PROCEEDINGS

Of the Seventh Annual

RIO GRANDE VALLEY HORTICULTURAL INSTITUTE

Weslaco, Texas

January 21, 1953

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OF

THE SEVENTH ANNUAL

RIO GRANDE VALLEY HORTICULTURAL INSTITUTE

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January 21, 1953

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Ground Water Quality in the Lower Rio Grande Valley of Texas – R. E. Daniell, Soil Conservation Service, Harlingen, Texas.

Fruit and Vegetable Processing – Dr. F. P. Griffith, Head, U. S. D. A. Fruit and Vegetable Products Laboratory, Weslaco, Texas.

Onion Breeding for South Texas – Dr. Bruce Perry, Superintendent, Texas Experiment Station No. 19, Winter Haven, Texas.

The Rio Grande Watershed – Karl F. Keeler, International Boundary and Water Commission, Laredo, Texas.

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Problems of the Valley Vegetable Industry – Austin Anson, Executive Manager, Texas Citrus and Vegetable Growers and Shippers Association.

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What's Ahead in Texas Citrus – Charles A. Rogers, Chairman of the Texas Citrus Commission, Weslaco, Texas.

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Address of Welcome

N. P. MAXWELL, *President, Rio Grande Valley Horticultural Club*

It is a pleasure to welcome you to the seventh annual Rio Grande Valley Horticultural Institute. We hope that you will enjoy the program selected by this year's institute committee.

The first institute was presented by the Rio Grande Valley Horticultural Club in 1946. Dr. Guy W. Adriance, Head of the Horticulture Department of Texas A & M College System, suggested an Institute be held and asked the Horticulture Club to sponsor it. Since that time, the Institute has become an annual event.

I would like to express the appreciation of the Rio Grande Horticulture Club to those who have contributed towards making the seventh institute a success. This includes members of the Rio Grande Valley Horticultural Club, the Staff of the Texas Agricultural Experiment Station, the Staff of Texas A & I Training Center, the Valley Chamber of Commerce, the Valley Farm Bureau, Valley newspapers, Valley radio stations and the business organizations who contributed financial support.

The Institute proceedings includes papers of the talks presented today and other scientific and semi-scientific papers of horticultural research projects. As time passes, a collection of the Institute proceedings will give an account of the horticultural research conducted in the Rio Grande Valley. We believe they will be valuable as a source of horticulture reference material for the Valley.

Again, may I extend a sincere welcome to all of you, and I hope that you will feel your day was well spent.

Observations On The Effects Of Salinity And Water Table On Young Grapefruit Trees[1]

G. A. PEARSON AND J. A. GOSS[2]

Very little published information is available describing the effects of water table or a combination of water table and salinity on the growth of plants. Such problems arise in parts of Texas where citrus is grown and may be expected to develop in other areas and with other crops where similar conditions prevail. This paper presents some preliminary observations on the response of young grapefruit trees to several salinity levels and water-table conditions resulting from an experiment conducted at the U. S. Salinity Laboratory, Riverside, Calif. A more detailed report will be presented at a later date.

Experimental Design

In February, 1951, Ruby red grapefruit trees on Cleopatra Mandarin rootstock[3] were set out in 72 lysimeters equipped with float valves permitting careful control of the water table. The Cleopatra Mandarin rootstock was selected because of its relative salt tolerance (Cooper and Edwards, 1950; Cooper, Gorton and Olson, 1952). The lysimeters are constructed of concrete tile 20 inches in diameter and 54 inches deep containing 50 inches of Pachappa loam soil.

The trees were allowed to become established in the lysimeters until April, 1952 at which time differential treatments were initiated. At that time, there was still some variability among the trees, but it was possible to group them in such a manner as to establish 12 treatments, each treatment being replicated six times. The trees of any one replicate were selected so as to be as nearly comparable as possible.

The 12 treatments included all combinations of four water-table treatments and three salinity levels attained by adding different amounts of salt to the irrigation water.

The water-table treatments and designations are as follows:

1. No water table.
2. Water table maintained constantly at two feet below the surface of the soil.

[1]Contribution from the U. S. Salinity Laboratory, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, Riverside, California in cooperation with the seventeen Western States and the Territory of Hawaii.

[2]Associate and Junior Plant Physiologist, respectively.

[3]The authors wish to thank Dr. W. C. Cooper, Division of Fruit and Nut Crops and Diseases, U. S. Department of Agriculture, Weslaco, Texas for advice and suggestions concerning the design of the experiment and cooperation in the procurement of the grapefruit trees.

3. Water table raised to one foot below the soil surface at each irrigation and gradually lowered to allow for drainage before the next irrigation (approximately two weeks).
4. Water table raised to one foot below the soil surface in the spring and in the fall and lowered at such a rate as to require approximately one month for drainage.

The salt concentrations and designations of the irrigation waters are as follows:

A. Riverside tap water (approximately 300 p.p.m. salt).

B. Tap water plus 2,000 p.p.m. of a 50-50 mixture of sodium and calcium chlorides.

C. Tap water plus 4,000 p.p.m. of a 50-50 mixture of sodium and calcium chlorides.

These treatments were initiated on April 9, 1952 at which time the water table was raised to one foot below the soil surface in treatments 3 and 4. On May 20, the water table of treatment 4 (seasonal water table) had reached the bottom of the lysimeter. This treatment was allowed to drain after each irrigation subsequent to that time, but will be raised to within one foot of the soil surface during the fall rainy season.

The salinity status of each lysimeter is being determined by periodic soil sampling and measurement of the electrical conductivity of the saturation extracts (ECe). The results obtained to date are summarized in table 1. The water table imposed in treatments 2 and 3 is tending to result in an increased salt concentration in that portion of the lysimeter in which the major root activity probably occurs. This build-up of salts in the active-root zone might be expected to accentuate the effects of a given salinity treatment.

Table 1. Average ECe values for six replicates resulting from the various treatments, in millimhos/cm.

Water-table treatment	*Depth of sampling, inches*	*May, 1952*			*September, 1952*		
		A *300 ppm*	*B* *2300 ppm*	*C* *4300 ppm*	*A* *300 ppm*	*B* *2300 ppm*	*C* *4300 ppm*
1	0-48	0.8	3.5	7.2	1.4	6.8	8.5
2	0-24	1.7	3.8	6.4	2.2	10.8	11.6
3	0-48	.6	3.4	5.9	1.0	4.0	6.6
3	0-12	.8	6.0	9.1	2.0	6.4	8.7
4	0-48	.9	3.3	4.5	1.2	6.5	8.9

Observations

The experiment was designed in such a manner that the effects of water table or salinity independently, or a combination of these two factors might be compared to that obtained under normal conditions.

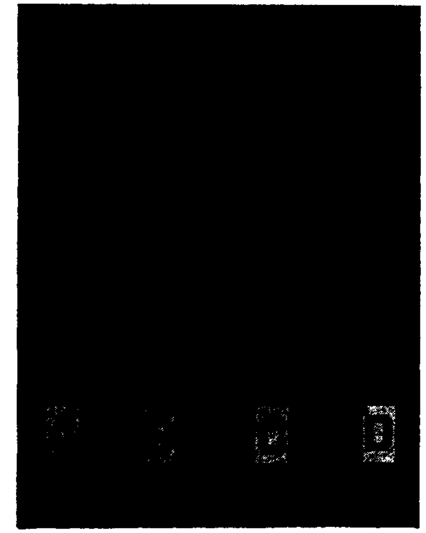


Fig. 1. A. Normal green leaf. B. Mottling associated with a high water table. C and D. Bronzed and burned leaves from trees irrigated with saline water.

In general, a high water table (treatment 2 or 3) caused a distinct mottling of the leaves. This mottling is characterized by an intense yellowing of the midribs and major veins as shown in figure 1B. As the season progressed these leaves turned completely yellow and fell from the tree (figure 4).

High salt concentrations in the irrigation water were associated with a bronzing and burning of the leaves (figures 1 C and D). The most saline irrigation water (4,300 p.p.m.) also caused defoliation (figure 3) and in conjunction with fluctuating water table, dieback as well as defoliation (figure 5). A comparison of figures 2, 3, 4 and 5 indicates that the interaction of water table and salinity affects young grapefruit trees much more drastically than either condition alone.

Fig. 2. Normal tree. (November 24, 1952)

Fig. 3. Saline water (4300 p.p.m.), no water table. Note bronzed leaves and partial defoliation. (November 24, 1952)

Fig. 4. Nonsaline water, fluctuating water table. Note partial defoliation and mottled leaves. (November 24, 1952)

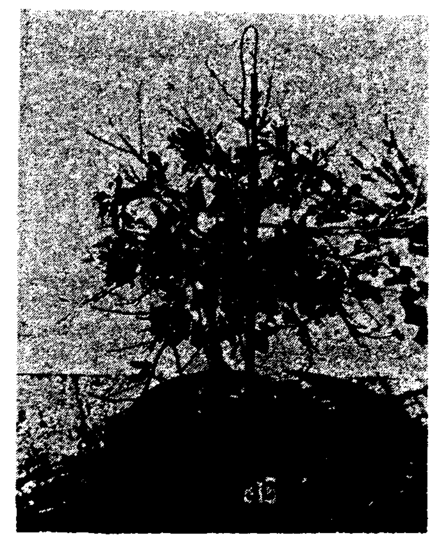


Fig. 5. Saline water (4300 p.p.m.), fluctuating water table. Spring cycle leaves have abscised, summer leaves are stunted and bronzed. Note progressive dieback. (November 24, 1952)

Table 2 gives the approximate time that the majority of the trees in any of the treatments receiving the most saline irrigation water: (1) began to drop their leaves, (2) had lost all leaves of the spring cycle or older, and (3) showed pronounced dieback of twigs.

Table 2. Effect of water-table treatment in conjunction with saline water (4300 p.p.m.) on leaf-drop and dieback of twigs.

Water-table treatment	*Leaf-drop started*	*Leaf-drop completed*	*Twig dieback started*
3–Raised to one foot below the soil surface at each irrigation	Mid-July	August	Late August to early September
2–Maintained at two feet below the soil surface	Mid-July	Early October	No dieback as of November
4–Raised to one foot below the soil surface in April. Receded slowly.	Mid-July	October (3 of 6 trees)	No dieback as of November
1–No water table	September	October (3 of 6 trees)	No dieback as of November

Although all trees irrigated with the most saline irrigation water lost some of their leaves, the rate of defoliation was greatly accelerated by adverse water-table conditions. A frequently fluctuating water table (treatment 3C, figure 5) caused complete defoliation of spring cycle leaves and twig dieback before any other treatment exhibited these symptoms.

By early August, the trees receiving water with an intermediate salt content were developing symptoms related to the water-table treatment in very much the same sequence as that described for the trees receiving irrigation water with a higher salt concentration. Some of those trees receiving nonsaline irrigation water combined with a fluctuating water table (treatment 3A) started to lose their leaves in early November. None of the trees on the other water-table treatments receiving nonsaline water are showing abnormal abscission.

While water table has caused an increase in the concentration of salts in the soil solution and has probably had an effect on root development, the results of water table and salinity on root development, mineral composition of the trees, and related problems cannot be evaluated at this time.

Literature Cited

Cooper, W. C. and Edwards, C. 1950. Salt and boron tolerance of Shary red grapefruit and Valencia orange on sour orange and Cleopatra Mandarin rootstocks. Proc. Rio Grande Valley Citrus and Vegetable Institute 4: 58-79.

————————, Gorton, B. S. and Olson, E. O. 1952. Ionic accumulation in citrus as influenced by rootstock and scion and concentration of salts and boron in the substrate. Plant Physiol. 27: 191-203.

Ground Water Quality In Lower Rio Grande Valley, Texas

ROBERT E. DANIELL, *Soil Conservation Service, Harlingen*

The permanence of any irrigated area depends on the quality as well as the quantity of the water. The inadequate supply of water from the Rio Grande River has caused increased activity in seeking a supply of underground water for irrigation in the Lower Rio Grande Valley. Many wells have been drilled in this area in the past several years and water from some of these wells has been used for irrigation. This paper deals principally with quality of irrigation water as applied to conditions in the Lower Rio Grande Valley.

There are three ways salts may be harmful to the productiveness of the soil. (1) Salts may accumulate in a soil to the extent that plant growth is retarded. This is what is called a saline soil. The excess soluble salts in such a soil prevent the plant roots from taking up enough water for optimum plant growth. The soil solution has such a high concentration of salts that it is not possible for water to pass from the soil into the roots of the plant.

(2) Sodium, when in sufficient quantities in the soil in relation to the soluble calcium and magnesium, will exchange with the calcium and magnesium on the clay colloid to form an alkali soil. Sodium soils are dispersed soils. They have much lower permeability than normal soils. Water containing a high percentage of sodium in relation to the other bases is detrimental to the soil. An alkali soil is not a good medium for high production of crops.

(3) Some salts in the soil may actually be toxic to plants. Chlorides and boron are two elements that may be taken up by plants in large enough quantities to interfere with the plants' growth. Chlorides and boron are especially toxic to citrus. They may accumulate in citrus leaves to the extent that they interfere with the normal functioning of the leaves and thus production is limited.

Therefore, for permanent irrigated agriculture, the water that is used should not add more salts to the soil than can be leached downward below the root zone. It should not contain amounts of sodium in proportion to the other bases that will form an alkali soil nor should it contain excess chlorides or boron that will permit toxic amounts of these elements to be taken up by the plants.

From this we can see that the desirability of water for irrigation use depends on these factors:

1. Total amounts of salts in the water
2. Amount of sodium in proportion to the other bases (calcium, magnesium, and potassium)
3. Amount of chlorides
4. Amount of boron

All underground water contains salts. Table I shows the total salt content from a few of the shallow wells drilled during the last two years in the Valley. The amount of dissolved salts varies considerably.

Whenever irrigation water is applied to the land, salt is added to the soil. The amount of salt that accumulates in the soil depends on the amount of salt in the irrigation water, the amount of water applied to the soil and the sub-surface drainage of the soil.

From Table I it can be seen that water in many of the wells has enough soluble salts to produce saline soils over a period of years, especially in those areas that do not have adequate sub-surface drainage. Characteristic of many areas in the Valley is the existence several feet below the surface of a heavy clay layer which prevents much leaching of excess salts below the root zone. Where excess water has to be applied to the soil to continually flush out large amounts of excess salts, the water table in these areas is raised to a dangerous level and thus causes a saline soil. Where the water table is near enough to the surface of the soil, water will rise by capillary action and evaporate from the surface thus leaving salts near or at the surface of the soil.

Table 1. Total salt content in typical shallow wells in central and lower part of Lower Rio Grande Valley.

Well No.	*Depth of Well*	*Total Salt Content*	
	Ft.	*ppm*	*t.a.f.*
1	26	1749	2.4
2	21	1270	1.7
3	58	2513	3.4
4	15	2800	3.8
5	30	960	1.3
6	20	2384	3.2
7	30	5220	7.0
8	–	8203	11.2
9	22	3089	4.1

When irrigation water approaches 2000 parts per million of total salts, the other factors such as kind of soil, efficiency of irrigation and kind of crop to be grown should be thoroughly investigated before the water is used.

The sodium percentage or the ratio of the amount of sodium to the total amount of calcium, magnesium, potassium and sodium is a very important factor in determining the desirability of water for irrigation. When the percent of sodium is above 60% of the total bases, the sodium will replace the calcium on the clay colloids to form an alkali soil. Sodium soils are characterized by their lower permeability and running together of the surface to form a crust that transmits air and water very slowly. This soil dispersion or running together is detrimental to good plant growth.

It should be emphasized here that the high sodium percentage affects the physical and chemical make-up of the soil. When this takes place to a great enough degree, it is necessary to apply soil amendments such as gypsum or sulfur to reclaim the soil and bring it back to productiveness.

If waters high in sodium percentage but very low in total salts are used, gypsum might be added to the soil and prevent the formation of an alkali soil. Sulfur can be substituted for gypsum where there is enough calcium in the soil to combine with the oxidized sulfur to form gypsum. However, if the water contains a large amount of total salts and a high sodium percentage, it would take large amounts of gypsum and then it would not be likely that the water could be safely used.

From Table 2 it can be seen that many of the wells in the Lower Rio Grande Valley have water that has excess sodium percentage; some have an extremely high sodium percentage.

Table 2. Analysis of waters from wells in Lower Rio Grande Valley.

Well	*Depth of Well Ft.*	*Total Salts ppm*	*% of Sodium*	*Chlorides ppm*	*Boron ppm*
12	162	1016	53	115	–
13	147	2551	53	589	–
14	150	2945	76	750	–
15	160	2095	75	385	–
16	174	3546	76	1195	–
17	–	3840	58	1429	5.0
18	–	2400	89	780	5.2
19	–	720	58	102	0.4
20	334	3010	90	894	–

Table 2 also shows that water from many wells in the Valley have high chlorides and boron. It has been found and reported that water containing more than 250 parts per million of chlorides is injurious to citrus. Slightly higher contents can be used for most other crops.

Water containing more than 1 part per million of boron is not considered suitable to be used for citrus.

Generally in the Rio Grande Valley, the waters high in boron or chlorides are associated with a high total salt content.

Most of the soils in the Lower Rio Grande Valley are considered suitable for irrigation. However, some soils are easier leached of salts than others; that is, some of them have better permeability and subsurface drainage than others. Water with moderately high total salts can be used on those soils that have good permeability and sub-surface drainage with less damage than on soils of low permeability or a slowly permeable sub-strata layer. If the soil and sub-strata has good permeability, accumulated salts can be leached by adding slight excesses of irrigation water or by letting the rainfall flush the salts downward. In areas where the water table is likely to rise if excess water is applied, one should be extremely cautious in trying to do too much leaching. In such cases damage may be done by creating a very high water table and thus make it more difficult to leach the salts.

Because of the danger of a water table being formed, another very important factor is efficient irrigation; that is, being able to supply the amount of water the soil and crop needs and no more. It only takes a few inches of excess water to raise a perched water table several feet in a soil. When water contains more salt than normal, it is important that no more water is applied than is necessary, since the more water that is applied, the more salt is added.

Therefore, efficient application of water is very important. This should include not only the application of the proper amounts of water but also even distribution of this water. The soil management and irrigation system should also be such that all of the rainfall is utilized for plant growth and leaching. Since the saline or alkali soils are less permeable than normal soils, it may be necessary to level the land to get even distribution of rainfall and irrigation water.

Where irrigation water is not of good or excellent quality, the crops to be grown should be adjusted. Perhaps vegetables should not be grown as often, as they are usually irrigated frequently thus tending towards an accumulation of salts. Such crops as grass, especially the more salt tolerant ones (Angletongrass, Coastal Bermudagrass and Rhodesgrass), can be more safely grown with water of questionable quality since the grass roots will keep the soil open and salts can be more easily leached. At the same time the grass roots will grow deep into the soil and utilize more of the rainfall.

From the analysis of water in Tables 1 and 2, one can see the variability of the ground water in this area. These are just a few analyses of water from Rio Grande Valley wells but the trend indicates that a majority of the wells have a higher salt content than is desirable for use as irrigation. The sodium percentage on many of the wells is such that it will seriously affect the soil over a period of years. Also, usually associated with a high salt content is a high boron and chloride content which will affect such crops as citrus.

Of 227 analyses of water in Lower Rio Grande Valley that the author had access to, 108 of these showed a total salt content of more than 2000 parts per million, 34 had a salt content of 1500 to 2000 ppm, 56 had a salt content of 1000 to 1500 ppm, and only 29 had a salt content less than 1000 parts per million. The analyses referred to were made by Soil Conservation Service, Weslaco Agricultural Experiment Station, San Benito Water District, and Central Power and Light Company.

Of 118 water samples for which the sodium percentage was available, 74 of these had a sodium percentage above 60%.

It is apparent that before water is applied to the land in this area, a

complete analysis of the water should be made. After an analysis has been made and there is doubt about the suitability of the water for irrigation, advice and recommendations can be obtained from agricultural agencies or workers such as the Soil Conservation Service technicians who are cooperating with the Southmost and Willacy-Hidalgo Soil Conservation Districts.

Influence Of Mild Winters On Peaches And Other Deciduous Fruits In South Texas

E. Mortensen, *Texas Agricultural Experiment Station, Winter Haven*

INTRODUCTION

In South Texas many commercial varieties of deciduous fruit, such as the Elberta peach, fail to blossom or leaf-out normally except following unusually cold winters. The few flowers, if any, which appear following a mild winter are usually shed without setting fruit. Sometimes, leaves are delayed in coming out or, in some severe cases, may fail to appear on young twigs. This condition was first described as "delayed foliation" and the cause attributed to unseasonably high temperatures and bright sunlight accompanied by low humidity in February (Horne *et al*, 1926). The injury to twigs also gave rise to the term "dieback" in extreme cases (Reinecke, 1931).

Attempts to discover a definite chilling index for various varieties has not met with much success (Chandler et al, 1937, and Yarnell, 1939). In addition to the effects of temperature, sunlight is also a factor. G. D. B. de Villiers (1940) has devised a radiation index to forecast delayed foliation in South Africa. Too much direct sunlight during winter days tends to prolong dormancy because it raises the temperature of buds and twigs (Bennett, 1940).

Methods and Materials

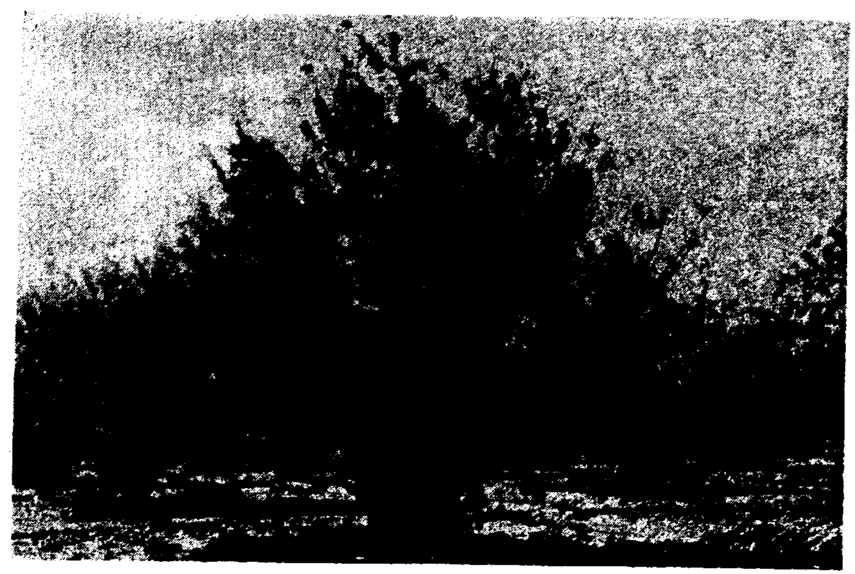
Variety plantings of peaches, plums, apricots and other deciduous fruits were made in 1931 and later years at the Winter Garden Experiment Station, Winter Haven, Texas. These were grown under irrigation at the usual commercial spacing and records kept of flowering and fruiting. Temperature and relative humidity readings were taken daily in a standard U. S. Weather Bureau installation. Sunshine was calculated from the number of clear, partly cloudy and cloudy days recorded. Thermograph records were kept for 11 years but were not available for the whole period. Hours below 45°F. were obtained from the thermograph charts. Estimates of crop performance are based on Elberta or similar peach varieties. No crop records are available for 1942 because of a severe hail on April 7.

Results and Discussion

Records of performance for 16 crop seasons are given in table 1 together with total hours below 45°F, average daily temperature, sunshine index and average relative humidity for each preceeding winter season.

Each of the 3 good crop years for which thermograph records are available had 500 or more hours of temperatures below 45°F. The 3 poor crop years had 553, 269 and 446 hours below 45°F., respectively. This does not indicate a clear correlation between hours below 45°F. and fruit set although there is a trend toward good crops with a high number of hours of cold.

Up-to-Date peach, July, 1952, showing delayed foliation. Contrast with sprouts of 61302 rootstock at base and portion of Peento peach tree at right.



Melba peach in foreground July, 1952, showing lack of foliation on the twigs.

Comparison of the average daily temperatures for the winter season from November through March with the crop performance in the following season is given in table 1. In the 5 years when good peach crops occurred, the average daily winter temperature varied from 57.6 to 59.9. In the 5 poor years the average daily winter temperature ranged from 58.7 to 62.9. These data show no definite correlation of average daily winter temperature with fruit set but does indicate a trend toward poor crops following winters with high average temperatures.

The sunshine index for the same seasons shows that in good crop years the average for the preceding winter varied from 46 to 62. Preceding the years with poor fruit crops the index varied from 44 to 66. There was no definite correlation of sunshine index with fruit set. However, there was a trend toward poor crops when the previous winter had above normal sunshine.

The average relative humidity for the five good crop years ranged from 68.5 to 75.7 percent. For the five poor years the range was 60.6 to 81.2 percent. There is no direct correlation between the average relative humidity readings for the winter months with the fruit crop for the following season.

These results demonstrate that several factors affect blossoming, fruit set and yield of peaches and some other deciduous fruits in South Texas. While there is no definite correlation with any one factor, it can be said that poor crops tend to follow winters with high temperatures and high

Table 1. Influence of Mild Winters on Peach Crops at Winter Haven, Texas.

Season	*Total hours below 45°F. Nov.-Mar.*	*Average Daily temperatures. Nov.-Mar. degree F.*	*Sunshine Index** Dec.-Feb.*	*Average Relative humidity Dec.-Feb. Percent*	*Peach crop following season*
1935-1936	*	59.0	55	75.7	good
1936-1937	556	58.5	46	69.4	good
1937-1938	539	61.5	44	76.3	fair
1938-1939	563	60.5	59	62.3	poor
1939-1940	655	57.6	62	68.5	good
1940-1941	269	58.7	50	74.7	poor
1941-1942	530	58.6	51	72.9	hail, no crop
1942-1943	446	61.5	66	71.9	poor
1943-1944	453	59.6	52	78.0	fair
1944-1945	347	60.7	53	79.6	fair (hail)
1945-1946	480	60.2	57	75.9	fair
1946-1947	846	57.6	55	71.7	good
1947-1948	*	58.7	51	77.0	fair***
1948-1949	*	59.9	46	75.6	good
1949-1950	*	62.9	44	81.2	poor
1950-1951	*	60.1	71	66.7	fair
1951-1952	*	62.3	63	60.6	poor

*Thermograph records not available.

**Obtained by assigning a value of 90 to clear days, 50 to partly cloudy and 10 to cloudy days.

***March freeze destroyed much of crop.

Table 2. Response of fruit varieties following mild winters.

Fruit	*Normal leafage and crop*	*Delayed foliation in extreme years*	*Crops in 50% of years*	*Crops only 25% of years*	*No crops any years*
Apples	Transcendent Crab	Delicious Helm San Jacinto Bledsoe	Texas Red		
Apricots		Trevatt Toyahvale Royal Tilton		Cluster Real	
Cherry	Nanking	Hansen Bush	Sapa Opata		Early Richmond Hanska
Peaches	Saucer (Peento) Honey Smith C. O. Smith Waldo PI 61302 Tardio Amarillo Jewel Luttichau A. P. Johnson Chinese Dwarf	Babcock Frank Lukens Imperial Pallas Salwey Strawberry Free Shalil Melba Chilow	Bokhara Hiley Leona Belle Bestmay Carpenter Greensboro Japan Dwarf Katherine Anna Texaberta	Admiral Dewey Best June Carman Curry Elberta Mamie Ross Mikado Millers Late Palora Slappey Somerset Stanford Katie Tena Barbara	Arp Briggs Red May Early Wheeler Heath Cling Indian Cling J. H. Hale Red Bird Stinson
Pears	Douglas LeConte Pineapple	Garber	Wilder Early	Winter Bartlett	Gorham Bartlett
Plums	Methley Hunt Shiro Excelsior Kelsey	Bruce Beauty Munson Bests Hybrid Santa Rosa Duarte Burbank Wickson America			
Walnut	Thomas Black			Grande	

sunshine. Good crops tend to follow winters with below-normal temperatures and sunshine normal or below. No indication of any effect of relative humidity is shown.

