "healthy" showed positive viral infection. Also, the virus was recovered from only 46% of the fruits with visible symptoms of infection. The most important result, however, was the recovery of TRSV from 45% of the melons with symptoms of blossom end rot only. The importance of this can be seen if one considers that this category would be considered "healthy" if visual appraisal only were used to detect the presence of TRSV. The fourth category, "pimples and blossom end rot," yielded a 25% recovery of the virus. The explantation of this rather low percentage of recovery may lie in the fact that fruits with these symptoms were often more completely decayed at harvest than were other fruits, thus yielding poor tissue for virus recovery.

Watermelon fruits infected with TRSV may be more susceptible to blossom end rot than are fruits that are free of the virus. This may be due in part to an upset of normal morphological development in TRSV-infected fruits (Figure 1).

LITERATURE CITED

1. Rosberg, David W. 1953. Association of a strain of the tobacco ringspot virus with pimples disease of watermelon in Texas. Plant Dis. Reptr. 37:392-396.

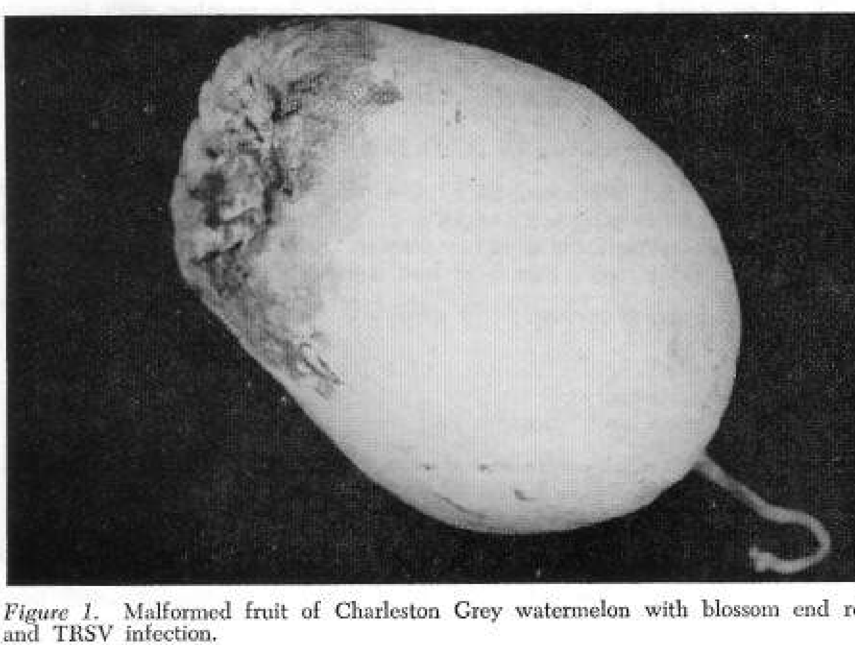

Figure 1. Malformed fruit of Charleston Grey watermelon with blossom end rot and TRSV infection.

Conditioning Onion Bulbs in a Mechanized Production System

WAYNE LEPORI, CHARLES BROWN and PAUL LEEPER[1]

Abstract: Artificial conditioning tests on freshly harvested onions has shown that bulbs can be adequately prepared for grading in 48 hours or less using heated forced air. Air temperatures near 95° appear to be most desirable and air flow rates above 7 cfm per cubic foot onions does not appear to reduce conditioning time. Other information is included in this paper which may be useful in design of artificial conditioning systems.

INTRODUCTION

South Texas has gained a reputation for producing mild, sweet onions. These high-quality onions are in great demand in the early spring since Texas is the only state where onions are being harvested for 2 to 3 months each year. These factors have contributed in making onions the leading vegetable crop produced in the state.

The major criticism of Texas' short-day onions is their keeping quality. Sometimes the onions deteriorate in shipment, and this is primarily attributed to improper curing caused by adverse weather conditions. Harvesting practices vary, but most onions are field cured in sacks. High humidity and warm temperature exist at harvest time, and these conditions are conducive to infection of bulbs with decay organisms. Rainfall at harvest time also increases the risk of losses due to these decay organism.

To maintain stable prices and good markets, the keeping quality of Texas onions must be improved. Artificial conditioning of bulbs at harvest has potential of reducing problems of bulb decay during the marketing process. In addition, it provides a method to reduce risk of losses from rains and permits a more uniform flow of onions through the packing shed during adverse weather conditions. With mechanized harvesting, artificial conditioning is anticipated to be more important in preparing bulbs for grading and reducing risk of losses.

Although several commercial installations are in operation in South Texas, engineering design information is lacking. Optimum air flow rates, air temperatures, resistance to air flow through bulbs and conditioning time need to be estabilshed for designing an efficient conditioning system.

Experiments in artificial conditioning of onion bulbs have been

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initiated at Texas A&M University in conjunction with mechanical harvesting tests. The purpose of this paper is to present preliminary results from these tests.

PREVIOUS WORK

Most artificial conditioning studies have been devoted to controlling decay organisms in storage onions. These studies (1, 3, 4, 6) have shown that forced-air systems can be used to satisfactorily cure onions for storage where field curing was unsatisfactory. Results of several studies are summarized below.

In California, Hoyle (4, 5, 7) found that artificial curing was highly satisfactory even where green tops were added. He used a sack dryer with air at a rate of 1 cfm per pound onions and temperature maintained between 105° and 118°F. Early Grano Variety onions were included in the tests and he concluded that bulbs could withstand 115°F for as long as 16 hours without damage.

Rosberg and Johnson (8) compared infra-red to several other methods including heated forced air for curing South Texas onions. A three-minute exposure time was found to be adequate to control neck rot with gas-fired infra-red maintained at 250°F. Neck rot was also adequately controlled using air maintained at 116°F to 118°F at a rate of 16 cfm per pound onions for 24 hours.

In Oregon, Vaughan, Cropsey and Hoffman (9) have studied effects of artificial drying in the control of neck rot in stored onions. Their studies included experiments with onions topped immediately after lifting. Sixteen to 24 hours curing time gave excellent control of neck rot where air temperature was maintained at 115°F, but up to 72 hours was required where air temperature was 95°F. Shrinkage losses due to artificial drying were negligible in all cases.

Franklin, Works and Williams (3) conducted experiments in artificial curing of Yellow Sweet Spanish Onions for storage in Idaho. They used natural air at the rate of 1.5 cfm per cubic foot of onions to cool bulbs to 33°F to 35°F as well as cure bulbs for storage. After onions were cured, air flow rates could be reduced by approximately one-half for aerating onions in storage.

Ang, Isenberg and Hartman (1) have studied effects of air temperature, humidity and firmness of bulbs in curing storage onions in New York. They concluded that the best treatment for curing onions was a temperature of 50°F and 50 to 65 percent relative humidity. With these conditions and an air flow rate of 0.05 cfm per pound of onions, approximately 15 days were required to cure bulbs.

OBJECTIVES OF ARTIFICIAL CONDITIONING

Artificial conditioning is used in this paper to denote the preparation of bulbs for grading after harvesting. Curing or drying are terms commonly used to describe the time period between harvesting and grading. Curing has been defined as a moisture removal process, but no index has been established to indicate degree of curing. Personal judgement through visual inspection is the most common method used by researchers and industry personnel, to evaluate degree of curing.

Appearance of bulbs is an important factor affecting sales, so the primary objective of any process after harvesting should be to obtain an appealing appearance and maintain keeping quality of bulbs. Artificial conditioning includes this among the objectives which are summarized as follows:

1. Dry outer skin and toughen bulb to prevent damage in grading and marketing.
2. Dry neck to destroy and prevent entrance of decay organisms.
3. Dry soil adhering to bulb so that brushes in grading lines can clean bulbs.
4. Improve keeping quality and maintain clean appealing appearance of bulbs.

EXPERIMENTAL PROCEDURES

Onions used in conditioning tests were mechanically harvested with the TAMU Experimental Onion Harvester. Roots were not clipped except for these cut by the digging blade of the harvester. Bulbs were transferred to conditioning bins by hand and doubles, seedstalks and other culls were removed at that time.

The conditioning unit is shown in Figures 1 and 2. Rate of air flow through onions was measured with an orifice attached to the intake duct of the fan. An LP gas heater with modulating control valve heated air to desired temperature in the intake duct. Since air was heated in the intake duct, the fan mixed air thoroughly to provide uniform air temperature before it was forced through the onions.

Three bins having a volume of approximately 33 cubic feet each, provided a 12 foot column of onions. Air was blown horizontally through onions and a layer of foam rubber inserted above the onions to prevent air channeling along the top surface. Each bin was weighed at the beginning and end of tests, and capacity of the three bins when filled was approximately 1.75 tons.

Wet-bulb and dry-bulb temperatures were measured for outside air and air leaving onions. Dry-bulb air temperatures were measured with thermocouples at depths of 0, 4, 8 and 12 feet. Temperatures approximately ¼ inch deep in onion bulbs were also measured at 0, 4, 8 and 12 feet.

After completing a conditioning test, bulbs were graded at a commercial packing house and a portion of the bulbs used in a small marketing test.

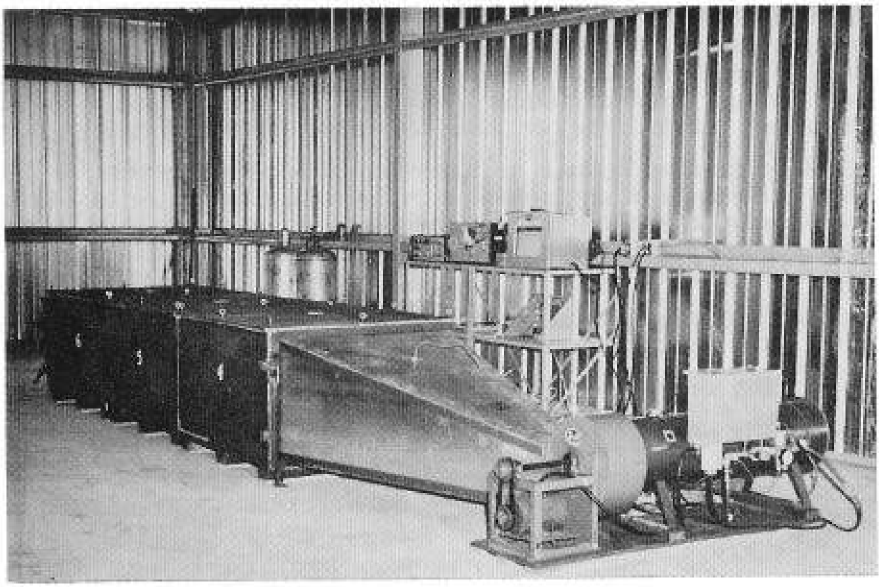

Figure 1. Experimental artificial conditioning unit showing heater duct, fan, transition duct, bins and instrumentation.

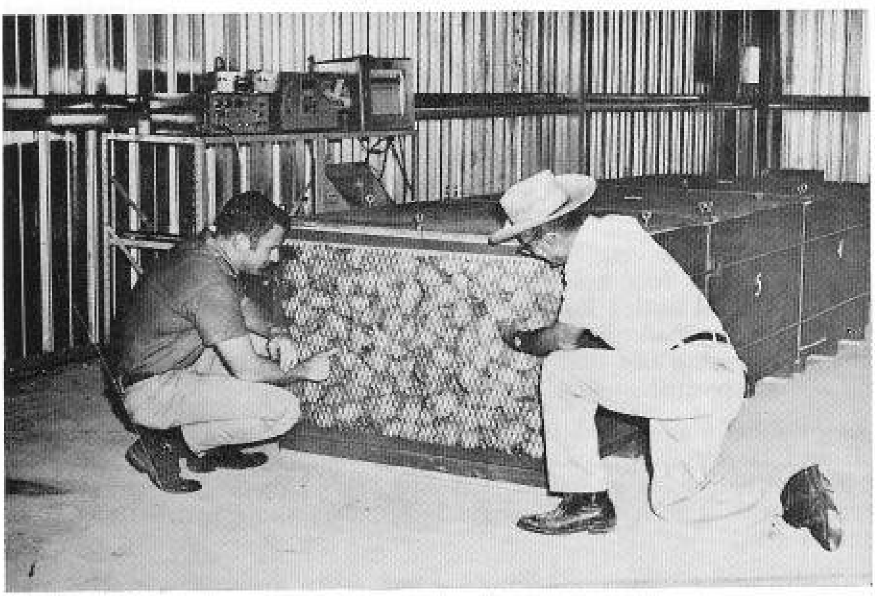

Figure 2. Experimental artificial conditioning unit showing onions where air is leaving bins.

OBSERVATIONS

Resistance of onions to air flow is shown in Figure 3. Resistance will vary slightly with size and amount of trash in onions, but this curve should permit an estimate for unsized field run medium and large onions. Larger installations may have less channeling of air along sides and this could cause higher values than those shown. However, system static pressure is essential in selecting a fan for a specific design and this curve is included for determining an estimate of resistance to air flow through the onions.

Air flow rates are also important in system design and fan selection, but optimum air flow rate for rapid curing has not been determined from the limited tests conducted to date. Air channeling within the onion mass is evident and flow rates must be adequate to provide conditioning of the entire mass. However, flow rates higher than 7.0 cfm per cubic foot of onions have not appeared to descrease conditioning time within the test unit. Bulb maturity at harvest is the most important factor affecting conditioning time, and the more immature bulbs require longer times.

The changes which occur within the onion mass during conditioning is illustrated in Figures 4 through 7. These data were obtained from transplanted Yellow Granex onions harvested when less than 15 percent of the tops were lodged. Artificial conditioning began immediately after harvesting.

Air temperatures at various depths within the onions are shown

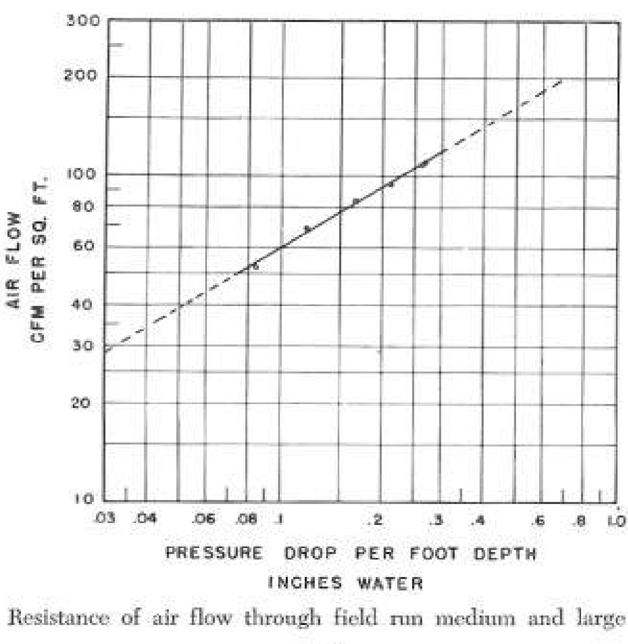

Figure 3. Resistance of air flow through field run medium and large onions.

in Figure 4. The evaporative cooling effect on air temperature is very evident in the first few hours of conditioning. Temperatures approximately ¼ inch below surface of onion bulbs are shown in Figure 5. By comparing Figure 4 to Figure 5, it is seen that bulb temperatures rapidly approach air temperature.

Early tests revealed "over-conditioning" when air temperatures were maintained at 105°F. Apparently several layers were partially dried and created loose fitting exterior scales. As the exterior scales continued to dry after grading, they exhibited a wrinkled or "dimpled" appearance. Reducing air temperatures resulted in a firmer bulb. In the test shown in Figures 4 and 5, air temperature was reduced to 95°F when bulb temperature reached 100°F. Natural air could probably be used much of the time for conditioning except when humidities are extremely high.

Percent saturation of air entering and leaving onions is shown in Figure 6. The moisture in the air leaving onions has a decreasing trend over the entire conditioning period and even drops below that of air entering onions for a short time period. During this period, the onions are taking moisture from the air rather than giving off moisture. This is more evident when the approximate curve of the percent moisture removed from onions, Figure 7, is examined. During the period from approximately 44 hours to 52 hours, moisture was being added to onions and conditioning beyond 44 hours in this case was apparently of little value.

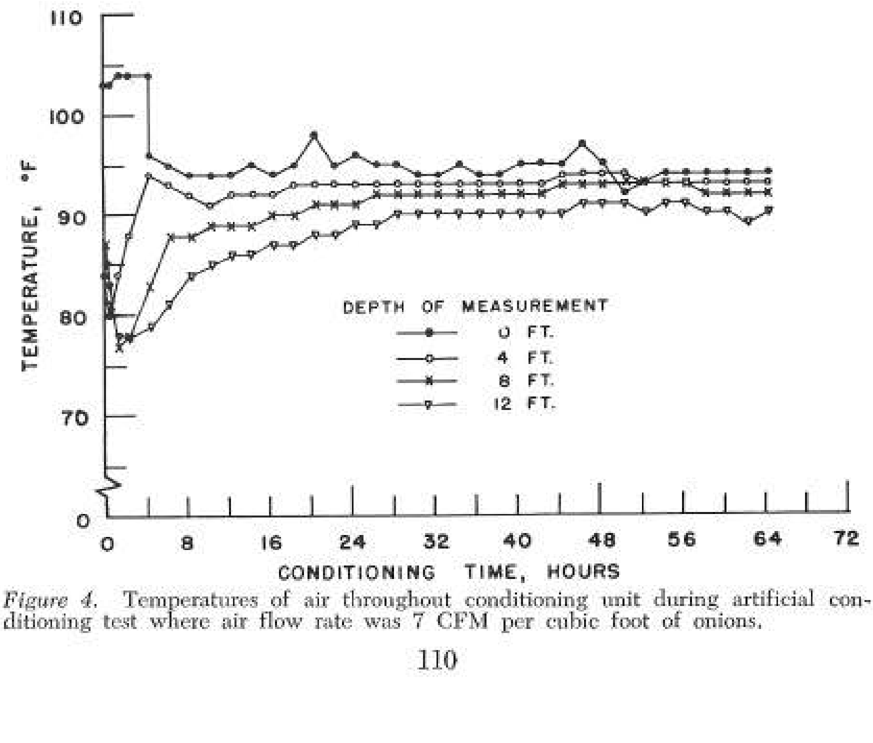

Figure 4. Temperatures of air throughout conditioning unit during artificial conditioning test where air flow rate was 7 CFM per cubic foot of onions.

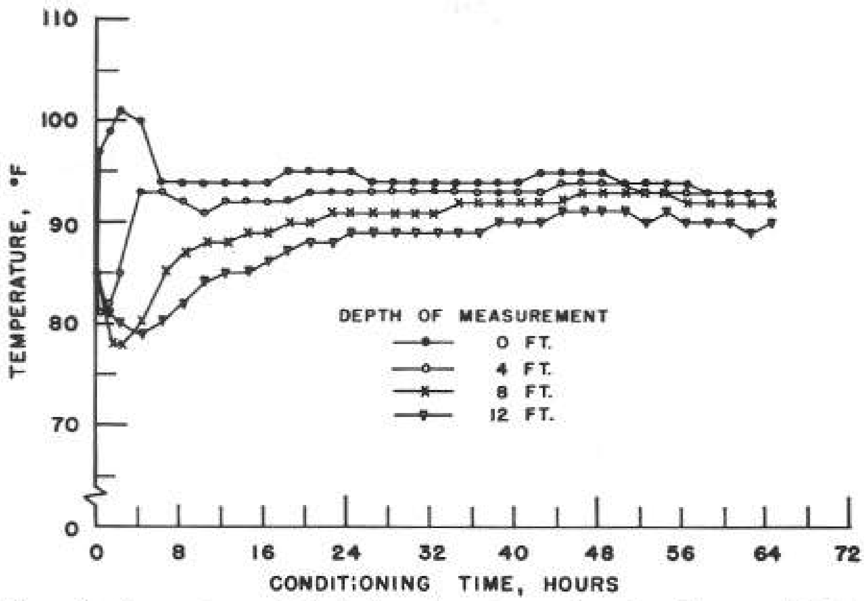

Figure 5. Temperatures ¼ inch beneath onion surface throughout conditioning unit during artificial conditioning test where air flow rate was 7 CFM per cubic foot on onions.

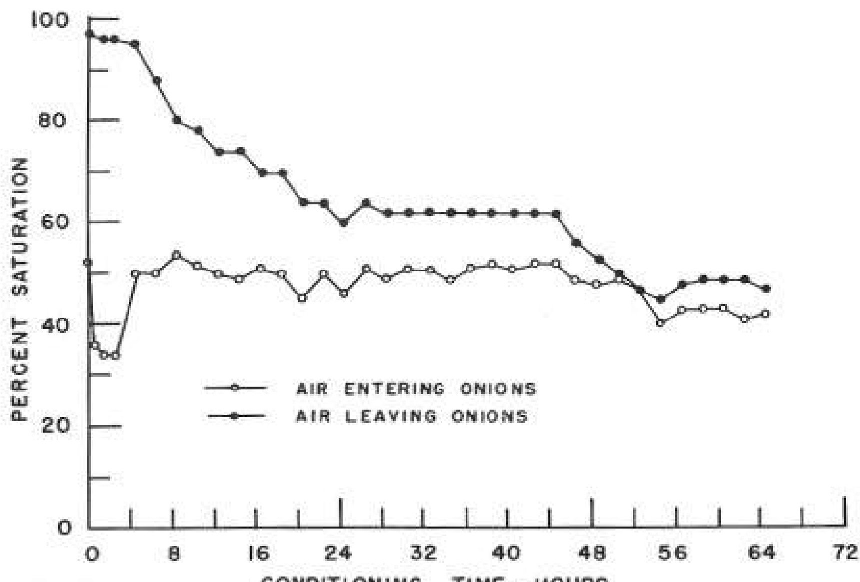

Figure 6. Percent saturation of air entering and leaving 12 foot column of onions when air flow was 7 CFM per cubic foot of onions.

SUMMARY

From observations of conditioning tests, it appears that heated forced air can be used to adequately condition bulbs for grading. Bulb maturity was observed to be the most important factor affecting conditioning time. However, with air flow rates of approximately 7.0 cfm per cubic foot of onions and air temperature maintained at 95°F, freshly harvested onions can be conditioned in 48 hours or less.

Tests need to be established to indicate bulb maturity at harvest and degree of curing of bulbs prior to grading and shipping. Moisture content in the neck of bulbs appears to have potential for such a test. A standard establishing maximum moisture content permitted in necks of onions before shipment might offer the industry a more adequate means of controlling quality.

Examples of conditions occurring within the onion mass during an artificial conditioning test are given to provide a more thorough understanding of the process. Some of this information should be useful in design of artificial conditioning systems.

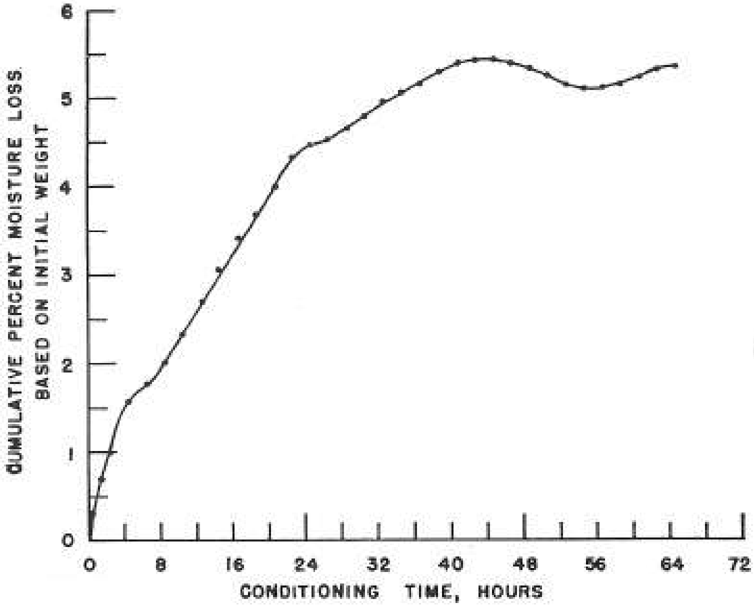

Figure 7. Approximate weight loss of onions during conditioning. Values were determined from air conditions entering and leaving onions.

REFERENCES

1. Ang, J. K., F. M. Isenberg and J. D. Hartman. Temperature, Humidity and Firmness in Curing and Storage of Onions, Stran Steel Farm Structures Research Conference. 1958.

2. Chawan, Tukaram and I. J. Pflug. Controlled Atmosphere Storage of Onions, Michigan Quarterly Bulletin, Vol. 50, No. 4.

3. Franklin, DeLance F., D. W. Works and L. G. Williams. Experiments in Harvesting, Curing and Storing Yellow Sweet Spanish Onions, Idaho Agricultural Experiment Station, Bulletin No. 479.

4. Hoyle, Burton J. Onion Curing – A Comparison of Storage Losses From Artificial, Field and Non-Cured Onions, American Society for Horticultural Science, 52:407-414.

5. Hoyle, Burton J. Storage Breakdown of Onions as Affected by Stage of Maturity and Length of Topping, American Society for Horticultural Science, 50:353-361.

6. Kampe, D., B. F. Cargill and C. M. Hansen. Harvesting and Storage of Onions in Michigan, Agricultural Engineering Department, Cooperative Extension Service, Michigan State University, File No. 18.144, Information Series #218.

7. Lorenz, O. A. and B. J. Hoyle. Effect of Curing and Time of Topping on Weight Loss and Chemical Composition of Onion Bulbs, American Society for Horticultural Science, 47:301-308.

8. Rosberg, David W. and H. B. Johnson. Artificial Curing of Texas Onions, Texas Agricultural Experiment Station, College Station, Texas, MP-395, December 1959.

9. Vaughan, Edward K., Myron G. Cropsey and E. N. Hoffman. Effects of Field-Curing Practices, Artificial Drying, and Other Factors in the Control of Neck Rot in Stored Onions, Agricultural Experiment Station, Oregon State University, Technical Bulletin 77, September 1964.

New Techniques in Harvesting South Texas Onions[1]

WAYNE LEPORI, PAUL LEEPER and PRICE HOBGOOD[2]

Abstract: Design principles and field test results for an experimental onion harvester are presented. The machine digs, lifts, tops and conveys bulbs to bulk bins which are used to haul them from the field. Field tests revealed bulbs can be accurately topped so that there are less than 2.5 percent bulbs with neck length of more than two inches. The machine provides a potential for mechanically harvesting Texas onions when hand labor is no longer available or economical.

INTRODUCTION

With approximately 28,000 acres and 20 million dollars in value, Texas leads all other states in value and acreage of onions produced (5). Approximately 80 percent of the state's onions are produced in South Texas which has a reputation for producing high quality, sweet onions.

All of the onions produced in Texas are presently hand harvested. Sixteen man-minutes of labor are required for harvesting a 50-pound sack. Ninety-five percent of this time is consumed in pulling the onions, clipping tops and roots and sacking (4). Increasing cost of hand labor and decreasing availability of seasonal labor makes mechanizing the harvest phase of production economically attractive.

Work has been initiated at Texas A&M University to develop a mechanized onion production system with emphasis on mechanizing the harvest. The purpose of this paper is to describe principles of a harvesting machine which has been developed and tested at Texas A&M which appears to have potential for mechanizing the onion harvest.

HARVESTER REQUIREMENTS

A harvesting machine must satisfy many requirements before it can be incorporated into a production system. There are several unique factors that must be considered in relation to mechanizing onion harvesting in Texas.

Harvesting practices vary but are influenced primarily by market prices. Lodged tops are an indication of natural bulb maturity, and when a field has approximately "50 percent tops down" it is considered mature enough for harvest. It is not uncommon for early fields to be uprooted or undercut before natural maturity occurs to force maturity and take

1 Authorized for publication by Texas Agricultural Experiment Station as Technical Article

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advantage of high, early-market prices. At this stage of maturity, many bulbs have large green tops and a harvesting machine must be capable of operating where these green tops exist. All onions shipped from Texas have uniform neck lengths and roots completely removed which provides a uniform product with an appealing appearance. Only the shelf life of the high quality Texas onions is criticized. An ideal, mechanized harvesting system would leave bulbs with the same appealing appearance as presently provided in hand harvesting and improve the shelf life.

Recent trends in the industry toward replacing the field sack with bulk handling methods and installation of artificial drying systems should fit nicely into a mechanized system. A mechanical harvester should compliment these trends and insure a higher quality product. Risks of losses from high humidities and rains at harvest time should also be reduced through adapting these methods.

DESIGN PRINCIPLES

Commercial machines are available and are being used in other areas (2), but have not proved successful in harvesting the tender Texas onions. Based on previous experimental work in California (1, 3), the belt lifting principle was selected for initial experimental testing in Texas. It appeared to have potential for complementing the trends in the Texas onion industry, and was expected to provide advantages in gentle handling of bulbs, ease of separating bulbs from clods and ease of positioning bulbs for topping.

The drawing in Figure 1 shows the principles conceived for digging, lifting and topping onions. As the machine travels down the row, tops are lifted and directed bewteen two V-belts. A digging blade cuts

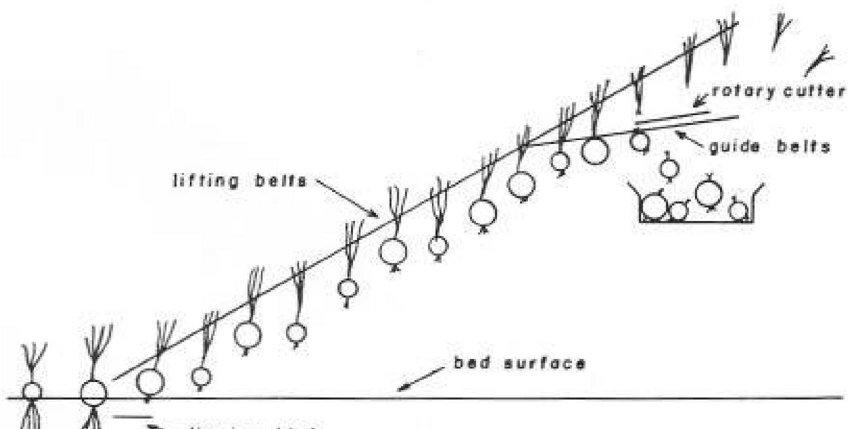

Figure 1. Schematic drawing showing principles of TAMU Experimental Onion Harvester.

the onion roots and loosens the soil as the lifting belts grasp the onion tops. With onion tops held between the lifting belts, bulbs are elevated at an angle of 30° to the ground surface until they contact two guide belts. These belts position bulbs for accurate topping by a rotary cutter placed above the belts.

A machine which harvested one row was built in 1968 to test the harvesting principles described above. Based on these initial tests, the machine was modified to harvest two rows or one bed in 1969. A conveyor was also added to the machine to make it more closely resemble a commercial prototype, but primary consideration in design of the machine was to test functions of the principles in harvesting. Much flexibility was incorporated to test the principles over a wide range of conditions. Fluid power was selected as a means of power transmission and an air-cooled engine driving a hydraulic pump provided independent power to operate all hydraulic components.

Design details are discussed below in relation to functions they perform. Although a commercial version of the machine may not appear the same as the one shown in Figures 2 and 3, the basic principles may be used.

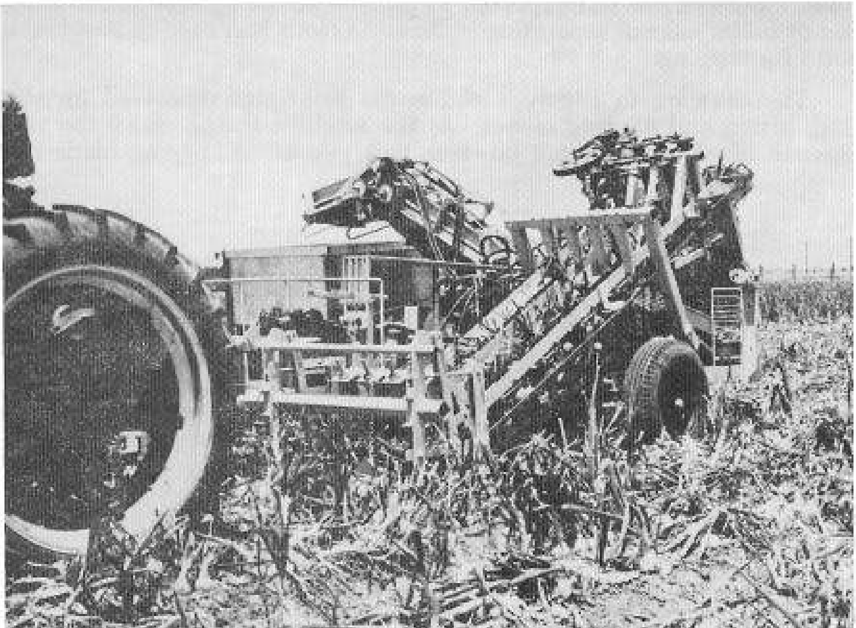

Figure 2. Front view of TAMU Experimental Onion Harvester, 1969.

Lifting Lodged Tops. Floating lifting shields in combination with flexible rotating paddles are used for lifting lodged tops. The shields lift and align tops over the bulbs, while paddles direct the tops into the lifting belts. The paddles are constructed from fabric belting material and have a tip speed of approximately 275 feet per minute for a harvesting speed of 1 mile per hour. They are positioned on each side of a row and rotate in a plane parallel to the lifting belts.

Digging Bulbs. Onions grow upward and outward from their planting dept, therefore, the location of the onion base and root system is not a function of bulb size or maturity. This characteristic permits roots to be cut near the base of bulbs at the same time they are dug with a thin sharp cutting blade mounted perpendicular to the direction of travel. Position of the digging blade is controlled by a manually operated hydraulic control valve and is independent of lifting belt position. Certain weeds wrap around the blade and cause clogging, but where fields are relatively clean, it functions satisfactorily.

Lifting Bulbs. Two C-section V-belts supported by spring-loaded idlers are used to elevate bulbs to the topping unit. A rough neoprene rubber surface was vulcanized to the back of the V-belts to provide a positive gripping surface to hold the tops while elevating bulbs. Posi-

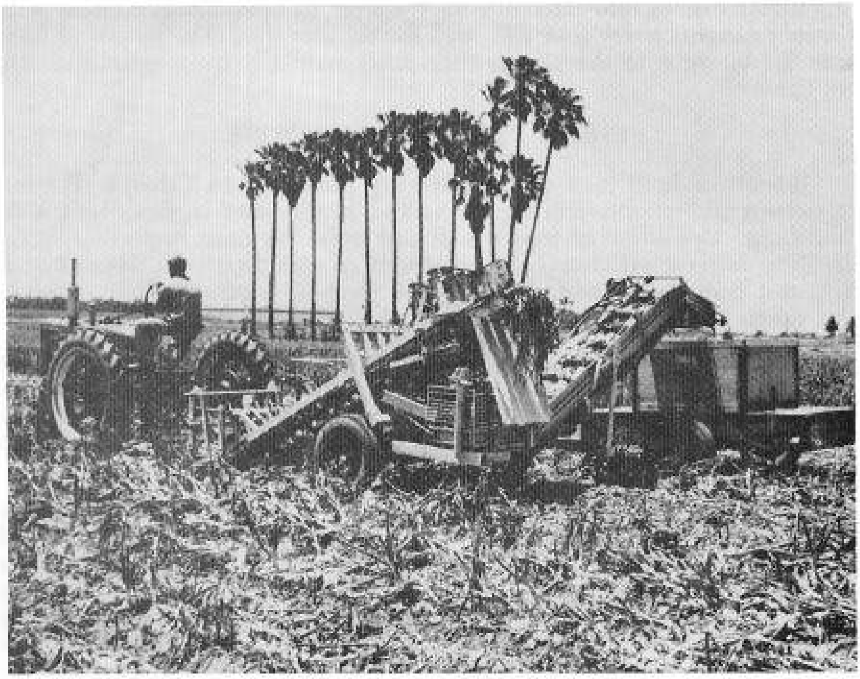

Figure 3. Overall view of TAMU Experimental Onion Harvester, 1969.

tion of belts above bulbs is controlled by a manually operated control valve. Ratio of belt speed to ground speed was found to be important and ratios between 1.2 and 1.5 were found to provide satisfactory operation in average field conditions.

Topping Bulbs. For accurate topping, bulbs must be repositioned in relation to the cutter, because all tops are not grasped the same distance above bulbs by the lifting belts. Guide belts consisting of AA section V-belts placed at an angle to lifting belts form a wedge for positioning bulbs for topping. The wedge causes tops to be pulled down between lifting belts as bulbs contact the guide belts and move toward the cutter.

An opening between the guide belts of 7/8 inch permits bulbs with stem diameters of one inch and larger to be accurately topped leaving approximately 1 inch of neck length. The speed of guide belts is synchronized with the speed of the lifting belts to provide a surface which is stationary in relation to bulbs for the positioning operation. The guide belts prevent damage to the bulb during positioning and topping. A rotary cutter consisting of serrated knife sections riveted to a hub is placed above the guide belts for topping. A peripheral speed of 3600 feet per minute was used for the cutter in field tests, but cutter speed is not critical.

Loading Bulbs. After bulbs are topped, they drop onto a conveyor which loads them into bulk bins or trailers. Rubber-covered chain with 3" rubber flights every foot was used for the elevator. The height of drop from the elevator to the bins is controlled manually by a hydraulic control valve.

FIELD TEST OBSERVATIONS

Results of field tests during 1969 are presented in Table 1. Percent tops down and condition of tops were two factors used in describing field conditions. Condition of tops was found to be the most important factor affecting harvest efficiency, but methods of quantitatively describing it have not been developed. Where tops were in good condition, percent tops down has little effect on harvesting efficiency.

Condition of tops was described as good or deteriorated. Good was used to describe the condition where tops were green in color with some turgidity remaining in the leaves. Deteriorated was used to describe the condition where there was no turgidity in the leaves, color was brown and tops were weak or brittle.

Where tops were in good condition, harvesting efficiency generally exceed 90 percent. The guide of 50 percent tops down presently used by growers appears to be an adequate guide for indicating maturity for mechanical harvesting with the belt-lifting principle. Additional study is needed to determine the optimum range of maturity for harvesting with the belt-lifting principle, but the range of 35 to 75 percent tops down appears to be the optimum range. Because of the large number of bulbs being harvested, only random checks were made to determine percent damaged bulbs and bulbs with long tops. Bulbs with tops longer than 2 inches were generally less than 2.5 percent and damaged bulbs less than 3 percent. Damaged bulbs were generally caused by the digging blade cutting bases of the bulbs, and could be reduced with some type of automatic gauging device to control depth.