The most promising solution to the difficulties caused by mild winters is to plant varieties that are adapted to such conditions. Table 2 gives a classification of varieties on the basis of their performance following mild winters at Winter Haven. The variation in performance indicates the importance of planting adapted varieties of deciduous fruits in South Texas.

Varieties rated as adapted to mild winters in other areas may suffer from delayed foliation in South Texas. An example is a recent planting of young trees of ten new varieties especially developed for mild winters in Southern California. All of these were more or less retarded in leafing out following the extremely mild winter of 1951-52. Silver Lode nectarine and Sunglow and Redwing peaches had normal leafage by summer. Those with about medium leafage included Bobolink and Panamint nectarines and Meadow Lark, Pioneer and Robin peaches. This was about the same as Babcock. Two apple varieties, Beverly Hills and Valmore, had only scant foliage by midsummer. In comparison with these Jewel, Saucer, Lukens, Smith and Chinese Dwarf showed no delay in flowering or leafing.

Burbank plum, July, 1952, showing delayed foliation.

Trevatt apricot, which normally shows no disorders in leafing or blossoming, in the spring of 1952 blossomed and set a normal crop of fruit without producing leaves. Leaves gradually appeared from the base and gained full leafage by summer. There were two separate bloom periods, about February 8 and April 7 and two sets of fruit. The delay in leafing caused a month to 6 weeks delay in ripening of the fruit.

Summary

Fruit yields of peaches, apricots and other deciduous fruits are compared with climatological records for 16 crop seasons at Winter Haven, Texas.

Several factors affect blossoming, fruit set and yields of peaches and some other deciduous fruits in South Texas. No definite correlation was found between fruit yields and any one climatological factor. There was a trend toward poor crops following winters with unusually high temperatures and high sunshine. Good crops are usually preceded by winters with below normal temperatures and with sunshine normal or below. No effect of relative humidity was shown.

The most promising solution to the difficulties caused by mild winters is to plant varieties known to be adapted to these conditions. Varieties adapted to mild winters in Southern California are not necessarily adapted to South Texas winters. The performance of 95 varieties of apple, apricot, cherry, peach, pear, plum and walnut is summarized.

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Varieties And Strains Of Citrus Originating In The Lower Rio Grande Valley Of Texas

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The citrus industry is comparatively young in Texas considering that citrus fruits have been cultivated for thousands of years in the Orient. They are native to southwest Asia, Indo-China, South China, and the Philippines. From the Orient the various types and varieties spread to other parts of the world along the trade routes. On his second voyage to the New World in 1493 Columbus stopped off for two days early in October at Gomera, Grand Canary Islands, where he purchased livestock, fruit and vegetable seeds, among which were "seeds of orange, lemon, and citrons." He reached the island of Hisponiola on November 22, 1493 and, in the course of establishing a colony, he "set out orchards, and planted gardens." Citrus fruits were established at St. Augustine, eastern Florida, by 1591. They were introduced into southern California in 1769 by Franciscan monks at San Diego, and there were undoubtedly many similar introductions into Mexico and other regions settled by the Spanish. The early settlers secured orange trees from the missions, and a number of plantings were found in private gardens in the 1830's and 1840's in the vicinity of Los Angeles.

In general, it may be said that grapefruit has been America's contribution to citrus culture. Grapefruit first attained commercial importance in the United States between 1880 and 1885, when the first grapefruit were shipped from Florida to Philadelphia and New York markets. Its recognition in Florida as an appetizing breakfast fruit gradually changed this curiosity of the citrus family into a rival of the sweet orange in the national diet.

The grapefruit industry in the Southwest California and Arizona began after the introduction of the Marsh variety in 1890. The planting of other varieties previous to that time did not prove profitable.

The historical records of citrus introduction into Texas are not very clear. It is no doubt similar to the history of Lower California where the first introductions were made by the Franciscan monks. Many citrus seedlings have been found in mission yards along the Gulf Coast, and the Rio Grande. The age of these trees is unknown. At the Bryan Ranch, about ten miles out of Brazoria, in Brazoria County, H. Arnold Hume (1909) examined seedlings that were planted in 1849 and grown from seed thought to have been brought from Louisiana. Hume also reported seedlings near Beaumont in the Neches River district, planted in 1850 and 1855 from seed obtained from Mexico. These seedlings were frozen back many times but sprouted out again and, after a few years, again bore fruit.

One of the earliest orchard plantings in Texas is reported to be at Alvin. Satsuma trees on trifoliata rootstock were planted in 1893 by Mr. E. S. Stockwell. Another grove, at Arcadia, planted in 1901 by Mr. J. M. Powers, contained 200 trees and, in 1907, yielded an income of $400. The

Satsuma was popular in the Gulf Coast area, having proved its cold resistance in the freeze in Florida of 1894-5. By the beginning of the twentieth century, recurrent freezes had demonstrated that consistent citrus production could not be expected in the region north of the Lower Rio Grande Valley.

The oldest seedling citrus trees known in the Lower Rio Grande Valley still exist and still bear fruit (Sasser and Atwood, 1950). They were planted by Don Macedona on the La Guna Seco Ranch, located in the redlands twenty miles northwest of Edinburg in the early 1880's. The seed was brought from the interior of Mexico.

Up to 1899 citrus fruits were grown for home use only and no particular attention was given to rootstocks. Seedlings and trees budded on trifoliata stock were planted. The resistance to frost shown by budded trees led to extensive use of trifoliate stock during the following decade. Difficulties were encountered as trifoliate stock dwarfed the scion varieties and itself was subject to foot rot and cotton root rot (Traub and Robinson, 1937). Charles J. Volz, pioneer Texas citrus grower, demonstrated the value of sour orange rootstock for citrus in the Lower Rio Grande Valley in 1908. This demonstration proved to be a turning point in the development of the citrus industry in this section. The citrus shipments from this section consisted mainly of grapefruit reached 13 carlots in 1921, and over 52,000 carlots in 1939-40. The seedless type of grapefruit varieties and its pink and red fleshed mutations aided the new industry in meeting a favorable reception in the many markets.

Texas has contributed many varieties to world citrus culture. Many citrus varieties grown in the Lower Rio Grande Valley have been described by members of the Texas Agricultural Experiment Station (Friend and Wood, 1941; and Maxwell, 1948). Fawcett (1948) also listed the origin of several strains of red grapefruit in a report of psorosis survey in the Valley. These earlier reports provided a description of certain varieties and strains that had originated in Texas. In order to preserve a more complete record, the original propagators or discoverers of certain strains were asked to describe the history of the individual strains and varieties with which they were directly concerned. This information is considered of value because certain of these men have died or left the Valley since they were interviewed. This paper, a summary of interviews over a five year period. presents a record of the origin of certain Texas varieties and strains that may be of interest to the industry in the future.

ORANGE

DUGAT ORANGE—This variety was considered by Hume to be the most important Texas variety in 1909. The tree was purchased from California and planted in 1871 in the yard of Mrs. W. S. Dugat. of Beeville. The tree bore fruit three years after planting, and its round fruit attracted much attention. This variety, now propagated in limited quantities in one nursery, has been replaced by other varieties. The original tree was purchased as a Satsuma, but proved to be a Dugat orange.

CURRY EARLY ORANGE—Mr. R. B. Curry, of Edinburg, investigated a seedling tree on a ranch north of Edinburg in 1926. It is believed the seed for the original seedling tree was brought in from Spain. This seedling tree produced an orange with larger size than the Hamlin and with the texture of a Valencia. Mr. Curry took budwood and propagated several trees which were planted on his place near Edinburg. These trees produced fruit that were sweet in August. This orange, which has very few seeds and takes "color-add" nicely, has been accepted as an outstanding early orange. Mr. Curry claims the seedling parent tree to be from the "Ruby King" orange. It appears that it may be a seedling selection of the Ruby orange, and that the name may have been a reference to its location on the King Ranch.

MARRS EARLY ORANGE—In 1925, Mr. O. F. Marrs, of Donna, ordered trees from the Nuisbickle Warren Nursery, in California and 26 Navel orange trees were among those received. In 1927 Mr. Marrs discovered that a limb on one tree hung almost to the ground with heavy clusters of perfectly round fruit with no navels. Due to the heavy clusters of fruit on the one limb, budwood was not available until 1929 when 200 trees were budded from the sport. In 1929 freeze all but four budded trees were lost. The next year Mr. Marrs budded 200 more trees from the sport, but again lost all but six trees in the freeze that year. The ten trees remaining were planted and were heavily laden with fruit in 1933 when the September hurricane hit, twisting and splitting the small trees and tearing the sport limb from the original mother tree. In a short time, however, the young trees were again producing fruit. Mr. Marrs budded the progeny for five successive years to prove to himself that it was a true bud strain. The first trees were sold in 1940.

The trees bear cluster fruit at an early age. The fruit is uniform in size and pass the maturity test in late August and early September. The trees do not grow large but produce heavy crops.

Information on the Marrs Early Orange was supplied by Miss Gwynevere Marrs.

TEXAS NAVEL—While the Texas Navel is not a true Texas contribution to world citriculture, it deserves mention as a Texas variety. It is believed to be a bud strain of the Washington Navel selected in 1916 near Bahia, Brazil. It was introduced and distributed by the United States Department of Agriculture as S.P.I. No. 37783. In 1924, W. H. Friend, of Texas Experiment Station, Weslaco, obtained budwood from the U. S. Department of Agriculture. The trees at the Experiment Station proved to be superior to most of the Navel orange varieties under test at that time (Friend and Wood, 1941). Commercial plantings of this variety proved to be very productive in some areas of the Valley, while in others it had no advantages over the Washington Navel.

RED VALENCIA—In 1949 a nurseryman in the Edinburg area discovered a sport on a Valencia tree producing red-skinned and red-meated fruit. The sport limb was so small that only graft wood was available. Several grafts from the sport were made, but the young trees were lost in the freeze of 1951. Another attempt is being made to propagate from it.

LEMON

KENNEDY LEMON—In 1900 lemon seeds were planted of fruit brought by boat to Corpus Christi. It is believed the fruit came from Spain. The seed was planted by a Mr. Turcotte, an employee of Mr. John G. Kennedy, Sr., and the fruit from this tree took first prize at the World's Fair in 1904. At the time of the interview, Mrs. John G. Kennedy still had several ribbons that were won at various fairs throughout the United States. About 1905, the gardener of the Kennedy Ranch took bud sticks from this tree and budded them on seedlings in the Valley for Mr. Robert Holbert.

In 1909, the Kennedy Lemon was considered a variety of high quality. It was smooth-skinned and chemical analysis showed it contains 68.69 percent juice and the juice contains 7.40 percent acid (Hume, 1909). The trees appear to be quite hardy and very prolific and the fruit is seedless.

LIMON—Mr. Ballard, of Weslaco, who was interviewed, cut buds from a seedling lime tree at Tamazunchale, Mexico in 1923. In 1925, the trees propagated from this thorny lime seedling were frozen to the ground. One of the trees sprouted at the ground and came back. This thornless tree bore its fruit in 1930. The fruit was thin-skinned and was less oval and had fewer seeds than its thorny parent. The variety was described as a heavy producer and the large, green fruit can be sold as a lime, while the yellow fruit can be sold as a lemon. Mr. Ballard stated that each propagation makes the limon trees less cold hardy.

GRAPEFRUIT

HOLLERBACH SEEDLESS FOSTER—In 1928 seedless fruit were found in some of the fruit taken from the A. J. Barga Grove of 40 Foster Pink Grapefruit trees purchased from Florida. The sport tree was not located until three years later. After the death of Mr. Barga, a Mr. Jenks propagated nursery stock from buds of the Barga grove which he planted 2 miles north of Mission. It was in this planting the seedless sport was found in 1932, by Joseph Hollerbach, according to Mr. E. W. Halstead. The fruit resembles the Foster in every respect, except that it is seedless.

HENNINGER RUBY RED—In 1926 Mr. Albert E. Henninger, of McAllen, purchased several Thompson Pink Marsh trees from a Mr. Hart, of McAllen. These trees were shipped to Texas from the Reasoner Brothers, of the Royal Palm Nursery, Oneco Florida. While harvesting the fruit crop from these pink grapefruit trees in the spring of 1929, several fruit showed a red color on the peel skin and a deep red flesh. The sport limb was located in the fall of the same year. Buds were taken and its progeny produced fruit the same as the sport limb. In 1934 Mr. Henninger proved the merit of the new variety and was granted a United States patent. This variety was the first citrus fruit ever to be patented. This report was supplied by Mr. Henninger.

WEBB REDBLUSH—In 1926 Dr. J. B. Webb, of Donna, purchased three Thompson Pink Marsh trees from the Sam J. Baker Nursery who purchased the trees from Reasoner Brothers of the Royal Palms Nursery, Oneco, Florida. These three trees were part of a shipment of trees from

Florida that was divided on arrival between Mr. Baker and Mr. Hart.

Dr. Webb planted the three trees close to his house. In 1929 he purchased enough Thompson Pink trees to plant four acres. While cultivating around the young trees, the mule broke loose and broke the top from one of the young trees. Dr. Webb allowed the rootstock to sucker and then cut a bud stick from one of the original Pink Marsh trees near his house and budded the damaged tree.

In 1931 Dr. Webb noticed the fruit on the rebudded tree was larger than that on the other young Pink Marsh trees. He also found a red blush on the outer skin and a deep red flesh. The original sport limb on the tree near the house was lost in the freeze of 1930. Several generations of nursery stock, propagated from the young tree, showed the same red blush and red flesh. Later, buds were taken from the young tree to topwork the remaining trees in the four acre planting to this new variety, Webb Red Blush, to increase the budwood supply. The original red tree is still alive and productive.

This information was supplied by Dr. Webb.

RIDDLE RED GOLD—According to Mr. H. W. Riddle, of San Juan, he purchased 112 Foster Pink Grapefruit trees from Mr. Hart, of McAllen, Texas in 1928. The trees were shipped from Florida and were planted two miles south on Steward Road, San Juan. In harvesting the fruit in 1930-31, Mr. Riddle noticed the fruit on one of three limbs of a single tree had a red outer skin and deep red flesh.

CURRY RED RADIANCE—In 1926 Mr. John Shary purchased three Thompson Pink grapefruit trees from an unidentified nursery in Florida. These trees were planted in an orchard near Mission. Early in 1928, Mr. R. B. Curry cut budwood from one of these trees and budded his own seedlings. In the fall of 1929 he set these trees out in his orchard just south of Edinburg. In 1934 Mr. Curry discovered that a sport limb on one pink grapefruit tree was producing fruit showing red on the exterior and deep red flesh. Budded trees from this sport limb produced the same red fruit.

This information was given by Mr. and Mrs. R. B. Curry.

LANGFORD RED NO. 1—According to Mr. T. F. Langford, of Weslaco, he purchased several Thompson Pink Marsh grapefruit trees from Mr. Hart, of McAllen. Mr. Hart had purchased these trees from the Glen St. Mary Nursery in Florida in 1926. In 1930 Mr. Langford noticed that the fruit on one limb of one Pink Marsh tree showed a red blush on the outside skin and a bright red flesh. Trees propagated from this sport limb produced the same red fruit.

LANGFORD RED NO. 2—In 1929 Mr. T. F. Langford, of Weslaco, made a second purchase of Marsh Pink grapefruit trees. This group of trees was purchased from a Mr. Nichols who had obtained the trees from the Glen St. Mary Nursery in Florida. These trees were planted in his grove southeast of Weslaco. In 1932 Mr. Langford found a sport limb on

one of these trees producing red-meated fruit. This tree was seldom used as a bud source, according to Mr. Langford, because the fruit was smaller than that on the first sport limb. This tree later proved to be infected with Psorosis (Fawcett, 1948) and was therefore unsuitable for further propagation.

SHARY RED—In 1927 a Mr. Brisco purchased 150 Pink grapefruit trees from a nursery in Florida. These trees were planted on the Klatt Ranch near Mission. In 1932, Mr. Klatt discovered a sport limb on one tree producing a red-blushed, red-meated fruit. According to Mr. Klatt, who propagated 500 trees for a Mr. Krusemark, the trees were divided and planted in two locations. Both groves produced heavy crops of large-sized red fruit.

BALLARD RED—In 1923 a Dr. Larriby, of Weslaco planted 5 acres of White Marsh grapefruit trees purchased from the Glen St. Mary Nursery in Florida. This grove was later known as the Mehaffey Grove. During the fruit harvest in 1927, Chester Ballard noted that the bottom limb on one White Marsh tree produced red blush and red meated fruit. The progeny from this strain was called the Ballard Red, according to Mr. E. Ballard.

STANFIELD RED—In 1923 Mr. T. F. Langford, of Weslaco purchased White Marsh grapefruit trees from a Mr. Black to plant several acres on his place southeast of Weslaco. Mr. Black purchased the stock from the Glen St. Mary Nursery of Florida.

In 1931 Mr. Stanfield, of Weslaco cut budwood from these White Marsh trees to propagate trees for his own grove. In 1942 a picker discovered red fruit on one of the trees and called Mr. Stanfield's attention to it. The sport limb was located and buds were taken the next year. The progeny of this sport produced fruit with a heavy red blush and a deep red meat.

This information was supplied by Mr. T. Langford and Mr. Stanfield.

FAWCETT RED—According to Mr. F. Everhard, a Mr. G. Barnes purchased Marsh Pink trees in 1932 from the Miller Brothers Nursery, of San Juan, to plant 20 acres north of Alamo. In 1940 Mr. Everhard, of Pharr, noticed red fruit mixed in with pink fruit from the Barnes Grove going through the packing shed. The fruit seemed to be of superior quality, so the next year Mr. Everhard checked the grove and found that one tree in the grove of pinks produced only red fruit. Progeny from this sport tree have produced excellent quality red fruit and, in 1948, this strain was named the Fawcett Red in honor of Dr. Howard Samuel Fawcett, world-known citrus pathologist of California, who passed away that year.

Many other sports have been reported in the Lower Rio Grande Valley of Texas. Several of these red meated mutations have been found in the Goodwin Groves, at Mission, and as many as seven in one small grove at the Baker-Potts Nursery near Harlingen. In recent years several have been discovered in pink grapefruit groves in Florida, where one grower has registered such a strain.

Each nurseryman claims that his strain of red grapefruit is superior. Observations made on different strains at widely scattered locations indicate that some strains were early maturing, while others proved midseason and others later. Some strains had larger sizes, some showed a deeper red color of meat and held their color longer. In other years, distinctly different results were obtained. The early plantings of these varieties or strains of red grapefruit were planted on different soils, the cultural practices were different in each case, and the trees were different ages. Thus, a variation in fruit characteristics would be expected.

Many feel that some or all of these red strains may be the same and that the variation is due to differences in soils and cultural practices. Mr. N. Maxwell, of the Texas Experiment Station in Weslaco, is growing the most widely used strains in replicated blocks on both Cleo and Sour orange rootstocks on the same soil, with the same cultivation, irrigation and fertilization practices. The results from this test should determine if there are consistent differences between these strains of red grapefruit.

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Cotton Root Rot Of Various Citrus Rootstock Seedlings[1]

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INTRODUCTION

Cotton root rot, a disease caused by *Phymatotrichum omnivorum*, is known to kill citrus trees in the Rio Grande Valley. The sour orange rootstock appears to be highly resistant to the disease, but the relative susceptibility to cotton root rot of many other rootstocks now being tested in the Rio Grande Valley is unknown.

The first reports of cotton root rot on citrus were by Bach (1929), who reported it occurred occasionally on sour orange stocks. Streets (1937) mentioned two instances of cotton root rot of citrus in Arizona. Inoculation studies by Bach indicated that the sour orange was slightly susceptible and that the trifoliate orange and Cleopatra mandarin were very susceptible. Where cotton root rot was prevalent, Bach (1931) recommended that growers avoid intercropping between young trees with very susceptible crops, such as sweet potatoes, cotton or okra.

Taubenhaus and Ezekiel (1936) considered that roots of the sour orange and the trifoliate orange were resistant. Lemon, citron and satsuma on their own roots were considered moderately susceptible; and Mexican limes, grapefruit, tangerine, and sweet orange on their own roots were considered highly susceptible.

Rigler and Greathouse (1940) reported that the hybrid Meyer lemon, in contrast to other lemon varieties, is resistant to cotton root rot.

Additional observations made by the junior writer during 1946 on the occurrence of cotton root rot of citrus in the Lower Rio Grande Valley have not been previously published. Thirty orange trees on sour orange rootstock in a two-year-old grove near LaFeria, Texas, died from cotton root rot. The losses occurred during a rainy period in early summer, and only where cotton root rot was extremely severe in alfalfa closely adjacent to the trees. After the alfalfa was destroyed by disking, and the moisture content of the soil was reduced by dry weather, no new losses occurred, either that year or in subsequent years. Thus, extremely heavy soil infestation and a continued period of moisture conditions favorable for the development of the disease appeared to be necessary for cotton root rot attack of the sour orange rootstock. A two-year-old citrus tree (variety not recorded) on sweet orange root also died of cotton root rot in June 1946 at Substation 15.

In studies made by the junior writer during 1946, *P. omnivorum* inocula was grown by the method of Dunlap (1941). This inocula was used to infest the soil of plots where cotton plants were interspersed between

[1]These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the U. S. Department of Agriculture, certain phases of which were carried on under the Research Marketing Act of 1946. The cooperation of Rio Farms, Inc., Monte Alto, is greatly appreciated.

year-old seedlings of Cleopatra mandarin and sour orange. In August, 1946, 31.7 percent of the cotton plants were affected with cotton root rot. Neither sour orange nor Cleopatra mandarin showed infection of their root systems even though Phymatotrichum hyphae were seen in abundance in cotton roots intermingled with the citrus roots.

Olson (1952) reported that seedling trees killed by *P. omnivorum* in experiments during 1951 were of the following varieties or species: Yalaha and Watt tangelos, Ponkan and Willowleaf mandarins, Thong Dee and Siam pummelo, Leonardy grapefruit, Hamlin orange, Moroccan lemon, trifoliate orange, *Severinia buxifolia*, Rangpur lime, and Lakeland limequat.

This article reports progress during 1952 of studies to determine the relative susceptibility of various citrus species and varieties to cotton root rot.

MATERIALS AND METHODS

Three separate collections of citrus rootstock seedlings were used in these investigations. One was located at Rio Farms, Inc. at Monte Alto, Texas, and the other two at the Texas Agricultural Experiment Substation 15 at Weslaco, Texas.

The Rio Farms planting consisted of sour orange and twenty other varieties and species of citrus. The trees were planted in two plots arranged in a series of five latin squares in each plot. The individual latin squares were 15 feet by 15 feet and consisted of five rows of trees with one tree of each of five rootstocks in each row. Sour orange was included as a standard or control in each latin square. Thus, four test rootstocks in addition to sour orange were included in each latin square. Thus, the original planting consisted of 10 trees of each of 20 rootstocks and 50 trees of sour orange.

The trees in these plots were originally budded to grapefruit for studies of boron tolerance, one plot receiving canal water and the duplicate plot receiving water containing 6 p.p.m. boron (Cooper and Gorton, 1951). The freeze of January, 1951 killed the grapefruit scions but many of the rootstocks remained alive (Cooper, 1952) and developed into small trees during the Spring of 1951. Some trees had died from various causes prior to the start of the root-rot tests.

The two rootstock collections at Substation 15 were planted in plots similar to those described for the Rio Farms planting. Work on one of these collections, consisting of more than 40 varieties, was begun in 1950. The second planting was made in December of 1951 and consisted of 24 varieties of citrus seedlings.

Phymatotrichum omnivorum, isolated from cotton, was used to infest soil in 1950, and a culture isolated from natural infection of a Lakeland limequat seedling was used in subsequent inoculations. Cultures of *P. omnivorum*, grown on a soil-milo mixture (Dunlap, 1941), were added to the soil adjacent to the trees in plots of the Rio Farms planting in July,

1951, and the soil of the Substation 15 plots in May, 1950 and May, 1952, respectively. Cotton and alfalfa interplanted between the trees of the infested plots died of cotton root rot during the summer.

The occurrence of typical wilt symptoms and subsequent death of citrus seedlings was recorded.

RESULTS

In these experiments the above-ground symptoms of cotton root rot on citrus showed first as a yellowing of the foliage of the trees, which often were less vigorous than healthy trees. In some cases the leaf wilt symptom developed slowly. In other cases the leaves wilted suddenly, and the trees died within a few days. In either case the dried leaves hung to the dead tree. Below-ground symptoms on recently killed trees were the brown strands and the characteristic acicular, cruciform hyphae of *P. omnivorum* on the wet and disintegrating bark of the tap root and larger lateral roots. A white spore mat of *P. omnivorum*, which later turned tan in color, sometimes formed on the surface of the soil around the base of the affected tree, usually when the surface soil remained moist for extended periods.

The number of seedling trees of various varieties dying from cotton root rot at Rio Farms is recorded in table 1. Most of these trees were

Table 1. Susceptibility of citrus seedlings to cotton root rot during 1952 at Rio Farms plots, inoculated in 1951.

Rootstock variety	*No. deaths from cotton root rot*	*No. alive Sept. 1952*
Sour orange	0	5
Williams tangelo	0	4
Minneola tangelo	0	4
Sampson tangelo	1	7
Florida sweet orange	4	5
Sour orange	0	9
Pineapple orange	2	8
Cuban shaddock	1	9
Nakorn pummelo	3	6
Duncan grapefruit	0	7
Sour orange	0	10
Rough lemon	0	9
Rangpur lime	0	9
Sweet lemon	0	9
Columbian sweet lime	0	7
Sour orange	0	10
Cleopatra mandarin	1	4
Calamondin	1	9
C. noblis	0	1
Rusk citrange	1	5
Sour orange	0	7
Trifoliate orange	1	0
Severinia buxifolia	1	8
Citron	0	3
Citrumelo No. 4475	0	4

three to five feet tall at the time death occurred. The Florida Sweet and Pineapple orange, and the Nakorn pummelo seedlings appeared to be more susceptible than the other varieties in the test. Other seedling trees killed by cotton root rot were of the following varieties or species: Sampson tangelo, Cuban shaddock, Cleopatra mandarin, calamondin, Rusk citrange, trifoliate orange and *Severinia buxifolia*. None of the sour orange seedlings died from cotton root rot during 1952.

Various seedlings died from cotton root rot in the Substation 15 seedling collection grown in plots infested with *P. omnivorum* in 1950. These results are reported in table 2. Susceptible varieties not previously re-

Table 2. Susceptibility of citrus seedlings to cotton root rot during 1951-1952 at Substation 15 plots, inoculated in 1950.