Certain cultural practices were found to be more compatible with these harvesting principles than others. Straight drill rows with uniformly-spaced bulbs 2½ to 3 inches apart are ideal for the machine. Crowding of bulbs in the row or scatter row plantings decreased the harvester effectiveness. These conditions slightly decreased harvesting efficiency and the percent long tops increased somewhat.

Table 1. Summary of field tests with 1969 Texas A&M experimental onion harvester. Weslaco, Spring, 1969.

Variety	*Condition of Tops*	*Date*	*Test No.*	*Tops Down (%)*	*Speed (mph)*	*Ratio of Belt Speed to Ground Speed*	*Bulbs Harvested (%)*
Dessex	Good Condition	4/ 9/69	1	75	.9	—	90
			2	68	2.1	1.4	91
			3	77	1.7	1.7	98
			4	74	2.6	1.1	92
	Good Condition	4/10/69	1	66	—	—	98
			2	73	—	—	88
			3	72	—	—	92
Yellow	Good Condition	4/10/69	1	63	2.0	—	99
Granex		4/11/69	1	82	1.5	—	88
Hybrid	Some Tops Deteriorated	4/22/69	1	82	1.1	—	82
			2	69	1.6	1.1	87
			3	73	1.5	1.5	80
			4	90	1.1	1.6	78
	Good Condition	4/22/69	1	70	—	—	90
			2	67	1.1	2.4	90
	Good Condition	4/23/69	1	88	1.4	—	84
			2	78	1.5	1.2	93
			3	58	1.4	1.3	94
			4	54	1.4	1.4	97
			5	69	1.4	—	91
			6	58	1.4	1.5	95
	Good Condition	4/24/69	1	78	1.7	—	96
			2	66	1.5	1.6	93
			3	80	1.7	1.4	94
	Some Tops Deteriorated	5/ 7/69	1	80	—	—	87
			2	91	—	—	84
			3	87	—	—	96
			4	91	—	—	84
			5	88	—	—	84
Texas	Some Tops Deteriorated	4/22/69	1	85	1.11	1.5	72
Early	Jumbo size bulbs		2	93	1.70	1.5	76
Grano 502			3	93	1.60	—	63

Cutting roots and lifting lodged tops can be more efficiently done in clean, uniform beds. Since the lifting units were not independent, both rows need to be the same elevation. If one row is higher than the other, the lifting belts have to be positioned for the high row, and the digging unit must be positioned for the low one. This decreases effectiveness of the belts in grasping the tops on one row and increases lifting resistance due to long roots on the other. In loose sandy soils, weeds and grass tend to pull up and wrap around the cutting blade rather than being cut. This clogs the machine, therefore, a different design is needed for these conditions.

The depth and position of the digging blade in relation to the throat of the lifting belts also influence operation of the machine. The blade should be positioned as near the base plate of the bulb as possible to cut roots and loosen soil so that tops will not pull through the lifting belts. Roots should be cut simultaneously with the grasping of the top by the lifting belts.

Under certain conditions, particularly in heavy soils, soil adheres to the base of the bulb and roots. Positioning the cutting blade near the base of the bulbs reduces the amount of soil being picked up with the bulbs, but additional work is needed to provide a more positive means of separating soil from bulbs. Several mechanical devices have been tested for removing roots on the machine, but additional work is needed to obtain satisfactory results. Additional cleaning is also needed to separate dried leaves, small tips of green leaves, and any grass or weeds from the bulbs.

CONCLUSIONS

Principles have been developed and tested in an experimental onion harvester which digs, lifts, tops and conveys bulbs to bulb bins or trailers. These principles appear to compliment present practices and recent trends in the industry. Gentle handling of bulbs and uniformity in topping are outstanding features of this machine. Condition of onion tops was found to be the most important factor affecting harvesting efficiency of the experimental machine. Where tops were in good condition harvesting efficiency was better than 90 percent. Lodged tops did not affect efficiency of the machine.

These principles appear to provide potential for mechanically harvesting Texas onions when labor is no longer available or economical, yet maintain the high standards of quality expected in Texas onions.

LITERATURE CITED

1. Cropsey, M. G., Lunde, R. N., and Stafford, D. E. Machine Harvests Gladiolus Corms, Ag.Eng. 35 (8): 565-67, 573, 1954.

2. Kampe, D., Cargill, B. F., and Hansen, C. M. Harvesting and Storage of Onions in Michigan, Ag. Eng. Dept. Cooperative Extension Service, Michigan State University.

3. Lorenzen, C., Jr. The Development of a Mechanical Onion Harvester, Ag. Eng. 31 (1): 13-15, 1950.

4. Sorensen, H. B. Unpublished Data, Agricultural Economics Department, Texas A&M University.

5. Texas Commercial Vegetables, Annual Crop Summary – 1969, Texas Crop and Livestock Reporting Service, ARS-USDA.

Effects of the Incorporation Tool on Performance of Herbicides Applied to Soil[1]

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

Abstract: Six tools were tested in the field for incorporation efficiency of three herbicides in furrow-irrigated soil. Soil profile studies with a fluorescent tracer showed that the power-take-off (PTO)-driven rotary tiller uniformly incorporated the tracer 2 inches deep in dry soil. A double-tiered, rolling cultivator incorporated ½ to 2½ inches deep. A reel mower blade incorporated the tracer to a depth of 1 to 1½ inches. Both of the latter two gave poor distribution of the tracer across the beds. Mesh wheel, tine wheels, and rolling bar incorporation tools uniformly incorporated the tracer ¾ inch deep in soil.

Redroot pigweed (*Amaranthus retroflexus* L.), Palmer amaranth (*Amaranthus palmeri* S. Wats.), and barnyardgrass (*Echinochloa crusgalli* (L.) Beauv.) were efficiently controlled with *O,O*-diisopropyl phosphorodithioate S-ester with *N*-(2-mercaptoethyl)benzenesulfonamide (bensulide)[3], dimethyl 2,3,5,6-tetrachloroterephthalate (DCPA)[4], and *a,a,a*-trifluoro-2,6-dinitro-*N,N*-dipropyl-*p*-toluidine (trifluralin)[5] when incorporated into the soil with a PTO-rotary tiller or tine wheels. Moderate control was achieved with mesh wheel or rolling bar incorporators. Results with a reel mower blade or rolling cultivator were poor and ineffective, respectively. Only bensulide was uniformly effective irrespective of incorporation tool used. Control of redroot pigweed was more dependent than barnyardgrass on uniformity of herbicide incorporation.

INTRODUCTION

The power-take-off-driven (PTO) rotary tiller has generally outperformed other tools for incorporation of several herbicide families in soils in the Lower Rio Grande Valley of Texas and in other areas (1, 2, 3, 4, 5, 6, 7, 8, 9). Under certain soil and climatic conditions in humid areas, ground-driven tools have been comparable. The present experiment was designed to test the relative efficiency of several incorporation tools under dry field conditions.

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[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 A&M University Agricultural Research and Extension Center at Weslaco, Weslaco, Texas.

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

[3] Bensulide formulated as Prefar furnished gratis by Stauffer Chemical Co. Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture, and does not imply its approval to the exclusion of other products that may also be suitable.

[4] DPCA formulated as Dacthal furnished gratis by Diamond Alkali Co.

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

MATERIALS AND METHODS

Willacy fine sandy loam[6] was listed and then formed into beds (38 inch) and furrows with a PTO-tiller, bed former, and roller. The site was on the Texas A&M University Agricultural Research and Extension Center at Weslaco, Weslaco, Texas.

Performance of six incorporation tools was first tested with a fluorescent tracer (Sylvania 2282, Zn-o-silicate). The tools included: (1) a steel mesh wheel consisting of a 15-inch diameter by 21-inch wide wheel fabricated with a grid of angle-positioned steel bars[7] (Fig. 1); (2) a rolling cultivator[8] arranged to afford a double-pass by mounting one unit just ahead of another; (3) a PTO-rotary tiller[9] with L-shaped cut-

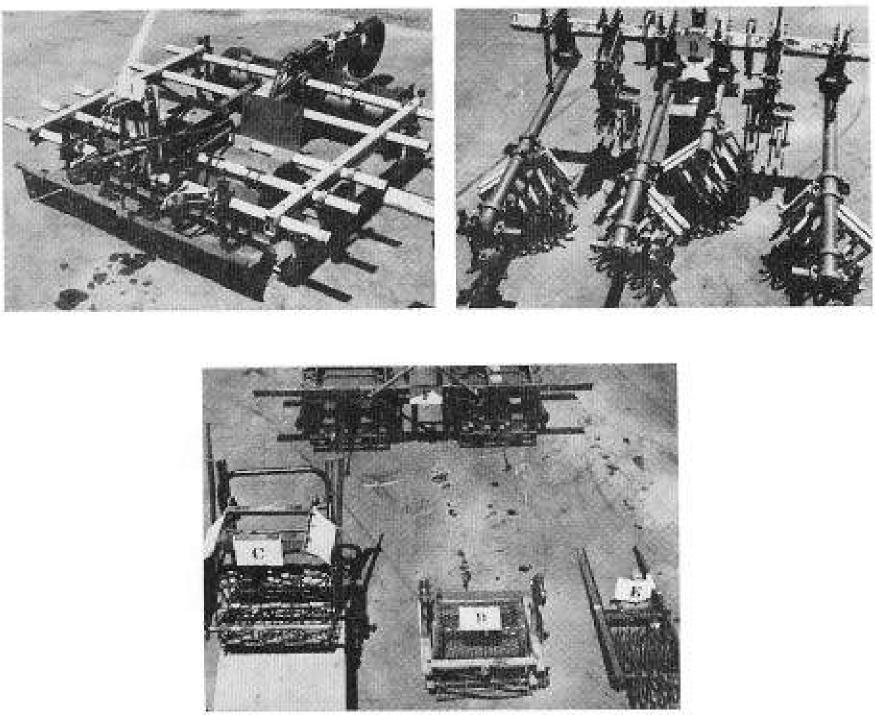

Figure 1. The incorporation tools studied were A. PTO-driven rotary tiller, and ground-driven B. rolling cultivator, C. mesh wheel, D. reel mower blade, E. tine wheels, and F. rolling bars.

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[6] Willacy fine sandy loam contained 66% sand, 17% clay, and 17% salt; 1.0% organic matter, 8.7 pH, and 16% water at field capacity.
[7] 'Ro-Wheel' manufactured by Gandy Co., Owatonna, Minn.
[8] Lilliston Implement Co., Waco, Texas.
[9] 'Bye Hoe' manufactured by Robinson Blower & Engineering Corp., San Martin, California.

ting teeth (2 mph, 320 rpm); (4) tine wheels[10], both 10- and 12-inch diameter; (5) rolling solid and toothed-bars[11], and (6) a reel mower blade[12], one unit with two differential speed, chain-driven blades and another unit with one blade followed with a chain-driven, fine-mesh steel, rolling cage.

The tracer was sprayed on beds at 110 gal/A. Each tool was used to incorporate the tracer in separate areas. After irrigation, soil profiles were inspected for incorporation efficiency with each tool. In a preliminary experiment, the 10-inch tine wheels incorporated more uniformly than did the 12-inch tine wheels; and the single reel mower blade with cage performed better than the 2-reel unit. Because of uniformity of performance, the 10-inch tine wheel and the single reel mower were selected for the main experiment.

All tools but the rotary tiller were ground-driven at 5 mph. Herbicides were sprayed July 19, 1968, in 32 gal/A of water at 22 psi and immediately incorporated.

Treatments were replicated three times in a split plot design with herbicide treatments assigned to main plots and incorporation tools to subplots. The seedbeds were in general finely prepared but contained some ½-inch clods. Moisture level at the surface ½-inch and the 1½ to 2-inch depths of soil were 3.2 and 3.7% of the field capacity (19%), respectively, at time of treatment. Redroot pigweed (*Amaranthus retroflexus* L.) was seeded ½-inch deep. Barnyardgrass (*Echinochloa crus-galli* (L.) Beauv.) was seeded ¾-inch deep. Single rows of each species were spaced 11 inches apart on the beds.

Profiles of soil treated with the tracer were studied after irrigation to evaluate efficiency of incorporation. Visual ratings of weed control (0 = no control, 100 = complete control) were taken from two rows in a central 10-inch band of plots to determine herbicidal efficiency.

RESULTS AND DISCUSSION

The PTO-rotary tiller uniformly distributed the tracer in the surface 2 inches of soil. The rolling cultivator produced incorporation patterns that varied in depth from ½ to 2½ inches, and were poorly distributed across the bed. The greatest depths occurred in the paths of the teeth. The mesh wheel, tine wheels, and rolling bars incorporators performed uniformly in the surface ¾ inch of soil. The reel mower blade with rolling cage incorporated 1 to 1½ inches but with uneven patterns across the beds. The weed control ratings therefore evaluated the effects of treatment to differential depths as well as differential mixing.

A total of 1.6 inches of rain fell within one day after treatment, 5.8 inches of rain fell in 12 days after treatment, and weeds germinated

[10] Nueces Tine Wheel Co., Corpus Christi, Texas.
[11] W & A Incorporators, Pine Bluff, Arkansas.
[12] 'Yellow Devil' manufactured by Emparco, Cleveland, Ohio.

readily without irrigation. The heavy rainfall tended to mask the potential differences between the treatments. Under these conditions, the PTO-rotary tiller performed better than the rolling cultivator (Tables 1 and 2).

The PTO-rotary tiller and tine wheels were outstanding tools for incorporation of herbicides. The rolling cultivator was least effective for broadleaf weed control. It was also inferior to the PTO-tiller, rolling

Table 1. Control of redroot pigweed and Palmer amaranth in furrow-irrigated Willacy fine sandy loam with herbicides soil-incorporated with six incorporation tools.

		Percent control					
Herbicide	*Rate (lb/A)*	*Mesh wheel*	*Rolling cultivator*	*PTO-tiller*	*Tine wheels*	*Rolling bars*	*Reel mower*
Bensulide	3	79 a[a]	71 a	85 a	76 a	76 a	74 a
	6	84 a	83 a	89 a	90 a	90 a	87 a
DCPA	3	56 a	58 a	58 a	58 a	55 a	32 b
	6	67 d	70 d	87 a	85 abc	75 abcd	87 ab
Trifluralin	¼	76 a	64 b	80 a	71 a	71 a	73 a
	½	86 a	75 b	95 a	84 a	95 a	81 a
Av. all herbicides		75	70	82	77	79	72
None, non-weeded check		15 a	13 a	13 a	13 a	17 a	13 a

[a] Means within any one horizontal line followed by the same letter are not different at the 5% level.

Table 2. Control of barnyardgrass in furrow-irrigated Willacy fine sandy loam with herbicides soil-incorporated with six incorporation tools.

		Percent control					
Herbicide	*Rate (lb/A)*	*Mesh wheel*	*Rolling cultivator*	*PTO-tiller*	*Tine wheels*	*Rolling bars*	*Reel mower*
Bensulide	3	99 a[a]	95 a	94 a	93 a	94 a	93 a
	6	93 a	99 a	96 a	99 a	97 a	98 a
DCPA	3	70 a	45 c	67 a	70 a	44 c	55 b
	6	91 a	85 b	92 a	89 a	89 a	94 a
Trifluralin	¼	84 ab	77 b	85 a	82 ab	84 ab	86 a
	½	94 ab	89 b	97 a	92 ab	97 a	95 ab
Av. all herbicides		89	82	90	88	84	87
None, non-weeded check		16 a	15 a	16 a	16 a	14 a	16 a

[a] Means within any one horizontal line followed by the same letter are not different at the 5% level.

bars, and reel mower for grass control with trifluralin. The rolling cultivator and reel mower were the least efficient, and the PTO-tiller and tine wheels the most efficient tools for incorporation of DCPA. Bensulide applications were unaffected by the selection of incorporation tool.

The soil was air-dry at treatment but was extremely wet for several weeks after treatment. The third replication was twice under water. During the first 6 days, the daily maximum and minimum soil temperatures were 107 and 76 F, respectively, at the ¼-inch depth, with lower temperatures at the 2-inch depth (Table 3).

Table 3. Temperature (F) at the ¼ inch and 2 inch depths in fine sandy loam during the first 6 days after herbicide incorporation.[a]

Soil	*Mean temp.*		*Total hrs above*					
depth (in.)	*Max.*	*Min.*	*70*	*80*	*90*	*100*	*110*	*120*
¼	107	76	144	91	53	26	12	–
2	98	79	144	110	42	13	–	–

[a] Recordings were taken from soil incorporated with the PTO-tiller; recordings were similar in soil incorporated with the reel mower blade.

LITERATURE CITED

1. Antognini, J. 1962. Field aspects of soil incorporation of herbicides. Proc. Calif. Weed Conf. 14:39-46.
2. Barrentine, W. L., O. B. Wooten, and J. T. Holstun, Jr. 1965. Evaluation of soil-incorporators-dye techniques. Miss. Agr. Exp. Sta. Bull. 702. 6 pp.
3. Bode, L. E., K. H. Read, M. R. Gebhardt, and C. L. Day. 1969. An evaluation of herbicide incorporation equipment. Missouri Agr. Exp. Sta. Res. Bull. 945. 42 pp.
4. Jordan, L. S., J. M. Lyons, W. H. Isom, and B. E. Day. 1968. Factors affecting performance of preemergence herbicides. Weed Sci. 16:457-462.
5. Klingman, G. C., R. J. Schramm, Jr., and H. Cardenas. 1961. Applying EPTC with emphasis on method of soil incorporation. Proc. So. Weed Conf.:63-68.
6. Menges, R. M., and J. L. Hubbard. 1968. Influence of climate and soil incorporation on herbicides in onions. Proc. Amer. Soc. Hort. Sci. 92:498-507.
7. ————, and ————. 1969. Weed Control by soil-incorporated herbicides as affected by the incorporation tool. Res. Prog. Rept. West. Soc. Weed Sci.:70 (Abst.).

8. Staniland, L. N. 1964. The incorporation of chemicals into soil by various implements. Plant Pathol. 13:78-80.

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

Foam Materials, Field Foam Generator and Small Trench System for Freeze Protection of Plants[1]

JON F. BARTHOLIC and MARVIN D. HEILMAN[2]

Abstract: A combination of materials has been found that will form a stable foam when as dilute as 2.5% by volume in water. The material insulates tender vegetables from freezing conditions and lasts 8 to 16 hours under field conditions. The material is economical and no visual toxicity has been observed on plants tested. A prototype field generator for producing stable foam has been built and tested. Expansion rates have been 1:60 or higher. This economical ($0.001 per gallon of foam) means of freeze protection kept foamed seedlings in small trenches 22°F warmer than nonfoamed plants. The shallow, narrow trenches reduced the volume of foam required for plant coverage to about one-fourth that required in conventional bed planting. Restricting the foam to the trench increased its stability. The cost of foaming young melons could be as low as $15.00 per acre.

INTRODUCTION

Numerous advances have been made in the use of foam for frost protection in the past decade. Siminovitch, et al. (8) in Canada and braud and Chesness (3) and Chesness, et al. (4) in the United States have described foam materials and dispensers. Foams have been found that will last from a few hours up to several days and various types of dispensers or generators have been tried, both in the laboratory and in the field. The foams have been tried on a variety of crops. Bartholic, et al. (2) have shown that in the Lower Rio Grande Valley foam will effectively insulate tender vegetation from mild freezing conditions. They pointed out that better materials and dispenser were required for providing a more stable foam under field conditions.

Several problems still existed despite the great potential for the use of foam to protect tender vegetables. Further evaluation of materials was required and the various generators proposed were too complicated for field use. Thus, the objectives of the work reported here were: (1) to evaluate materials which might form a stable foam and develop a technique for making the foam; (2) once the materials had been found, to evaluate the foam-forming technique on small-scale experiments; and (3) if the small-scale experiments proved successful, to build a prototype field generator and test it extensively under field conditions.

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[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 Scientists, USDA, Weslaco, Texas.

METHODS AND MATERIALS

Foaming materials

Many potential foam-forming materials have been evaluated (3, 5, 7). We first tried materials in the laboratory, cold chambers, and greenhouses that were recommended in earlier investigations. We found that either the materials were slightly toxic to plants or would not persist as long as necessary under the conditions frequently found during nocturnal radiational freezes.

Since the materials suggested were not completely satisfactory, we contacted 12 chemical companies. As a result of extensive discussions with them, 18 products were obtained and tried either individually or in various combinations. All products were first tested in the laboratory for their ability to form a stable foam after agitation. The four best candidates were then evaluated further in the greenhouse and cold chambers. In the cold chambers the insulating and persistence capabilities of the materials were evaluated, while in the greenhouse the possible toxicity of the material to plants was examined.

From these studies, a combination of three materials was obtained which appeared to have all the characteristics of an acceptable foam-forming material. The three materials were combined with water as follows:

1% by volume Retzloff Chemical Retzolate 30S,
Alkyl (C_{12}–C_{15}) sulfate, sodium salt

.5% by volume Wyandotte Chemical Pluronic F-68,
Poly (oxyethylene) Poly (oxypropylene) poly (oxyethylene) block copolymer, average molecular weight 8350

.5% to 1.5% by volume U. S. Gelatin 7APM Gelatin.[3]

Foaming methods

There are a variety of ways to form foam. The bubble size, persistence, and complexity of the method vary greatly depending on the technique used. Methods include agitation, bubbling air through solution, and mixing water and a foam-forming material and blowing it through a screen, as is done to form fire-fighting foam.

The simplest method that provided a stable foam was to force air to the bottom of a container which held the foam-forming solution. The air was dispersed through a ceramic or sponge material. Air emerging from the porous material formed small bubbles that rose to the surface and the foam was formed as these bubbles broke through the surface. As more bubbles were formed, the foam eventually rose out the top of the container.

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

Using the combination of materials described above and the technique of dispersing air through a foamer in the bottom of a solution, we set about building a field-scale system that could be trailer mounted. This field-scale foam generator would allow evaluation of the materials and technique in the field.

Trench system

If dispersed on a slope or top of a bed, the foam tends to flow off the bed. Thus, it was necessary to evaluate a system for restricting the foam. One approach was to plant in the bottom of small depressions or trenches. The plants could then be planted early in the growing season when there was a chance of freeze. Then on cold nights the foam could be applied in the trench to protect the crop. This system had the additional advantage of requiring a minimum amount of foam to cover the seedlings.

In January, cantaloupe, peppers and tomatoes were planted in trenches 6 inches deep and 7 inches across. Temperature sensors were then placed to record leaf temperatures in both foamed and nonfoamed areas (6).

RESULTS AND DISCUSSION

Figure 1 shows the field-scale foam generator mounted on a three-wheel trailer. Foam material is shown coming from the dispensing tubes of the generator. The foam generator consists of a motor and positive displacement blower. The air from the blower is ducted to the bottom of the tank in which two large cages are covered with one-half inch thick foam rubber to disperse the air. The small bubbles dispersed from the foam rubber then rise in the solution, forming foam at the surface of the solution. The foam then rises in the foam drainage area of the system. Here excess solution drains back into the tank while the foam moves to the top of this drainage area and out the dispensing tubes onto the field (1).

The blower, rated at 180 cfm at 2 lb. per in.^{2} gauge, produced 130 cubic feet of foam per minute in the system. One gallon of solution will make 60 gallons of foam. The foam produced is quite viscous and stable, with a density of about one pound per cubic foot. The foam produced costs only $0.001 per gallon. When applied about sundown, it will easily last all night under most radiation freeze conditions.

Table 1 shows these temperatures at leaf height on the night of February 2 and 3, 1970. Temperatures dropped rapidly after sundown and at approximately 10:30 p.m. the area in the trenches was foamed. Temperatures in the foamed area increased rapidly while those in the nonfoamed area continued to decrease. The foamed area stayed 14 to 22°F warmer during the night, reaching a maximum of 22°F difference at 6:00 a.m., the time of minimum temperature for the night. By 10:00 a.m., or 12 hours after application, the foam had nearly dissipated and the temperatures were nearly equal in foamed and nonfoamed areas.

It is clear from this and other similar experiments that the foam is a good insulater and should protect small low-lying vegetation under many freezing conditions.

Table 1. Temperatures for foamed and nonfoamed seedlings on night of February 2-3, 1970.

Time	*Foamed plants*	*Nonfoamed plants*	*Temperature difference**
	°F	°F	°F
6 p.m.	57	56	
8 p.m.	46	44	
10 p.m.	43	42	
11 p.m.	54	40	14
Midnight	56	38	18
2 a.m.	56	35	21
4 a.m.	55	35	20
6 a.m.	55	33	22
8 a.m.	55	39	16
10 a.m.	62	64	

* Foam was applied at 10:30 p.m., Feb. 2.

Figure 1. Foam being applied to a low-lying crop with the trailer-mounted foam generator. 1. Motor and positive displacement blower. 2. Tank with solution that has foamers in the bottom. 3. Foam drainage area. 4. Foam dispensing tubes.

The cost of materials for filling trenches 6 inches deep and 7 inches wide with row spacing of 38 inches would be about $30.00 per acre. For cantaloupes whose row spacings are generally twice as wide, the cost would be $15.00 per acre. These values are approximate since changes in material prices and required volume of foam could vary and cause considerable change in the cost.

SUMMARY

Work reported last year in the Valley Horticultural Society Proceedings showed that foam would protect temperature-sensitive crops (2). However, two problems were pointed out. One was lack of materials that form a stable foam; and the second was the need for a field-scale foam generator. Because research at other locations had not provided completely satisfactory material or foam generator for many applications, research was conducted to find both satisfactory materials and a foam generator for field applications.

A combination of three materials was found that provides a stable foam lasting from 8 to 16 hours. The foam has been shown to be nontoxic to several vegetable plants, and provides up to 22°F temperature increase. The cost of protection could be as low as $15.00/acre for melons.

A simple foam generator for field applications proved reliable and provided foam with the proper bubble size for stability. The system can be easily modified to allow the foam to be generated from tractor or other vehicle mounting system.

LITERATURE CITED

1. Bartholic, J. F., M. D. Heilman and B. M. Farris. 1970. Large volume generator of stable foam for freeze protection. Submitted to Hort. Science.

2. Bartholic, J. F., R. J. Rektorik and M. D. Heilman. 1969. Foam for frost protection. J. Rio Grande Valley Hort. Soc. 23:143-148.

3. Braud, Harry J. and Jerry L. Chesness. 1968. Physical properties of foam insulation for protecting plants against cold weather. Paper No. 68-923 presented at the 1968 Winter Meeting, American Society of Agricultural Engineers, Chicago, Illinois.

4. Chesness, Jerry L., Harry J. Braud, Jr., and P. L. Hawthorne. 1970. Foam protects strawberries during freeze. Agr. Engr. 51(2):80-81.

5. Eggert, Dean A. 1968. Use of liquid foam to prevent freeze injury to strawberry blossoms. HortScience 3(1):11-12.

6. Heilman, M. D., J. F. Bartholic, C. L. Gonzalez, and B. M. Farris. 1970. Cultural system utilizing small trenches and foam for frost protection. Prepared for publication in HortScience.

7. Shear, C. B. and H. L. Barrows. 1953. Insulating foams for the protection of plants against frost. USDA-ARS-CR Progress Report 44-63. 6 pp.

8. Siminovitch, David, Bernard Rheaume, Lloyd H. Lyall and James Butler. Undated. Stable nontoxic protein based foam protects field plantings of crops from damage by frost. Contribution No. 653 from the Cell Biology Research Institute and Contribution No. 222 from the Ottawa Research Station Research Branch, Canada Department of Agriculture, Ottawa, Ontario. 21 pp.

Refrigerated Storage Properties of Liquid-Nitrogen Peeled Fresh Tomatoes

THOMAS S. STEPHENS, GUADALUPE SALDANA, FRANCIS P. GRIFFITHS and HAROLD E. BROWN[1]

Abstract: El Monte variety tomatoes which were peeled by submerging for 20 sec. in liquid nitrogen and thawing 30 sec. in 90°F water were sealed in polyethylene bags and stored at 40°F. At the end of 5 and 11 days, the nitrogen peeled tomatoes were compared with tomatoes which had been peeled in boiling water and stored under like conditions. The maximum exudation of liquid from 900 g of tomatoes was approximately 1.0 g from the hand peeled, 9 g from the nitrogen peeled and 40 g from the water peeled tomatoes and occurred within the first 5 days of storage. The differences that were measured in titratable acidity, pH, and °Brix of the tomatoes from each of the treatments were very small. There were small differences in the color notations but the differences were not consistent. At the end of 5 days of storage at 40°F, judges rated tomatoes peeled with nitrogen to be as good as freshly peeled tomatoes. At the end of 11 days storage, the hand peeled tomatoes and the nitrogen peeled tomatoes had developed a sour smell.

INTRODUCTION

Peeling tomatoes with liquid nitrogen offers a new method of preparing a pre-peeled fresh tomato product for distribution to the institutional and possibly the retail trade. Irish potatoes were one of the first vegetables to be pre-peeled and offered to the consumer in quantity. Anderson, *et al.*, (1) stated that as early as 1954 there were 2,500,000 bu. of potatoes pre-peeled annually. Some other vegetables which have been pre-peeled for distribution to the consumer include sweet potatoes (7), squash (4,5), and carrots (3).

The purpose of this investigation was to determine if tomatoes peeled with liquid nitrogen and packaged in polyethylene bags could be stored at 40°F as long as tomatoes which had been hand peeled or tomatoes which had been peeled with hot water.

MATERIALS AND METHODS

El Monte variety, a round shaped, fresh market type tomato, was used for this study. Approximately 300 pounds of red-ripe tomatoes of uniform size were harvested and divided into 4 equal lots. The tomatoes which weighed approximately 100 g each were selected from each lot. A control sample of unpeeled tomatoes was packaged in 15 polyethylene bags with 9 tomatoes in each bag for a total weight of about 900 g per bag. A second sample, of the same size, was composed of tomatoes which

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had been carefully hand peeled. The third sample was made up of tomatoes which had been submerged 20 seconds in liquid nitrogen, thawed 30 seconds in 90°F water and the skin sack slipped from the tomato (2). The fourth sample was composed of tomatoes which had been submerged 60 seconds in boiling water, cooled in tap water and hand peeled. Three bags of tomatoes of each treatment were examined for exudation loss, titratable acidity, pH, °Brix, color, and an evaluation made for taste. The remainder of the bags of tomatoes were sealed and stored at 40°F. Three bags from each treatment were removed and examined at the end of 5 days and again at the end of 11 days of storage. Prior to examination, the control sample of tomatoes was hand peeled. The tomatoes from each bag were sliced in half and one half used for analysis and the other half for taste evaluation. Each bag of tomatoes was analyzed independently.

The exudation loss was determined by cutting a hole in the bottom of the polyethylene bag and allowing the tomatoes to drain for 5 minutes. The bag and tomatoes were supported in a 4 inch 60° funnel. Total titratable acidity was determined by titrating with standardized sodium hydroxide, °Brix was measured on a Bausch and Lomb[2] refractometer, pH was measured by a Corning Model 10 pH meter, and color was determined with a Gardner Color Difference meter standardized with a tomato red color plate; Rd 5.36, a 30.4 and b 14.6.

The taste evaluation was conducted by 11 judges, according to the hedonic scale method of Peryam and Pilgrim (6). The tomato halves were cut into 12 bite-size slices and at least 5 slices from different tomatoes were presented to each judge in an effort to reduce maturity variability. Each judge was asked to rate the tomato slices according to flavor. The tomato slices were unsalted for the taste evaluation.

The data were subjected to an analysis of variance according to Steel and Torrie (8).

RESULTS AND DISCUSSION

Tomatoes which had been peeled by submerging in liquid nitrogen and stored in sealed polyethylene bags at 40°F were compared with tomatoes which had been hand peeled and tomatoes which had been peeled with boiling water and stored under the same conditions.

The maximum exudation of a watery phase from the peeled tomatoes occurred within the first 5 days of storage and remained rather constant through the 11th day of storage, Table 1. The 1.1 g and .1 g of liquid from the 900 g of hand peeled tomatoes amounted to a few drops in the bottom of the polyethylene bag. The 9.4 g and 9.1 g of liquid in the bags of the nitrogen peeled tomatoes did not distract from

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

Table 1. Evaluation of tomatoes peeled with liquid nitrogen compared with hand peeled and hot water peeled fruit.[1]

Days stored at 40°F	*Treatment*	*Exudation*	*Titratable Acidity*	*pH*	*Brix*	*Color Notation*	*Sensory Score*
		g	%		°	a/b	
0	Control	–	.55a[2]	4.3a	5.35a	2.38a	7.5a
	Hand peeled	–	.50b	4.3a	5.00b	2.35a	7.2a
	N_2 peeled	–	.51b	4.3a	4.95b	2.19b	7.0a
	Water peeled	–	.50b	4.3a	5.15b	2.13b	6.3b
5	Control	–	.49a	4.4a	5.00a	2.35a	7.1a
	Hand peeled	1.1	.49a	4.4a	4.84a	2.43a	6.4a
	N_2 peeled	9.4	.50a	4.3a	4.94a	2.43a	6.2a
	Water peeled	41.1	.50a	4.4a	4.87a	2.18b	5.9b
11	Control	–	.42a	4.4a	4.70a	2.39a	7.0
	Hand peeled	.1	.45a	4.4a	4.56a	2.21a	Sour
	N_2 peeled	9.1	.50a	4.4a	4.63a	2.30a	Sour
	Water peeled	37.8	.49a	4.3a	4.80a	2.11b	5.0

1 The data represent the means of duplicate determinations on 3 bags of tomatoes.

2 Values followed by the same letter are not significantly different at the 5% level by Duncan's multiple range test.

the appearance of the packages of tomatoes. In fact, the small amount of exudation may be desirable to maintain a moist surface, otherwise the tomatoes may lose their shiny fresh peeled appearance. The 41.4 g and 37.8 g of liquid in the bags of the hot water peeled tomatoes were excessive. The liquid was very noticeable and was described as giving the tomatoes a soggy appearance. These tomatoes were soft and the locules had collapsed where they were in contact with one another in the polyethylene bag, resulting in flat sided misshapen fruit.

The differences that were measured in titratable acidity, pH and °Brix of the tomatoes from each of the treatments was very small. There was a significant decrease in titratable acidity and °Brix which occurred between the control and the treatment samples for the initial determinations, but these differences did not occur in samples stored 5 or 11 days. There were greater differences in analytical values for pH, °Brix, and acidity between the three bags of tomatoes comprising each sample than there were between treatments or between samples held different periods in storage at 40°F.

There was a small statistical difference in the color notations of tomato samples representing different treatments and a small color difference occasioned by length of storage of the tomatoes but the differences were not consistent. Although a concerted effort was made to select tomatoes of exactly the same red color, it is evident that some tomatoes in each bag had a more intense red color than others in the same bag. However, the color of all samples of tomatoes was good.

The sensory evaluation scores which were given the tomatoes by the judges were all a little low, possibly because salt was not added. A value of 8 out of a possible 9 was the highest score given any sample. Salt was not added because it might have altered or masked the flavor of the tomatoes.

The judges could consistently detect a flavor difference of tomatoes peeled with hot water. At the end of 5 days of storage, the sensory evaluation scores for all treatments and the control were a little lower than they were initially. However, the importance of the taste evaluation is that the flavor of the nitrogen peeled tomatoes was as good as the freshly peeled control or of the hand peeled tomatoes and was better than the hot water peeled fruit.

At the end of 11 days of storage, the hand peeled tomatoes and the nitrogen peeled tomatoes had a sour smell. Not all of the tomatoes in each bag were sour, but the change in aroma of all tomatoes was affected so these samples were omitted from further taste evaluation. Mold growth had started around the stem scar on a total of 5 tomatoes in the 3 control bags. The tomatoes in the water peeled samples did not have a sour smell, indicating the treatment given the tomatoes during the boiling water peeling operation was sufficient to retard the organisms causing the sour smell. Francis (3) has shown that a dip into a solution of sorbic acid prolonged the acceptable shelf life of pre-peeled carrots and Francis and Jimenez (5) demonstrated that sodium dehydroacetate would extend the shelf life of pre-peeled cubed squash by 1½ to 2 times. In a preliminary investigation at this laboratory, liquid nitrogen peeled tomatoes which had been dipped one second into .1% sodium benzoate solution, had not soured and were of good flavor after 12 days storage at 40°F. It is reasonable to believe that the shelf life of pre-peeled tomatoes could be extended by treatment with an acceptable preservative. Investigations are being conducted with several preservatives to determine their inhibitory effect on the organisms responsible for the sour smell in the tomatoes.

A pre-peeled tomato product would be an additional item a processor of pre-peeled potatoes, onions, carrots, or other vegetables could add to his business for distribution to restaurants, sandwich shops, or other institutional outlets using pre-peeled products.

LITERATURE CITED

1. Anderson, E. E., M. B. Esselen and C. R. Fellers. 1954. Factors affecting the quality of pre-peeled potatoes. Food Technol. *8*(12): 569-573.
2. Brown, H. E., F. I. Meredith, G. Saldana and T. S. Stephens. 1970. Freeze peeling improves quality of tomatoes. J. Food Sci., 35(4): 485-488.
3. Francis, F. J. 1955. Pre-peeled carrots. Pre-Package *9*(4): 8, 10, 11, 15.
4. ———————— and M. A. Jimenez. 1961. Dehydroacetic acid treatments for pre-peeled cubed squash. Food Technol. *15*(6): 322-327.
5. ———————— and C. L. Thompson. 1961. Varieties of squash for pre-peling. Proc. Amer. Soc. Hort. Sci. *78*: 427-430.
6. Peryam, D. R. and F. J. Pilgrim. 1957. Hedonic scale method of measuring food preference. Food Technol. *10*(9): Sup. 9-14.
7. Sistrunk, W. A. 1957. Problems involved in the pre-peeling and packaging of sweetpotatoes. Food Technol. *11*(6): 336-339.
8. Steel, G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co. Inc., New York, N. Y.

Pectic Substances and Viscosities of Juices Prepared from Chico, Chico Grande, La Bonita and Homestead-24 Varieties of Tomatoes

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Abstract: The amounts of water soluble, oxalate soluble and acid soluble fractions of pectic substances were determined on fresh tomatoes and canned juice of Chico, Chico Grande, La Bonita and Homestead-24 varieties of tomatoes. The viscosity of the canned juice was also measured. In addition, the viscosity of the juice of the four varieties was determined at 10 minute intervals for 60 minutes and again at the end of 120 minutes to study the effect of prolonged heating at 190°F on the viscosity of the canned juice. Neither the amounts of the total pectic substances nor the amounts of the three extracted fractions in the fresh tomatoes were indicative of the amounts of those pectic substances to be found in the canned juice. The viscosity of canned juice of Chico variety was, according to our judgment, excellent with a viscosity of 206 cps and the juice of Homestead-24 variety was noticeably watery with a viscosity of 119 cps. Canned juice of Chico variety had the best consistency and retained its consistency longer during heating at 190°F than the other varieties studied. Homestead-24 variety had an initial consistency of about 100 cps which was considered watery and at the end of 120 minutes at 190°F the consistency had not changed.