Variety[a]	*No. Deaths from Cotton root rot* 1951	1952	*No. Alive Sept. 1952*
Sour orange	0	0	40
Cleopatra mandarin	0	1	9
Ponkan mandarin	1	0	0
Willowleaf mandarin	1	0	1
Sunki mandarin	0	0	12
Leonardy grapefruit	1	0	11
Duncan grapefruit	0	0	7
Thong Dee pummelo	2	2	4
Siam pummelo	1	1	2
Columbian sweet lime	0	0	1
Rangpur lime	1	0	12
Rough lemon	0	0	5
Sweet lemon	0	0	3
Hamlin orange	1	0	5
Fla. Sweet	0	0	3
Yalaha tangelo	2	0	1
Minneola tangelo	0	0	7
Watt tangelo	1	1	15
Williams tangelo	0	0	4
Trifoliate orange	1	1	5
Citrumelo No. 4475	0	1	2
Sanders citrange	0	0	7
Calamondin	0	1	1
Severinia buxifolia	1	0	1
Clementine tangerine	0	1	3
Citrus noblis	0	1	0
Moroccan lemon	0	1	0

[a]A number of other varieties included in this collection have been omitted from this table because of other complicating factors, which include freeze injury, other diseases, and different dates of planting.

corded (Olson, 1952) included Cleopatra mandarin, citrumelo 4475, calamondin, Clementine tangerine, and *Citrus noblis*.

In the other Substation 15 collection (data not included), transplanted in December, 1951, various seedlings were killed by cotton root rot in certain plots where *P. omnimorum* infected volunteer alfalfa. Three of 10 Koa Phuang shaddock seedlings died during the summer of 1952. One seedling each of Dancy tangerine, Changsha mandarin, and Altoona tangelo also died of cotton root rot.

DISCUSSION

The experiments described in this paper are not sufficient to determine the relative susceptibility of species and varieties of citrus rootstock seedlings. However, it has been demonstrated again that certain rootstocks were more susceptible to cotton root rot than the sour orange.

A promising rootstock for the Lower Rio Grande Valley is the Cleopatra mandarin, which is tolerant of tristeza and more tolerant to salt than the sour orange (Cooper and Gorton, 1951). Of the small number of Cleopatra mandarin seedlings that were tested, plants died at two separate locations. Bach (1929) also considered the Cleopatra mandarin to be susceptible. It may be hazardous for nurserymen to line out Cleopatra mandarin seedlings on land infested with cotton root rot, a successful practice with sour orange seedlings.

On the basis of present knowledge, cotton root rot is a minor disease of Texas citrus on sour orange rootstock. However, it may become important if *P. omnivorum* builds up in susceptible crops grown adjacent to young trees on susceptible rootstocks.

SUMMARY

Collections of rootstock seedlings were grown on soil infested with *P. omnivorum*, the cause of cotton root rot. The number and variety of seedlings showing foliage wilt and subsequent death is reported.

Sour orange seedlings were highly resistant to cotton root rot, while seedling pummelo, shaddock, and sweet orange varieties tended to be susceptible. Cleopatra mandarin seedlings died of cotton root rot at each of two locations. In addition seedling trees killed by cotton root rot included the following: mandarin, tangerine, tangelo, lemon, trifoliate orange, *Severinia buxifolia*, Rangpur lime, limequat, citrange, citrumelo and *Citrus noblis*.

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An Old-Citrus-Soil Problem In The Lower Rio Grande Valley

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Replanted citrus trees have been observed to grow not as vigorously or as rapidly as the trees that were first planted in certain groves in the Lower Rio Grande Valley. A similar problem in replanting citrus orchard land occurs in California where reduced yields have followed retardation in growth. On some soils in California, Martin and Batchelor (1952) have reported that fruit production has been reduced as much as 20 to 60 percent in replanted groves compared to comparable yields of the first planting. Such a condition may occur in the Lower Rio Grande Valley a few years hence, when the groves now being replanted come into production. However, one would expect that the problem of obtaining satisfactory growth and production on a replanted grove site would be more serious on land that had been in citrus for several years. Because of the tremendous replanting program that will take place in the next few years to replace the groves lost by the 1951 freeze and droughts which followed and possible replacements of trees killed by diseases, an investigation was started in 1951 to determine the cause or causes of retarded growth of replanted citrus trees and to develop remedial measures.

The problem associated with retarded growth and reduced production of citrus trees growing on land planted a second or third time to citrus, or the replacement of single trees has been commonly called an old-citrus-soil problem. It is doubtless a complex problem and may be caused by one or more conditions or factors, or combination of factors. Some of the probable causes or contributing factors are the citrus-root nematode, other parasitic root feeding nematodes, pathogenic organisms as Pythium, Phytophthora, Fusarium, etc., toxic substances resulting from several years growth of citrus, a nutritional unbalance as depletion or excessive accumulation of certain chemical substances, and physical and chemical changes in the soil itself. Baines (1950) has shown that citrus trees infested with citrus-root nematodes grow more slowly than uninfested trees. A survey made in 1951 (Sleeth 1952) disclosed that the citrus-root nematode was well distributed throughout the citrus growing area of the Lower Rio Grande Valley. Thus we know that at least one of the probable factors associated with the old-citrus-soil problem is present in the Valley. Evidence that factors other than nematodes are involved is indicated by the positive results obtained in California (Martin and Batchelor, 1952, Aldrich and Martin 1952) by the use of fumigant dosages 2 to 10 times higher than the commercial recommended dosages for nematode control.

A test was recently completed which was set-up to determine if an old-citrus-soil problem existed in the Lower Rio Grande Valley. It was found that an application of 800 pounds per acre of D-D (a mixture of dichloropropane and dichloropropene) increased the growth of one-year-old sour orange seedlings nearly 50 percent in one instance. The increase in growth, as might be expected, varied with soil source. The increase resulting from fumigation was 15 percent for soil from grove A, 45 percent for soil from grove B and 49 percent for soil from grove C. In the case of non-citrus soil the increase in growth was 13 percent, which may have been caused by a stimulating effect of the fumigant. The non-citrus soil results indicate that if soil fumigants are properly used, no injurious or deleterious effects will likely occur. It is interesting to note that these results were obtained by the use of what might be considered a minimum dosage for old-citrus-soils. The results would undoubtedly have been more striking if a dosage rate of 3000 to 4000 pounds per acre had been used.

The results of this test confirms the existence of an old-citrus-soil problem in this area and also indicates that soil fumigation has possibilities as a control measure. Much additional work needs to be done to determine the cause or causes of the trouble; the seriousness of the problem as related to age of grove to be replanted, to soil type and structure, to cultural practices and crop rotation; the most effective fumigant and dosage for different soil types; and to work out the most economical and practical control measures possible. We can profit much by the work done elsewhere and take some short-cuts but it is going to take a lot of hard work and the cooperation of Valley citrus growers with the research workers to solve this problem in the Lower Rio Grande Valley. The present extensive replanting program has greatly intensified the need for finding out, as soon as we can, how serious is the old-citrus-soil problem and what to do about it.

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Avoiding Some Hazards In Banking Trees

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The desirability of banking young trees for protection against freeze damage is well established and has long been in practice. Certainly the need for it was demonstrated in the Lower Rio Grande Valley in the recent damaging freezes. It is justified for its insurance value alone. Then, if the season proves to be a really cold one, the saving of valuable trees far more than justifies the cost. Simply banking soil around the tree alone is not sufficient. The application of supplementary treatments and precautions will avoid certain hazards that go with the banking.

Protecting the Bark Against Decay

The most disastrous consequence of *not* doing this that I know of occurred one year when some 40-odd 2-year old trees in a young planting died in the banks. This was in April (later than normal for unbanking) and the warm moist soil around the trunks was an unnatural condition which was more than they could take. Laboratory studies showed several different fungi in areas of decayed bark on the trunks, among them Fusarium, Rhizoctonia and even *Sclerotium rolfsii* which is ordinarily found only on soft-stemmed vegetables.

A simple pre-banking fungicidal treatment of the portion of the trunk to be covered will give complete protection against bark decay caused by soil organisms. In my experience a cuprous oxide (Cuprocide) water paint has given the best results. A thin paint is first made by stirring water into a pan of Cuprocide until the paste is uniform in consistency. This paste may then be diluted still further with water until the concentration of the copper compound is about 2 per cent by weight. About 3 ounces to a gallon of water is right. This must be stirred frequently while in use since the copper is heavy and will sink to the bottom. Application with a brush from a shallow container will keep it well mixed. As the paint becomes thicker, added water will renew its original consistency and will extend its use to a good many more trees.

The exact thickness of the water paint of cuprous oxide does not make much difference so long as a distinct reddish color is evident on the trunk after drying. In a test on a young 10-acre grove, two paints were used, one double the concentration of the other. When the trees were unbanked in the spring the color was still plain in both. As long as the color is there the decay preventive agent is there and serving its purpose. In this test no damage took place on the trunks, either from the paint or from decay. Incidentally, in this same test a Bordeaux paste had been applied experimentally on a few rows, and when the banks were removed scarcely a trace of it was to be found, since it had flaked off.

Sometimes ants or termites damage the bark of the trees in the bank. An improvement in the all-around efficiency of the paint, therefore, can be brought about by adding an insect repellant. One of the best is chlordane. One pound of the 40 per cent wettable chlordane to 25 gallons of the diluted paint (2/3 ounce to 1 gallon) is recommended. This can be made into a thin paste and poured into the diluted paint, or it can be mixed with the Cuprocide paste before diluting. Never use any kind of arsenic compound for this purpose. Many trees have been killed by doing so.

Removal of Dead Wood

A dead branch or stub or unprotected pruning wounds on the lower part of the tree can easily be the points of entrance of wood decay fungi, especially in grapefruit, if covered with soil for a considerable period. By starting early enough in the fall, in preparation for banking, it is possible (and advisable) to remove sour orange suckers and dead stubs and to treat the wounds with a good tree-wound paint. It would be advisable at the same time to renew the coating on the wounds left after the disastrous freeze of early 1951.

Height of the Bank

Even a too low bank might be considered one of the hazards of banking. As we all know now, since it is so fresh in our memories, the higher the bank the better – to a reasonable degree – on 1, 2 and 3 year old trees in a severe freeze. Covering the bases of framework branches if possible is desirable. Certainly a quicker and better top can be built with shoots from framework branches than with those from irregular intervals on the uninjured base of the trunk. This, incidentally, is a strong argument for low-headed rather than high-headed nursery trees. Even now it might be well to repair and raise the banks in anticipation of a possible late January freeze.

Structure of the Bank

It is best to avoid getting undecayed trash such as grass and leaves into the bank. Trash may loosen the soil and make it more penetrable to cold than straight soil. Also the decaying of the trash in the soil may have a harmful effect on the tree. Excessive wet soil should not be used in the bank. Make the bank fairly compact by tapping with the shovel.

Avoid the Use of Sulphur in the Bank

Some years ago a campaign for applications of sulphur in citrus groves induced some growers actually to apply sulphur in the soil used for banking. Following this, one grower brought to the Station some dead and near-dead trees, and reported that a lot of his trees were in the same condition, still in the banks. By chance, particles of sulphur were seen in the soil still clinging to the bottom of the tree trunk. A test showed that this clinging soil had a pH of 1.25, which means a terrific lot of acid. The trees were burned to death by the acid developed from the sulphur.

Removing the Banks

This should normally be done in March after probable danger from a freeze is over. There is reason to believe that it is advisable to do this gradually, starting on the shady side (north) in order to dry the soil and harden the bank before exposing the soft bark on the south side to the hot sun of early spring. In a week or two the remainder of the bank can then be levelled down.

A Survey Of Freeze Damage To Citrus Trees In The Lower Rio Grande Valley And Its Effect Upon Fruit Quality

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The freeze of December 6th, 1950 was the first of two damaging cold periods to strike the Valley during the winter of 1950-51. It was a radiant type freeze and of rather short duration although the temperatures reached a low of 18°F. in the Upper Valley and 29°F. in the Brownsville are. It was at once apparent that fruit injury was spotty even within a given orchard or on a given tree. This survey was undertaken in an attempt to determine the extent of tree and fruit damage as well as to provide some information on the effect of fruit quality factors following such a freeze.

Materials and Methods

In view of the variability of minimum temperature readings throughout the Valley the latter was divided into four areas for the purpose of sampling. Area A included the Mission-McAllen district; Area B, the Donna-Mercedes region; Area C, Adams Gardens; and Area D, the Brownsville-Bayview locale. In each area a typical grove was selected for sampling, divided into three blocks and 18 fruits on the outer periphery of the trees and 18 fruits on the inside were harvested at random within each block.

Factors Considered

1. *Fruit Flavor.* The samples of inside and outside fruits from each block and area were judged for flavor and given a numerical value on the following basis: (1) very good; (2) good; (3) fair; and (4) poor.

2. *Fruit Texture.* The fruits were catalogued for flesh texture in the same manner as they were for flavor; i.e., very good, good, fair, and poor.

3. *Hesperidin Crystals.* The degree of crystal formation occurring in the orange samples was classified as None (1), Few (2), and Many (3).

4. *Soluble Solids.* Soluble solids were quantitatively determined with a hand refractometer by taking two readings of juice from the stem end and two readings from the blossom end of each of 18 fruits from the outside canopy of the trees and 18 fruits from the inside. This method was followed in sampling both oranges and grapefruit in all blocks in all four areas.

Notes were also taken as to the general appearance of the trees in the four areas under observation.

Results

The mean values for fruit flavor for both oranges and grapefruit in respect to position on the tree and location in the Valley are shown in table 1. The flavor of the Bayview fruit was the least affected by the freeze and on the average the fruit of both oranges and grapefruit was rated only slightly less than very good. In fact, the flavor of fruit from the Bayview area was significantly better than from any other area with the exception of grapefruit from the Weslaco area. The difference between the flavor of fruit from the outside canopy of the trees as compared to fruit from the inside was not great enough to be statistically significant, although there was a tendency for the outside fruit to be slightly better. The fruit in the Adams Gardens area had the lowest flavor rating.

The disposition of the means for fruit texture shown in table 2 fol-

Table 1. Mean Evaluations for Fruit Flavor in Oranges and Grapefruit for Outside and Inside Fruit from Four Locations in the Valley following December 1950 Freeze.

	Grapefruit			*Oranges*		
	Position of Fruit on Tree			*Position of Fruit on Tree*		
Location	*Outside*	*Inside*	*Average*	*Outside*	*Inside*	*Average*
McAllen	1.87	1.31	1.59	1.74	1.33	1.54
Weslaco	1.59	1.46	1.53	1.82	1.35	1.58
Adam's Gardens	2.17	1.84	2.00	2.37	1.83	2.10
Bayview	1.35	1.15	1.25	1.04	1.00	1.02
Average	1.75	1.44		1.74	1.38	

Grapefruit: Location L.S.D. at 5% = .31; L.S.D. at 1% = .47
Position L.S.D. at 1% = .49; 5% = .34

Oranges: Location L.S.D. at 5% = .40; 1% = .58
Position L.S.D. at 5% = .12; 1% = .19

Table 2. Mean Evaluations for Fruit Texture in Oranges and Grapefruit for Outside and Inside Fruit from Four Locations in the Valley following December 1950 Freeze.

	Grapefruit			*Oranges*		
	Position of Fruit on Tree			*Position of Fruit on Tree*		
Location	*Outside*	*Inside*	*Average*	*Outside*	*Inside*	*Average*
McAllen	3.44	3.00	3.22	3.22	2.72	2.97
Weslaco	3.00	2.24	2.67	3.42	3.11	3.27
Adam's Gardens	3.81	3.48	3.65	3.80	3.85	3.83
Bayview	2.37	1.79	2.08	1.67	1.61	1.64
Average	3.16	2.63		3.03	2.82	

Grapefruit: Location L.S.D. at 5% = .45; L.S.D. at 1% = .68
Position L.S.D. at 5% = .18; L.S.D. at 1% = .26

Oranges: Location L.S.D. at 5% = .45; L.S.D. at 1% = .68
Position L.S.D. at 5% = .45; L.S.D. at 1% = .66

lowed in general the trends established by fruit flavor. The fruit in the Adam's Garden area was lowest in texture rating averaging about halfway between fair and poor, while at the other end the Bayview fruit had a texture rating between good and very good. The position of the fruit on the tree had little or no effect on the texture of the oranges, but with grapefruit the texture of fruit on the inside of the canopy was much better than on the outside.

The amount of hesperidin crystals present in oranges varied from virtually none to few in the Bayview area and to many in the Adam's Garden area as is shown in table 3. On the average there was no signifi-

Table 3. Mean Evaluations for Hesperidin Crystals found in Oranges from Outside and Inside Fruit from Four Locations in the Valley following December 1950 Freeze.

	Position of Fruit on Tree		
Location	*Outside*	*Inside*	*Average*
McAllen	2.04	1.78	1.91
Weslaco	2.28	1.44	1.86
Adam's Gardens	2.63	2.11	2.37
Bayview	1.09	1.00	1.04
Average	2.01	1.58	

Location L.S.D. at 5% = .54; L.S.D. at 1% = .82
Position L.S.D. at 5% = .63; L.S.D. at 1% = .91

Table 4. Mean Values for Soluble Solids in Oranges and Grapefruit on Inside and Outside Fruit from Four Locations in the Valley following December 1950 Freeze.

	Grapefruit			*Oranges*		
	Position of Fruit on Tree			*Position of Fruit on Tree*		
Location	*Outside*	*Inside*	*Average*	*Outside*	*Inside*	*Average*
McAllen	10.57	10.67	10.62	11.40	10.82	11.11
Weslaco	9.85	9.65	9.75	11.53	10.82	11.17
Adam's Gardens	9.12	9.38	9.25	10.23	9.33	9.78
Bayview	10.58	10.28	10.43	11.22	10.54	10.71
Average	10.03	10.00		11.10	10.38	

Grapefruit: Location L.S.D. at 5% = .52; L.S.D. at 1% = .78
Position L.S.D. at 5% = .28; L.S.D. at 1% = .40

Oranges: Location L.S.D. at 5% = .37; L.S.D. at 1% = .57
Position L.S.D. at 5% = .28; L.S.D. at 1% = .41

cant difference between the amount of crystallization in fruits from the outside of the tree and the inside, but, as might be expected, more outside rruits were found containing crystals than inside fruits.

The soluble solid contents of the juice of fruits from the four observed areas in this study appeared to be the least affected by the freeze. However, as can be seen from table 4, the mean values of soluble solids in fruits from the Adam's Garden area were much lower than the rest which conforms to the trend shown by the data in the three previous tables. It is interesting to note, however, that the effect of the freeze on soluble solid content of the juice was a lowering one, and explains in part the peculiar behavior of the mean soluble solid values from the standpoint of area and position of the tree. The data on fruit quality factors presented earlier in this paper established the fact that the fruit in the Bayview area had suffered no apparent loss in quality. It is reasonable to assume then, that the soluble solid values obtained on fruit from this area represented values which would be obtained under normal conditions. In this case the soluble solid content of juice from outside fruits was higher than inside fruits, the difference being .30% for grapefruit and .68% for oranges. The difference in soluble solids between inside and outside grapefruit in the Adam's Gardens area was a minus .26%, while the difference in the Weslaco and McAllen areas was .20% and .10% respectively. The soluble solid content of the juice of orange fruits did not follow this pattern at all suggesting that the significant difference obtained for position of fruit on the tree was not a difference due to freeze damage, but merely a reflection of the relative state of maturity of the fruit.

Summary

This paper has presented the behavior of certain fruit quality factors of oranges and grapefruit following a sharp radiant type freeze. The factors under observation were fruit flavor, fruit texture, hesperidin crystal formation in oranges and soluble solid content of juice.

Comparisons Of Budding Cleopatra And Sour Orange Seedlings

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The use of Cleopatra mandarin as a citrus rootstock in the Lower Rio Grande Valley of Texas is expected to increase because of its resistance to tristeza. This is a serious virus disease of citrus when sour orange rootstock is used. It has been known for several years in California and is now present in Louisiana and Florida. The performance of Cleo in Florida has been both good and poor, varying with location and soil type. Recently, it has been recommended as a satisfactory rootstock for California after ten years of testing. Less is known about its adaptibility to the Valley because of its more recent introduction. However, it appears to be a promising rootstock under most Valley conditions.

It has been shown by Cooper (1950) that the Cleo rootstock is more resistant to salt injury than the sour orange, which is an advantage in irrigated areas. On the other hand it is somewhat more susceptible to lime-induced chlorosis in the seedling stage than sour orange. Some Texas citrus nurserymen have been reluctant to grow Cleo as a rootstock because it grows slower than sour orange in the seedling stage and is thought to be more susceptible to certain nursery diseases such as damping-off and seedling-tip blight. While some Valley nurserymen claim that they have trouble in getting buds to take on Cleo seedlings, others claim that they can bud Cleo as successfully as sour orange seedlings.

An excellent opportunity was provided to compare the percentage of successfully budded Cleo and sour orange seedlings in the Texas Citrus Registration Program Test Nursery at the Texas Agricultural Experiment Station at Weslaco. This nursery is maintained through the cooperative efforts of the Valley Nurserymen Association, Texas Department of Agriculture and Texas Agricultural Experiment Station for the purpose of testing budwood trees for psorosis and other virus diseases. Within the past 4 years 996 sour orange seedling and 1028 Cleo were successfully budded under comparable conditions.

In the 1948 test block, 4 sour orange and 4 Cleo seedlings were planted in a single row plot. The 8 trees in each plot were all budded with buds from a single parent tree, which was being tested for State registration. The 1948 test block contained 316 plots of 8 trees each, all of which were irrigated, cultivated and fertilized essentially alike. All seedlings were planted on the same day and budded at a later date by a budder furnished by the Nurserymen's Association. The 1950 and 1952 test blocks were treated like the 1948 block, except 3 seedlings of each rootstock were planted in a single row plot instead of 4 seedlings. All the budding in the 1950 and 1952 blocks was done by a single budder, also furnished by the Nurserymen's Association, but not the same person that budded the 1948 block of seedlings. The results obtained on bud takes on the two rootstocks are given in table 1.

The condition of the sour orange seedlings appeared to be more favorable, in most instances, for successful budding than the Cleo when budded. All the seedlings in the 1948 block were budded on the same day, June 15, 1949. The sour orange seedlings were in an ideal condition for budding as the bark slipped readily. The condition of the Cleo seedlings was not as good and, in many instances, the buds had to be forced into place. A bud take count of the first budding was made on August 7, 1949.

The 1950 block of seedlings was budded on March 27, 1951, at which time the bark of both the sour orange and Cleo seedlings slipped well and took buds equally well. The Cleos, however, were somewhat smaller than the sour orange seedlings. A bud take count of the first budding was made on May 3, 1951.

The 1952 block of seedlings was budded on July 10, 1952. The sour orange seedlings were in good condition and were readily budded as the bark slipped well. The Cleo seedlings were smaller than the sour orange and in many places the bark was tight and the bud had to be forced into place. A bud take count of the first budding was made on August 23, 1952.

Of the budded rootstock the percentage of successful bud take was higher than on the sour orange seedlings in all three test blocks. Because of the large number of seedlings involved, it would seem that these comparisons are valid and that Cleo seedlings may be budded as successfully as sour orange under nursery conditions.

The difficulty with Cleo in the test blocks was not getting buds to take but in obtaining a high survival of lined out seedlings. So, the problem of obtaining satisfactory seedling survival and growth may be more

Table 1. Comparative bud take on budded Cleo and sour orange seedlings.*

Rootstock	*Block planted*	*Seedlings lined out*	*Seedling mortality*	*Seedlings budded*	*Successful bud takes*	
	Year	*Number*	*Percent*	*Number*	*Number*	*Percent*
Sour Orange	1948	1264	5	1196	630	52
Cleo	1948	1264	17	1044	739	71
Sour Orange	1950	462	12	406	175	43
Cleo	1950	462	63	170	92	54
Sour Orange	1952	465	4	444	191	43
Cleo	1952	421	29	297	197	66

*Data based on first budding.

difficult than that of budding. From the data presented in Table 1, it would appear that good nurserymen should be as successful in budding Cleo seedlings as sour orange under comparable circumstances.

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Some Beneficial Insects Of Citrus In The Lower Rio Grande Valley Of Texas

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Biological control of citrus insects in the Lower Rio Grande Valley has been generally effective in years past. This area has been widely recognized as an outstanding example of satisfactory, low-cost control by means of beneficial insects. The results have been so good since 1934 that the added cost of scale control by chemicals could seldom be justified. Scale insects, however, had increased to such large population numbers by the Fall of 1950 that many growers had given chemical scale control serious thought. Beneficial insect populations were known to be extremely high at the time. Scale and parasitic insect populations were reduced to extremely low numbers as a result of the freeze of January 29-February 3, 1951. The survival of pest and beneficial insects was a question of considerable importance.

Many citrus growers do not have control over the crops that are planted to the windward side of their orchards. Abnormal increases in certain pest insects have been noted in the first two or three rows of citrus trees adjacent to row crops treated with various insecticides. Most of the chemicals used in the control of insects attacking row crops are known to be toxic to the various beneficial insects in citrus. During the 1951 season, a large number of growers interplanted freeze-injured citrus groves with cotton and other quick-money crops. The number of rows of cotton varied from 2 to 9, depending somewhat on the size of the trees and the width of the citrus tree rows. Very little to no insecticides were applied to the interplanted crops in the 1951 season. A few instances of heavy scale increases were observed where insecticidal applications had been made to interplanted cotton or corn. Heavy infestations of armored scale, aphids and soft scale developed on citrus during the 1952 season where insecticidal treatment was applied to adjacent row crops or to the interplanted crops. Such observations are convincing evidence that chemical control of insects in crops adjacent to citrus trees is many times indirectly harmful to the biological control of citrus insects.

The various pests of citrus found after the freeze and those beneficial insects of importance in biological control are reported in sequence. In certain instances where the pest insects have not been found in large numbers little to no consideration is given. Numerous references are made to unpublished records of the Station. The 1937 annual report of this Station contains a report of the progress (1935-37) on a project entitled, "Biological Control of Citrus Insects." Mr. S. W. Clark, Entomologist of this Station at the time, reported the golden chalcid parasite, *Aphytis chrysomphali* Mercet; *Prospaltella aurantii* How. and various

[1]Acknowledgement is due various members of the Division of Insect Detection and Identification, Washington 25, D. C., and Harold Compere, Division of Biological Control, Citrus Experiment Station, Riverside, California for identifying various insects reported in this paper.

Prospaltella species; and *Aspidiophagus citrinus* Craw. and various *Aspidiophagus* species to be the most abundant citrus scale parasites in this area. A visit was made to the Valley citrus area in 1949 by Dr. Paul De Bach of the Division of Biological Control, Riverside, California, and reference will be made to his findings as reported.

California red scale, Aonidiella aurantii Mask.

The golden chalcid parasite, *A. chrysomphali* Mercet; the unnamed parasite *Aphytis* "A" and the scale feeding lady beetles, *Chilocorus cacti* L. and *Cybocephalus* sp., have been found to be the most important natural enemies of this scale in this area. The latter is a small black elliptical beetle, found in areas of heavy scale insect infestations and does not seem to be of major importance at this time.

Aphytis "A" was introduced into California in 1905 but evidently disappeared for Dr. Paul De Bach of the Citrus Experiment Station, Riverside, California reported by personal correspondence that *Aphytis* "A" was not recovered for a period from 1905 until 1948 when the parasite was again introduced into California from China. Probably the first report of *Aphytis* "A" as occurring in the Valley area was made by De Bach (1951).

Aphytis "A" was found in a grove north of La Feria on March 26, 1952, just before releasing a colony of the parasites furnished by the Division of Biological Control, Riverside, California. Both *Aphytis* parasites were found commonly throughout the Valley in August, 1952.

Yellow scale, Aonidiella citrinus

For all practical purposes, no differentiation has been made between California red and yellow scale. De Bach reported that *A. Chrysomphali* Mercet and *Aphytis* "A" commonly parasitized yellow scale.

A colony of the yellow scale parasite, *Comperiella bifasciata* How. was released in the Engleman Garden's area in 1933, but the parasite has not been recovered. Only chaff and Glover's scale were found on a visit to the grove in the spring of 1952.

Glover's scale, Lepidosaphes gloveri Pack.

Glover's scale has increased to rather high numbers in a few groves since the freeze. The parasite, *Prospaltella aurantii* How. (Burks) or *elongata* Doz. (Compere), was found at every location where this scale was commonly noted.

Clark reported the above parasite to attack yellow scale in 1929 and purple scale in 1936. De Bach (1951) reported *P. elongata* Doz. as frequently parasitizing Glover's scale, and *Aphytis* sp. and *Thysanus* sp. (probably a hyperparasite) being taken from the scale.

Purple scale, Lepidosaphes beckii Newm.

During the past two years, no evidence of parasitism of this scale has been noted on citrus. Clark reported the parasite, *Aspidiophagus cit-*

rinus Craw., attacking the scale in 1937. This parasite was taken from an eleagnus shrub known to be infested with purple scale in October, 1951. De Bach (1950) reported the lady beetle, *Chilocorus cacti* L. as feeding on heavy infestations of the scale.

Only a few scattered infestations of the purple scale have been noted in the Valley. The Division of Biological Control, Riverside, California, furnished colonies of the purple scale parasite, *Aphytis* "X." Two colonies were released in a grove south and west of Weslaco and one colony was released in a grove east of Mercedes. The parasites have apparently established themselves in the first grove. Flanders (1952) reported on the progress of two introduced purple scale parasites, *Physcus* "B" and *Aphytis* "X", from the far east.

Florida Red Scale, Chrysomphalus aonidium Linn.

Although Florida red scale was infesting a large acreage of citrus particularly in the middle part of the Valley before the freeze, the scale insect may be considered non-existent in the area at this time. De Bach (1951) found immature stages of *Aphytis* in the scale. Dean (1952) found numerous specimens of *Pseudohomalapoda prima* Gir. presumably parasitic on this scale just prior to the freeze. The latter parasite has been found following the freeze on an eleagnus shrub heavily infested with the following scale insects: *Aspidiotus lantaniae* Sign., *Chrysomphalus albopictus* Ckll. (or close), yellow and purple. Clark reported the parasite from this scale at only one location.

Chaff scale, Parlatoria pergandii Coms.

Aphytis diaspidis How. has been the only parasite reared from chaff scale following the freeze. High populations have been observed in many instances and it has been found to be the most widely distributed parasite over the Valley area at this time. Ebeling (1950) reported the parasite to be of minor importance in California attacking the lantanae scale, *Hemiberlesia lantaniae* Sign., however, the chaff scale has not been reported in California.

Clark did not report this parasite in 1937. De Bach (1951) reported the parasite to be attacking chaff scale commonly and Dean (1952) reported the parasite to be very numerous during the fall of 1951.

The chaff scale was widely distributed throughout the Valley just prior to the freeze, and during the 18 months following the freeze has been found to be the most widely distributed of the scale insects.

Cottony cushion scale, Icerya purchasi Mask.

Dean (1952) reported a few of the numerous instances of cottony cushion scale infestations on citrus and pittosporum shrubs during 1951. The infestations on citrus usually had vedalia beetles developing at the same time. Humpback flies, *Syneura cocciphila* Coq., are known to be of minor importance in the control of the scale and specimens were taken around infestations at the Experiment Station. The scale was noted on a rare citrus twig or so during 1952 but vedalia beetles or other beneficial

insects have been observed present which have kept populations in small numbers.

Soft scale, Coccus hesperidum Linn.

Soft scale secretes a honey dew which falls to the leaves below. A black sooty mold develops in the sticky substance and causes the leaves to appear to be blackened with carbon black. Ants tend the scale and feed upon the honey dew. Ant control is particularly important if parasites are to be effective in controlling this scale. The acrobat ants which nests in the trees have been found far more numerous in the trees infested with this scale.

Three infestations of soft scale have been observed from time to time during the 1951-52 season. In every case, *Coccophagus lycimnia* Walk. was by far the most numerous parasite found. Clark only reported this one soft scale parasite. At one location this parasite was the only one collected.

Several soft scale parasites were found at an infestation at Mile 11 North and Baseline Road during the fall of 1951. In addition to *C. lycimnia* Walk., a few specimens of *Aneristus youngi* Gir., *Aphycus eriococci* Timb. and *Aphycus* sp. were collected. During January and February, 1952, a few specimens of *Aphycus maculipes* How., *Aphycus flavus* How. and *Thysanus flavopalliatus* Ashm. were collected. In the 1937 report, Clark stated that *T. flavopalliatus* Ashm. was moderately abundant. *Thysanus fasciatus* Grlt. was definitely determined by B. D. Burks as a first record of the parasite in the U. S. A. from February 6th collections. The two *Thysanus* parasites are probably hyperparasitic.

At a location .3 mile west of Sugar Road on Highway 495, grapefruit trees were found in October, 1951 to be very heavily infested with soft scale. *C. lycimnis* Walk. and *T. fasciatus* Grlt. were the only parasites collected. A small lady beetle, *Hyperaspis octonotata* Csy. was found very numerous as were scale and aphid feeding lady beetles, lace-wing flies and other beneficial insects. Soft scale were brought under control during November 1951. During May 1952, heavy infestations had again developed and acrobat ants were as numerous in this grove as in any other grove observed in the Valley.

Aphids

Clark reported the spirea aphid, *Aphis spiraecola* Patch, in 1929 with no particular notation of its attacking citrus until 1937. This aphid has been observed during 1952 attacking citrus and seems to be capable of causing more leaf damage than other aphids. No parasites were taken around such infestations and aphid-feeding lady beetles did not seem to offer much control.

The black citrus aphid, *Toxoptera aurantii* Fonsc., was observed attacking citrus in 1930 and in scattered infestations in 1936 by Clark. During 1952, the aphid was found at one location in the Valley under partial control by the parasite, *Aphidius (Lysiphelebus) testiceipes* Cress.

In November, 1950, the cotton aphid, *Aphis gossypii* Glov., was observed to have attacked young citrus leaves. The cowpea aphid, *Aphis medicaginis* Koch, was found attacking the young flush of scattered citrus trees north and east of Harlingen during April, 1951. These two aphids have not been found to severely attack citrus during the past two years.

Aphids can only feed on the young leaves. When the leaves harden, the aphid must find other food. Ants tend the aphids for the honey-dew secreted by the aphids. Ants disturb the beneficial insects and lowers their effectiveness in controlling citrus insects.

Ants

For maximum effectiveness in the biological control of citrus insects, it is considered necessary to control the following species of ants: the fire ant, *Solenopsis geminata* F.; *Forelius* sp.; a small entirely black acrobat ant, *Cremastogaster orthocrema (arizonensis* or undescribed); and a red-orange and black acrobat ant, *Cremostogaster acrocoelia laeviuscula* Myers. The fire ant and *Forelius* sp. are similar in movement and appearance and come on to the trees from the gorund. The acrobat ants nest in the tree or at the base of the tree trunk.

Roberts (1946) suggested an ant control program in citrus to further parasite and predaceous activity and Dean (1952) emphasized the importance of such a program. If a 10% chlordane dust is used for protection against those ants which infest the trees from the ground, care should be exercised to allow as little dust as possible from drifting on to the trees. All possible places should be treated where ants may gain entrance to the tree. If a spray is used, no less than two pounds of 50% wettable powder or its equivalent should be used. Acrobat ants may best be controlled by painting with a paint brush, a chlordane solution upon the nests in the trees. One tablespoon of 74% chlordane emulsion per gallon of water is a suitable mixture. Precautions should be exercised in the handling of chlordane formulations. Applications should be made in early spring, summer and fall for best results.

Summary

The various beneficial insects as found during the past two years to attack certain citrus pests have been presented. The planting of citrus orchards to the windward side of row crops has been suggested as a means of possible prevention of injurious infestations by certain pest insects. The numerous instances of heavy pest increases were evidence of adverse affect of insecticidal drift on beneficial insect populations.

Although *Aphytis diaspidis* How. has been reported of minor importance as a parasite of lantanae scale in California, the parasite has been found to be of economic importance against chaff scale in this area and to show a decided preference for the scale at this time.

Florida red scale has been found virtually eliminated as a result of the freeze.

Ant control has been emphasized as a good practice in order that maximum efficiency of beneficial insects might be had in the biological control of citrus pest insects.

No attempt has been made in this study to fully evaluate the efficiency of the various beneficial insects of citrus scale insects as several years study will be required for such an evaluation. The efficiency of various beneficial insects will be evaluated in further study as well as the effect of ant control practices and introduction of beneficial insects from other areas in attaining better natural control.

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Chemical Weed Control

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Developments in the field of agricultural chemicals during the past twenty years have been amazing. The number of new materials introduced to replace or supplement older materials opens new horizons for pest control for farmers and commercial growers of plants. Among the most significant of these innovations is the development of new herbicides which has paralleled and has often been more spectacular than the rise of pesticides as a whole.

The control of weeds by chemical means is not a substitute for other methods of weed control such as plowing and hand hoeing. Weed-killing chemicals make it possible to reduce the amount of hand weeding in row crops. In drilled crops and in crops like alfalfa and in pastures they make possible the control of weeds which otherwise would not be controlled. Discoveries of new weed-killing chemicals during the past few years and an understanding of the special techniques necessary to properly apply them are a basis for their successful use.

It is important for every grower to understand that there is no shotgun chemical or method of controlling weeds. The right material must be used in the right way at the right time. This requires a certain amount of basic information regarding herbicides and how to use them. We can divide chemical weedkillers into several general classes, based on the manner in which they act.

Soil Sterilants

Soil sterilants kill by creating a toxic condition in the soil, the duration of which depends on the chemical used and the quantity applied, as well as soil and rainfall factors. Where a vegetation-free condition is desired, materials like the arsenicals, boron, chlorates and, more recently, a new material, CMU, may be used provided sufficiently heavy applications are made and repeat treatments put on as required in the event of some plant recovery. For use these chemicals are formulated in such a way they may be easily handled by the user. Chlorates are formulated by such companies as Chipman Chemical Company under such names as Atlacide. Among the companies offering boron compounds is the Pacific Coast Borax Company which has formulations under such names as Borascu, Concentrated Borascu and others. A relatively new material is called CMU and is offered by the DuPont Company. When used at relatively high dosages this material apparently gives rather long residual effect. At lighter dosages it has been successfully used to selectively weed such crops as cotton. Many of the companies which sell agricultural chemicals have formulations of TCA which, when used at proper dosages will cause temporary sterility and will kill such perennial grasses as Johnson grass and Bermuda grass. At relatively light dosages TCA will kill annual grasses in sugar beets, flax, certain legumes and other crops.

Contact Herbicides

A number of chemicals kill top growth by purely contact action. These materials are not absorbed, translocated and carried into the roots. Also, there is a little likelihood of drift injuring other vegetation in the vicinity, if reasonable care is taken to prevent the spray from actually wetting the other vegetation. In fact, thorough wetting is necessary for these contact herbicides to be effective as weed killers. Small annual weeds and grasses are killed by a single treatment but perennial plants are killed only by repeated application and gradual exhaustion of root reserves. Among the more common contact herbicides are the various oil fractions. Other common contact herbicides are the phenolic compounds applied in oil emulsions. These sprays give a contact action similar to that of straight oil and since they contain considerable water are in many instances less expensive for treating ditch banks, roadsides, orchard areas and fence rows.

These contact herbicides are sometimes used to eradicate annual weeds from such established perennial crops as alfalfa in the season when the alfalfa is relatively dormant or immediately following the cutting of alfalfa. The alfalfa is harmed very little if at all, but most small weeds are killed. In one sense this is a selective spraying technique, yet all exposed vegetation is burned.

Selective Herbicides

When applied under proper conditions and at suitable concentrations, selective weedkillers control weeds without harming crops. There are several types of selective weedkillers, based on the way they affect the plant.

1. Selective wetting of the crop and limited absorption of a toxicant because of leaf wax protection, is one type. If the foliage of these crops is treated while the crop plants are quite small, grains, flax, peas, alfalfa, gladiolus, and under some conditions onions, are difficult to wet by water sprays because of their leaf shape and relatively thick and continuous leaf wax or cutin. That part of the toxicant which does adhere to the plant is not readily absorbed. Salts of certain phenolic derivatives have been widely used for the control of annual weeds, particularly in the United States and Canada. Among the commercial products which are now used as selective herbicides in this category are Sinox-W and Dow Selective Weedkiller, Premerge, Sinox PE, American Cyanamid's Aero Cyanate and others.

2. Another type of selective weedkiller is based on the physiological resistance of carrots, parsley, parsnips and related plants to certain petroleum fractions. Since about 1942, Stoddard Solvent, stove oil and other light petroleum fractions have been used for the selective spraying of carrots and related crops. Why most small weeds are killed by this treatment, while the crops mentioned grow unharmed is not clearly understood. This use is common in the Rio Grande Valley, particularly on small carrots, and I feel that no further discussion is needed.

3. Another type of selectivity is based on the physiological resistance to the herbicidal action of growth regulating substances or plant hormone type of selective weed killers such as 2,4-D 2,4,5-T and MCP. 2,4-D is representative of this group and is selective in that most members of the grass family and some other kinds of plants are not seriously affected by it when it is used in the right way and at the right dosage. They are used as selective weed killers on grain, rice, sugar cane, grass sorghums and corn. If these materials are properly applied, their uses are legion. However, such sensitive plants as grapes, tomatoes, cotton, okra, cucumbers, sweet potatoes, blackeye peas, snap beans and many ornamentals can be adversely affected by very low dosages which are characteristic of spray drift of 2,4-D. Even with liquid sprays, 2,4-D may drift dangerously if applied in winds or if too high pressures are used. Amine formulations are generally considered safer in this respect than are the ester formulations. Certainly I do not need to elaborate on the hazards of this type of weed killer in this area.

This group of herbicides is particularly useful in controlling brush or woody plants. Research work in Texas has shown that 2,4,5-T is much safer to use in the vicinity of cotton than 2,4-D.

Residual Pre-Emergence

Residual pre-emergence means application of such chemicals as DNOSBP, CMU, TCA, CIPC to the soil surface after the crop is planted and before the crop seedlings emerge. These chemicals are applied in dosages large enough to control such small seeded annuals, grasses as crab grass and weeds such as pig weed or amaranthus (commonly called careless weed). The DN compounds such as Sinox PE and Premerge have been used commercially on cotton, corn, potatoes, lima beans, snap beans, field beans, gladiolus, peanuts and English peas.

CMU has been used successfully in tests for residual pre-emergence treatment on cotton, and recent reports indicate possibilities on asparagus and spinach.

Chloro IPC can be used as a residual pre-emergence treatment on cotton, and probably on certain other crops.

For more detailed information on CMU, you should contact representatives of the DuPont Company; and for information on CIPC I suggest that you contact Niagara Chemical Company, Columbia-Southern Chemical Company, or Monsanto Chemical Company. A number of other companies have indicated they will have Chloro IPC available this year.

TCA is being used successfully for residual pre-emergence weed control on such crops as sugar beets and crucifers and is being used experimentally on garden beets. A number of companies offer Sodium TCA.

All of these chemicals have proved successful under weather and soil conditions which are somewhat different from those found in the Rio Grande Valley. All have proved successful where the rainfall during the early growing season was greater than the moisture evaporation from soil

plus plant transpiration. All of these materials work best when application is made on moist soil and where moderate rainfall follows before crop seedlings emerge. Perhaps the use of a sprinkler or overhead irrigation would result in conditions conducive to successful use of these materials in this area.

In many sugar beet growing areas where annual grass is a problem the application of 7 pounds Sodium TCA, 90%, per acre before beets have emerged has given excellent results. However, in some irrigated areas which might be similar to the Lower Rio Grande Valley, this use has not been too successful.

Based on my own experience and on reports from other sources, the indications seem to be that adequate weed control from residual pre-emergence applications is not obtained where row or flood irrigation is practiced. Certainly the Experiment Station workers as well as representatives of the Chemical Companies will continue their work to develop chemicals and techniques so that successful residual pre-emergence applications can result where such irrigation practices are followed. At present our Company (The Dow Chemical Company) cannot recommend residual pre-emergence weed control for use on large scale in the Rio Grande Valley on such crops as cotton, corn, etc.

Other conditions which apparently limit the use of residual pre-emergence weed killers in the Rio Grande Valley are the soil types and method of planting. Apparently this technique is most successful when the chemical is applied to firm, smooth seed beds reasonably free from clods. Often a roller is used to firm and smooth the seed bed after planting. The local method of planting cotton and other crops in a furrow is unfavorable because of untreated soil moving down on the treated area. Cloddy soil does not lend itself to residual pre-emergence weed control.

Contact Pre-Emergence and Pre-Planting Weed Control

Another technique is the use of pre-emergence sprays to destroy the emerging weed seedlings just prior to the emergence of crop plants. In addition to using these sprays after the planting of crops, they can be used to a distinct advantage to clean out weeds immediately before the crop is planted. Cultivation not only destroys weeds but also brings up other weed seeds to the place where they can germinate.

If emergent weeds are killed with chemicals or flame and the crop planted without soil disturbance the crop seedlings often emerge relatively weed free. In this case use a planter with a sword or knife opener and press wheel for covering device.

Contact pre-emergence spraying has certain limitations, but it seems to have a definite place in the production of some crops as a practical method of reducing hand weeding and hoeing costs.

The production of Bell peppers in the Rio Grande Valley is often costly because of the weed problem, particularly in the summer months. I am told that normally it takes about 10 days and two irrigations for pepper seedlings to emerge. By that time a good stand of pigweed as well as other weed species is present. Both Mr. Bill Godbey and Mr. D. J. McAlexander, with some assistance from the writer, have successfully used contact pre-emergence weed control in peppers. The peppers were planted on the sides of the beds in a normal manner and were row-irrigated. In about six days the beds were sprayed with a dilute DN-oil emulsion that was strong enough to kill the weed seedlings. The fields were then irrigated again and the pepper plants came up relatively weed-free. The success of this method depended on several factors as outlined above. The weeds came up several days before the pepper plants emerged. The chemical spray was strong enough to kill the weeds but did not leave a residue which would affect the peppers when they emerged several days later. The chief weed species was pigweed. Sufficient volume of solution was used to wet the tiny weed seedlings.

Spinach has also been treated in South Texas in a similar manner, using a mixture of 5/8 lb. DN plus 1 gal. Diesel oil plus 34 gallons water per acre as an overall spray applied just before the spinach emerged.

Premerge and Sinox PE can be used safely on a number of crops at "come up stage" or even later, and, if germination of weeds and grasses has started, these weeds and grass seedlings will be killed. Due to the irrigation techniques, etc., used in the Rio Grande Valley the length of residual weed control is uncertain. However, based on results from other sections, corn can be treated following emergence up to two or even four inches in height, with dosages ranging from two quarts of Premerge per acre up to one gallon per acre. The low dosage would not be expected to give much residual action and the one gallon per acre on loam soil would be expected to not only kill the weeds which are up but also to kill emerging weeds for several weeks. The injury to corn from the higher dosages would be comparable to frost damage and should not be significant.

Gladiolus can be treated similarly, and will tolerate up to four gallons Premerge per acre when applied before emergence.

Lima beans can be treated in the early crook stage without damage, using dosages up to three gallons Premerge per acre.

Snap beans and field beans will tolerate up to one gallon Premerge per acre overall but should be treated just before the beans emerge.

Potatoes can be treated just before emerging with two quarts Premerge in 30 gallons water in warm, sunny weather to kill weed seedlings. In general, however, recommendation will be four quarts Premerge in 30-50 gallons water per acre just before potatoes emerge.

I am sure that both CMU and CIPC can also be used in numbers of instances, but I do not have detailed information to give you on these products.

This technique of applying weed killers just before crop seedlings emerge (and in certain crops shortly after emergence) should be of considerable value in the Rio Grande Valley since weed and grass seedlings already emerging will be killed. The special problem involved in row or flood irrigation should not be a factor since the weeds are treated rather than the soil. However, if a grower is using this material and technique for the first time he should try a limited acreage until he is thoroughly familiar with the technique. In addition, the information given here unless indicated was developed elsewhere under entirely different conditions than those which may exist in the Valley.

Post-Emergence Weed Control

It is not necessary to discuss selective weeding of carrots with special oil fractions except to refer to the California Experiment Station Circular No. 136 which gives full information on this subject.

On onions, the American Cyanamid Company has been recommending use of their product, Aero Cyanate. When used according to their directions and under the conditions they have set forth, it has generally been successful.

An enormous amount of information on post-emergence weed control on cotton has been developed in the past few years. This involves directional spraying of special herbicidal oils and chemical solutions so that only the base of the cotton stem is contacted with spray.

The cotton plants should be on a low, relatively flat bed approximately two to three inches higher than the middle. The bed should be smooth, flat on top, and free from clods. The special oil fraction is applied to each row by two specially designed spray applicators which are attached to the tractor and spray laterally into the row in such a manner that the oil spray effectively covers a zone eight to ten inches wide which includes the drill region of the row. It seems to be physically impossible with existing equipment and knowledge to successfully use this technique on cotton planted in the furrow. For additional information on use of herbicidal oil on cotton, you should contact your Experiment Station. The Lion Oil Company at Eldorado, Arkansas; The Standard Oil Company; or the Humble Oil Company at Houston, Texas.

Later in the season, when the cotton is larger, the same general techniques and principles for applying herbicidal oils are used to apply certain chemicals. For additional information, you should refer to Texas Experiment Station Progress Report No. 1511 dated December 2, 1952, entitled "Control of Weeds and Grass in Old Cotton," by H. E. Rea. Mr. Rea reports that Premerge and Sinox PE gave almost perfect "clean-up" as lay-by sprays. Flame cultivation done at the same time was less effective, although it did give significant control.

Very recent developments indicate that not only the herbicidal oils but also such chemical formulations as Sinox PE, Chloro IPC and Premerge can be used to a decided advantage for weed control in older cotton. It seems likely as mentioned previously that some changes in the present planting techniques in the Valley will be necessary. Likewise it seems that there may have to be some changes in application equipment and technique.

In conclusion I would like to say that I have discussed some of the important fields in which chemical weedkillers may be used, and I would suggest that for further information you should consult the Experiment Station, the County Agricultural Agent, and representatives of the concerns who manufacture and sell weedkilling chemicals.

It seems apparent that regardless of how good a chemical may be or how efficient and foolproof the application equipment may be the real secret of success lies in the farmer being personally familiar with both the chemical and application thereof and then properly training the equipment operator and finally adequately supervising the application.

Chemical Weed Control

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The subject "Chemical Weed Control" has been well chosen. Too often we are prone to think of using chemicals as a "cure-all" rather than in terms of another important tool to be used in agricultural production. I would like to emphasize that herbicides when properly used for specific problems are important control factors in connection with undesirable weeds, but should not always be regarded as guaranteeing 100 per cent eradication of such undesirable plants. Such factors as type of weed plants, stage of growth, climate, selection of a proper herbicide for the job, and method of application contribute materially to good weed control.

In this report we will only attempt to point out some of the more important facts regarding chemical weed control, and wish to point out that you as a user of agricultural chemicals have an important obligation to perform in selecting the herbicide to use in relation to your specific problem of weed control. After deciding upon the chemical to be used I would further recommend very strongly that you read and adhere to the recommendations listed on the manufacturer's label. Such label recommendations are based on experimental proof, approved by the Federal Department of Agriculture and the State of Texas. Your local dealer representative will be glad to further interpret these label recommendations for you.

Chemical control of weeds should be considered in the following broad classifications:

Perennial broad-leaved weeds

Perennial grassy weeds

Annual weeds

Woody plants, such as mesquite

Perennial Broad-Leaved Weeds

Many perennial weeds can be controlled with 2-4-D but eradication is often difficult. Best results have been obtained by treating during the actively growing stage, generally near the bud stage. One application of 2-4-D seldom gives eradication and repeat treatments are necessary.

The value of chlorates, borates and similar chemicals for the control of perennial weeds should be recognized. These chemicals are especially valuable for quick eradication of small patches of weeds where a period of one or more years of soil sterility is not objectionable.

Perennial Grassy Weeds

Johnson Grass: Summer cultivation appears to be the most practical method of controlling extensive infestations. For spot treatments and where cultivation cannot be accomplished, effective herbicides include sodium chlorate, polybar chlorate and TCA. Rates of application will vary with local conditions.

Quackgrass: Cultivation during summer and fall months is most practical method of control. TCA is effective when applied at rates of 40 to 50 pounds per acre. Followup cultivation and chemical applications are needed. Sufficient moisture to remove the chemical to the root is necessary for effective control.

Annual Weeds

Pre-emergence Treatment: 2-4-D can be used for control of both grassy and broad-leaved weeds when applied during minimum moisture conditions. TCA is also effective. Rates of application will vary according to cropping conditions.

Post-emergence: 2-4-D can be used to control many annual broad-leaved weeds but some species are quite tolerant. Annuals are more 2-4-D susceptible when in the seedling, early stages of growth, and vigorous growth stages. Dosages as low as 1/8 pound 2-4-D acid equivalent per acre will control some annual broad-leaved weeds.

Use of herbicides in field crops such as small-seeded legumes, large-seeded legumes, spring-planted barley, oats, wheat, fall wheat, rice, corn and pasture and range grasses has been demonstrated to be quite practical from a dollars and cents standpoint. Specific recommendations depend on the crop and local growth factors. We emphasize again to you the recommendations on the manufacturer's label to ascertain rate of dosage, whether pre-emergence or post-emergence treatment is to be followed, and type of chemical to be used. 2-4-D is by far the most important weed chemical to use in field crops.

Control of broad-leaved annual weeds in pasture and range grasses can be accomplished by applications of 2-4-D. 2-4-5T can also be used where woody plants are a problem in addition to the broad-leaved weeds.

Use of herbicides in horticultural crops must be considered as a supplement to standard cultural practices. By the wise use of chemicals it is possible to reduce the cost of weeding many horticultural crops and to save some crops when wet weather makes it impossible to cultivate. Herbicidal treatments suggested should only be used once in any one season.

Treatment with herbicides for weed control on the following horticultural crops has been found economically practical.

Asparagus: 2-4-D amine at the rate of two pounds acid equivalent per acre as a pre-emergence treatment on established beds after disking

in the spring or following post-harvest disking, when no spears are showing. To improve control of annual grasses add TCA at the rate of five to ten pounds per acre to the 2-4-D spray. The use of Stoddard solvent at 80 to 100 gallons, DNOSBP (in oil emulsion) at pound per acre or 2-4-D amine at one pound per acre is recommended as a contact pre-emergence treatment to control weeds in seed beds.

Beans: A residual pre-emergence application of six to eight pounds of DNOSBP or 16 to 20 pounds of sodium PCP per acre will control most annual weeds in beans. Higher rates of application will control annual grasses in lima beans.