INTRODUCTION

Processors of tomato products in South Texas have at times experienced difficulty producing fancy quality products from tomatoes grown in this area because the viscosity of the products may be somewhat erratic. The introduction of new varieties suitable for production in this area has greatly improved the ability of processors to produce higher quality products. However, during the canning season the products from some tomato varieties may exhibit excellent viscosity while the products of other tomato varieties may be deficient in viscosity. This variation in viscosity may not be due entirely to the tomatoes but rather to the handling procedures employed within each canning plant. Whatever the reason for the variation in viscosity, additional information about the amounts of pectic substances of tomato varieties grown in this area may partially explain the viscosity differences.

The information in the literature on pectic substance content of tomato varieties and its influence on products prepared from these varieties is somewhat conflicting. Appleman and Conrad (2) studied the

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changes which occur in the pectic substances of four tomato varieties and reported that the degree of ripening of the tomatoes was of more importance on the condition of the raw product than were differences due to varieties. However, Kassab (7) determined the pectic substances content of six varieties of tomatoes of approximately the same degree of ripeness and concluded that the pectic substances content of different varieties varies considerably. Also, Saywell and Cruess (18) concluded that the pectin content of ripe tomatoes varied considerably with the variety, time of picking, ripeness of the fruit and the locality. Kertesz and McColloch (10) determined the pectic substances of unripe, ripe and overripe John Baer tomatoes and concluded that the pectic constituents do not show definite trends in either quantity or composition during the period from just before until just after the peak of optimum ripeness for processing. Luh, *et al.*, (12) extracted the water soluble, oxalate soluble and .05N HC1 soluble pectic substances from the Pearson and the San Marzano varieties and a hybrid of the two varieties. They reported the San Marzano had a higher total pectic substance content than the Pearson and the total pectic substances content of the hybrid was between the two varieties. Love (11) compared the viscosities of juice prepared from three varieties of tomatoes, KC-146, Mat, and Y-13, and found that the variety exhibiting the least flesh firmness, Mat, produced the most viscous juice.

The purpose of this investigation is, first, to obtain information on the pectic substances in fresh fruit and canned juice of Chico, Chico Grande, La Bonita and Homestead-24 varieties of tomatoes, and, second, to determine the effect that prolonged heating at 190°F prior to canning has on the viscosity of juice prepared from each of these varieties.

MATERIALS AND METHODS

The varieties of tomatoes were harvested from the variety trial plots at the Texas A&M University Agricultural Research and Extension Center, Weslaco, Texas. Careful selection was made at the time of harvest to select only firm, red-ripe tomatoes of uniform size, free of cracks, skin blemishes and insect damage. Approximately 15 pounds of fruit were harvested the first day from each variety for the preparation of samples for the determination of pectic substances, total solids and °Brix in the fresh fruit and for the preparation of samples for the determination of pectic substances and viscosity of the canned juice. Approximately 40 pounds of fruit were harvested the following day for the preparation of samples for the determination of the effect of prolonged heating at 190°F on the consistency of juice. The harvesting and preparation was repeated a second time on subsequent lots of tomatoes.

The fruit was harvested and placed into 40°F storage and one variety at a time removed for sample preparation. The varieties were in storage for a maximum time of 6 hours. Stier, *et al.*, (19) found that total pectic substances of freshly picked Queens variety tomatoes decreased during storage at 40°F, therefore the tomatoes for this investigation were stored as short a time as possible.

Samples of tomato juice canned for the determination of pectic substances and viscosity were prepared by a hot-break method. A 3000 g sample of tomatoes was selected from each variety. A Chisholm-Ryder[2] Model F screw-type juice extractor fitted with a 5/16 inch screen was mounted 4 inches above a 5 gal capacity tilting type steam jacket kettle. The kettle was pre-heated with 15 psig (249.1°F) steam pressure. The tomatoes were poured into the juice extractor and as they were forced through the 5/16 inch screen they dropped into the pre-heated kettle. The first part of the chopped tomatoes was heated rapidly to 185°-190°F on the hot kettle surface and as the remainder of the tomatoes fell into the already hot mixture it too was rapidly heated to 185°-190°F (17). The juice was immediately extracted from the hot chopped tomatoes with a laboratory model Langsenkamp paddle finisher fitted with a .020 inch screen operating at a paddle speed of 1100 rpm. The juice was placed back into the steam kettle and heated to 190°F, filled into 303x406 plain tin cans, sealed and the cans of juice processed 20 minutes in boiling water, then cooled in tap water.

The 40 pound sample of tomatoes to be used for the second part of the investigation was poured into a pre-heated, 249.1°F, 20 gallon steam kettle and crushed. As the tomatoes were being crushed they were heated to 185°-190°F as rapidly as possible. The hot mashed tomatoes were juiced in the same paddle finisher used in the first part of the investigation. The hot juice was poured back into the steam kettle and heated to 190°F. An investigation of local canning plants disclosed that holding tanks and filler bowls on closing machines are maintained between 180° and 200°F. As soon as the juice reached 190°F, two 303x406 plain tin cans were filled, closed and processed 20 minutes in boiling water, then cooled in tap water. This sample of juice was used as the control sample and considered to have 0 minutes holding time. The remainder of the juice was maintained at 190°F ±2° and each 10 minutes for a 1-hour period, 2 cans were filled and processed. Two additional cans were filled and processed at the end of 2 hours.

The fresh tomato samples were prepared for alcohol-insoluble solids extraction according to the procedure of Luh, *et al.* (12). The tomato juice samples were prepared for alcohol-insoluble solids extraction by the procedure of McColloch, *et al.* (17). The pectic substances of the fresh tomatoes and the canned juice samples were determined as calcium pectate in the alcohol-insoluble solids according to the method of McColloch (16).

Total solids were determined according to A.O.A.C. (1), and the °Brix of the canned juice was determined on a Zeiss refractometer.

The viscosity of the juice was measured with a Brookfield viscosimeter, LV Model fitted with a No. 2 spindle operating at 60 rpm at a

[2] Mention of company or trade name does not imply endorsement by the United States Department of Agriculture over others not mentioned.

constant temperature of 20°C (68°F). The cans of juice which had been prepared for the determination of the effects of prolonged heating at 190°F on the viscosity of the juice, lost a little moisture during the heating period; therefore, were adjusted with distilled water to the same specific gravity as that of the sample considered to have 0 minutes holding time (control sample). The method described by Biglow, *et al.*, (3) was used to determine the specific gravity.

RESULTS AND DISCUSSION

The total solids, °Brix, pectic substances and the effect of prolonged heating on the viscosity of juice from four tomato varieties was determined. The °Brix and total solids content of Chico Grande were significantly higher than the other varieties and La Bonita was significantly lower, Table 1. Luh, *et al.*, (12) found there was a difference in total solids and soluble solids among varieties. They reported that Pearson variety was lower in both total solids and soluble solids than either San Marzano variety or a cross between the two varieties.

The total pectic substances of the fresh tomatoes were 5.07% to 7.49% greater than were found in the canned juice for the same varieties, Table 2. The total pectic substances in the fresh tomatoes of a variety is not indicative of the amount of total pectic substances which may be found in the canned juice of that or the other varieties. Neither was the water soluble, oxalate soluble or acid soluble fractions of pectic substances in one variety of fresh tomatoes indicative of the amounts of these fractions which would be found in the canned juice of the other varieties.

The viscosity of canned juice of Chico variety was excellent, according to our judgment, at 206 cps. The juice of Homestead-24 variety was very thin and watery with the lowest viscosity, 119 cps. Neither the amount of total pectic substances nor the water soluble fraction nor the oxalate soluble fraction could be related to the viscosity of the canned juice. However, the acid soluble fraction of the varieties decreased from 4.26% for Chico variety to 2.52% for Homestead-24 and the viscosity of the juice decreased from 206 cps to 119 cps for the same varieties.

Table 1. The °Brix and total solids of canned tomato juice.[1]

Variety	*°Brix*	*Total Solids %*
Chico	5.9	6.62
Chico Grande	6.2	6.93
La Bonita	5.2	5.75
Homestead-24	5.6	6.46
LSD .05	.11	.17

[1] Data represent the mean of duplicate determinations on 2 replications.

Table 2. The percent pectic substances in fresh tomatoes and percent pectic substances and viscosity of canned juice.[1]

	Fresh tomatoes[2]				Canned juice[2]				
Variety	*Water soluble*	*Oxalate soluble*	*Acid soluble*	*Total*	*Water soluble*	*Oxalate soluble*	*Acid soluble*	*Total*	*Viscosity*[3] *in centip.*
	%	%	%	%	%	%	%	%	
Chico	7.87	4.24	5.95	18.06	6.63	2.10	4.26	12.99	206
Chico Grande	9.15	5.64	4.43	19.22	5.45	2.53	4.17	12.15	165
La Bonita	9.21	3.81	5.61	18.63	7.80	2.38	3.10	13.28	126
Homestead-24	7.94	4.24	6.11	18.29	6.26	2.00	2.52	10.80	119
LSD .05	.63	.80	NS	NS	1.57	NS	.91	1.83	2.23

[1] Expressed as % of alcohol insoluble solids.

[2] Data represent the mean of triplicate determinations on 2 replications.

[3] Data represent the mean of five determinations on 2 replications.

Luh, *et al.*, (13) stated that pear-shaped varieties were higher in total pectin and protopectin fractions than round-shaped varieties. Chico and Chico Grande are considered pear-shaped, La Bonita and Homestead-24 are round-shaped varieties. In this study Chico and Chico Grande were significantly higher in the acid soluble fraction than La Bonita or Homestead-24 but total pectic substance content could not be related to the shape of the tomatoes.

This study, like those of Luh, *et al.*, (12), Love (11), and Kertesz and McColloch (10), shows that the pectic substances content alone does not determine the viscosity of canned juice prepared from these varieties. The pectic substances, according to Kertesz and McColloch (10), do play an important part in determining the viscosity of processed tomato products and as determined by Luh, *et al.*, (12) the quality of the pectic material is as important as the quantity. Not only is the quality of the pectic substances as important as the quantity but it seems reasonable to believe the cell walls of each tomato variety might have mixed with the pectic substances to help cause the variation in viscosity of canned juice among the four varieties. In support of this assumption the work of Kertesz and Loconti (9) has shown that whole juice viscosity may be increased by adding increasing amounts of cellular material to the serum. Whittenberger and Nutting (20) demonstrated that the amount of cell walls and the shape of the cell wall fragments can be related to the viscosity of whole juice. Although the findings of each of these investigators differ somewhat from the results of this experiment they do point out that cell wall content plays a part in juice viscosity which may be the reason that the juice of Chico variety has the best viscosity and Homestead-24 the poorest.

Canned juice of Chico variety had the best viscosity and retained it longer during heating at 190°F than the other varieties studied, Table 3. The initial viscosity of Chico was 202 cps and after

Table 3. Viscosity in centiposes of juice heated at 190°F for different intervals of time.[1]

Time in	*Variety*			
minutes	*Chico*	*Chico Grande*	*La Bonita*	*Homestead-24*
0	202	181	154	99
10	189	152	149	100
20	164	155	147	105
30	148	142	130	106
40	140	152	126	109
50	148	152	128	110
60	138	150	120	107
120	131	149	122	100
LSD .05	3.5	6.7	8.4	8.9

[1] Data represent the mean of triplicate determinations on 2 replications.

30 minutes heating at 190°F had decreased to 148 cps; then for the next 90 minutes, slowly decreased to 131 cps. Chico Grande, on the other hand, had an initial viscosity of 181 cps, at the end of 10 minutes heating it decreased to 152 cps and remained at about this level for the remainder of the heating period. La Bonita variety, like Chico Grande, decreased rapidly in viscosity during heating, while the viscosity of Homestead-24 variety was about 100 cps at the beginning of the heating process and remained at approximately this same low viscosity throughout the heating period. Several investigators (4,5,8,15) have shown that prolonged heating causes denaturation of pectic substances so it is not surprising that the viscosity of the juice of these tomato varieties decreased as the juice was held at an elevated temperature. It is important, however, to note the effect of prolonged heating on the viscosity of the juice of each of the different varieties. Canning plant operators who are careless about allowing the juice of these varieties of tomatoes to remain in holding tanks or filler machine bowls at elevated temperatures are sacrificing juice quality. Operators who make a practice of blending the juice of Homestead-24 variety with the juice of other varieties should exercise caution in the quantity of Homestead-24 added so as not to downgrade the viscosity of the entire batch of juice.

LITERATURE CITED

1. A.O.A.C. 1965. Official Methods of Analysis, 10th Ed. Assoc. Off. Agr. Chemists, Washington, D. C.

2. Appleman, C. O. and C. M. Conrad. 1927. The pectic constituents of tomatoes and their relation to the canned product. Univ. of Maryland Agri. Expt. Sta. Bull. 291.

3. Biglow, W. D., H. R. Smith and C. A. Greenleaf. 1950. Tomato products. Bull.27-L, revised.

4. Doesburg, J. J. 1965. Pectic substances in fresh and preserved fruits and vegetables. I.B.V.T. Communication No. 25. Institute for Research on Storage and Processing of Hort. Produce. Wageningen, The Netherlands.

5. Joslyn, M. A. 1962. The chemistry of protopectin: A critical review of historical data and recent developments. Advances in Food Research, Vol. 11. Academic Press, Inc., New York, N. Y. p. 42.

6. Kattan, A. A., W. L. Ogle and A. Kramer. 1956. Effect of process variables on quality of canned tomato juice. Proc. Amer. Soc. Hort. Sci. *68*: 470-481.

7. Kassab, M. A. 1931. Observations on the pectic content of California tomatoes. Fruit Prod. Jour. *11*: 69-70.

8. Kertesz, Z. I. 1951. "The pectic substances," Interscience Publishers, New York, N. Y. p. 167.

9. Kertesz, Z. I., and J. D. Loconti. 1944. Factors determining the determining the consistency of commercial canned tomato juice. New York State Agri. Expt. Sta. Tech. Bull. 272.

10. ———————— and R. J. McColloch. 1950. The pectic substances of mature John Baer tomatoes. New York Agr. Expt. Sta. Bull. 745.

11. Love, J. E. 1963. Effect of variety and ripeness on physical and chemical factors associated with the quality of fresh and processed tomatoes. Ph.D. Thesis, Univ. of Illinois.

12. Luh, B. S., S. J. Leonard and W. Dempsey. 1954. Pectic substances of Pearson and San Marzano tomatoes. Food Res. *19*(1): 146-153.

13. ————————., F. Villarreal, S. J. Leonard and M. Yamaguchi. 1960. Effect of ripeness level on consistency of canned tomato juice. Food Technol. *14*(12): 635-639.

14. Marsh, G. L., J. Davies, J. F. Shaver, D. Tombropanlos and R. C. Pearl. 1965. Factors affecting the consistency of tomato concentrates. Univ. of Calif., Dept. of Food Sci. and Technol., Progress Report, June 21. 29 pp. (Processed)

15. Merrill, R. C., and M. Weeks. 1945. The thermal degradation of pectin. J. Amer. Chem. Soc. *67*: 2244-2247.

16. McColloch, R. J. 1952. Determination of pectic substances and pectic enzymes in citrus and tomato products. U. S. Dept. of Agri. AIC-337. 13 pp. (Processed)

17. ————————., B. W. Nielsen and E. A. Beavens. 1950. Factors influencing the quality of tomato paste. II. Pectic changes during processing. Food Technol. *4*(9): 339-343.

18. Saywell, L. G., and W. V. Cruess. 1932. The composition of canning tomatoes. Univ. of Calif. College of Agri. Expt. Sta. Bull. 545.

19. Stier, E. F., C. O. Ball and W. A. Maclinn. 1956. Changes in pectic substances of tomatoes during storage. Food Technol. *10*(1): 39-43.

20. Whittenberger, R. T. and G. C. Nutting. 1957. Effect of tomato cell structures on consistency of tomato juice. Food Technol. *11*(1): 19-22.

ORNAMENTAL SECTION

Spider Mite Control on Violets and Other Ornamentals[1]

George P. Wene[2]

Abstract: The two-spotted spider mite, *Tetranychus (Tetranychus) cinnabarinus* (Bois) is a destructive pest of the perennial violet and many other ornamentals. The perennial violet is very susceptible to insecticide injury. Preliminary tests show that low dosages of aldicarb and disulfoton granules failed to control the two-spotted spider mite on violets. Heavy applications of aldicarb granules control the spider mite but injured the violet plants. Heavy applications of disulfoton granules failed to control this spider mite and also killed the violet plants. Soil drenches of dimethoate and oxydemetonmethyl control this pest but were very phytotoxic to the violet plants. Galecron spray controlled this spider mite on violets, the India devil tree, elephant ears, and the banana plant without injuring the plants.

The two-spotted spider mite, *Tetranychus (Tetranychus) cinnabarinus* (Bois), is a destructive pest of the perennial violet, *Viola odorata*, and many other ornamentals. Since this violet grows throughout the year in the Tucson area, once the spider mite infestation is established, it can build up to destructive levels even in the winter months. In the spring these spider mites migrate to homeowners' vegetable gardens and are very destructive to strawberries, eggplants, beans and other vegetables. Many homeowners will not use miticides on their vegetables but are willing to control the spider mites on their violets. Unfortunately, there is no adequate control for two-spotted mites on violets, and as a result many people have destroyed their violet beds in order to prevent spider mites from infesting their vegetables.

Although the violet is considered a hardy plant it is very susceptible to insecticide injury. It is so susceptible that local nurserymen will only recommend plant destruction as the means of control. Because of this experiments were initiated for the control of this spider mite infesting violets and three ornamental plants grown in a greenhouse.

Dimethoate sprayed at weekly intervals is recommended by Smith (1967). In Arizona dico-fol and fimethoate are recommended as miticides for use on flowers (Roney and Wene 1969). Good control of the two-spotted spider mites on chrysanthemums were obtained with soil drenches of demeton, dimethoate and phosphamidon (Neiswander 1962). Neiswander also obtained control with 10% disulfoton granules applied at the rate of 250 pounds per acre. He also applied 10% disulfoton granules at the rate of 950 pounds per acre without obtaining any phytotoxicity on the chrysanthemums. His studies showed that demeton

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gave 5 weeks' control when used at the rate of 32 ml of the 26.2% EC per 100 square feet. Dimethoate burned the plants at all concentrations tested as soil drenches (Neiswander (1962). Good control of the pyracantha mite, *Paratetranychus platani* McGregor, was obtained with the use of disulfoton granules and drenches of dimethoate and oxydemetonmethyl (Wene, 1969). Drenches of dimethoate and oxydemetonmethyl also gave good control of aphids on calendulas without injuring the plants (Wene 1968).

PRELIMINARY EXPERIMENTS

These experiments were conducted on a bed of violets 200 feet long and 15 feet wide. In the first experiment the bed was divided into 3 plots. Plot 1 was treated with 10% disulfoton granules at 30 pounds per acre. Plot 2 was treated with 10% aldicarb (Temik®) granules also at 30 pounds per acre. The third plot was sprayed with Dimethoate used at the 0.33 pounds per 100 gallons of water. One week later the data showed no reductions of mites in the aldicarb and disulfoton plots. There was a slight but insignificant reduction of the two-spotted mite population in the dimethoate sprayed plot. Some leaf injury was noticed in the dimethoate plot whereas no phytotoxicity was observed in the aldicarb and disulfoton plots.