Beets: For the control of annual grasses TCA at eight to ten pounds per acre applied at least two days before any beets will emerge is recommended.

Carrots, Celery, Parsnips and Parsley: Stoddard solvent at 80 to 100 gallons per acre gives good control of annual weeds. Apply as soon as most weeds have emerged but before any are over two inches high. Do not spray carrots or parsnips after the tap root is more than ¼ inch in diameter. On celery use only in the seed bed.

Onions: For the control of weeds emerging before the onions use Stoddard Solvent at 40 to 80 gallons per acre as a pre-emergence spray. Post-emergence sprays of 2 to 3% sulfuric acid at the rate of 100 gallons per acre applied when the onions are at the "knee" stage or have one or more true leaves will control many small annual weeds.

Potatoes: Blend cultivation is preferred but chemical treatments with 1½ to 2 pounds 2-4-D amine when applied two to six days before emergence may be valuable under very wet cultivation conditions.

Sweet Corn: A rate of ¼ to ½ pound acid equivalent per acre is satisfactory using esters of 2-4-D at lower rates than amines in a post-emergence spray. Some injury can be expected to the corn and this treatment should only be used in an emergency. Pre-emergence treatment with 1 to 2 pounds 2-4-D per acre will control annual grasses and some tolerant broad-leaved weeds. Specific recommendations should be secured to meet local conditions.

Strawberries: The use of 2-4-D amine at one pound per acre is suggested for control of weeds in established strawberry beds. Do not use on flowering or fruited strawberries.

Citrus Fruits: Use 2-4-D and 2-4-5-T in low concentrations for weed control only after specific local recommendations. The low volatile esters of 2-4-D and 2-4-5-T have a definite place in woody plant control. For general foliage spraying of mixed brush, a mixture of 2-4-D and 2-4-5-T are recommended. 2-4-5-T is especially effective in killing mesquite, blackberries, numerous hardwoods, poison ivy and osage orange.

Woody Plants, Such as Mesquite

Extensive experimental work has been accomplished using 2-4-5-T mixtures at the Texas Range Experiment Station, Spur, Texas, and throughout the State of Texas. A recent report listing the 1952 recommendations has been issued and is available to you from the above station.

Economical control of mesquite and consequent increase in range grasses has been secured using 2/3 pound acid equivalent low volatile 2-4-5-T esters combined with 3 gallons diesel oil and one gallon water applied to one acre by aerial application. The best time for application is in the active new leaf spring growing stages. This is roughly May 15 to July 1 in West Texas and of course varies in other sections of Texas. Application by an approved aerial applicator is recommended.

In closing this talk on chemical weed control I would like to call to your attention that a certain amount of caution should be observed in using chemical weed control methods.

Control Of Careless Weeds In Cantaloupe Plantings

George A. Livingston, *Texas A. & I. College, Weslaco*

Introduction

It is possible to control the initial weed population in cantaloupe plantings by use of some of the dinitro compounds as pre-emergence sprays. Under most conditions, however, the residual action of these compounds is limited. Therefore, each rain or irrigation is followed by a new crop of weeds.

The initial crop of weeds can be easily controlled by hand or mechanical methods or by dinitro compounds applied as sprays but weeds germinating after the vines have begun to elongate are difficult to control except by hand methods. Obviously what is needed is a herbicide that can be applied either pre-emergence or post-emergence to the crop resulting in good weed control and no crop injury.

Tests were conducted during the spring and fall growing seasons of 1952 with a series of herbicides on several crops including cantaloupe. These tests have shown that at least under our conditions, N-1 naphthyl phthalamic acid (Alanap) has excellent characteristics for weed control in cantaloupe plantings.

Methods and Materials

In the spring tests cantaloupe seed of local origin were planted in hills spaced five feet apart on a seed bed. The seed were planted, ten to each hill on March 22, 1952. Immediately after planting, replicated plots, each containing two hills of cantaloupe, were sprayed with different formulations and different rates of Alanap (material utilized as supplied by United States Rubber Co., Naugatuck Chemical Division, Naugatuck, Conn.). The formulations and rates used were as follows: Formulation Number 1 (N-1 naphthyl phthalamic acid) 3.36 and 6.72 pounds per acre; Formulation Number 2 (Imide of N-1 naphthyl phthalamic acid) 9.42 pounds per acre and; Formulation Number 5 (1:1 mixture of the acid and the imide forms) 3.13 and 6.26 pounds per acre.

In the fall tests (initiated September 23, 1952) the cantaloupe seed was planted in a row on the bed rather than in hills. The rates of application for the fall tests were: Formulation Number 1 – 2.4 and 4.8 pounds per acre; Formulation Number 2 – .85 and 1.7 pounds per acre and; Formulation Number 5 – 2.8 and 5.6 pounds per acre. All rates of application listed are in pounds per acre of the active ingredient. The material was supplied as a wettable powder containing 90% of the active ingredient.

The sprays were applied to the treated areas, in all cases immediately after planting, by use of a hand carried spray boom designed to spray a strip ten feet wide. The spray jets used on the boom were Teejet Number 9503 each giving a flat, fan shaped spray. The material was suspended in water for spraying and the suspension was applied at the rates of 35 gallons per acre for the low rates of application and 70 gallons per acre for the high rates of application. A pressure of 35 pounds per square inch was maintained during the spraying operations.

Water was applied to the plots by means of furrow irrigation the day after the application of the chemical in the fall tests. A shortage of water delayed irrigation during the spring tests until May 6th.

Results

Counts of weeds and crop plants were made in all of the treated plots and adjacent control plots about two weeks after germination of the seed in both the spring and fall tests. The figures listed in table 1 are percentages computed from the data of the treated plots and the untreated adjacent control plots. A second count of the weeds was not made but many of the careless weeds present at the time of the count either subsequently died or were stunted, giving a much better weed control than indicated by the percentages listed in table 1. Grass seedlings affected by the herbicide die slowly and at the time the count was made many of the grasses included in the count were dying, so the final weed control would be better than that indicated in table 1.

Fig. 1 shows the weed control obtained by the application of 3.36 pounds per acre of Alanap (Formulation Number 1). This photograph was taken twenty days after the plots had been irrigated. The plots had been flooded during the irrigation and the photograph shows that almost all of the plants except the cantaloupe had been eradicated or suppressed in the treated area.

Table 1. Effect of alanap on emergence of cantaloupe and control of weeds.

Formulation Number	*Time of Application*	*Pounds per acre*	*Percent* Cantaloupe Emergence*	*Percent* Careless Weed Control*	*Percent* Grass Seedling Control*
1	Spring	3.36	105	85	41
		6.72	110	95	60
	Fall	2.4	106	56	
		4.8	88	74	
2	Spring	9.42	130	95	33
	Fall	.85	116	15	
		1.7	111	24	
5	Spring	3.13	89	95	45
		6.26	121	88	51
	Fall	2.8	81	72	
		5.6	96	72	

*Figures listed are percentages as compared to the adjacent control plots.

Fig. 1 Comparison of untreated control plot (right) and plot treated with 3.36 pounds per acre of Alanap (Formulation Number 1). The cantaloupe in the control plot are almost hidden in the Careless weeds while those in the treated plot have practically no competition from the weeds.

For a short time after emergence of the cantaloupe the rate of growth of the plants in the treated areas was less than that of the plants in the adjacent control plots. Two weeks after emergence, however, no stunting was evident and in some cases the plants in the treated plots were larger than those in the adjacent control plots. This increase in growth over that evidenced in the control plots is ascribed to the beneficial effect of reduced competition between the weeds and crop plants for water and nutrients.

In both the spring and fall tests some of the treated areas, due to their uneven topography, were flooded. This flooding actually enhanced instead of dissipated the herbicidal effect of the chemical as is true with some other herbicides.

Fruit was harvested from some of the plots of the spring tests and shipped to the Naugatuck Chemical Co., for residue analysis. Their analysis of the fruit grown in a plot treated with 6.7 pounds per acre of Formulation Number 1 did not detect the presence of any Alanap. The method of analysis used (described in a paper given at the 122nd meeting of the American Chemical Society at Atlantic City, September 16, 1952) is capable of detecting less than 0.5 p.p.m. of the herbicide in the tissue tested.

At the time the fruit was harvested for analysis (127 days after treatment or 81 days after germination) the control of weeds in the treated plots was still good even though no cultivation or hand weeding had been practiced. The control plots were abandoned shortly after germination of the seeds due to the tremendous growth of the weeds and choking out of the crop plants.

Seed from fruit grown during the spring tests were planted in untreated soil during the fall of 1952. The germination of these seed was not apparently reduced by the treatment of the parent plants and there were no indications of changes in growth or form in the plants grown from these seeds.

Conclusions

The herbicidal effect of the various formulations of Alanap on careless weeds (*Amaranthus spp.*) and seedlings of Johnson Grass (*Sorghum halepense*) was fair to excellent when the compound was applied at the rate of four pounds per acre or higher. The material, at the rates used in these tests, induced a stunting of cantaloupe plants for a short time after germination. Recovery from this condition was complete by two or three weeks after germination, however, and the subsequent growth was normal. No detectable residue of the material was found in the fruit and no harmful effects were evident in the plants grown from seed harvested from treated plots. The residual effect of the material in the soil was good, resulting in extended weed control. Neither extended dry period nor flood irrigation of the sprayed areas tended to lessen the herbicidal effect of the material.

Preliminary Report On The Reaction Of Radish Plants

George A. Livingston, *Texas A. & I. College, Weslaco*

The use of isopropyl N-(3-chlorophenyl) carbamate (Chloro IPC) as a pre-emergence spray has been reported by many investigators. It has been utilized with varying success on vegetables, cereals, cotton and many other crops.

Methods and Materials

A series of vegetable-herbicide test plots was set up November 21, 1951 including the Early Scarlet Globe radish and the herbicide Chloro IPC. The Chloro IPC was applied at the rates of five and ten pounds per acre of the active ingredient. The material, as supplied by the Columbia Southern Chemical Co., contained 40.6% of the active ingredient. Other herbicides and vegetables in this experiment are not described in the present paper. A known amount of Chloro IPC was added to water which was applied to the soil by means of a sprinkling can. Excellent coverage of a 100 square foot plot was obtained in this way. The soil was dry at the time of planting but a rain of 0.81 inches on November 26th brought about germination of the radishes in three days.

Results and Discussion

When radishes were grown in soils sprayed with Chloro IPC, the effect was similar to that reported for other crops. That is, the germination rate of the plants was slower than the controls and the growth rate after germination was slower than the controls. Both of these reductions were in proportion to the rate of application of the chemical.

In January 1952 it was noted that the radishes were apparently badly distorted in the Chloro IPC plots. On January 14, 47 days after germination. all of the surviving radishes from the treated plots and a representative sample of plants from the control plots were harvested. The number of plants harvested were: 88 from the 5 pound per acre treatment; 57 from the 10 pound per acre treatment; and 122 from the untreated control plot.

The diameter of the fleshy axis, the length of the fleshy axis, and the length of the freshy axis exhibiting lateral roots were measured immediately after harvest. The averages computed from these data and the ratio of the length to the diameter of the fleshy axis are given in table 1.

The increase in length of the fleshy axis of the plants was in direct proportion to the rate of application of the Chloro IPC and the average diameter increased in an inverse proportion to the strength of the applied Chloro IPC.

Figs. 1, 2 and 3 show representative plants harvested from the two treated plots and the adjacent untreated control plot. These plants were representative of the plants of the treatments. The plants identified by the attached tags are those whose measurements are nearest to the averages of the plants from the three plots.

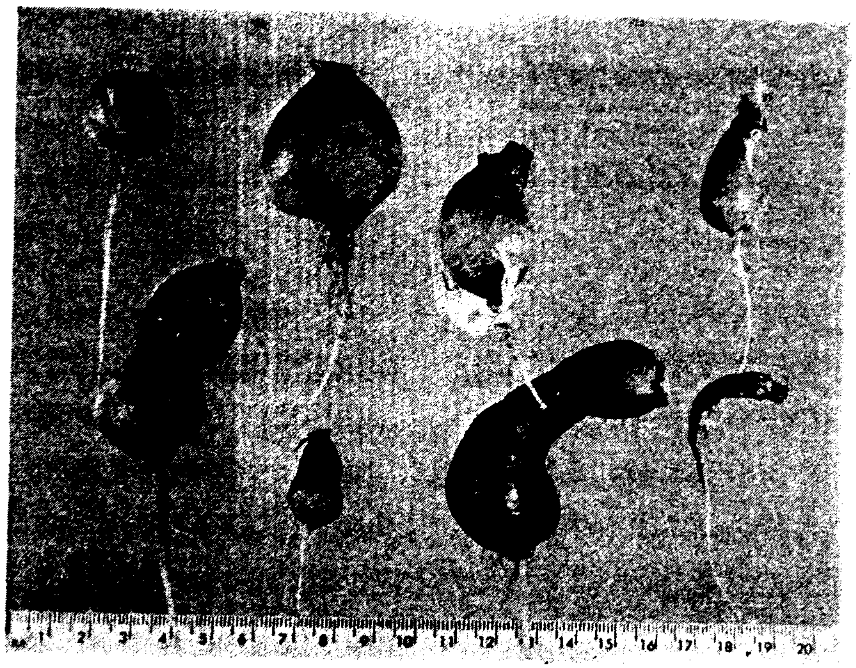

Fig. 1 Representative radishes harvested from plot sprayed with five pounds per acre of Chloro IPC. The plant showing an attached tag most nearly approximates the average measurements as shown in Table 1.

Table 1. Effect of Chloro IPC, applied to the soil, on the length and diameter of radishes.

Average dimensions and ratios of fleshy axis	*Response of Radishes to the Following Treatments* Control (mm)	5 Pounds Chloro IPC per acre (mm)	10 Pounds Chloro IPC per acre (mm)
Diameter	26.45	20.87	16.38
Total length	29.87	35.22	41.60
Length of region where lateral roots originate	8.29	5.65	7.16
Ratio of total length to the diameter	1.13	1.69	2.54

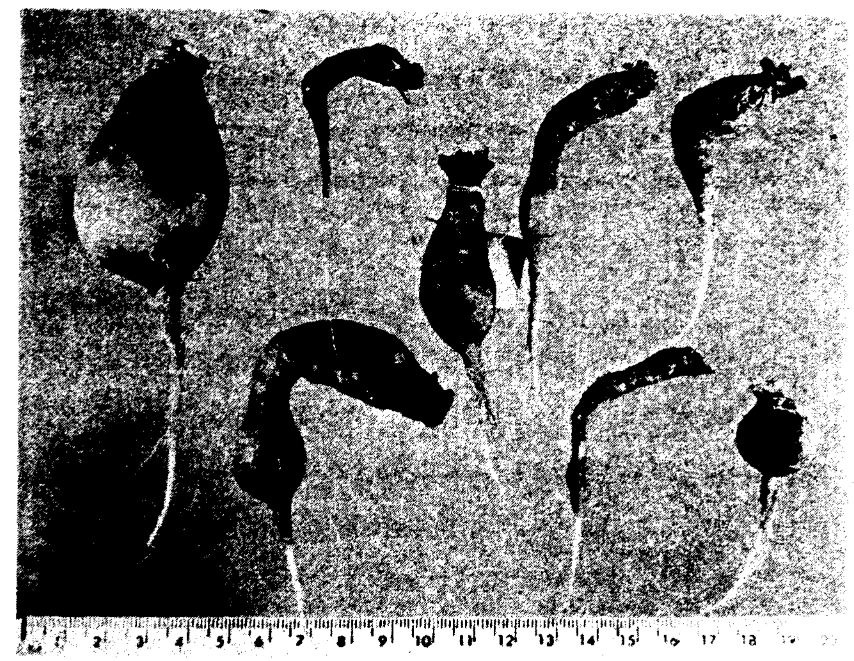

Fig. 2. Representative radishes harvested from plot sprayed with ten pounds per acre of Chloro IPC. The plant showing an attached tag most nearly approximates the average measurements as shown in Table 1.

A statistical analysis of variance was made on the data obtained by the measurements. The variations in measurements were highly significant (beyond the 1% level of probability) when considering all three treatments or any combination of two treatments. This degree of significance was found for all data except the measurements of that portion of the fleshy axis of the plant exhibiting lateral roots, where no consistent differences occurred (table 1).

The lower portion of the fleshy axis of the plant is derived from the radicle, and normally produces lateral roots, and the upper portion is derived from the hypocotyl, and does not normally produce lateral roots. The growth effect of Chloro IPC on radishes was primarily exhibited in that portion of the plant derived from the hypocotyl.

The leaf length of the plants in the five pound per acre treated plots was not reduced from that of the control plants. The only difference in size of the above-ground parts of the plants from the plots treated with ten pounds per acre of Chloro IPC was that the minimum sized plants were smaller than those of the control plot. There was no difference in length of above-ground parts in the larger plants of any of the treatments.

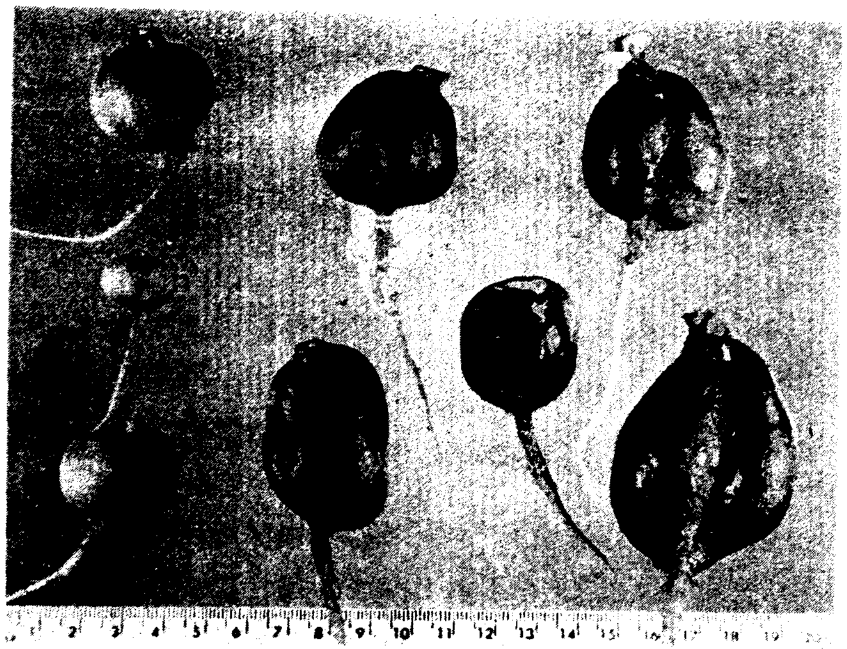

Fig. 3. Representative radishes harvested from untreated control plot. The plant showing an attached tag most nearly approximates the average measurements as shown in Table 1.

Summary

Plots of field grown radishes were treated with 0, 5 and 10 pounds of Chloro IPC per acre as a pre-emergence spray. The plants from the plots treated with Chloro IPC exhibited an elongated but thinner fleshy axis than did those from the control plots.

The length of the fleshy axis of the plant derived from the radicle was not noticeable affected by the treatment. Therefore, the elongation due to the treatment was primarily restricted to the fleshy axis of the plant derived from the hypocotyl.

Control of the Red Lettuce Aphid

GEORGE P. WENE, *Texas Agricultural Experiment Station, Weslaco*

Heavy infestations of the red lettuce aphid, *Microsiphum ambrosiae* (Thomas), seldom produce injury symptoms such as plant stunting or off-coloring. The red lettuce aphid, if uncontrolled, will multiply between the lettuce leaves. When the lettuce is marketed some of the aphids will remain alive and the housewife will object. Many of the aphids will die as the head is being shipped to market and the head will become "slimy" in the aphid infested area causing more consumer's resistance.

The red lettuce aphid is a cool weather insect. Infestations on lettuce usually develop when the maximum daily temperature is below 75°F. for prolonged periods. When the temperature is above 75°F. a predator, *Geocoris punctipes* (Say), has been found feeding on the red lettuce aphid.

Red lettuce aphid infestations usually will appear on plants in the 4 or 5 leaf stage of growth providing the temperature is cool. The aphids will be found on the lower half of the ventral side of the inner leaves. As the lettuce plant grows, the lettuce leaves fold over each other to form the head and will enclose any aphids present on the inner leaves. The immature head, consisting of loosely folded leaves, allows the aphids present to multiply. This illustrates the importance of controlling the red lettuce aphid before the lettuce head is formed.

It is very difficult to detect red lettuce aphid infestations on lettuce after the head has been formed. The aphids usually migrate to a single head in an area. Aphids are first seen on the ventral side of the top half of a loose leaf, adjacent to the head. As the aphid population increases, the aphids migrate to the lower part of the leaf and are eventually folded into the head. As the aphid population increases in these individual lettuce heads, winged aphids develop and the infestation spreads over the entire field from these local infestations. Because of the type of initial infestations, it is very important for growers to examine their fields very thoroughly.

Control of the red lettuce aphid was obtained by Wene (1950) with an airplane spray application of 50 percent hexaethyl tetraphosphate at the rate of 1.5 pints per acre in 6 gallons of water. Seven days after dusting with 1-percent parathion dust, Wene (1952) found only minute quantities of parathion had been absorbed by lettuce heads. Because of growers complaints on the ineffectiveness of TEPP sprays and also of the reported injury of TEPP sprays, experiments were conducted to find a more efficient insecticide to use for controlling the red lettuce aphid.

Materials and Methods. – In the first experiment the treatments were applied to half grown lettuce with a tractor attached low volume sprayer. The 9 row sprayer was equipped with 3 nozzles per row and applied a total of 15 gallons of spray per acre. Each plot consisted of 18 lettuce rows (spaced 36 inches apart) and was about one acre in size. The treatments, shown in table 1, were replicated three times. The 20-percent TEPP differed from the 40-percent TEPP in that it contained an emulsifier. Because of the high initial aphid infestation, the grower would not allow an untreated plot. Therefore, one day before treatment application and again one, four and seven days after, a leaf in close proximity to the lettuce head was pulled from 20 random plants and the number of aphids recorded.

The second experiment was conducted in a lettuce field which was in the five or six leaf stage of growth. Each plot was 0.025 acre in size. The treatments, shown in table 2, were applied with rotary hand dusters at approximately 20 pounds per acre. Each treatment was replicated three times. At definite intervals after treatment 20 plants were selected at random and the number of aphids counted.

Discussion. – The data in table 1 show that all concentrations of TEPP were equally effective one day after application. An examination made seven days after the treatment application shows that the higher concentration of TEPP, 1-pint of 40% and 1-quart of 20%, were more effective than the lower dosage. When comparing actual amounts of toxicants applied, the 20% TEPP which contained an emulsifier was no more effective than the 40% TEPP which contained no emulsifier.

One day after the treatment application the plots receiving the higher TEPP application showed considerable injury on the outer leaves. This consisted of numerous reddish-brown spots about the size of a straight-pin head. The upper third of the outer leaves were injured in the plots receiving 1 pint of 40% TEPP and the quart of 20% TEPP. Some injury

Table 1. Effectiveness of TEPP sprays in controlling the red lettuce aphid.

	Aphids per Leaf			
Amount TEPP per Acre in 15 gallons Water	*1 Day Before*	*1 Day After*	*4 Days After*	*7 Days After*
0.5 Pt. 40% TEPP	5.4	1.0	2.9	7.2
1.0 Pt. 40% TEPP	5.4	0.3	1.5	3.6
1.0 Pt. 20% TEPP	4.9	1.5	1.5	7.2
2.0 Pt. 20% TEPP	6.4	0.3	1.2	3.6

Table 2. Effectiveness of insecticidal dusts in controlling the red lettuce aphid.

	Aphids per plant after Treatment		
Treatments	*1 Day*	*8 Days*	*14 Days*
1% Parathion	0.0	0.4	7.4
2% Parathion	0.0	0.4	3.5
1.5% Metacide	0.0	0.3	8.9
1% Rotenone	1.6	1.0	3.9
Untreated	5.2	6.8	9.0

was noticed in the plots receiving the lower TEPP concentration. A week later these reddish-brown spots had become grey in color and the injury was hardly noticeable.

The data in table 2 show that 1-percent parathion dust gave excellent control of the red lettuce aphid for a period of 8 days. Increasing the concentration of parathion to a 2-percent dust increased the residual effectiveness. A 1-percent rotenone dust was not as effective as 1-percent parathion dust one day after application but data taken 14 days after application show that 1-percent rotenone was equal to 2-percent parathion as a control for the red lettuce aphid. Rotenone is a safe insecticide and should be used by small growers who apply their insecticides with hand dusters.

Summary. – One pint of 40% TEPP and one quart of 20% TEPP were more effective than 0.5 pint of 40% TEPP or 1-pint of 20% TEPP in controlling the red lettuce aphid. The higher concentration of TEPP burned the outer leaves severely but this injury was hardly noticeable one week after treatment application.

A 1-percent parathion dust gave good control of red lettuce aphids for a period of eight days. Increasing the parathion concentration to 2-percent dust increased the residual effectiveness. One and one-half percent metacide dust was as effective as the 1-percent parathion dust and a 1-percent rotenone dust was equal to the 2-percent parathion in controlling the red lettuce aphid.

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New Insecticides For Cabbage Aphid Control

George P. Wene and A. N. White[1]

The cabbage aphid, *Brevicoryne brassicae* (L.), is one of the most difficult species of aphids to control. Excellent control of cabbage aphids was obtained by Wene (1950) with an airplane application of a 1-percent tetraethyl pyrophosphate dust. In the same experiment, 3-percent gamma benzene hexachloride dust controlled only 70 percent of the aphids. In small plot tests conducted by Wene and White (1952) excellent control was obtained with 0.25 pound gamma benzene hexachloride, 0.25 pound parathion, 0.5 pound octamethyl pyrophosphoramide, and 0.19 pound systox, per 100 gallons of water, applied as a high volume spray. Since systox, TEPP and parathion are considered highly dangerous to applicators of these insecticides and benzene hexachloride has an objectionable odor, research work was conducted in order to find safer insecticides, and also those without the disagreeable odor of benzene hexachloride.

Materials and Methods

The insecticidal dusts, shown in tables 1 and 2 were applied with rotary hand dusters at approximately 25 pounds per acre. The cabbage plots were 0.02 acre in size and each treatment was replicated three times.

The spray treatments, shown in tables 3 and 4, were applied with a three gallon garden sprayer at approximately 125 gallons per acre. A plot consisted of a single row of cabbages 25 feet in length. Each treatment was replicated three times.

The efficiency of the various materials was determined by pulling ten leaves at random from each plot and then counting the number of aphids in a square inch area of the heaviest populated portion on the underside of the cabbage leaves at specific time intervals after treatment applications.

Results

The 1-percent TEPP dust had been made with a special diluent and was stored a month in a tight metal container before being used. The data in table 1 show that this TEPP, which is highly toxic to the applicator, gave 76 percent reduction of the cabbage aphid. This shows the possibilities of manufacturing a TEPP dust which could be stored during a short period of time in which unfavorable conditions might exist for application. Since the TEPP dust breaks down within 24 hours after application, it could be used effectively in those fields requiring aphid control a day or so prior to harvest. The 1-percent parathion dust gave effective aphid control but precautions must be taken as this dust is highly toxic to the applicator. In table 2, the data show that 1.5 percent methyl parathion is just as effective as a 1-percent parathion dust in controlling

[1]Respectively, entomologist, Lower Rio Grande Valley Experiment Station, Weslaco, Texas and Associate County Agent, Texas A. & M. System, Weslaco, Texas.

cabbage aphids. Both 2.5 and 5-percent concentrations of malathon dust gave excellent control of this aphid. Since malathon is less toxic to the operator, this material should be further investigated since it could be used with safety by the small grower who applies his insecticide treatments with hand dusters. As shown by the data in table 2, a 3-percent gamma benzene hexachloride dust gave excellent control of this aphid. However, benzene hexachloride has an objectionable odor and should be used with caution on vegetables because of the danger of vegetables absorbing an off flavor. The data in table 2 show that a 1-percent systox dust failed to control the cabbage aphid, however, it was very effective when applied as a high volume spray. A 4-percent EPN dust was less effective than 1-percent parathion dust, as can be seen by the data in table 1.

Table 1. Control of cabbage aphids with insecticidal dusts.

Insecticides	Aphids per Sq. Inch and Percent Reduction			
	1 Day		8 Days	
	No.	%	No.	%
1% TEPP[1]	9.6	76	31.7	51
1% Parathion	0.8	98	0.5	99
2.5% Malathon	2.1	95	4.3	93
5% Malathon	1.7	96	2.0	97
Untreated	39.1	—	65.2	—

[1]The TEPP was made with a special diluent and had been stored for a month in a tight container before being used.

Table 2. Control of cabbage aphids with insecticidal dusts.

Insecticides	Aphids per Sq. Inch and Percent Reduction			
	1 Day		8 Days	
	No.	%	No.	%
1% Parathion	0.4	99	1.3	98
4% EPN	5.3	84	12.4	75
1.5% Methyl Parathion	0.7	98	3.0	94
1% Systox	6.1	82	30.9	40
3% gBHC	1.3	96	0.7	99
Untreated	33.3	—	50.8	—

The effectiveness of insecticides applied as sprays are shown in tables 3 and 4. Metacide and systox, which are highly toxic to the applicator, gave very effective aphid control. The data also show that EPN, at the rate of 0.5 pounds per 100 gallons of water, was effective. Lower concentrations of EPN failed to give satisfactory aphid control. Lindane, a safe material from the operators standpoint, was just as effective as 0.19

pounds of systox when used at the rate of 0.25 pound per 100 gallons of water. Two new insecticides, malathon and NPD (tetra-n-propyl dithionopyrophosphate), which are considered less hazardous to the operator than parathion, gave effective aphid control. For effective aphid control the data show that malathon should be used at a concentration of 0.32 pounds per 100 gallons of water while NPD should be used at a 0.5 pound rate.

Table 3. Control of cabbage aphids with high volume sprays.

Insecticides per 100 gallons water	*Aphids per Sq. Inch and Percent Reduction*			
	1 Day		*8 Days*	
	No.	%	*No.*	%
0.63 lb. Malathon	0.3	99	1.0	98
0.32 lb. Malathon	0.6	98	1.5	97
0.16 lb. Malathon	1.4	96	7.9	85
0.25 lb. Lindane	1.9	95	0.8	99
0.13 lb. Lindane	4.8	88	5.8	89
0.07 lb. Lindane	11.9	70	23.4	56
0.38 lb. Systox	0.5	99	0.6	99
0.19 lb. Systox	0.2	99	2.2	96
Untreated	39.1	—	53.6	—

Table 4. Control of cabbage aphids with high volume sprays.

Insecticides per 100 gallons water	*Aphids per Sq. Inch and Percent Reduction*			
	1 Day		*8 Days*	
	No.	%	*No.*	%
0.5 lb. EPN	12.0	80	4.5	93
0.25 lb. EPN	20.4	65	20.9	66
0.13 lb. EPN	33.3	43	30.4	51
1 lb. NPD	5.2	91	0.6	99
0.5 lb. NPD	11.1	81	2.4	96
0.25 lb. NPD	26.0	56	11.3	82
0.19 lb. Metacide	0.9	98	0.0	100
Untreated	58.7	—	61.5	—

Summary

The data show that 1-percent parathion, 1.5-percent methyl parathion and 3-percent gamma benzene hexachloride dusts gave effective cabbage aphid control. Malathon, a new and safer insecticide from the operator's standpoint, was effective at 2.5 and 5-percent concentrations. A 1-percent TEPP dust, which had been stored for a month before use, was not as effective as the 1-percent parathion dust. Dusts containing 4-percent EPN and 1-percent systox did not give satisfactory aphid control.

Systox and metacide gave effective aphid control when applied as high volume sprays. EPN at 0.5 pound per 100 gallons of water also gave good aphid control. The following materials which are less toxic than parathion or metacide to the applicator gave effective aphid control at the following concentrations per 100 gallons of water: 0.25 pound lindane; 0.32 pound malathon; and 0.5 pound NPD.

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The False Chinch Bug

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The false chinch bug, *Nysius raphasus* Howard, was found in destructive numbers on lettuce, turnips, and mustard greens during February and March of 1952. In one large field mustard greens were interplanted with collards. As many as 30 false chinch bugs were found on a single mustard leaf while none were found on any of the collard leaves, indicating that this insect prefers the more succulent type of vegetation. This insect was also seen on cabbage but no damage was found on the cabbage plant which could be attributed to the false chinch bug.

The Lower Rio Grande Valley area was suffering from a prolonged drought at the time of the false chinch bug appearance. The vegetation in uncultivated fields and brush areas was dying from a lack of moisture. The false chinch bug apparently migrated in damaging numbers from the dying vegetation because in no instances were the false chinch bugs found in small numbers on any crop which would afford future population build-up. Towards the end of March, *Nysius Californicus* Stahl was found in large proportions in the false chinch bug infestations.

The false chinch bug was very active when the temperatre was 80 F. or above. No activity was seen when the temperature was 70 F. or lower. During these periods of low temperatures, the false chinch bug was found on the surface of the ground, usually under decaying organic matter such as leaves, or under clods of dirt.

On turnips the false chinch bug was found feeding on the ventral surface of the leaves, usually on the outer portion. As a necrotic area developed where the insect was feeding, the insect would move to living portions of the leaves.

Heavy false chinch bug infestations destroyed some lettuce fields in four or five days. These bugs, as many as 70 per square inch, at first fed on the dorsal surface of the outer leaves. In a day or so the outer leaves collapsed, and fell to the ground. After the outer leaves had collapsed, the false chinch started feeding on the lettuce heads which soon were greyish white in appearance.

Since the false chinch bug is a migratory insect, it was necessary to conduct control experiments on large plots, which made replications impossible. The plots in the first experiment, which was conducted on a field of lettuce, were three and one third acres in size, with two acre buffer strips between each treatment plot. The treatments, 2.5 percent aldrin, 20 percent toxaphene, and 2 percent parathion were applied by airplane at the rate of 30 pounds per acre. A fourth strip was used as the check or untreated for evaluating the efficiency of the insecticides tested. The effectiveness of the various insecticides was determined one day after application. Twenty-five plants were selected at random from each plot and the average number of surviving false chinch bugs per square inch area on the dorsal surface of a single lettuce leaf from each plant

was used in determining the effectiveness of the various insecticides. The data in table 1 show that 2.5 percent aldrin gave an 88 percent reduction in the false chinch bug population. A 20 percent toxaphene dust reduced the population only 58 percent while 2 percent parathion was ineffective. The cooperator was so well satisfied with the control obtained that he dusted the entire field with 2.5 percent aldrin the day after the insect infestation records were taken.

The false chinch bug was found in the south end of a 40 acre cabbage field which had been dusted at regular intervals with 10 percent DDT dust. The west half of the field was dusted with 2-10-40 (2 percent gamma benzene hexachloride, 10 percent DDT, and 40 percent sulphur). Infestation counts were made two days after the treatment was applied. Fifty plants were selected at random from the south and north portions of both the treated and untreated sections of the field and a leaf from each cabbage plant was examined for the presence of false chinch bugs. The north portion of the cabbage field, which had a low infestation originally, averaged 0.5 false chinch bugs per cabbage leaf in the untreated portion and 0.1 bugs in the treated portion. The south portion of the field which had a heavier initial infestation averaged 4.6 false chinch bugs in the untreated plot and 0.1 in the treated plot. The data show that benzene hexachloride controlled the false chinch bug. Since the false chinch bug had migrated into the cabbage field while it was being dusted regularly with 10 percent DDT dusts, one can assume that the 10 percent DDT in the 2-10-40 was of little value in controlling the false chinch bug.

A 10 acre field of turnips was dusted with a plane using 3 percent gamma benzene hexachloride. One-half of the field was dusted at the rate of 30 pounds per acre while the other half received only 20 pounds. The temperature on the following days was around 70 degrees F. and as a result very few false chinch bugs were seen in nearby fields which were known to be heavily infested. The effectiveness of the two dosages was determined by counting the dead insects on ten square inch areas on the soil surface near the base of the plant. The section of the field which received 30 pounds of benzene hexachloride per acre averaged 18.3 dead false chinch bugs per square inch while that section dusted with 20 pounds of benzene hexachloride averaged only 9.9 dead false chinch bugs per square inch. This data indicate that benzene hexachloride is effective in controlling the false chinch bug. Of greater importance is that in air-

Table 1. Control of false chinch bugs with airplane applications of insecticidal dusts.

	False chinch bug per sq. in. on lettuce 24 hours after treatment	
Treatment	*No.*	*% Red.*
2.5% Aldrin	6	88
20% Toxaphene	22	58
2% Parathion	60	0
Untreated	52	—

plane applications 30 pounds of 3 percent benzene hexachloride was more effective than 20 pounds.

Summary. — The false chinch bug, *Nysius raphasus* Howard, was found in destructive numbers on lettuce, mustard greens, and turnips during February and March of 1952. Control was obtained with airplane applications of 2.5 percent aldrin, 3 percent gamma benzene hexachloride, and 2-10-40 (2 percent gamma benzene hexachloride, 10 percent DDT, and 40 percent sulphur).

Curly Top Virus Disease Of Tomatoes

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Curly top (Western Yellow Tomato Blight) was unusually destructive to tomatoes this year in Texas near Lubbock and El Paso, and did some damage in the Lower Rio Grande Valley. It killed or spoiled 15% to 100% of the tomatoes in many fields in West Texas by July 31, 1952.

The following are common symptoms of tomato curly top: A few leaflets become yellowish green, upward-rolled, brittle and leathery. Soon, most of the leaves roll and become yellow or yellowish-green, and finally they wilt and turn brown. A normal leaflet may be folded without breaking but a leaflet with curly top usually cracks when it is folded tightly. A tomato plant with many rolled leaflets rustles like a newspaper when it is shaken. The lower sides of the leaf veins commonly are purple. Curly top stops the growth of the plant and it becomes noticeably grayish-green. Any little fruits on the plants stop growing and turn red without maturing their seeds. Thus, plants with curly top are unlikely to bear marketable fruits.

Pepper curly top: Plants with this disease were found in 2 fields near Lubbock. Nearly 80% of the plants were killed or spoiled in one field. Living plants showed the following symptoms: The plants were dwarfed (only 1 to 8 inches tall) while the normal plants were 15 to 24 inches tall. Most of the sick leaves were upward rolled, brittle, and yellowish with green veins. Some of the little plants had unusual symptoms. The new top leaves were cupped, green, and had crimped margins. Large plants in the other field showed yellowing, rolling, and brittleness of the leaves and dwarfing of the plants as symptoms of curly top. Also, about 1/10% of the plants had these symptoms in a field of bell peppers near Rio Grande City on Nov. 9, 1950.

Squash curly top: A field of Straight Neck squash north of Lubbock showed the following symptoms of curly top in 10% of the plants: Dwarfing with white to yellow discoloration and leathery texture of the leaves. The plants produced few if any marketable fruits despite continued growth of stems that had ceased in normal plants.

Other important crops with curly top have been reported to include beet, pansy, cabbage, radish, geranium, spinach, watermelon, cucumber, cantaloupe, bean, cowpea, sweet clover, vetch, zinnia, potato, petunia, and many species of weeds.

Cause of curly top: This is a virus disease caused by Beta Virus I. Parasitic particles probably too small to see (even with an ordinary microscope) live in the food-conducting tubes of diseased plants. Possibly some virus-masses are large enough to see but do not have definite shapes that distinguish them from plant or animal protoplasm of the hosts in which they live. A virus seems to be an intermediate form between non-living proteins and living bacteria or amoeba with definite shapes. The curly-top virus can endure temperatures as high as 160°F, and solutions of poisonous chemicals that kill ordinary living creatures with recognizable shapes. Maybe the shape of the curly-top virus particles can be determined by photographing them with an electron microscope, enlarging them 50,000 times or more as has been done with tobacco-mosaic virus, example.

Leafhoppers carry the curly-top virus: The beet leafhopper (*Eutettix* –*Circulifer* tenellus) is wedge-shaped, pale green to yellow, and about 1/8 inch long. It jumps quickly and flies well. Leafhoppers suck the juice from diseased plants and inject the curly-top virus into healthy plants. These inoculated plants soon develop symptoms of disease. The leafhoppers are transient feeders on many species of plants but multiply only on certain ones, especially beets and some weeds. They do not breed nor live long on tomatoes.

Source of the leafhoppers: Beet leafhoppers commonly live on range weeds such as Russian thistle, greasewood, wild mustard (peppergrass), filaree, and sea blite. There are several breeding areas in the western states. However, the leafhoppers that attack Texas crops probably come from a long breeding area near the Rio Grande River from El Paso to Langtry, or maybe smaller undiscovered areas farther south. In May and June, great swarms of the leafhoppers fly (and are carried by wind) for hundreds of miles to Amarillo, Texas; Pueblo, Colorado; and south into the Rio Grande Valley, as described in Farmers Bulletin No. 1886 of the U. S. Dept. of Agriculture. A swarm of these leafhoppers landed in East Texas in 1940 as later shown by curly top in 1% to 10% of the tomato plants.

Control of curly top: This is one of the most difficult of plant diseases to control. DDT kills the leafhopper, but often not before they have injected the virus of curly top into the plants. A dust or spray chemical to repel them remains to be discovered, and this problem was referred to the research department of a chemical company. Controlling host weeds in and near fields is helpful. It would seem unnecessarily hazardous to raise beets near fields of tomatoes, beans, or peppers. In central California, about half of the leafhoppers are killed by spraying insecticides on the leafhoppers on their weed hosts in the breeding area near the mountains. Natural enemies kill many of the leafhoppers. Usually, leaf hoppers are least abundant after severe winters. Conversely, farmers might be warned of the hazard of abundant leafhoppers after unusually warm winters like the winter of 1951-1952. It helps to plant crops at times to avoid the migration of the leafhoppers, such as a winter tomato crop.

What's Ahead In Texas Citrus

Chas. A. Rogers, *Texas Citrus Commission, Weslaco*

I am always a little reluctant to make a prediction about what's going to happen in the future on any fruit or vegetable.

There are too many things that can happen in the interim which will completely change the picture. This is especially true of citrus.

However, in this particular instance, I am going to make an exception and stick my neck way out. I am going to predict that the Texas Citrus Industry is headed for the greatest expansion in its history.

I believe this prediction is based on facts that are sound and fundamental.

Of course, when you contemplate growing any agricultural product in the Rio Grande Valley nowadays, one of the first considerations is the availability of an adequate supply of good water. I am not going to go into any details on the water situation. That would take too long and besides, it is "too hot a potato" to latch onto.

However, it is one that must be solved. The public interest is involved. We must give and take and find some common ground, in between, that is fair, equitable and workable for all.

Falcon Dam water, which will be available before long, will not solve all our water problems, but it will help very substantially.

We will get some additional water when we regain our normal rainfall, and a great number of wells have been and are being dug, some of which are producing poor water, some of which are producing water that is good only for emergencies, and others that are producing excellent water.

The conversion of open land to citrus groves will be very beneficial. Citrus requires less water than vegetables. Citrus groves will serve as windbreaks, protecting vegetable crops and other groves against hot drying winds, as well as cold winds, and many authorities believe that the groves will be conducive to producing rainfall.

There is no question but that the hot air that goes up from open hot land absorbs a lot of rainfall before it reaches the ground.

Our serious shortage of rainfall started with the bulldozing of citrus trees.

California, in solving its water problem, went so far as to build big pipelines through the mountains for as far as 300 miles.

I have confidence that the people of South Texas are fair enough, resourceful enough and intelligent enough to solve this problem and furnish us with an adequate supply of good water.

The foundation for any citrus grove is its soil and rootstock, and we have in the Rio Grande Valley a tremendous amount of the richest citrus soil to be found anywhere.

During the early years, 25 to 35 years ago, and for a number of years after that, we paid little attention to selecting soil that was suitable for citrus. We didn't prepare the land. We didn't level the land. We had inexperienced citrus growers.

We didn't know much about fertilizing, dusting, spraying and irrigating.

We planted groves on land that had poor drainage. We had poor nursery stock, and quite a few of our growers said we had some poor citrus salesmen too.

But, in spite of all of this, our citrus industry grew and prospered.

We expanded in all directions, North, South, East and West, just like an Army spearheads its drives.

And why was it that we were able to do this? It was because our rich soil and ideal climate produced quality that was so outstanding that the housewife, the final judge, demanded Texas citrus from her grocer.

And we grew it on rootstock, and will continue to grow it on rootstock, that is known not for its high production, but rather for its high quality.

The fruit that is on the tree can be no better than the soil and rootstock that is below the ground.

And if competition gets tough in the future, our quality fruit will enable us to keep on shipping at a profit when poorer quality fruit from other sections will not get by.

Another big and important improvement in our future citrus industry is that we will have better varieties than ever before.

All indications are that plantings will be very heavy to Ruby Red Grapefruit and Valencia Oranges. I hope we do not go overboard on these two varieties, especially on Rubies. Rubies are our best grapefruit, but they have several serious drawbacks.

One is the difficulty in getting good sizes. You hear a lot about Rubies bringing $75 to $100 per ton, but that is only on the sizes that are large enough to sell on the fresh fruit market.

The smaller sizes go to the canneries at much lower prices, if they will take them at all.

In the past, the canners insisted on a large percentage of White juice fruit to go with the Pinks and Rubies, but where are the Whites coming from if we plant all Rubies and Pinks?

Another big disadvantage of Rubies is that both the trees and fruit suffer to a far greater extent from cold weather than any other variety of citrus.

Still another serious drawback of Rubies is that they definitely will not stand the present sterilization process which we are compelled to resort to by government regulation around the 1st of March.

If all our grapefruit are Rubies, we will have a short marketing season.

The Pinks and Whites will stand sterilization.

We must sterilize grapefruit for shipment to California even before the Federal regulation goes into effect, and California is going to be the best grapefruit market we have next to Texas.

And on oranges, if we plant all Valencias, we will have practically no oranges to offer our trade until February or March. There will be a good demand for early varieties such as Hamlins, Pineapples and Navels, especially from the territory where we have a big freight advantage. We should have early oranges, as well as Tangerines and Temples, to mix in the cars with all kinds of grapefruit.

Research and advertising are two phases of our industry that have been sadly neglected in Texas.

Florida and California are spending around $7,500,000.00 per year advertising citrus, whereas the most we ever spent was $250,000.00. In other words, they have been spending thirty times as much as we have on advertising.

Florida and California are spending huge sums on research, and don't forget that on a lot, if not most, research work, the U. S. Department of Agriculture will match funds with the individual states.

Many of our present and most vexing problems would have already been solved if we had been working on them through research during the past years.

Let's not keep on repeating this mistake. Let's not be facing the same problems ten or twenty years from now that we are facing today.

Just one example of the benefits of research is the matter of certified trees. We were losing a tremendous amount of trees every year because of two diseases – Gummosis and Psorosis. We learned very recently through research how to detect Psorosis on the parent trees, and we can now buy nursery stock that is certified to be free from this dangerous disease.

Another example of the benefits of research is the project to remove the muddy color of Pink and Red Grapefruit juice.

Before the freeze, when our production was 75% White grapefruit, the canners could mix the juice from Pink and Red fruit with the White and get a satisfactory color, but with the crops from now on going to run 75% to 85% Pinks and Reds, we will not be able to do this mixing, but thanks to the excellent research work done by the U. S. Department of Agriculture, Fruit & Vegetable Laboratory at Weslaco, we now are able to get a satisfactory color on straight Pink or Red juice, but this process needs further improvement.

This project is one of many other citrus projects being carried on under Research and Marketing Act Funds of which Dr. Roy Magruder is Research Coordinator.

The fresh frozen orange concentrate product is a result of research work in Florida.

However, there are many very important problems that have not as yet been solved.

For example, the rootstock problem, another very important one under Research and Marketing Act and regular Federal Funds.

We must now start to replant our groves and we aren't sure whether it should be on Sour orange, Cleopatra mandarin or some new rootstock that hasn't as yet been fully tested to ascertain its adaptability to Rio Grande Valley conditions.

Nearly 100% of our citrus trees are planted on Sour orange rootstock, but this rootstock is susceptible to Tristeza, one of the most dangerous of all citrus diseases. It was found eight years ago in California, two years ago in Louisiana and about six months ago in Florida. It could be in Texas.

Up to now, Sour orange rootstock is the only one that has been proven satisfactory in Texas. Cleopatra mandarin is very promising, but has not been thoroughly tested as yet.

Dr. Cooper of the U. S. Department of Agriculture at Weslaco, is at the present time testing 275 different rootstocks, and it is the opinion of most experts that the ideal rootstock for Texas is among these 275, but only time and reseacrh will make this rootstock known to us.

If we had been carrying on this research work years ago, like California and Florida have, we would know, like they do, what the best rootstock would be on which to plant.

We have ben working on the Black Fly in Mexico and think we have it pretty well under control, but the Mexican Fruit Fly is as big a problem as ever. This is the pest that forces us to sterilize our fruit.

I am sorry to be compelled to say that for the past two or three years Florida and California, working jointly with the U. S. Department of Agriculture and private- research organizations, have been paying our share of the expenses in addition to their own on certain problems that concern all three states.

I believe they have done this because of the close relationship and harmony that has existed between the representatives of the three states and the U. S. Department of Agriculture during the past ten years.

But I know also that they expect us to take steps to share our percentage of the burden as soon as we are on our feet.

And I think Texas is too proud and too fair to expect them to carry our load indefinitely. We must find some way to do our part so that we may with justification and dignity ask that a fair share of this research work be done right here in Texas.

And now, in predicting a big citrus comeback, I am arriving at the most important thing of all. The U. S. Bureau of Census official figures show that the population of the states West of the Mississippi was 47 million in 1950, and is expected to increase to 55 million by 1960.

California alone is expected to increase from 10½ million to 14 million during this period.

This is the territory in which we have a tremendous advantage in freight over our principal rival – Florida.

We have a freight advantage to Texas markets of nearly $1.00 a box. In the territory from Louisiana, Arkansas and Oklahoma up through Kansas City, Omaha and Minneapolis, we have an advantge of 65c to 75c per box.

In the big citrus consuming territory of California, Washington and Oregon, we have an advantage of around $1.25 per box.

In the states of Wisconsin, Michigan, Illinois and Indiana, there were 22 million people in 1950 and it is expected that this will be increased to 25 mllion by 1960. Our freight rates for these states average about the same as from Florida.

In the states of Ohio, Kentucky, Tennessee and Mississippi there were 16 million people in 1950, and it is expected that there will be 18 million by 1960.

Our slight freight disadvantage to these states is more than offset by the premium our quality fruit brings.

So, you can figure there are 98 million consumers who are waiting for Texas grapefruit and oranges in territories where we have equality to a tremendous freight advantage.

By 1960, California will be right on the heels of New York in population, with Texas, Illinois and Ohio bunched very closely for 4th place.

This trend in population increase is definitely Westward – in the territory where we have the big freight advantage. Maybe Horace Greely was right.

It will take years for us to catch up with the demand from this territory and it means that the citrus grower, seeing this demand and opportunity for making a profit, will plant heavily.

A citrus grower is happier growing citrus, and I think a lot of vegetable growers will be happier also when the citrus grower is again growing citrus. Because, there's too much land in the Rio Grande Valley for just vegetables and cotton, and the idea that cotton was a sure thing in the Valley was disproved this past summer.

No one disputes the fact that the Valley economy will never be sound and stabilized until the great citrus industry is restored to its former prominent position.

A tree census taken by the U. S. Department of Agriculture on July 1st, 1952, showed that there were 3,679,473 good trees left – about half grapefruit and half oranges. About two-thirds of the grapefruit were pinks and reds. And about two-thirds of the trees were five years and older, which means a rapid increase in production each year.

A survey completed last September by the Texas State Department of Agriculture showed that there were 1,117,000 excellent trees in the nurseries at that time ready to plant during the Fall and this Spring, and an additional 1,800,000 that will be ready next Fall.

This is approximately 3,000,000 trees that will be ready within the next year. And the growers have been buying and setting out trees. They are continuing buying trees and getting more land ready to set them out.

There are another 1,500,000 now in the nurseries that will be ready soon after these 3,000,000 trees.

So, you can see why I am optimistic about the future of Texas citrus.

I am looking forward to the day, and it is not too far away, when I shall see a bigger and better Texas Citrus Industry than ever before.

I feel very sure about this. Those big idle packing plants will be humming before long.

And then the Rio Grande Valley will again be the Magic Valley, a prosperous and beautiful Valley – the home of the world's finest citrus.

Rio Grande Gummosis In Relation to Diplodia Infection In Texas Citrus[1]

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Introduction

Rio Grande gummosis is an infectious disease of grapefruit trees characterized by gum exudation from blisters on the trunk or large limbs. Under each blister a gum pocket is found, and the wood is gum-infiltrated; the affected wood beneath a blister is buff-colored and usually the buff color is bordered by a salmon-orange to pink color that deepens in shade when exposed to the air. As used in this paper, "pink-wood" and "pink-chips" refer to this characteristically stained wood. The affected wood has an odor similar to that of smoked fish. The wood stain does not extend beyond the bud union into the sour orange rootstock (Godfrey, 1945). Black necrotic areas, containing mycelium of *Diplodia natalensis* occur in the older parts of the lesion, according to Godfrey (1945), who reported the occurrence of Rio Grande gummosis in Texas. Childs (1950) considered the disease to be the same as "gummosis" described by Fawcett (1907) in Florida. Bach (1931) described a "gummosis" in Texas apparently identical with that described in Florida.

Transmission of Rio Grande gummosis was reported by Godfrey (1945), who placed chips of affected pink-wood in chisel cuts in grapefruit wood. Godfrey (1945) considered that an actinomycete-like organism was the probable cause of the disease, although pure cultures of such an organism were not isolated from diseased tissue. Olson and Waibel (1951) demonstrated that the pink-wood stain occurred in uncovered chisel cuts in the wood. In 1952 Olson reported that *Diplodia natalensis* inoculations in the wood produced the pink-wood stain; uninoculated controls and *Diplodia* inoculations in the cambium region did not cause such a wood-stain within the 90 day test period.

The ultimate objective of the study reported here was to find an effective method of transmitting Rio Grande gummosis to healthy trees so that rootstock susceptibility to this disease might be determined. The attainment of this objective could be materially aided if the causal agent of the disorder were definitely known. This article presents additional evidence that infection by *D. natalensis* is associated with Rio Grande gummosis. The relationships between tree vigor, *Diplodia* infection, and Rio Grande gummosis are discussed. Comments on the relative seriousness and control of Rio Grande gummosis are also included.