In the greenhouse, dimethoate sprayed at the rate of 0.5 pound per 100 gallons of water failed to control the two-spotted spider mite infesting India devil trees, elephant ears, and banana plants.

GREENHOUSE EXPERIMENTS

In the first experiment violets, heavily infested with two-spotted spider mites, were planted singly in 8-inch pots which were then placed in a greenhouse and watered every other day. Because of the severity of the mite infestation it was necessary to start the experiment seven days after transplanting. Each pot was considered as a single treatment plot. Each treatment was replicated 4 times.

Since the preliminary experiments showed that low dosages of disulfoton and aldicarb failed to control this spider mite both of these insecticides were applied at the rate of 753 pounds per acre (or 17.2 pounds per 1000 square feet) which was lower than the maximum rate used by Neiswander (1962). Two and a half grams of the 10 percent granular formulations were spread over the soil surface of each pot (plot) which was then watered. In the drench treatments, 1.25 ml of the emulsifiable concentrates, oxydemetonmethyl (2 pounds per gallon) and dimethoate (2.67 pounds per gallon) were mixed with one pint of water which was then poured over the soil surface of each pot. The conventional garden-hose sprayer was used in applying Galecron (N,N-dimethyl-N^1-(2-methyl-4-chlorophenyl)-formamidine) at the rate of 1-pound per 100 gallons of water. The plants were sprayed until run-off started. A second application was made 4 weeks after the first.

At periodic intervals after treatment applications a hand lens was used in counting the mites in 0.3 square inch area on one infested leaf from each plants. In addition the number of old and new leaves (less than one-half normal size) were counted. Data on phytotoxicity were also taken.

Because of the severity of the mite infestation the best looking plants were selected for the control (untreated) plants. A leaf was considered dead when it lost all its green color and became brown and limp. The effect of a severe spider mite infestation on violets is illustrated by Figure 1 which shows a plant killed one month after the start of the experiment. The surviving plant at the end of the experiment was sickly and would not have lived much longer.

Aldicarb applied, as 10% granules, at the rate of 17.2 pounds per 100 square feet (or 753 pounds per acre) gave effective control of the spider mite (Table 1). At this high rate Aldicarb was phytotoxic to the violets. Within a week after application the leaves developed a cuplike appearance (Figure 2) with a white border on the margin of the leaves. This white area became progressively larger with the passing of time so that a month after the treatment application as much as three quarters of the leaf area on some leaves were white. Shortly afterwards three of the four plants were dead.

Good control was obtained with Galecron spray applied at the rate of one pound per 100 gallons of water. The data in Table 1 show that re-treatment was required 3 weeks after the original application. On a few of the leaves a white area about a quarter of an inch in width developed along the margins (Figure 3). The data also show that at the end of the experimentation all the plants were living and actually had more leaves that at the start of the experimentation.

The 10% disulfoton (Di-Syston) granules failed to control this spider mite even though used at the rate of 17.2 pounds per 1000 square feet. This is evident by the number of mites on the plants 2 and 3 weeks after treatment application. Figure 4 taken one month after treatment applications shows the typical yellowish stipled leaves caused by the feeding of spider mites. The decline in spider mite populations 3 weeks after treatment application was probably the result of the unattractiveness of the leaves which were injured by the earlier feeding of the spider mites. The data in table 1 show that this heavy application of disulfoton prevented the development of new leaves. Only one plant survived and it was greatly stunted.

Oxydemetonmethyl (Meta-Systox-R) applied as a soil drench gave effective control of this spider mite. It killed 50% of the violets.

Dimethoate (Cygon) applied as drench gave effective spider mite control but was more phytotoxic than the oxydemetonmethyl drench as shown by the data in Table 1.

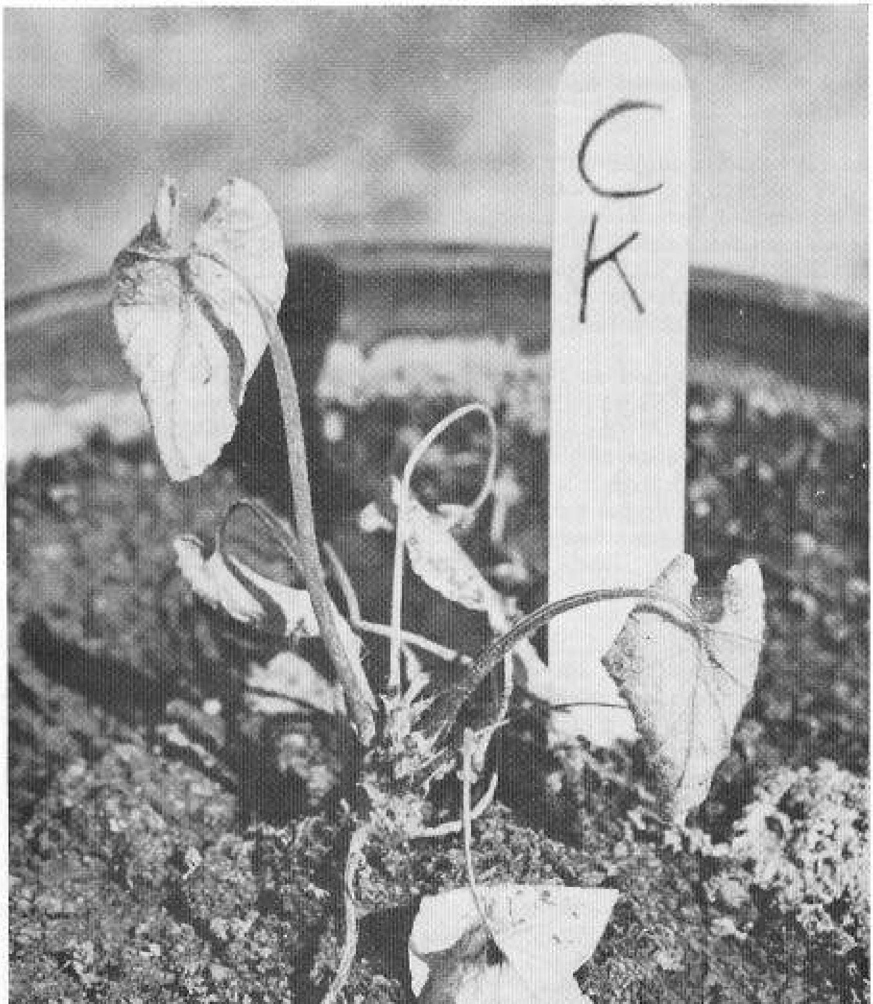

Figure 1. Effect of spider mite injury on untreated violet plant.

Figure 2. Injury to violet plant resulting from high application of aldicarb granules.

Figure 3. Control of spider mite injury on violet plant resulting from Galecron spray. Notice white margin on large leaf.

Figure 4. Failure of spider mite control and stunting of violet plant resulting from a high application of disulfoton granules.

Table 1. Effect of various insecticidal treatments on the spider mite, *Tetranychus (Tetranychus) cinnabarinus* and on the growth of violets.

	No. spider mites on 0.3 sq. in. at following days after treatment application							
	3	*7*	*14*	*21*	*28*	*35*	*42*	*49*
Aldicarb, 2.5g. of 10% granules per pot								
No. plants	4	4	4	4	4	3	3	1
Avg. no old leaves	1.5	2.0	3.5	2.0	1.5	2.3	1.7	2
Avg. no. new leaves	1.8	1.3	0.8	0.5	0.8	0.3	0	0
Avg. mites per 0.2 sq. in.	0.5	0	0	0	0	0	0	0
Disulfoton®, 2.5g. 10% granules per pot								
No. plants	4	3	3	3	3	2	1	1
Avg. no. old leaves	2.8	3.0	5.2	5.0	5.0	4.5	7.0	8
Avg. no new leaves	1.8	1.7	1.0	3.0	0.3	0	0.3	0
Avg. mites per 0.2 sq. in.	3.0	2.7	9.0	2.5	3.0	1.0	1.0	1
Oxydemetonmethyl (2 lbs. Conc.) drench, 1.25 ml, in pt. water per pot								
No. plants	4	4	3	3	2	2	2	2
Avg. no. old leaves	3.8	4.5	5.0	5.0	4.0	3.5	3.5	5.0
Avg. no. new leaves	2.8	2.5	1.0	0.3	0	0	1.5	0
Avg. mites per 0.2 sq. in.	1.5	0	0	0	0	0	0	0
Dimethoate (2.67 lbs. Conc.) drench, 1.25 ml in pt. water per pot								
No. plants	4	4	4	2	1	1	0	0
Avg. no. old leaves	3.8	3.8	2.3	7.0	2	2.0	0	0
Avg. no. new leaves	1.0	1.0	1.5	0	1	0	0	0
Avg. mites per 0.2 sq. in.	3.3	0	0	0	0	0	0	0
Galecron spray, 1 lb. per 100 gallons water								
No. plants	4	4	4	4	4	4	4	4
Avg. no. old leaves	3.0	4.3	6.0	6.5	6.2	5.3	4.3	4.8
Avg. no. new leaves	1.8	1.0	0.8	0.8	0.8	0.3	1.7	1.0
Avg. mites per 0.2 sq. in.	0.5	0.3	0	3.3	2.3	0.0	0.3	0
Untreated								
No. plants 4	4	4	4	3	3	2	1	1
Avg. no. old plants	4.0	5.0	6.0	6.7	4.0	3.5	5.0	3
Avg. no. new leaves	2.3	1.0	0.8	0.3	1.3	1.0	1.0	1
Avg. mites per 0.2 sq. in.	6.5	8.0	18.5	11.7	11.3	4.5	3.0	0.3

Table 2. Effectiveness of Galecron in controlling the spider mite *Tetranychus (Tetranychus) cinnabarinus.*

	No. spider mites on 0.3 sq. in. before and after treatment with Galecron	
Plant	*1 day before*	*7 days after*
India devil tree	2.8	0
Elephant ears	2.7	0
Banana plant	2.3	0

Since Galecron gave good control of spider mites in this experiment a number of exotic plants were sprayed in the environmental greenhouse at the rate of 1-pound per 100 gallons of water. Before and after the treatment application population records were taken on twenty infested leaves of each plant variety. The data in table 2 show that Galecron gave effective spider mite control. The Galecron spray application did not cause any phytotoxicity to India devil trees, elephant ears or banana plants.

LITERATURE CITED

1. Neiswander, R. B. 1962. The use of systemic insecticides on potted chrysanthemums in the greenhouse. J. Econ. Entomol. 55(4): 497-501.
2. Roney, J. N. and George P. Wene. 1969. Insect control for flowers, shrubs, and shade trees 1969-70. Univ. Ariz. Coop. Ext. Serv., Agr. Expt. Sta. Bull. A-18: 1-16.
3. Smith, Floyd F. 1967. Controlling insects on flowers. U.S.D.A. Agr. Information Bull. no. 27: 1-81.
4. Wene, George P. 1968. Systemics, a lazy way to control aphids on calendulas. Progressive Agr. Arizona 20(6): 18-19.
5. Wene, George P. 1969. Systemic insecticides for the control of pests on ornamentals. Pest Control Operators News 29(3): 6-7, 9.

A Pit-Making Scale, *Asterolecanium pustulans* (Cockerell), on Rio Grande Valley Ornamentals[1]

H. A. Dean and Michael F. Schuster[2]

Abstract: The pit-making scale, *Asterolecanium pustulans* (Cockerell), was found on several host plants in the Lower Rio Grande Valley. Oleander and fig were particularly susceptible to attack.

Results on control tests with pesticides showed that oil-diazinon, oil-malathion, dimethoate and oxydemetonmethyl produced the best control. Systemic action of various pesticides did not result in consistent control of the scales. It was apparent that more than one thorough coverage spray would be required for adequate control. The granular systemic pesticides produced inconsistent, or poor, control at the rates applied.

A pit-making scale, *Asterolecanium pustulans* (Cockerell), was first observed in the Lower Rio Grande Valley on oleanders (*Nerium oleander* L.) at San Benito in 1956. The scale insect increased in importance during the 1960's to such an extent that some nurserymen stopped propagating oleander plants for sale. Investigations were begun in 1965 to determine the best means of control and to determine the host range of the insect.

A. *pustulans* was originally described by T. D. A. Cockerell in 1892 from specimens apparently taken from oleanders in Jamaica. Cockerell redescribed the species in 1893 placing it in another genus (1,2). Miss Louise M. Russell placed the species in the genus *Asterolecanium* based on her extensive studies with this large genus in 1941 (5).

Distribution of the scale insect is quite extensive. The insect has been reported from the following countries: Cuba, Dominican Republic, Jamaica, Puerto Rico, Trinidad, Virgin Islands, Brazil, Peru, Panama, Costa Rica, Honduras, Mexico, United States (Florida and Louisiana), Egypt, Israel, Madagascar, East Africa, Hawaii, Guam, Formosa and other islands in the western hemisphere and the Pacific (5).

The insect has been reported from a number of host plants. Host plants of particular interest are as follows: *Acacia* spp. (acacias), *Agave* sp. (possibly the century plant), *Bauhinia* sp. (orchid tree), *Bougainvillea* sp. (bougainvillea), *Cassia* sp. (senna), *Croton* sp. (croton), *Ficus* sp. (fig), *Gossypium* sp. (cotton), *Grevillea robusta* Cunn. (silk oak), *Hibiscus* sp. (hibiscus), *Jasminum* sp. (jasmine), *Lantana* sp. (lantana), *Magnolia* sp. (magnolia), *Mangifera* sp. (mango), *Melocactus* sp. (a

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cactus), *Morus* sp. (mulberry), *Nerium* sp. (oleander), *Passiflora* sp. (passion flower), *Persea* sp. (avocado), *Plumeria* sp. (frangipani), *Prosopis* sp. (mesquite or screw bean), *Prunus* (Amygdalus) (prob. peach), *Psidium guajava* Linn. (guava), *Pyrus* (Malus) *malus* (apple), *Russelia juncea* Zucc. (coral plant), *Sambucus* sp. (elder) and *Vanda teres* Lindl. (an orchid) (5). In 1949, the insect was reported from the following trees: *Acacia spp.*, marmalade, magnolia and mulberry (3). The latter author reported the insect may be very destructive on the trees it attacks. The silk oak practically disappeared from Puerto Rico during a 20-year period primarily because of this insect (6).

The extent to which the insect can induce pit formation, or pustule-like formation, is apparently governed by the susceptibility of the host plant to the insect (5,6). When deep pits are formed there is a tendency for the host tissue to draw together at the opening, thus concealing the insect (5). On oleanders, the tissue appears to swell around the seemingly-depressed area where the scale insect is found. Some members of the genus *Asterolecanium* seem to restrict their feeding to one part of the plant, such as leaves, stems or bark, while others live indiscriminately on leaves, stems, twigs, fruit and trunk (5). A. *pustulans* was found on both stems and fruit of fig.

A few reports were found in the literature concerning biological controlling agents of this scale insect. Parasite emergence holes were reported in the scales in Puerto Rico which were presumed to be the result of the endemic parasites, *Mercetiella reticulata* and *Euaphycus portoricensis*, described by H. L. Dozier from specimens from Puerto Rico several years prior to the time (4,6). However, these parasites had apparently not exerted more than partial control of A. *pustulans* (6). The ladybeetle, *Chilocorus cacti* L. introduced from Cuba into Puerto Rico in June 1938, was reported to prefer A. *pustulans* to other scale insects there and had done so complete a job on this scale insect that the scales were difficult to find for 12-14 years after introduction of the beetle (6,7). Station records show *C. cacti* (sometimes called the twice-stabbed lady beetle by mistake) was identified by Dr. E. A. Chapin of the U. S. National Museum from numerous collections in Lower Rio Grande Valley citrus trees prior to 1960 feeding on various armored scale insects. This beetle has been found on rare occasions in our area since 1960.

MATERIALS AND METHODS

Infested oleander plants in 1-gallon containers were furnished by nurserymen for the early tests while later tests were conducted with large plants at various locations at the Experiment Station.

Various ornamental nurserymen contributed much help for determination of the various plants in their nurseries which were infested with this scale insect.

Rates of materials shown in the text and tables are expressed in quantities of the following formulations: 10 G aldicarb, 80% WP carbaryl

(Sevin), 48.7% EC diazinon, 80% EC dicrotophos, 30.5% EC dimethoate (Cygon), experimental GS-13005 (O,O-dimethyl-S-(2-methoxy-1, 3, 4-thiadiazol-5- (4H)-onyl-(4)-methyl)-dithiophosphate), 5 G Lannate®, 56% EC malathion, 25.4% EC oxydemetonmethyl, 13.9% EC propoxur and Zectran® (4-dimethylamino-3, 5-xylyl methylcarbamate). The 443 oil (distillation temperature at 10 mm Hg.) was highly paraffinic with 0.25% Triton® X-207 for emulsification. Sprays were all-coverage sprays applied in the particular portions of the plants as indicated in the text while granular materials were applied as later indicated.

The number of live scales was determined by examining 25 scales on 8 to 10 inches of twigs. A minimum of 200 scales were examined from each treated group of plants. Following Test 2, no untreated plants (Test 6 excepted) were left because of the difficulty experienced in finding some pesticide that would adequately control the scale insect.

RESULTS

The following plants were found infested with this scale insect in the Rio Grande Valley area: fig, geranium, hibiscus, natal plum (*Carissa grandiflora* DC), oleander, peach and silk oak. Oleander has been the most heavily-infested host plant in this area (Figure 1). However, the double rose flowered variety of oleander evidently is not as heavily-infested as other varieties of oleanders. A light infestation found on the peach tree was probably the result of migrating individuals from heavily-infested oleanders close by. A few parasite emergence holes were observed in some scales on hibiscus at Weslaco in February 1970, however,

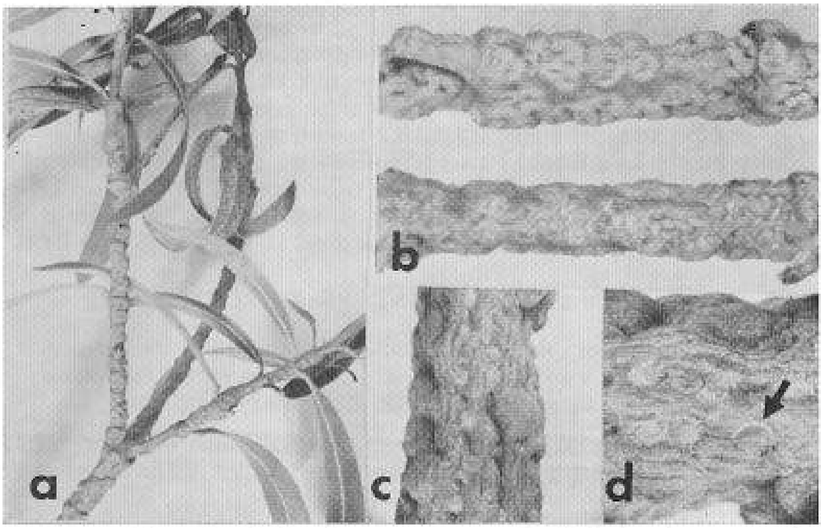

Figure 1. Swollen areas of oleander twigs as a result of feeding by *A. pustulans*: a, b and c. Closeup of scales: d.

none of the scales contained live parasites. A few predaceous chelytid mites, *Cheletogenes ornatus* (C & F), and several plant-feeding tuckerellid mites, *Tuckerella pavaniformis* (Ewing), were also found on the hibiscus.