[1]These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the U. S. Department of Agriculture, certain phases of which were carried out under the Research and Marketing Act of 1946. The cooperation of Rio Farms, Inc., of Monte Alto, is greatly appreciated.

Materials and Methods

A block of 15-year-old Marsh white grapefruit and Valencia orange at Rio Farms, Monte Alto, was used as test trees. A few four-year-old Red Blush trees at Weslaco were also used. The areas on the branch at the point of inoculation were disinfected, and various organisms were inserted into the wood. In the "chisel" technique, the organisms were placed in diagonal chisel cuts one-half inch deep and the incision was covered with adhesive tape. In the "dowel" technique, holes 7/32 inch in diameter and one inch deep were drilled, inoculum was added, and the hole was plugged by a flamed dowel one-fourth inch in diameter. The surface of the plugged hole and adjacent bark was covered with a wound dressing containing 0.4% pentachlorophenol. The inoculated limbs were chiseled open 75 to 100 days or more after the date of inoculation, and the length of the pink-stain parallel to the grain of the wood was measured.

RESULTS

Organisms isolated from the tissues of gummosis lesions

Pink-chips from naturally-occurring gummosis lesions were placed on slants of cornmeal agar and other common laboratory media. No organism grew upon 175 of 186 such slants, but five cultures of *Diplodia natalensis* and a culture of a pink bacterium were obtained. In contrast, *D. natalensis* was isolated frequently from dark-colored wood near the gumming lesion, as reported by Godfrey (1945), who considered *Diplodia* a secondary organism in older portions of gummosis lesions. *D. natalensis* was isolated also from the margin between pink and dark wood of a gumming seedling. When grown on potato dextrose or cornmeal agar, these *Diplodia* isolates caused a pink color in the substrate below the black mycelium.

Inoculation Studies

Four series of inoculations by the "chisel" technique were made between July 27 and October 27, 1950. This screening test, summarized in table 1, indicated that *Phytophthora palmivora, Phomopsis citri, Colletotrichum gloeosporioides* and the unidentified pink bacterium did not produce the wood stain characteristic of gummosis. An unidentified fungus often caused a grey wood stain with a thin border of pink-stained wood. However, isolates of *D. natalensis* from rotting fruit, gumming seedlings, and gummosis lesions consistently caused profuse gumming and an extensive pink-wood stain in inoculated trees of 15-year-old Marsh and four-year-old Red Blush grapefruit. The pink-wood stain following *Diplodia* infection was more extensive in grapefruit than in Valencia orange. In grapefruit pinkwood stain was also associated with open cuts, where natural infection of the wood could take place. Pink-wood stain also followed inoculations with chips from dead fruit spurs which were heavily infested with *Diplodia*. Wood stain was rarely observed in the uninoculated taped cuts used as controls.

The symptoms of *Diplodia* infection of grapefruit wood were similar to those of Rio Grande gummosis: profuse gumming, a wood stain of similar color and odor, and longitudinal bark cracks above or below the point of inoculation.

D. natalensis isolated from citrus trees and fruit in Texas and Florida also caused the pink-wood stain in grapefruit trees. Two *Diplodia* cultures isolated from cotton in Louisiana failed to cause the characteristic wood stain within a 100 day period, as shown in table 2.

As shown in tables 1 and 2, pink-chip inoculations sometimes caused

Table 1. Pink-wood stain in Valencia orange and Marsh grapefruit, 75 days after inoculation with various organisms and materials.

Inoculum	Occurrence of stain in: Orange — Inoculations stained (number)	Orange — Stain Index*	Grapefruit — Inoculations stained (number)	Grapefruit — Stain Index*
Phytophthora palmivora	—	—	0 of 12	0
Phomopsis citri	0 of 6	0	0 of 14	0
Colletotrichum gloeosporioides	0 of 3	0	0 of 9	0
Pink bacterium	0 of 13	0	0 of 28	0
Unidentified fungus	3 of 3	15.0	9 of 13	15.2
Diplodia natalensis	11 of 13	34.0	47 of 50	175.3
Dead fruit-spurs	2 of 10	2.8	10 of 10	120.0
Pink-chips	2 of 13	3.6	12 of 26	77.6
Controls				
Uninoculated open cut	0 of 13	0	11 of 23	82.2
Uninoculated taped cut	2 of 12	0.3	0 of 16	0

*Sum of lengths of pink stain (mm.) in successful inoculations / Number of inoculations made

Table 2. Pink-wood stain in Marsh grapefruit, 100 days after inoculations with *Diplodia* from various sources.

Inoculum	Inoculum source	Occurrence of stain in Marsh grapefruit: Inoculations stained (number)	Stain Index*
D. natalensis	Seedling citrus, Texas	10	189
D. natalensis	Stem-end-rot, Texas	9	145
D. natalensis	Stem-end-rot, Florida	5	100
D. natalensis	Gummosis lesion, Texas	7	125
Diplodia sp.	Cotton root, Louisiana	0	0
Diplodia sp.	Cotton boll, Louisiana	0	0
Controls			
Pink-chips	Gummosis lesion, Texas	3	52
Uninoculated open cut	....	4	40

*Sum of lengths of pink stain (mm.) in successful inoculations / Number of inoculations made (10)

pink-wood stain approximately equal to that occuring in uninoculated open cuts. It seemed probable that such infection was a result of *Diplodia* contamination, probably during the inoculation procedure, since *Diplodia* was rarely isolated from pink-wood occurring in gummosis lesions. Therefore, it seemed desirable to determine whether pink-chips free of *Diplodia* could transmit the disease to healthy trees.

Pink-chips were placed in slants and incubated for six days to establish their freedom from *Diplodia*. Twenty *Diplodia*-free pink-chips were inserted into healthy grapefruit wood by the "dowel" technique for comparison with an equal number of inoculations with other materials. After 200 days the inoculations were chiseled open. The pink-wood stain from each of the two different isolates of *Diplodia* was approximately 100 times that from the pink-chips (table 3). The pink-wood stain from natural infection of open drill holes was 11 times that from pink-chip inoculation. Dead fruit spurs heavily infested with *Diplodia* were more effective in transmitting the pink-stain symptom and the blister symptom than were pink-chips. In each of the treatments, the amount of pink-stain was roughly proportional to the extent of dark wood stain. *D. natalensis* was reisolated from the dark wood stain occurring in three of the 20 uninoculated plugged drill holes, from dead fruit spur inoculations, and from *D. natalensis* inoculations. Gum pockets between the bark and the wood, and blisters similar to those of Rio Grande gummosis commonly occurred adjacent to inoculations with *Diplodia or Diplodia*-infected fruit spurs.

Pink-Wood Stain in Relation to the Bud Union

Godfrey (1945) reported that the wood stain of gummosis did not extend beyond the bud union into the sour orange rootstock. It seemed

Table 3. Wood stain and blister symptoms of grapefruit, 200 days after inoculations by the "dowel" technique.

Inoculum	Inoculations causing pink stain — No.	Index*	Inoculations causing dark stain — No.	Index*	Inoculations causing blister symptoms — No.	Index**
Pink-chips	2	3	2	1	0	0
Dead fruit spurs	18	208	19	66	12	1
D. natalensis (seedling)	20	333	20	123	16	2
D. natalensis (gummosis lesion)	19	301	20	121	15	2
Controls						
Uninoculated plugged hole	3	39	3	22	0	0
Uninoculated open hole	4	33	7	13	0	0

*Sum of lengths of stain (mm.) in successful inoculations / Number of inoculations made (20)

**Sum of number of blisters in successful inoculations / Number of inoculations made (20) necessary to determine whether the *Diplodia*-induced wood stain also terminated at the bud union.

Five trees of 15-year-old Marsh grapefruit trees on sour orange rootstock were inoculated by the "chisel technique" in 1950 and three trees by the "dowel technique" in 1951. The inoculations and the controls were located within an inch of the bud union in both the grapefruit scion and the sour orange stock of each tree.

In the 1950 experiment (table 4), which was terminated after 100 days because of the January 1951 freeze, the pink-wood stain following *Diplodia* inoculation in grapefruit ended at the bud union. *Diplodia* inoculations below the bud union in the sour orange stock caused a dark wood stain, typically about 15 mm. in length, surrounded by a pink border one mm. wide.

In the 1952 experiment (table 5), the inoculations were chiselled open after 200 days. In the grapefruit scion the pink-wood stain caused by *Diplodia* generally extended to the bud union and stopped there. In one tree, however, the broad pink band in the grapefruit scion terminated at the bud union, but a thin sliver of pink-stained wood extended into the sour rootstock for 57 mm. Two blisters occurred, 135 mm. and 165 mm. above the point of inoculation, in the grapefruit scion. In this same tree, *Diplodia* inoculation into the sour orange stock caused a pink-wood stain that extended 50 mm. up to the bud union, where it terminated. The downward extension of the stain was 161 mm. and a gummosis-like blister developed between the wood and the bark on the sour stock at a point 40 mm. below the point of inoculation of the sour stock.

Table 4. Pink-wood stain in grapefruit scion and sour orange stock of five trees, 100 days after inoculation in 1950.

Inoculum	*Part inoculated*	*Inoculations stained (No.)*	*Stain index**	*Stain extending to bud union (No.)*	*Stain extending past bud union (No.)*
Control					
Uninoculated taped cut	Grapefruit	1	3	0	0
Pink-chip	Grapefruit	2	4	0	0
D. natalensis	Grapefruit	5	111	5	0
Control					
Uninoculated taped cut	Sour orange	1	**	0	0
Pink-chip	Sour orange	4	**	0	0
D. natalensis	Sour orange	5	**	0	0

*Sum of lengths of pink stain (mm.) in successful inoculations / Number of inoculations made (5)

**Dark wood stain about 15 mm. in length surrounded by a pink border one mm. wide

Organisms Occurring in Stained Wood Subsequent to Inoculation of Healthy Branches

Chips of pink- and dark-stained wood resulting from various inoculations were placed on common laboratory media, usually corn meal agar. The results are summarized in table 6. Few organisms were cultured from the pink-wood stain, whether caused by accidental infection of the controls, pink-chip inoculation, or *Diplodia* inoculation. *Diplodia* was readily cultured from the dark-wood stain following *Diplodia* inoculation or contamination. In addition, *D. natalensis* was also cultured from the dark-wood stain associated with the pink-wood stain in nine taped, uninoculated controls, and eight pink-chip inoculations.

Table 5. Pink-wood stain in grapefruit scion and sour orange stock of three trees, 200 days after inoculation in 1951 by the "dowel" technique.

		Occurrence of stain			
Inoculum	*Part inoculated*	*Inoculations stained (No.)*	*Stain index**	*Stain extending to bud union (No.)*	*Stain extending past bud union (No.)*
Control					
Uninoculated plugged hole	Grapefruit	1	64	1	0
D. natalensis (seedling)	Grapefruit	3	323	3	1
D. natalensis (gummosis lesion)	Grapefruit	3	208	2	0
Control					
Uninoculated plugged hole	Sour orange	0	0	0	0
D. natalensis (seedling)	Sour orange	2	118	1	0
D. natalensis (gummosis lesion)	Sour orange	2	27	1	0

*Sum of lengths of pink stain (mm.) in successful inoculations / Number of inoculations made (3)

Table 6. Isolation of *Diplodia natalensis* from pink- and dark-stained citrus wood subsequent to infection of various origins.

Origin of infection	*Color of wood stain*	*Organisms isolated from stained wood (No. of slants)* Diplodia	Others	None
Diplodia inoculation	pink	2	3	187
Open cut, natural infection	pink	0	0	26
Pink-chip inoculation	pink	0	0	22
Diplodia inoculation	dark	59	0	23
Open cut, natural infection	dark	27	0	9
Pink-chip inoculation	dark	4	0	12

DISCUSSION

Symptoms of Rio Grande gummosis produced by Diplodia infection

Diplodia infection in these experiments produced the following symptoms characteristic of Rio Grande gummosis:

a. *Profuse gumming:* Gumming occurred at the point of inoculation by the "chisel" technique, and commonly at points a foot or more above or below the point of inoculation by the "dowel" technique. Gumming of Rio Grande gummosis also occurs above or below the point of initial infection.

b. *Gum pockets:* The gum pockets occurred between the bark and the wood and were the approximate size of gum pockets underlying gummosis blisters. Many of them were under inch-long cracks in the bark and could therefore become infected by other organisms. In the older gum pockets abundant cell proliferation near the gum pockets, similar to that found in gummosis lesions, was observed. The gum pockets and blisters were underlain by a band of pink-wood. The *Diplodia* infection of the wood did not extend through the bark to the gum pockets and blisters.

c. *Pink-wood stain:* The salmon-orange to pink wood stain was identical in color, odor, and location in the wood with that underlying the blisters of Rio Grande gummosis.

d. *Blister stage on the trunk:* The blister stage of Rio Grande gummosis of Texas grapefruit and "gummosis" of Florida grapefruit (Fig. 25, Rhoades and DeBusk, 1931) was duplicated by *D. natalensis* inoculation. It seems possible that the blister stage, with a gum pocket buried in the wood, arises as gum pockets are buried by new wood cells laid down by the cambium.

e. *Bud union effect:* The pink-wood stain in grapefruit trunks normally stopped at the bud union and except in one instance did not penetrate into the sour orange stock. An unexpected development was the observation that the pink-wood stain in the sour orange stock also stopped at the bud union. These fragmentary data would suggest that some characteristic of the bud union may interfere with the movement of the material causing the pink stain. In these experiments, it was observed that gnarled wood, such as often occurs at the bud union, caused termination of the pink stain in grapefruit branches.

On the basis of reasoning or unsuccessful inoculations, other workers have considered that *Diplodia* infection was not related to gummosis. Childs (1950) eliminated *Diplodia* as a cause of Rio Grande gummosis for two reasons: (a) *Diplodia* infections cause the wood to become dark-gray to black, contrasting sharply with the buff and orange color of wood affected with gummosis and (b) *Diplodia* readily attacks sour orange, but in Rio Grande gummosis, the wood stain does not extend beyond the bud union into the sour stock.

Childs kindly supplied a culture of *D. natalensis* from Florida (table 2), which caused a dark-gray to black wood stain and a pink-wood stain extending substantially beyond the dark stain. In this paper, experiments in which the pink-wood caused by *Diplodia* infection of sour orange also stopped at the bud union are described.

Fawcett (1911, 1912) and Stevens (1914) inserted *D. natalensis* in citrus bark and induced profuse gumming, but they did not observe a pink-wood stain. Bark inoculations with *Diplodia* failed to produce the pink-wood stain, but inoculations into the wood produced the wood stain in 90 days or less (Olson, 1952). Fawcett's and Stevens' failures to produce the symptoms of gummosis by *Diplodia* inoculations may be explained by differences in techniques.

In Texas *D. natalensis* was constantly associated with the dark wood of gummosis lesions. *Diplodia* inoculations consistently produced symptoms of Rio Grande gummosis, and *Diplodia* was consistently reisolated from the dark wood adjacent to inoculations. However, the evidence is not adequate to establish *Diplodia* as the sole cause of Rio Grande gummosis, since *Diplodia* was not recovered from the advancing margin of the pink-wood stain associated with either natural or experimental infections. Furthermore, the blister and stain symptoms of gummosis may be a response to gum-infiltrated wood, a condition sometimes caused by agents other than *Diplodia*.

Possible Nature of Pink-Wood Strain

In the absence of *Diplodia*, the pink-wood apparently is not infectious, since it does not transmit Rio Grande gummosis to healthy trees. When wood chips contain *Diplodia*, as did the dead fruit spurs, they are capable of consistent transmission of the disease.

The relation of *Diplodia* to the pink stain may be similar to that observed in "red rot" of sugarcane. Edgerton and Carvajal (1944) reported that a zone in advance of the mycelium turns red because of the presence of a soluble dye and that the growth of the advancing mycelium is stopped or checked temporarily by this red zone. In Rio Grande gummosis, a comparable condition may exist. When the pink stain results from *Diplodia* infection, the gumming lesion and dark wood stain with abundant *Diplodia* mycelium may be surrounded by a pink-wood stain with no mycelium.

Diplodia is capable of producing a pink dye or pigment when grown at 37°C., producing a pink to red color in the substrate. This chromogenic characteristic, reported by Voorhees (1942) and Verrall (1942), was noted in the isolates studied. However, this chromogenic characteristic also occurred in *Diplodia* isolates from cotton, which did not produce the wood stain in citrus within a period of 100 days. Although the pink-wood stain of gummosis might be caused by a pigment produced by the fungus alone, it seems more probable that it is caused by an interaction between the fungus and the citrus wood.

Tree Vigor in Relation to Rio Grande Gummosis and Diplodia Infection

Earle and Rogers (1915) considered that actively growing tissues have considerable resistance to *Diplodia*. No tissue seemed to be attacked until fully matured or enfeebled by unfavorable conditions. Wounds in the trunk or large limbs were likely to become infected with *Diplodia*, which, in the experience of Earle and Rogers, was one of the most frequent causes of trunk gummosis. In California, Fawcett and Klotz (1948) considered that *Diplodia* twig blight often followed unfavorable conditions of tree health.

Rhoades and DeBusk (1931) considered that gummosis in Florida could be prevented to a large extent by maintaining the trees in a vigorous condition. In Texas, Apple *et al* (1947) surveyed 3643 grapefruit trees in four groves. They reported that 61 to 63% of the trees on two poorly drained sites showed Rio Grande gummosis, while only 3% of the trees on the two well-drained sites were infected.

In Texas, the majority of gummosis lesions healed over in grapefruit groves where tree vigor was increased by better water management, drainage, or fertilizer applications. Improvement of drainage in the groves subsequent to the survey by Apple *et al* (1947) reduced the incidence of gummosis to the point where it was difficult to find new lesions. The same beneficial effects of improved drainage were observed in other locations where gummosis had been a problem.

Relative Seriousness of Rio Grande Gummosis

Rio Grande gummosis has been considered the most serious disease of Texas citrus, but under normal conditions psorosis is more serious. During 1950, for example, psorosis commonly affected both grapefruit and oranges, while gummosis blisters and lesions were common only on grapefruit. Trees with the scaly bark symptoms of psorosis did not recover; trees affected with gummosis recovered when soil and water management was improved. Thousands of trees were killed by psorosis under conditions where no other cause was apparent; thousands of declining grapefruit trees showed gummosis, but when such trees died the true cause of decline was generally considered to be high water table, unsuitable irrigation water, psorosis or neglect.

Control

Most of the gummosis lesions in Florida (Childs, 1950) and Texas (Godfrey, 1945) occur adjacent to unprotected wounds, indicating that these wounds are the most important points of entry for the causal agent. The greatest hazard is from the wounds resulting from cutting off large branches. Such wounds require several years to heal. In the meantime, the wound is open to infection by *Diplodia*. Since *Diplodia* occurs in decaying fruit and dead wood in the grove, the organism is widespread and abundant. Both Godfrey (1943, 1946) and Childs (1950) recommended compounds to cover and protect pruning wounds.

The practice of chiselling-out infected or stained wood, advocated by Godfrey (1946) and Childs (1950), presents serious disadvantages. First, new infections may arise from wounds made in the chiselling operation. Second, tree surgery techniques are expensive and are not clearly understood by most growers. Increasing tree vigor by improved cultural methods may be a more feasible method of causing the gumming lesions to heal.

SUMMARY

The results reported here are part of a study to find an effective way to produce the symptoms of Rio Grande gummosis in healthy grapefruit trees.

Inoculations of the wood with *Diplodia natalensis* consistently produced the pink-stain symptom of the disease, while certain other organisms failed to produce this symptom. One unidentified fungus caused a pinkwood stain that spread a short distance in comparison with that produced by *Diplodia*.

The symptoms occuring on grapefruit trees inoculated with *D. natalensis* were those of Rio Grande gummosis: profuse gumming, gum pocket formation, blister formation, and wood stain of similar color, odor and location in the wood.

Diplodia inoculum in the grapefruit scion caused a wood stain that normally terminated at the bud union with the sour orange stock. This is also a characteristic of Rio Grande gummosis. However, in one instance a very thin band of pink-stained wood extended past the bud union with sour orange. In two instances inoculations of the sour orange stock caused a pink-wood stain that terminated at the bud union with grapefruit.

D. natalensis consistently occurred in dark and necrotic wood of gummosis lesions, but not in the pink-wood stain. The pink color of the wood stain in advance of the fungus mycelium is probably caused by a pigment, either a product of *Diplodia* or of the interaction between the fungus and the host tissues. When not contaminated with *Diplodia*, the pink-stained wood did not transmit the disease to healthy trees.

Infection by *D. natalensis* is considered to be related to Rio Grande gummosis, but the evidence is not adequate to consider *Diplodia* the sole cause of the disease.

Rio Grande gummosis, which in normal years causes less damage to Texas citrus than psorosis, should not be considered the most serious disease of Texas citrus.

Control measures comprise two phases: protection of pruning wounds against infection and improving the vigor of trees by better soil and water management.

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A Comparison Of Sour Orange And Cleopatra Mandarin Seedlings On Salty and Calcareous Nursery Soils[1]

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INTRODUCTION

In recent years nurserymen in the Rio Grande Valley have grown a large number of Cleopatra mandarin seedlings for rootstock purposes. This variety is tolerant to tristeza while sour orange rootstock is highly intolerant (Grant and Costa, 1948). During the past year Cleopatra mandarin seedlings in certain nurseries have shown chlorosis (a yellowing of the leaves) and a marked lack of vitality irrespective of good nursery management. Sour orange seedlings in seedbeds and nursery rows adjacent to chlorotic Cleopatra mandarin seedlings either had green foliage and vigorous growth or were not chlorotic but showed bronzing and burning of the tip and margin of the leaf.

A previous study on young grapefruit trees showed that bronzing and leaf burning are symptoms of salt injury and that trees on sour orange rootstock are more susceptible than those on Cleopatra mandarin (Cooper and Edwards, 1950). On the other hand, the chlorosis shown by Cleopatra mandarin in the nurseries of the Rio Grande Valley resembles iron chlorosis (Chapman and Kelly, 1943). In mild cases the leaf veins were darker green than the interveinal areas. In more advanced stages the interveinal areas were yellow or ivory. The chlorosis symptom is distinctly different from the bronzing and leaf-burning symptoms of excess salt.

The present report deals with observed responses of Cleopatra mandarin and sour orange seedlings growing in commercial nurseries under varying soil conditions. A study was undertaken to ascertain the influence of soil condition on certain chemical components of foliage of the two rootstocks. While the work is exploratory in nature, it is hoped it will lead to a better understanding of the factors involved in growing Cleopatra mandarin seedlings.

METHODS AND MATERIALS

Leaf samples were collected on August 25, 1952, from sour orange and Cleopatra mandarin seedlings growing under various conditions. In some instances the two rootstocks grown on the same soil can be compared and in others a rootstock grown under one soil condition can be compared with the same species grown under other conditions.

The leaves in all instances were mature, being approximately three months old. Each sample consisted of five leaves from each of ten plants. In a few cases duplicate samples were taken. Therefore, only gross differences can be discussed.

The leaves were wiped with a moist cloth, rinsed three times with distilled water, oven dried at 75 degrees C., and ground to a fine powder in a Wiley mill. Chloride was determined by the standard A.O.A.C. (1945) procedure for plant tissue. Sodium and potassium were determined on a flame photometer in which lithium was used as an internal standard. Calcium was determined by the versenate method (Cheng and Bray, 1951).

A sample of soil consisting of 4 soil cores was taken with a soil tube in the approximate root zone of several of the ten plants from which each leaf sample was collected. In the case of five- to six-month-old seedlings in the seedbed, this soil sample consisted of the upper three inches of soil. For eighteen-month-old seedlings lined out in the nursery row, the surface foot of soil was sampled.

The soil was dried and ground to powder, and a soil paste was made up to a saturated condition by adding distilled water while stirring. Tests for pH and lime were made on the soil paste. The lime test involved estimating the effervescence produced on the saturated paste by a drop of dilute hydrochloric acid (U. S. Regional Salinity Lab., 1947). Soil salinity was measured by determining the electrical conductivity of the saturation extract[2] of the soil. The conductivity measurements in millimhos per centimeter were converted to approximate parts per million (p.p.m.) of total soluble salts by multiplying by the factor of 700.[3]

OBSERVATIONS

Lime-induced Chlorosis

The data in table 1 show that chlorosis in Cleopatra mandarin seedlings was associated with lime (calcium carbonate) in the soil although no quantitive relation is indicated between the percentage of carbonate (as indicated by amount of effervescence with acid) and the incidence of chlorosis. Where the lime test was negative there was no chlorosis but where a high or a moderate amount of lime occurred in the soil interveinal chlorosis was present. Where only slight amounts of lime were detected, chlorosis was not always found (as in nursery H) or was sometimes severe (as in nursery G). The seedlings growing in nurseries B and C were of particular interest. The Cleopatra mandarin seedlings in B were green on soil showing no lime and were severely chlorotic on soil showing a strong lime test. In nursery C, Ruby grapefruit on Cleopatra mandarin rootstock were green on a soil showing a slight lime reaction but were chlorotic on a soil showing a strong lime test.

Most of the sour orange seedlings observed in this survey were remarkably free of chlorosis regardless of the lime content of the soil. Sour orange seedlings adjacent to chlorotic Cleopatra mandarin seedlings were usually free of chlorosis. There are, however, in the Valley known in-

[2]Saturation extract is the solution obtained by vacuum filtration of the soil paste made up to a standard condition.
[3]Conversion factor given by the U. S. Regional Salinity Laboratory (1943) for soil extracts. This conversion factor for soil extracts differs from the 600 factor given for irrigation water.

Table 1. Chlorosis and salt burn in Cleopatra mandarin and sour orange rootstocks in relation to soil conditions.

Nursery Symbol	*Approx. age of plants (months)*	*Rootstock Seedling or scion–rootstock combination*	*Leaf Symptom*	*Soil Characteristics*			*Percent of dry leaf weight*			
				pH	*Lime*[1]	*p.p.m. total salts*[2]	*Cl*	*Na*	*K*	*Ca*
A	5	sour orange	burn	7.4	–	1680	1.30	.12	2.15	3.0
	5	Cleopatra	green	7.4	–	1680	0.50	.17	1.50	3.0
	18	sour orange	burn	7.3	–	1400	2.28	.18	2.05	4.6
	18	Cleopatra	green	7.3	–	1190	0.42	.18	0.90	3.9
B	6	Cleopatra	green	5.7	–	1400	0.22	.36	1.80	3.2
	6	Cleopatra	chlorosis	7.8	°°°	420	0.02	.16	1.50	4.2
C	30	Ruby on Cleopatra	green	7.6	°	700	0.06	.18	2.05	4.0
	30	Ruby on Cleopatra	chlorosis	7.8	°°°	700	0.02	.18	1.75	3.2
D	18	sour orange	burn	7.1	°°	2310	1.08	.18	2.15	4.0
	18	sour orange	burn	7.2	°°°	1820	1.50	.18	1.50	5.0
	18	Cleopatra	chlorosis	7.5	°°°	1400	0.30	.17	1.25	4.8
	18	Cleopatra	chlorosis	7.3	°°°	1680	0.22	.18	1.05	5.0
	18	sour orange	green	7.5	°°°	980	0.44	.15	2.00	4.8
	18	sour orange	green	7.5	°°°	1190	0.30	.16	2.15	4.0
E	18	sour orange	burn	7.7	°°°	1610	1.66	.25	2.25	4.3
	18	Cleopatra	chlorosis	7.3	°°	1120	0.22	.18	1.05	4.9
F	18	sour orange	green	7.6	°°	1120	0.24	.15	1.85	3.2
	18	Cleopatra	chlorosis	7.4	°°	1120	0.14	.19	0.85	5.2
G	18	Ruby on sour orange	green	7.4	°	1190	1.15	.41	1.85	4.0
	18	Ruby on Cleopatra	chlorosis	7.3	°	1260	0.33	.25	1.05	3.9
H	18	sour orange	green	7.6	°	490	0.03	.07	2.00	6.1
	18	Cleopatra	green	7.7	°	560	0.01	.09	1.75	4.4
I	18	sour orange	burn mottle[3]	7.3	–	3710	2.14	.25	1.40	3.8
	18	Cleopatra	mottle	7.4	–	2520	0.70	.37	1.10	3.8

[1] – indicates no effervescence with acid, ° indicates slight effervescence, °° moderate, and °°° vigorous.
[2]Total soluble salts in the saturation extract of the soil.
[3]A yellowish-orange mottling commonly associated with excess boron in the leaves.

stances of chlorosis on sour orange seedlings. Nevertheless, sour orange seedlings in general appeared to be considerably more tolerant to lime in soils than were Cleopatra mandarin seedlings.