Test 1. Infested oleander plants in gallon containers were sprayed on June 18, 1965, with a 2½ gallon hand sprayer. The percentage reductions of scales after 27 days and the respectiive insecticide and rates of dilution were as follows: 26.2%-dimethoate (7.5 ml/gal), 48.8% - Zectran® (10 ml/gal), and 86.9% dicrotophos (2.5 ml/gal).

Test 2. Oleander plants in gallon containers were sprayed on August 13, 1965, using a 2½ gallon sprayer. The percentage reductions of scales after 35 days followed by the respective rates of insecticides per gallon of water were as follows: 54.5% dicrotophos (2.5 ml) (65.0% propoxur (25 ml), 53.1% - dicrotophos (5 ml), 85% - 443 oil (38 ml) — diazinon (10 ml), 61.6% - dimethoate (15 ml), and 64.4% - dimethoate (25 ml).

Test 3. Infested oleander plants (10-12 feet high) were sprayed with 1 lb carbaryl/gal water using a high pressure engine powered sprayer operated at 500 psi on August 4, 1966. Records made 12 days later showed 67% living scales.

Test 4. Oleanders, 10-12 feet high, were sprayed on August 18, 1966, from ground level up to 4 feet with various systemic pesticides from a 2½ gal sprayer, while granular 10 G aldicarb was mixed with the top 2 inches of the soil and irrigated immediately. Data shown in Table 1 indicated the 5 grams per square foot rate of aldicarb produced the best control. Considerable variations were found in the percentages of live scales following the spray treatments. Percentages of live scales were the same following dimethoate and dicrotophos on the first 3 dates while smaller numbers were found after dimethoate than dicrotophos 55 and 86 days after application. An increase in live scales was found 86 days after application. A reduction of live scales

Table 1. Percentage of live *A. pustulans* on oleander twigs following treatment with various insecticides on August 18, 1966, Test 4.

	Rates[a]		*Days after application*				
Materials	*gm/ft²*	*ml/gal*	*8*	*22*	*42*	*55*	*86*
Aldicarb 10 G	1		4	6	27	23	30
Aldicarb 10 G	5		2	5	2	1	6
Dimethoate		125	12	14	10	7	1
Dicrotophos		25	11	16	11	16	21
Oxydemetonmethyl		125	20	32	3	6	26

[a] Granules applied to the soil followed by irrigation immediately. Sprays applied from ground level up to 4 feet.

occurred 42 days after application of oxydemetonmethyl with a sharp increase after 86 days.

Test 5. Infested oleanders, 10-12 feet high, were sprayed on June 8, 1967, from ground level up to 4 feet with various pesticides from a 2½ gal sprayer, while granular 10 G aldicarb and 5 G Lannate® were mixed with the top 2 inches of the soil and irrigated immediately. Percentages of live scales remained at 60% or higher following treatment with all pesticides in samples taken from the upper portions of the plants (Table 2). The smallest percentages of live scales were found in samples taken from the lower areas of the plants where the pesticides were applied as sprays. The increased percentages of live scales on the lower portion of the plants 23 days after application of GS-13005 and oxydemetonmethyl were comprised mainly of scales with eggs. The systemic action of the various pesticides apparently was not adequate to provide much scale reduction. Reduction of live scales following dimethoate application was not as great 12 days after treatment as found with GS-13005 or oxydemetonmethyl on the lower portion of the plant where sprays were applied, however, 11 days later, live scale percentages were smaller after dimethoate. Control of the scales in the lower portion of the plant was not as good with the granular materials as found with the sprays in most instances.

Test 6. Infested oleanders, 15 feet in height, were sprayed with various formulations of insecticides on September 8, 1967, using a barrel type sprayer which developed 150-200 psi pressure. The percentage of live scales 28 days after treatment with the respective treatments per gallon of water were as follows: 8-(37 ml 443 oil + 20 ml diazinon), 24-(7 ml malathion), and 6-(37 ml 443 oil + 3 ml malathion). The average number of live scales found 28, 48, 70 and 98 days after application were 4%, 24% and 8% from plots of the respective treatments named above.

Table 2. Percentage of live *A. pustulans* on upper and lower stems of oleanders following treatment with various insecticides on June 8, 1967, Test 5.

			Days after application					
	Rates[a]		*12 days*		*23 days*		*34 days*	
Materials	*gm/ft*[2]	*ml/gal*	*upper*[b]	*lower*[b]	*upper*	*lower*	*upper*	*lower*
Aldicarb 10 G	8		96	78	61	47	76	56
Lannate® 5 G	15		74	23	84	81	99	74
GS-13005		50	94	16	60	89	60	1
Dimethoate		150	65	26	71	9	85	13
Oxydemetonmethyl		150	91	6	66	40	92	5

[a] Granules applied to the soil followed by irrigation immediately. Sprays applied from ground level up to 4 feet.

[b] Upper-above zone of spray application; lower-in zone of spray application.

LITERATURE CITED

1. Cockerell, T. D. A. 1892. Coccidae of Jamaica.J. Inst. Jamaica 1:142-3.
2. Cockerell, T. D. A. 1893. A curious group of Coccidae – The Lecaniodiaspini. Sci. Gossip 29:76-9.
3. Craighead, F. C. 1950. Insect enemies of eastern forests. U.S.D.A. Misc. Publ. 657. p. 143.
4. Dozier, H. L. 1926. Some new Puerto Rican scale parasites (Hymenoptera Encyrtidae). Proc. Entomol. Soc. Washington, D. C. 28:97-102.
5. Russell, L. M. 1941. A classification of the scale insect genus *Asterolecanium*. U.S.D.A. Misc. Publ. 424.
6. Wollcott, G. N. 1953. Biological control of the pustule scale in Puerto Rico. J. Agr. Univ. Puerto Rico. PR 37:228-33.
7. Wollcott, G. N. 1958. The evanescence of perfect biological control. Proc. 10th Inter. Cong. Entomol. 4:511-13.

ACKNOWLEDGEMENT

The authors wish to thank Dr. R. F. Wilkey, Systematic Entomologist, with the Bureau of Entomology, California Department of Agriculture, Sacramento for scale identifications and Dr. R. L. Smiley, Systematic Specialist, with Insect Identification and Parasite Introduction Research Branch, Entomology Research Division, Beltsville, Maryland, for mite identifications.

Control of Aphids Infesting Ornamentals[1]

George P. Wene, University of Arizona

Abstract: Two non-toxic insecticides, pyrethrum and SBP-1382, (5-benzyl-3-furyl) methyl 2,2-dimethyl-3 (methylpropenyl) cyclopropanecarboxylate, were evaluated as controls for aphids infesting ornamentals. Both insecticides effectively controlled *Aphis spiraecola* on pyracantha, *Aphis nerii* on oleander, *Cinara tujafiliana* on arborvitae, and *Acrythosiphum pisum* infesting ornamentals grown in a greenhouse. Both of these insecticides were as effective as either diazinon or Ethion. Pyrethrum and SBP-1382 gave as good control as the systemic insecticides, dimethoate and Meta-Systox-R, for a period of seven days.

Recently developed organophosphate insecticides are very effective in controlling aphid infestations on ornamentals, yet many people are afraid to use them. Some consider them too toxic to handle, while others have specialized situations where residues may be hazardous, such as treating ornamentals when grown beside vegetables. Too, there are fears that their children may become poisoned by playing in soil beneath plants treated with either a soil systemic or foliar spray.

Pyrethrum, the common name for pyrethrins, is an old insecticide introduced in the United States during 1870 (Gnadinger, 1936). It was used extensively before 1946 for the control of many horticultural and household insects, however, very little published work is available on its effectiveness as a control of aphids infesting ornamentals. Gnadinger (1936) lists 17 plants on which pyrethrum gave effective aphid control. Among these were asters, carnations, chrysanthemums, sweet peas, roses and violets. The aphid species were not disclosed.

Because of numerous requests for recommendations of insecticides with low mammalian toxicity, experiments were conducted to evaluate pyrethrum and a new synthetic pyrethrum-like compound for the control of aphids. Also evaluated were a number of organophosphate insecticides currently sold for aphid control.

APHID SPECIES

The spirea aphid, *Aphis spiraecola* Patch was the species infesting pyracantha. When numerous, this aphid gives the plant a dirty appearance. Heavy infestations can delay flowering, reduce the amount of fruit set and stunt plant growth.

Oleanders were infested by *Aphis nerii* Fonsc. This aphid has no approved common name but locally it is called the oleander aphid. It infests the terminal growth. When numerous, these aphids deposit large

[1] Arizona Agricultural Experiment Station Journal Series No. 1690.

amounts of honeydew which many people find objectionable. I have never see this aphid injuring an oleander.

Cinara tujafilina Del G. was the species attacking arborvitae. Locally it is called the arborvitae aphid. When numerous these aphids secrete large amounts of honeydew which many people consider objectionable. When numerous some aphids will occasionally migrate into nearby houses and have been mistankenly identified as brown dog ticks.

The pea aphid *Acrythosiphum pisum* Harris infests a wide range of ornamentals. Heavy infestations caused papaya to turn yellow and eventually drop. The feeding of this aphid was so severe that it caused the leaves on sestron and cup-of-gold to turn yellow.

PROCEDURE

The insecticides used in these experiments are shown in Table 1. All but one are available commercially. SBP-1382, (5 benzyl-3-furyl) methyl 2,2-dimethyl-3-(2-methylpropenyl) cyclopropanecarboxylate), is an experimental insecticide with a short residual life and is considered nontoxic to warm-blooded animals.

All experiments, except one, were conducted in homeowners' yards. One experiment was conducted in a small greenhouse which contained single specimens of exotic plants. In these experiments a single plant was considered as a treatment plot. As the number of plants were limited in individual yards, it was impossible to replicate treatments. This lack of replication was partially overcome by conducting experiments in two or more yards.

The conventional garden hose sprayer was used in applying all but those treatments on oleanders. In the oleander experiments a 2-gallon garden sprayer was used for treatment applications. Both the upper and lower surface of leaves were sprayed until run-off began. SBP-1382 was also tested as an aerosol. In applying the aerosol the dispenser was held 10 inches from the plants. Both the upper and lower surface of the leaves were thoroughly wetted. In the drench experiment 25 ml of a 23.6% emulsifiable dimethoate concentrate was mixed in 2.5 gallons of water and then poured into a basin surrounding the pyracantha trunk which had a diameter of one inch.

The dosages used were expressed in terms that a homeowner would use, namely teaspoons per gallon. On teaspoon per gallon is equal to one pint per 100 gallons.

Effectiveness of the various insecticides was determined by taking population counts before and after treatments. On pyracantha aphids were counted on ten 3-inch twig terminals. Aphid populations on oleanders and the greenhouse plants, papaya, sestron and cup-of-gold, were taken from ten terminal leaves of each plant. In evaluating arborvitae aphid populations four terminal twigs from each bush were shaken over a sheet of white paper. Then the number of aphids which had fallen on a square inch area was counted.

Table 1. The effectiveness of pyrethrum and SBP-1382 in controlling aphids infesting various ornamentals. Tucson, 1970.

Insecticide (Concentration)	Teaspoons per gallon	No. Tests	Avg. No. Aphids per Sample[a] 0	1	7	10
		Pyracantha (*Aphis spiraecola*)				
Pyrethrins, 1.4%	2	3	311	6	8	38
	4	1	72	11	14	6
SBP-1382,[b] 24.3%	1	1	283	117	9	16
	2	4	271	2	17	37
0.35% Aerosol		1	480	0	0	15
Dimethoate, 23.6%, drench[c]		1	243	150	0	0
Untreated		4	266	294	183	96
		Oleander (*Aphis nerii*)				
Pyrethrins, 1.4%	1	2	208	18	2	
	2	3	135	1	0	
SBP-1382, 24.3%	1	2	212	1	1	
	2	2	199	0	3	
0.35%, Aerosol		2	193	0	9	
Dimethoate, 23.6%	1	1	185	0	0	
	2	1	238	0	0	
Unt						
MSR,[d] 25%	1	1	160	0	0	
Diazinon, 25%	1	1	131	0	15	
Ethion, 4-lb/gal.	1	1	103	0	15	
Mixture: Carbaryl 5%; MSR 5%; Kelthane 2%	3	1	28	0	0	
	6	1	37	0	0	
Mixture: Carbaryl 5%; MSR 5%; Omite[e] 3%	6	1	70	0	0	
Untreated		4	193	142	52	
		Arborvitae (*Cinara tujafilina*)				
Pyrethrins, 1.4%	2	1	4	0	1	1
	4	1	3	0	0	0
SBP-1382, 24.3%	1	1	3	0	0	0
	2	1	3	0	1	0
MSR, 25%	1	1	3	0	1	1
Untreated		1	4	2	3	3
		Papaya (*Acrythosiphum pisum*)				
Pyrethrins, 1.4%	4	1	440	0	0	
		Sestron (*Acrythosiphum pisum*)				
SBP-1382, 24.3%	2	1	15	0	0	
		Cup-of-Gold (*Acrythosiphum pisum*)				
MSR, 25%	1	1	46	0	0	

[a] See text for methods used in sampling populations.

[b] SBP-1382, (5 benzyl-3-furyl) methyl 2,2-dimethyl-3 (methylpropenyl) cyclopropane-carboxylate.

[c] 25 ml in 2.5 gallons of water

[d] MSR, oxydemetonmethyl (Meta-Systox-R)

[e] Omite, 2-(p-tert-butylphenoxy)cyclohexel 2-propynyl sulfite.

DISCUSSION OF RESULTS

Good control of four aphid species, *Aphis spiraecola, Aphis nerii, Cinara tujafilina* and *Acrythosiphum pisum*, infesting ornamentals was obtained with spray applications of pyrethrum and SBP-1382. The data indicate that the 1.4% pyrethrum emulsion should be used at the rate of two teaspoons per gallon, whereas the 24.3% SBP-1382 emulsion was effective when used at the one teaspoon rate. Those data also indicate that both of these insecticides were losing their effectiveness seven days after treatment application.

An aerosol formulation containing 0.35% of SBP-1382 gave effective control of aphids infesting pyracantha and oleander. However, seven days after application aphids population had started to build up.

The systemics, dimethoate and MSR (oxydemetonmethyl) when applied as sprays eliminated the aphid pouulations. The commercial spray mixtures (Isotox) containing only 6% MSR were equally effective. The data show that dimethoate applied as a drench was slower than the spray applications in reducing aphid populations but was just as effective one week after treatment.

Sprays of diazinon and Ethion were as effective as the pyrethrum sprays. Populations started to increase seven days after treatment application.

All spray treatments had been applied during the heat of the day. No phytotoxicity was observed.

REFERENCES CITED

Gnadinger, C. B. 1936. Pyrethrum flowers. McLaughlin Gormley King Co. Minneapolis, Minnesota.

OTHER

Effect of Amistad Dam on Water Supply to Lower Rio Grande Valley

TATE DALRYMPLE[1]

Prior to the beginning of storage in the reservoir created by Amistad Dam, in June 1968, practically all flood flow in the Rio Grande was caught in Falcon Reservoir, but now much of the water formerly coming to Falcon is stopped at Amistad. What effect this will have on the water supply to the Lower Rio Grande Valley is of concern to all of us. Pertinent factors influencing the situation are: (1) the number of acres subject to irrigation; (2) the water supply; and (3) the effect of Amistad on the water supply; related to the last, and the most important factor of all, is the question of water use in the reach between the two dams.

The number of acres cultivated in the United States below Falcon Dam has increased from about 300,000 in 1935 to 600,000 in 1956 and to 778,000 in 1960, which is the acreage now allotted water by the 93rd District Court. Water rights for 743,000 acres was recognized in the judgment of the appellate court. Thus we see a steady increase in cultivated acres over the years, with only a small decrease due to the water suit.

The amount of water allotted by the court judgment is 1,840,000 acre-feet annually for irrigation plus 138,000 acre-feet for municipal, industrial and domestic uses, or a total of almost 2 million acre-feet per year, as measured at the point of diversion from the river. Considering the 60,000 acre-feet domestic reserve provided for in the judgment and a 20 percent reserve for evaporation and channel losses, a total annual yield of 2.5 million acre-feet of water must be provided by the Rio Grande for everyone to get his full legal allotment. What is the likelyhood of the river providing this much water?

Studies based on records obtained since 1945 indicate that only for 10 percent of the years will the annual flow (the U.S. Share) into Falcon Reservoir be as great as 2.5 million acre-feet. For 50 percent of the years – half the time – class A land (641,000 acres) would get only 1.21 acre-feet per acre and class B land (102,000 acres) would get only 0.70 acre-feet per acre. What this means is for most years a farmer will have less than half of a full supply of water and must reduce the amount applied to each acre or reduce the number of acres irrigated. A year of a full water supply will be a rarity. Can we expect the water supply to increase in the future?

The trend in the amount of U. S. water coming to the Valley has

[1] Special Water Master, 93rd District Court, Hidalgo Count.

been down. Prior to the construction of Falcon dam, the flow into the Gulf averaged over 2¾ million acre-feet per year – this was after everyone had taken all the water they wanted; there was more than enough for everybody. Extensive irrigation development in Mexico helped to reduce the water supply; since 1930 reservoirs have been built having a total capacity of over 3¼ million acre-feet. And hundreds of small reservoirs, or stock tanks, built in this country has contributed to reduce the amount of water reaching the river. The effect of these developments may be gauged by the records of flow in the Rio Grande. The U. S. Share of the flow at Falcon dam site, as computed by the IB&WC, averaged about 1,800,000 acre-feet for the period 1900-1953 but the U.S. flow into Falcon reservoir has averaged only 1,400,000 acre-feet, or about 80 percent as much, for the period 1954-68. This is not conclusive proof of a decline, but it does indicate the trend.

The construction of Amistad dam on the Rio Grande above Del Rio created a drastic change in the water supply situation – a change that can be very damaging to Falcon water users, as about 90 percent of the water coming to Falcon originates above Amistad dam.

A large reduction in water reaching Falcon reservoir has occurred since storage began at Amistad in July 1968. Over 1 million acre-feet of U. S. water has been released from Amistad, but much of this was taken out in the reach of the river between Amistad and Falcon Dams, and for several months last summer not enough water reached Falcon reservoir to make-up for the evaporation.

The construction of Amistad dam has been a great asset to water users between Amistad and Falcon. There has been a steady increase in acres irrigated in the reach from about 48,000 in 1960, when Amistad dam was authorized, to 60,000 in 1968. The Texas Water Rights Commission, the agency that controls releases of U. S. water from Amistad, in a recent report lists 63,000 acres claiming an irrigation right with an estimated annual use of 200,000 acre-feet, including 27,000 acre-feet for municipal, industrial and domestic uses. In addition, the report lists about 10,000 acres being irrigated that have no claim at all to a water right.

The TWRC is now in process of adjudicating water rights in the Amistad-Falcon reach, and until this adjudication is completed, they indicate they can exercise little control over water use in the reach; this probably will be a period of from 2 to 5 years. In the meantime they are releasing water from Amistad at a rate of about 1100 cfs; this is necessary, we are told, to provide for hydroelectric power generation by C.P.&L., operating under a permit held by the Maverick Count WC&ID No. 1 that provides for a diversion rate of 1500 cfs. The constant diversion of about 1000 cfs of U. S. water is a fine thing for the 100 pumps below Amistad and above Falcon, but it does no good for the water users below Falcon.

Several requests have been made to the TWRC for them to assign

Amistad water to Falcon users on a definite formula basis, and at monthly intervals so that Amistad water can be allocated to Falcon users. But the TWRC has not felt able to do this until the adjudication is completed. However they have agreed to assign water to us from time to time as they see fit, and not on a basis of a right we can demand. The only such assignment to date was 220,000 acre-feet transferred by letter dated December 17, 1969; this water has been allocated to Falcon users, as reflected in the Special Water Master's report dated January 15, 1970.

The declining yield of the river and increased use in the Amistad-Falcon reach poses a serious problem for the water users below Falcon. Nothing can be done about the declining water supply, but a close look should be made of the situation that exists between the dams.

This threat to the Falcon water supply has long been recognized by people in the Lower Valley. Twenty-five or more from this area appeared before committees of Congress when consideration was being given to approval of Amistad dam (this was in the 1958-60 period) and they pointed out the danger to the Falcon water supply posed by the construction of Amistad.

As a result of these efforts, the Texas Board of Water Engineers adopted an order on December 8, 1958, that was referred to in the Act of Congress authorizing construction of Amistad dam (Pub. Law 86-605, sec. 3.) that was approved July 7, 1960. Congress approved construction of the dam "* * with the understanding that * * (b) the State of Texas having stipulated that the amount of water that will be available for use in the United States below Falcon Dam after the proposed dam is placed in operation will be not less than the amount available under existing conditions of river development * * and it shall be the exclusive responsibility of the appropriate authority or authorities of said State to distribute available United States share of waters of the Rio Grande in such a manner as will comply with said stipulation." This wording says that water use between the two dams, under conditions existing today, cannot be a larger proportion of the total U. S. flow than was being used at the time Amistad dam was authorized, i. e., in 1960.

How much water was used in the Amistad-Falcon reach, and what percent was it of the total U. S. supply? There are several answers to this question:

(1) The IB&WC, in 1959, estimated that U. S. requirements in the Amistad-Falcon reach was 10.3 percent of total U. S. flow;

(2) The TWRC, in 1969, recognized water rights in the Amistad-Falcon reach as 9.5 percent of all water rights from Amistad dam to the Gulf;

(3) Data published by the IB&WC in their annual water bulletin for 1960 shows that the Amistad-Falcon reach used 11.4 percent of the total use below Amistad. The average of these three shows the Amistad-

Falcon reach is entitled to 10.4 percent of the total U. S. flow at Amistad; this figure agrees fairly well with the recorded 1960 use of 11.5 percent.

These computations indicate that the Amistad-Falcon reach is entitled to only about 11 percent of the total U. S. flow into Amistad reservoir. The 89 percent left should go to Falcon water users. This means 89 percent of every acre-foot of U. S. water that enters the reservoir, not 89 percent after a certain reserve is withheld for use in the Amistad-Falcon reach, as is now being done, nor does need, existing water rights, or potential future developments have a bearing on the situation. Do we get this 89 percent now?

Records of IB&WC show that since 1959 the Amistad-Falcon reach has used annually from 9 to 25 percent of the U. S. share of the flow at site of Amistad dam; naturally they tend to use a larger percent during years of lower flow, when Falcon users need it most. Since the beginning of storage in Amistad reservoir in late June of 1968, about one million acre-feet of U. S. water has been released; the rate of release has varied from about 800 to 1400 cfs, and averaging about 1000 cfs – just right for those above Falcon to pump what they want.

In June 1969, 53,000 acre-feet were released from Amistad, about 90 percent being U. S. water. The U. S. flow into Falcon during June, which includes some flow from tributaries below Amistad, was 23,000 acre-feet, but U. S. evaporation amounted to 35,000 acre-feet, so we made out poorly. Total U. S. flow into Falcon in July 1969, the last month of record, was only 9500 acre-feet, far less than the evaporation or the 50,000 acre-feet released at Amistad. Had Amistad dam not been built, and all water now stored there was in Falcon, the maximum allowable storage would be exceeded and every allottee below Falcon would now have a maximum allotment. Instead, many allottees are about out of water. It appears that we are not getting our proper share.

Several attempts have been made to get a proper share of Amistad water assigned to Falcon users; we have received only the 220,000 acre-feet mentioned earlier. A meeting was held in Austin last December 8, with all members of the TWRC, their Executive Director, and several staff members. This meeting has been accurately reported in the weekly publication "Texas Water Report" for December 11, 1969: "The group also talked about the percentage of the U. S. allocation in Amistad which can be allocated to Falcon for Lower Rio Grande Valley use under the Court decision. Chairman Dent said the Commission felt they can't talk in even the *most general terms* about this until they have completed the adjudication of the middle reach. * * The Commission has plans for complete *coordination* of Amistad and Falcon as a unit operation to get the maximum use of both reservoirs." In the meantime, what about water for Falcon users?

It is clear that the TWRC has no plan to allot Amistad water to Falcon users on a formula basis – a basis that gives Falcon users a right to a definite proportion of all water entering Amistad, even though Congress stated that Falcon users should get no less water than they would receive had Amistad dam not been built. It is doubtful that Amistad dam would have been built without the BWE stipulation on division of the water, a stipulation that recognizes a superior right of water users below Falcon dam. Nonrecognition of this right can be a serious factor in the economic welfare of people in the Lower Rio Grande Valley.

The water users below Falcon dam today are confronted with a situation where for the past few years the number of acres being irrigated has increased while there has been a decline in the amount of available water, plus a recently constructed dam and reservoir upstream that may be operated to seriously reduce the already inadequate flow. The next question is: What are you going to do about it?

Development and Preliminary Test of a Frozen Avocado Salad Base

O. C. Hester and T. S. Stephens[1]

Abstract: A frozen avocado salad base was prepared and distributed through a student cafeteria in Baton Rouge, Louisiana and several restaurants in New Orleans, Louisiana and Clemson, South Carolina area for evaluation as a salad preparation. The results of the ratings and use in the student cafeteria showed that the product was versatile, easy to prepare, had satisfactory "shelf life" after preparation and was acceptable. Almost all the restaurants which used the product were favorably impressed and the restaurant operators generally thought the estimated cost of $8.00 per case of twelve 32-ounce cans was reasonable, although it was higher per serving than other competing products.

INTRODUCTION

In a normal crop year, many avocados are left in the groves or sorted out and discarded at the packing shed because they are too ripe for shipping, misshapen, oversize or undersize, or have skin blemishes. Losses of this type vary from year to year depending on weather and other growing conditions and have been estimated to average about 5 million pounds per year.

A satisfactory process for freezing avocados and an acceptable frozen avocado product offers an opportunity for better utilization of the crop and for extending the marketing season. A processed product using fruit too ripe for shipment, scarred, misshapen, too large or too small, but otherwise sound, would give an outlet for a considerable portion of the crop now lost.

In 1957 and 1958, the Foods Crops Utilization Research Laboratory at Weslaco, Texas developed an excellent frozen avocado salad base similar to the Mexican dish "guacamole salad" (3, 4). To prevent the separation of a watery phase from the product upon thawing, it was necessary to add a thickening agent such as waxy rice flour or sodium alginate.

Later it was discovered that a satisfactory product could be prepared and separation overcome by the addition of cracker meal instead of the previously used more difficult to prepare thickening agents (2).

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[1] O. C. Hester is an agricultural economist in the Market Potentials Branch, Marketing Economics Division, Economic Research Service, and T. S. Stephens is a food technologist at the Food Crops Utilization Research Laboratory, one of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U.S. Department of Agriculture.

The following is the basic formula for the frozen avocado salad base:

Ingredients	*Wt. %*	*Wt. gms.*
Avocado meat	88.70	887.0
Lemon or lime juice	4.60	46.0
Onion powder (not flakes or onion salt)	.27	2.7
Salt	1.43	14.3
Cracker meal	5.00	50.0

The avocado meat is mashed with a potato masher to avoid air being incorporated into the product. The remaining ingredients are folded into the avocado meat. Fast blending or whipping incorporates an excessive amount of air which will cause oxidative rancidity during frozen storage. The lemon or lime juice and onion powder aid in preventing darkening during storage and after thawing, and therefore, should not be omitted. Other ingredients such as tomato, peppers, or bacon may be added: however, for commercial preparation, the addition of these items is left to the housewife.

The most desirable container is the plain tin can. The can is carefully packed in order to eliminate all airspaces that may occur in the product and headspace of the can. The frozen product can be stored at 0°F and retains good flavor, color, and texture for as long as 12 months.

METHODS

In cooperation with the South Florida Growers Association and a packing firm in Florida, arrangements were made to process and freeze in November 1964 a sufficient quantity of avocado salad base for preliminary tests. The basic formula was followed to prepare about 800 pounds of product.[2]

About half of the product was packed in 6-ounce tin cans for household use, and half was packed in 32-ounce cans for institutional use.

Although no formal testing program has been carried out, several groups requested samples and were most cooperative in supplying their results. These results, which are discussed below, were sufficiently favorable to indicate that more formal research should be carried out to test the potentials for the product.

The School of Home Economics[3], Louisiana State University, Baton Rouge, Louisiana adapted and tested 19 recipes for household use and 6 quantity recipes for restaurant use. Two soup recipes were included in

[2] Mr. Charles W. Wilson, III, Chemist, U.S. Fruit and Vegetable Products Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Winter Haven, Florida, assisted in the preparation and packaging of the product.

[3] The authors wish to express their appreciation to Professor Dorothy S. Moschette and the School of Home Economics, Louisiana State University, for their cooperation in adapting and testing recipes for the product.

each category. The recipes were rated for acceptability and, in some cases, compared with dishes prepared from fresh avocados. The results of the ratings and use in the student cafeteria showed that the product was versatile, easy to prepare, had satisfactory "shelf life" after preparation, and was acceptable.

Estimated Cost. The following direct cost estimates were based on the wholesale purchase of 400 pounds of avocados at 14.6 cents per pound and hand preparation of the product in the laboratory:

Yield	*Lbs.*
Avocado flesh yield (51.6% of fresh purchased)[4]	180
Other ingredients (12% of total mix)	22
Total avocado salad mix	202
Cost	*Per lb.*
Ingredients	$ .30
Labor[5]	.15
Packaging	.06
Freezing	.05
Direct cost per pound	$ .56

To this estimated cost of 21 cents per 6-ounce can must be added overhead, profit, distribution, brokerage, and retail markup. It is anticipated that avocado cost would be considerably less when those not suitable for shipping are obtained at the packing shed. Labor costs might also be reduced by the use of mechanical peeling, pitting, and pureeing equipment.

One of the cooperators estimated a total cost of approximately 44 cents per pound f.o.b. plant. This estimate was used as a basis for estimating the price to the institutional users.

RESULTS

Institutional Response. Through previous work with restaurants in the New Orleans area (1), it was possible to identify restaurants whose management and menu offerings indicated a possible use for dishes made from frozen avocado. Less than 10 percent of the restaurants were considered potential users of the product. Of these, approximately half include avocado on their menu. Those that do use avocados use them infrequently because of availability or price. Thus, less than 5 percent of the restaurants might be considered as immediate prospective users. In addition, the new product did not appeal to some regular users of avocados.

[4] A ripening loss of 12.5 percent could probably be reduced to 5 or 6 percent by use of a high humidity ripening room.
[5] Labor was based on output of 11 pounds per hour at $1.60 per hour.

Frozen avocado salad in 32-ounce containers was placed in a small number of restaurants in the New Orleans and Clemson areas.[6] Each operator was supplied recipes for quantity preparation but was not discouraged from improvising or modifying those supplied or from using his own recipes.

Almost all of the restaurants which used the product were favorably impressed. Several restaurants used the frozen avocado as a salad; others used it as a dip, a hot vegetable, and as a soup.

In restaurants where customer counts were obtained, the product was served to more than 600 customers. The reaction of the restaurant patrons appeared to be very favorable. In the Clemson area, the majority of those that did not like the dish were unfamiliar with avocados in any form.

The restaurant operators generally thought the estimated cost of $8.00 per case (twelve 32-ounce cans) was reasonable, although it resulted in a higher cost per serving than other competing products.

There is apparently only a small number of restaurants which might use frozen avocado salad. These are not frequent users of avocados. Despite the favorable response from the actual restaurant users of the product, the institutional market does not appear to offer a large enough volume potential to justify attempts at commercial development.

Consumer Response. Only limited and informal consumer response to the product is currently available. For example, exploratory efforts included an evaluation of the product by employees at the USDA Southern Regional Research Laboratory on a voluntary basis.

Each user was supplied a sufficient quantity of product for preparation of one dish for the family or group. Recipes were provided; however, no instructions on handling the product were given. In most cases, a list of ingredients was provided each user. Several home demonstration and other organizations supplied the product to their membership on a similar basis.

Reactions were favorable. Users indicated that the frozen product compared very well with dishes made from fresh avocado. The most frequent comment other than on flavor and texture was that it was in a convenient form to hold or have on hand and that it would be good to have available when fresh avocados were "out of season." Probable retail prices also appeared quite reasonable to users. Carefully designed consumer tests would be required, of course, before significant conclusions of consumer acceptance could be made.

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[6] Mr. H. W. Kerr, Jr., Agricultural Economist, Market Potentials Branch, Marketing Economics Division, Economic Research Service, U.S. Department of Agriculture, distributed the product in the Clemson, South Carolina area and obtained users' responses.

LITERATURE CITED

1. Dwoskin, P. B., O. C. Hester, H. W. Kerr, Jr., and J. A. Bayton. Market Test of Instant Sweetpotatoes in Selected Institutional Outlets. 1963. Marketing Res. Rept. No. 580, Econ. Res. Serv., USDA.

2. Stephens, T. S., and F. P. Griffiths. Guacamole Salad. Aug. 1961. Texas Farming and Citriculture *38*(2): 7a-8a.

3. Stephens, T. S., B. J. Lime, and F. P. Griffiths. Preparation of a Frozen Avocado Mixture for Guacamole. 1957. J. Rio Grande Valley Hort. Soc. *11*: 82-89.

4. Stephens, T. S., B. J. Lime, and F. P. Griffiths. The Effect of Thickening Agents in Reducing the Watery Separation of Frozen and Thawed Guacamole Products. 1958. J. Rio Grande Valley Hort. Soc. *12*: 81-87.

Variability in Hybrids of Vitis Candicans and Vitis Vinifera

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Abstract: This report describes the results obtained from crossing a seedling mustang grape (*Vitis candicans*) with Perlette (*Vitis vinifera*). Of the 149 seeds obtained from the cross, one exhibited enough vigor and fruit qualities to be worthy of further testing. There was wide variation in vigor and foliage characteristics among the F_1 vines.

INTRODUCTION

A large number of wild grape species grows in various areas of Texas. Some of these species have been used in the grape industry as nematode and cotton root rot tolerant rootstocks which are immune to grape phylloxera and increase the vigor of the scion.

There is also a very good possibility of obtaining new grape varieties by hybridizing wild grapes with established American and Vinifera varieties. This is an interesting easily learned hobby which may result in the development of a juice or table grape industry in Texas.

This paper reports the results of hybridizing a seedling mustang (*Vitis candicans*) *with Perlette* (*Vitis vinifera*).

METHODS

In March, 1967 a mustang grape (*Vitis candicans*) seedling was crossed with Perlette (*Vitis vinifera*), the latter being the pollen parent.

One hundred and forty nine seed were obtained from the crosses. The seeds were stored in a refrigerator at about 40°F until February 1968 when they were planted in gallon cans, 3 seed per can, in a well drained potting mixture. The plants were watered with rain water and placed under a clear plastic tent to provide high temperature for quick seed germination.

RESULTS

One hundred and one seeds germinated, but only 97 grew into plants large enough to be set into the field. Downy mildew attacked most of the plants and caused extensive defoliation.

One plant (No. 10) was very vigorous and set fruit (462 grams) after one year's growth. Figure 1 shows a comparison of the foliage of the parents, *Vitis candicans* and *Vitis vinifera* and the foliage of the hybrid (No. 10). The fruit set on No. 10 is shown in Figure 2. The grape bunches varied in berry numbers from 11 to 18. A comparison of bunch

Figure 1. Foliage of mustang, (*Vitis candicans*), Perlette (*Vitis vinifera*) and the hybrid No. 10.

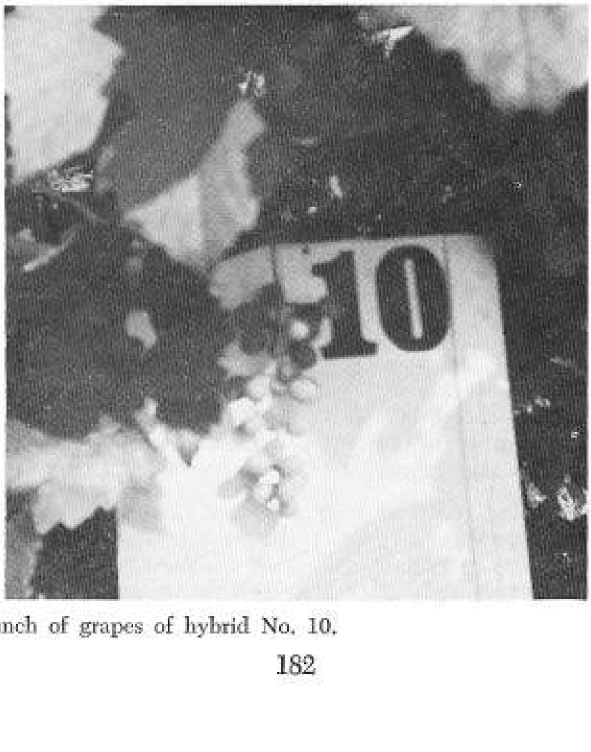

Figure 2 Bunch of grapes of hybrid No. 10.

Table 1. Comparison of Hybrid No. 10, *Vitis candicans* and Perlette (*Vitis vinifera*).

	No. 10	*Vitis candicans*[1]	*Perlette (1)*
Weight of bunch	81 gms	5.6 gms	450-750 gms
No. berries in bunch	18	4	225-375
Ave. berry weight	5.5 gms	1.4 gms	2.0 gms
Berry size			
Axial	22 mm	14 mm	
Equiter	21 mm	14 mm	
Color			
Endocarp	Colorless	Light pink	Colorless
Pericarp	Deep purple	Deep purple	White
Seed no.	2	2	Rudimentary
Brix[2]	14.4°	11.2°	13°-17°
Skin	Tough	Very tough	Very tender
Palatability	Acceptable	Sour	Fair

1 *Vitis candicans* bunches were small due to poor pollination.
2 Hybrid No. 10 and *Vitis candicans* were tested for Brix on July 9, 1970. Degree balling for Perlette was obtained from reference 1.

and berry characters of the hybrid (No. 10), *Vitis candicans* and Perlette (*Vitis vinifera*) is in Table 1.

There was considerable variation in leaf shape among the plants surviving in 1970, which indicates that they are true hybrids of *V. candicans* and *V. vinifera*.

CONCLUSIONS

Crosses of mustang grape (*V. candicans*) with Perlette (*V. vinifera*) vary widely in vigor and leaf characteristics. One of the seedlings which is intermediate in leaf, berry and bunch characteristics between mustang and Perlette grapes, appears to be promising and deserves further testing.

REFERENCES

1. Olmo, H. P. 1948. Perlette and Delight Two New Early Maturing Seedless Table Grape Varieties, California Agricultural Experiment Station Bulletin 705.