The pH of the calcareous (lime-containing) soil on which chlorotic Cleopatra seedlings were grown ranged from 7.3 to 7.8. The pH of the non-calcareous soils were only slightly lower, ranging from 7.3 to 7.4. No relation between concentration of total soluble salts and chlorosis on Cleopatra mandarin seedlings was noted. Lime in the soil appeared to be the principal factor associated with chlorosis of Cleopatra mandarin seedlings under these soil conditions.

Table 1 also presents data on the concentration of chloride, sodium, potassium and calcium ions in leaves. There was no apparent relation between the lime-induced chlorosis and chloride content of the leaves. There were instances of lower sodium content of chlorotic leaves as compared with green leaves but it was not consistent in the various locations. The calcium concentration of the leaves was approximately the same for green and chlorotic leaves. The calcium contents of the leaves of the rootstocks were not consistently different. There was markedly more potassium in the leaves of sour orange than in those of Cleopatra mandarin. This difference in potassium content of the foliage of the two rootstocks occurred at all locations regardless of the incidence of chlorosis. In nurseries B and C, where analysis was made of both green and chlorotic leaves of the Cleopatra mandarin, slightly more potassium occurred in green leaves than in chlorotic ones.

Injury Due to Excess Soluble Salts

While chlorosis was associated with the Cleopatra mandarin seedlings, salt-excess symptoms were associated with sour orange seedlings. These symptoms consisted of bronzing, tip and marginal burn, burned spots throughout the leaf, defoliation, and in severe cases dieback of the twigs and death of the plants. The data in Table 1 show that salt injury on sour orange seedlings was usually associated with a concentration of 1400 p.p.m. or more of salts in the saturation extract of the soil. In nursery I severe burning of leaves and stems of sour orange seedlings was associated with the 3710 p.p.m. salts found in the saturation extract of the soil. In nursery D a comparison was made of sour orange seedlings on soil with two different salinity levels. Seedlings on soil containing 980 and 1190 p.p.m. salt showed no leaf burn and were growing vigorously, while seedlings on soil containing 1820 and 2310 p.p.m. showed severe leaf burn and poor growth. In this instance the two lots of seedlings were within six feet of each other, one lot having received an irrigation of water from the Rio Grande containing 2400 p.p.m. total soluble salts which the other lot had not.

Observations on the chloride content of the leaves show that the leaf burn on sour orange seedlings was related to a relatively large accumulation of chlorides in the leaves. In all instances where leaf burn was observed the chloride content of the leaves was in excess of 1 percent of the dry weight of the leaf. In nurseries D and F where soil salinity was

low the chloride content of the leaves was less than 0.5 percent and no leaf burn occurred on sour orange seedlings.

The Cleopatra mandarin seedlings were remarkably free of leaf burn even when growing in salty soils. This salt tolerance of the Cleopatra mandarin was associated with a low accumulation of chlorides in the leaves. The highest concentration of chloride observed in the Cleopatra mandarin in these tests was 0.7 percent.

The sodium and calcium contents of the leaves varied but were not correlated with either salt injury or rootstock. The potassium content of the leaves, as mentioned previously, was markedly higher for the sour orange seedlings but there appeared to be no marked difference in the potassium content of different lots of sour orange seedlings showing differences in leaf burn and chloride content.

DISCUSSION

Lime-induced chlorosis in citrus is generally considered to be related to a disturbance in iron availability within the leaves. Recently, Smith *et al* (1950 showed a strong inverse relation of total iron content to the degree of chlorosis citrus grown in an acid soil in Florida. The chlorotic leaves were also low in manganese content. Analyses for iron and manganese were not made in the present investigation but the chlorosis pattern observed had a striking similarity to that described in the literature for iron chlorosis. Reuther *et al* (1951) reported a general low iron content of citrus leaves showing the "iron chlorosis" pattern whether it occurs in acid soil, calcareous soil, or poorly drained soil. They found that Valencia orange leaves obtained from Rio Farms at Monte Alto, Texas, showing iron chlorosis contained a low concentration of both iron and manganese. In this instance both a high water table and calcium carbonate in the soil were associated with the iron chlorosis.

Numerous investigators have shown that leaves with the iron chlorosis pattern are high in potassium and low in calcium as compared with green leaves (Smith *et al,* 1950). The same relation, however, was not found in these investigations. There was no marked difference in the calcium content of green and chlorotic leaves. However, there was less potassium in chlorotic Cleopatra mandarin leaves than in green leaves of the same variety. Also there was less potassium in Cleopatra mandarin leaves which tended to show chlorosis than in sour orange leaves free of chlorosis.

Practical methods of treatment of lime-induced chlorosis on citrus have not been fully developed. Iron sulfate sprays will bring about some improvement but the effects are transitory (Guest and Chapman, 1949). Soil treatment with iron sulfate have been ineffective. Beneficial effects from large applications of sulfur to the seedbed have been reported by some nurserymen. Mention has been made by numerous investigators (Reuther and Crawford, 1946) that better control of soil moisture has brought about more substantial improvement in chlorotic citrus than iron or sulfur treatments.

Recent work by Stewart and Leonard (1952) showed beneficial effects from the use of chelated iron in controlling iron chlorosis on citrus growing in acid soils in Florida. Sprays and soil treatments of one chelated iron compound known as sequestrene NaFe had no beneficial effect on chlorotic Cleopatra mandarin seedlings in one trial made in nursery G. Other chelates are now being tested.

These observations on lime-induced chlorosis on Cleopatra mandarin seedlings and salt injury on sour orange seedlings may explain difficulties in the commercial production of these two rootstocks in the seedbed and nursery. Carl Waibel of the Texas Department of Agriculture made a survey of seedbed losses during 1952 in twenty-two nurseries in the Valley. Of approximately 1,700,000 germinated sour orange seedlings in the seedbeds, fifty percent died in the seedbed during the spring and summer. Of an estimated 204,000 germinated Cleopatra mandarin seedlings in the seedbeds only twenty-two percent were lost. The gross losses were due to many causes including excess salt, tip blight, damping-off, and lime-induced chlorosis. Diseases, however, were slight in the seedbeds during the past season. The major cause of loss appeared to be excess salt and the damage was more severe on sour orange seedlings than on Cleopatra mandarin.

Cleopatra mandarin seedlings and citrus budded onto this rootstock in the nursery are not usually permanently stunted by chlorosis induced by calcareous soils. This disorder usually begins in the summer and may disappear in the fall and winter. Only a small number of the plants actually die of the disorder. Good grapefruit and orange trees have been produced on this rootstock in calcareous soils. The process of producing a tree, however, is slower and a little more costly under these conditions.

Larger trees in orchard plantings are usually not as susceptible to chlorosis as small trees of nursery size. In a five-year old Webb (Red Blush) grapefruit planting on a calcareous soil at the Experiment Station at Weslaco a slight amount of chlorosis occurs occasionally on trees on Cleopatra mandarin rootstock but it is never severe and these trees are growing nearly as rapidly as trees on sour orange rootstock. Some rootstock varieties, however, are very sensitive to chlorosis. All grapefruit trees on sweet orange rootstock in the Experiment Station rootstock planting (Cooper and Olson, 1951) died of this disorder.

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Processed Juices From Texas Red and Pink Grapefruit – A Progress Report

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INTRODUCTION

Utilization of red- and pink-meated varieties of grapefruit grown in the Lower Rio Grande Valley of Texas for processed juice had become a problem of critical importance to the economy of the citrus industry prior to the freeze of 1951. Some progress had been made toward the production of frozen concentrate, but no process had been devised for canning single strength juice of satisfactory color from these varieties. It is anticipated that the profitable processing of colored grapefruit not suitable for fresh market shipment because of size or blemishes will again become a problem as the industry in the Rio Grande Valley recovers to near its former volume. The purpose of this report is to describe progress in the preparation of products from these colored fruit.

Preparation of satisfactory canned single strength juice from such fruit presents two problems. First, it is impossible to prepare an attractively colored juice by the usual extraction methods because lycopene and beta-carotene, the main pigments of the colored varieties as identified by Matlack (1934, 1935), are intimately associated with the pulp and rag, and are not soluble in water or juice. Second, canned juice prepared from red or pink grapefruit by the usual industrial process undergoes a progressive browning or discoloration when stored at room temperature, making it unacceptable to the consumer.

The location and insolubility of the pigments makes production of a pink grapefruit juice from natural materials dependent upon some means of introducing the pigments into the juice. This may be by colloidal suspension of the pigments, solubilization of the pigments, or by colloidal suspension of the pigmented pulp in the juice. Two avenues of approach to practical solutions of the problem of obtaining a salable juice have been explored. These are the preparation of a single strength colored juice by colloidal suspension of pigmented pulp, and by the removal of suspended materials responsible for muddiness in canned single strength juice.

Both of these lines of work have now progressed through some of the preliminary stages. The preparation of the two experimental products is described herein. Fruit was available for research only in November and December of 1951, when it was not mature enough to yield the highest quality of juice for canning. For this reason, no emphasis is given in this

[1]Resigned, September 1, 1952.
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report to the organoleptic qualities of the experimental juices. Such tests are the object of current studies, along with quantitative determinations of lycopene and beta-carotene concentrations as correlated with maturity to provide basic information necessary for producing attractive pink juice from the fruit of optimum maturity. Fundamental knowledge of the pigments responsible for the color of fresh grapefruit has been meager. The process of isolating lycopene from Ruby Red grapefruit by the procedures described by Matlack (1935) is quite laborious and not well adapted to quantitative determination of pigment concentration. It was necessary for this laboratory to develop procedures which are expeditious, conservative of materials, and well-adapted to the quantitative isolation of the pigments. These procedures employ the extraction technics of Le Rosen (1942); stabilization of carotenoid pigments during extraction from acidic materials by neutralization of the raw material with sodium carbonate as suggested by Kuhn and Grundmann (1933); and separation and purification of the pigments on magnesia-filter aid mixtures in the absence of air, using an apparatus similar to that described by Zechmeister and Cholnoky (1951) for the chromatographic adsorption.

EXPERIMENTAL

Preparation of Pink Juice by Suspension of Pulp. One-third of a standard box of small size and cull Ruby Red grapefruit was washed, drained, and juiced with a laboratory burr type reamer. One and one-half gallons of fresh, deaerated juice was obtained, with 1.2% acid calculated as anhydrous citric acid, and 9.2% soluble solids.

The pint of pigmented pulp which was retained on a 40-mesh revolving screen during the juicing operation was freed from seeds and rag by hand-picking, or by passage through a cylindrical pressure strainer. Fresh juice, just sufficient to make the mixture fluid, was mixed with the finished pulp, and the mixture was passed through a colloid mill set at 0.002 to 0.001 in tolerance. The finely divided pigmented pulp was then intimately mixed by vigorous stirring with the original 1½ gallons of fresh juice to produce an attractive pink juice. Application is being made for a public service patent on this process by Huffman, Lime, and Scott (1953).

This preparation was flash-pasteurized at 194°F. in a tubular heat-exchanger and canned by the hot pack method, then cooled in running water below 100°F., and stored at room temperature. Several replicates of this canned pink single strength grapefruit juice were stored.

Preparation of Frozen Concentrated Pink Grapefruit Juice. A satisfactory frozen pink grapefruit juice concentrate was prepared by concentrating screened juice in a low temperature (70°F.) high vacuum evaporator to 56° Brix, and cutting back to 41° Brix by addition of pigmented pulp prepared as described above. The 3:1 concentrate was filled into 4-oz. cans and frozen.

Preparation of White Juice by Removal of Suspended Material. Approximately 1½ standard boxes of Marsh Pink grapefruit of early January maturity were juiced by reaming. One half the strained juice, about 2 gallons, was passed through a continuous, high-speed centrifuge. This operation removed a large portion of the suspended solids. The centrifuged juice was deaerated and canned by the usual procedures for single strength grapefruit juice, by heating to 194°F., filling hot, sealing, and water-cooling the cans. Twenty-four No. 1 cans were stored at room temperature. Blends of 50% centrifuged juice and 50% normal juice from white grapefruit were also prepared.

The remaining 2 gallons were deaerated without centrifuging, and 24 No. 1 cans were packed by the same procedure and stored under the same conditions for comparison.

RESULTS AND DISCUSSION

The results obtained indicate possible solutions of the problem of preparing a canned single strength grapefruit juice of satisfactory color. When similar preparations can be made from fruit juice of good quality for canning purposes, and can be adequately tested during storage, both analytically and organoleptically, a better evaluation may be made as to the quality of these juices.

Canned single strength pink grapefruit juice prepared as described under the experimental section of this report, and containing about 6% total suspended solids, retained an attractive pink color after 8 months' storage at room temperature. No muddiness was discernible in the stored canned juice. A sample of this juice centrifuged for 5 minutes at low speeds did exhibit a slight browning, indicating that the added suspended pigmented pulp masks the discoloration which develops during storage at room temperature of canned single strength grapefruit juice from red and pink fruit. Pink grapefruit juice preparations concentrated at low temperature and frozen retained excellent color. Reconstituted juice was indistinguishable from freshly prepared, pulp-fortified, single strength juice.

A possible objection to suspending pigment in pulp to enhance color is the high naringen content of the pulp, which may impart a distinctly bitter taste to the juice. Naringen determinations on juice from red and pink grapefruit during the season gave for the hand-squeezed juice 0.003% and for the pink juice with 6% suspended pulp 0.033%. This value indicates an 11-fold increase due to suspended pulp; however, the value compares very favorably with commercial grapefruit juice preparations. Naringen may be removed from the pulp before it is comminuted by extraction with warm water without seriously affecting the color.

An extract of the pigment from the canned single strength pink grapefruit juice prepared with pulp added, and stored for 6 months at room temperature, was examined chromatographically on a magnesia-filter aid column, and separate eluates were analyzed spectrophotometrically. In addition to lycopene and beta-carotene constituents of fresh red and pink grapefruit, a small, very strongly adsorbed yellowish brown zone from the column gave absorption data indicating oxidized lycopene and/or beta-carotene. Although no pronounced visual change is apparent in the pigments of pink grapefruit juice preparations after warm storage, it may be

necessary to close cans under vacuum, or to fill under inert gases to prevent this type of deterioration.

Canned single strength grapefruit juice from red or pink grapefruit, with no pulp added, developed pronounced browning during 6 months' storage at room temperature. The experimental pack of centrifuged juice from the same fruit after similar storage was only slightly different in appearance from canned single strength white grapefruit juice and the extent of browning in both these samples was not considered very objectionable.

A 50% blend of white grapefruit juice with the centrifuged juice from pink grapefruit, after having been canned and stored for 6 months at room temperature was excellent in appearance and compared favorably with the product from whole grapefruit.

SUMMARY

Progress made toward the utilization of pink and red varieties of grapefruit for canned juice and frozen concentrated juice is reported. The results, largely exploratory in nature, are encouraging for preparation of canned single strength pink grapefruit juice and pink frozen concentrates utilizing the naturally occurring ingredients of the fresh fruit. Blending of the juice from white grapefruit with centrifuged juice from red or pink grapefruit offers a practical method of utilizing pink and red grapefruit for canned juices, but does not capitalize on the natural pigmentation of colored citrus.

A final decision as to the quality and consumer acceptance of these products must await the results of research now in progress.

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Stabilization of Grapefruit Concentrates— A Progress Report

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A report on studies in progress on methods of preparing a concentrate from Texas-grown grapefruit which will remain stable for 6 to 12 months when stored at 40°F. (4.4° C.), or higher. Possible stabilizing methods investigated to date, singly and in combination include: Pasteurization; filling and sealing concentrates under superheated steam; addition of terpeneless oil to enhance flavor and aroma of heat-treated concentrates; varying the degree of concentration; addition of chemical preservatives and antioxidants; and adjusting the Brix-acid ratio by the addition of citric acid and sugars.

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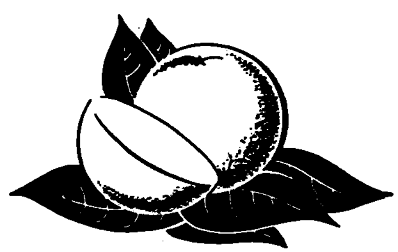

Salt Tolerance Of and Accumulation Of Sodium and Chloride Ions In Grapefruit On Various Rootstocks Grown In a Naturally Saline Soil

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INTRODUCTION

That rootstocks influence the salt tolerance of grapefruit is shown by earlier reports of the behavior of Shary Red grapefruit on 21 different rootstocks grown in soil plots uniformly salinized with a 4000 p.p.m. salt solution containing a 50-50 mixture of sodium chloride (NaCl) and calcium chloride (CaCl2). In these experiments a relation between rootstock, leaf burn, susceptibility to freeze damage, and accumulation of chlorides was established (Cooper *et al*, 1951; and Cooper, 1952). The severity of leaf burn and the extent of freeze damage correspond to chloride accumulation, which varied from 0.4% of dry weight of the leaf for Rangpur lime to 2.77% for trifoliate orange. Variations in the concentrations of sodium and calcium in the foliage were not related to any symptom of salt injury. Salt injury, resulting in both leaf burn and susceptibility of grapefruit to freeze injury, was caused by the accumulation of toxic amount of chloride in the tissues.

Observations (Cooper, 1952) on young Shary Red grapefruit trees in the Rio Farms Delta Lake rootstock planting, killed to the banks by the January, 1951, freeze, revealed an influence of rootstock on recovery. All grapefruit trees on 49 varieties of rootstock including Cleopatra mandarin showed 91 to 100 percent recovery. In contrast, grapefruit trees on Kara mandarin showed only eight percent recovery; on King mandarin, 41 percent; on Thomasville citrangequat, 58 percent; on Rusk citrange, 67 percent; and on Troyer citrange, 75 percent. Grapefruit on citrange rootstocks, considered fairly cold resistant in other citrus areas, were susceptible to cold injury when grown in this area.

It was deemed advisable to study the chloride accumulation in the leaves of grapefruit trees in the Delta Lake planting. The objective was to ascertain whether there was a correlation between chloride accumulation and the observed susceptibility to freeze damage. Additional information on accumulation of chlorides and sodium by grapefruit on other rootstoock varieties was also desired. Although previous tests did not indicate a specific adverse effect of the sodium ion in grapefruit tissue it

[1]These investigations are a part of the Cooperative Citrus Rootstock Investigations conducted by the Texas Agricultural Experiment Station and the U. S. Department of Agriculture, certain phases of which are carried on under the Research and Marketing Act of 1946. The cooperation of Rio Farms, Inc., Monte Alto, Texas, is greatly appreciated.

was possible that some of the untested rootstocks in the Delta Lake planting may have accumulated toxic quantities of sodium.

The Delta Lake rootstock test differed from the previous salt tolerance tests (Cooper *et al,* 1951) in that the Delta Lake planting was irrigated with naturally saline water from the Rio Grande. In addition to sodium and chloride ions, this water contained sulfates and bicarbonates and these ions in the soil solution may have influenced the accumulation of sodium and chloride ions.

MATERIALS AND METHODS

The Delta Lake rootstock planting, consisting of Shary Red grapefruit on 67 different rootstocks arranged in randomized blocks, was planted in April, 1950. The trees were frozen to the banks on January 31, 1951 and most trees developed new tops during 1951. The soil is Willacy fine sandy loam, and the topography is slightly rolling. The orchard site, owned by Rio Farms, Inc., Monte Alto, lies to the west of one arm of the Willacy County water reservoir known as Delta Lake. The soil has a pH of 6.7 to 7.0 in the top foot, 6.6 to 7.0 in the second foot, and 7.0 to 7.6 in the third foot. The top foot of soil is noncalcareous, the second is mostly noncalcareous, and the third foot ranges from slightly to highly calcareous. Open-ended four-inch pipe installed to a 10-foot depth in eight locations in the planting showed free ground water at 108 inches on July 15, 1951 and no free ground water at 10 feet on May 30, 1952.

The trees were irrigated by tank trucks with water from the Delta Lake reservoir. The analysis of the water used during the four month period prior to the two leaf-sampling dates is given in table 1. No determinations were made for sulfate and bicarbonate. It is known, however, that sulfates and bicarbonates occurred in the irrigation water. Delta Lake was filled with water from the Rio Grande on September 14. 1951 and some additional water was added on December 5, 1951. The report of water analysis by L. V. Wilcox, of the U. S. Salinity Laboratory, for

Table 1. Analysis of water used for irrigating the Delta Lake rootstock planting on various dates.

		Concentration of Ions				
Date of irrigation	*E.C.*[1] *(millimhos per cm)*	*Cl (e.p.m.)*	*Na (e.p.m.)*	*Ca + Mg*[2] *(e.p.m.)*	*Na (% of total bases)*	*Boron*[3] *(p.p.m.)*
Aug. 27, 1951	1.9	8.0	9.1	10.0	48	0.45
Oct. 9, 1951	1.2	4.2	4.4	7.8	36	––
Feb. 4, 1952	2.0	10.5	13.9	18.5	44	––
Mar. 27, 1952	2.9	14.4	17.4	6.0	74	1.3

[1]Electrical conductivity
[2]Versenate titration (Cheng and Bray, 1951)
[3]Carmine method described by Hatcher and Wilcox (1950)

water sample No. 21751, Rio Grande at Roma, Texas, for the month of September, 1951, shows 114 p.p.m. sulfate and 147 p.p.m. bicarbonate. Sample 21821 for the month of December, 1951, at the same location shows 230 p.p.m. sulfate and 116 p.p.m. bicarbonate.

Thirty mature grapefruit leaves were taken on January 3, 1952, and again on May 30, 1952, from each plot of three trees. Each of the four replications of each rootstock were sampled on each of the two dates. The leaves were approximately four months old for each sampling; those collected on January 3 were from an early September flush and those collected on May 30 were from an early February flush. The leaves were scrubbed with a moist cloth, rinsed four times in distilled water, dried at 75°C., and ground to a fine powder in a Wiley mill. Chloride was determined by the A. O. A. C. (1945) method and sodium was measured by flame photometry.

RESULTS

Composition of the Soil Solution

The salt content of the soil during the course of this experiment was generally low. The electrical conductivity of the saturation extract (ECe)[2] of the first foot of soil ranged from 0.5 to 0.6 millimhos per centimeter (cm) for the January sample and 1.4 to 1.7 for the April 30 sample. The ECe of the second and third foot of the April 30 sample was approximately equal to that of the first foot (table 2).

The concentration of salts in the actual soil solution is determined by

Table 2. Electrical conductivity and concentrations of sodium and chloride ions in the saturation extract of the soil 1, 2 and 3 feet from the surface.

Block	*Date Sample*	*ECe*[1] *(millimhos /cm)*			*Chloride (p.p.m.)*			*Sodium (p.p.m.)*			*Sodium (% of total bases)*		
		1st. ft.	*2nd. ft.*	*3rd. ft.*	*1st. ft.*	*2nd. ft.*	*3rd. ft.*	*1st. ft.*	*2nd. ft.*	*3rd. ft.*	*1st. ft.*	*2nd. ft.*	*3rd. ft.*
E	Jan. 8, 1952	0.6	–	–	124	–	–	83	–	–	45	–	–
F		0.5	–	–	142	–	–	83	–	–	44	–	–
G		0.5	–	–	115	–	–	67	–	–	45	–	–
H		0.6	–	–	124	–	–	78	–	–	43	–	–
Mean		0.55	–	–	126	–	–	78	–	–	44	–	–
E	Apr. 30, 1952	1.4	1.3	0.9	250	215	142	160	110	90	45	40	39
F		1.4	1.4	1.4	248	159	178	175	155	160	51	50	42
G		1.7	1.3	1.4	330	153	147	170	160	175	47	56	52
H		1.5	1.6	1.9	238	202	246	165	185	290	50	53	65
Mean		1.5	1.4	1.4	267	182	178	167	153	179	48	50	50

[1]Electrical conductance of saturation extract of soil.

[2]The saturation extract is the solution obtained by vacuum filtration of a soil made up to a saturated condition by adding distilled water while stirring. The electrical conductivity of the saturation extract is recommended (Reitemier and Wilcox, 1946) as suitable for general use for appraising soil salinity.

the amount of soil moisture as well as by the kind and amount of salts. The moisture content of most soils at field capacity is approximately one-half that of a saturated soil, while the moisture content at the wilting point is in the order of one-fourth that of the saturated soil. Soil-moisture determinations were not made on the rootstock planting but it is estimated that the moisture content of the soil was only slightly above the wilting point during part of March and April, 1952. Thus, the concentration of salts in the soil solution would be four-fold that found in the saturation extract.

The concentrations of sodium and chloride ions in the saturation extract are given in table 2. The chloride and sodium concentrations doubled between January 8 and April 30, 1952. The sodium percentage of the total bases in the saturation extract ranged from 39 to 65.

Growth and Appearance of Trees

The grapefruit trees on the different rootstocks were not equally vigorous. The trees on rough lemon and Rangpur lime were the largest Those on sour orange, Cleopatra mandarin and most of the sweet oranges were slightly smaller, while those on the trifoliate orange hybrids were generally the least vigorous. These differences in growth, however, cannot be attributed solely to differences in sodium and chloride accumulation or in salt tolerance. The root systems of different genera and species of citrus exercise some selectivity in their nutrient uptake (Smith *et al*, 1949). Nitrogen, phosphorus, potassium, calcium, magnesium, manganese, copper, iron, boron and zinc accumulation are influenced by the rootstock.

Fruit production was not a factor in this experiment, for most of the trees were too young to bear fruit. Only those on Rangpur lime, with vigorous growth, and those on Brownell citradia, with stunted growth, consistently set fruit during 1952.

On January 3 leaf necrosis was evident only on trees on Thomasville citrangequat and Troyer citrange, on which some tip burn of the foliage was present. In addition, chlorotic foliage was observed on trees on Troyer citrange.

On May 30 varying degrees of bronzing were common on some foliage of most trees in the planting. An iron-chlorosis pattern in the leaves was noted on a few trees on Cleopatra, Sanguinea, Oneco and Suenkat mandarins, on Avena Blood and Pineapple sweet orange, and on Troyer citrange. A spot was observed along the leaf margin of many of the varieties. This spot was usually shaped like a half-moon and had concentric zones of light and dark brown burned tissue. The spot remained attached to the leaf and did not fall out. The data in table 3 show that the leaf spot occurred to some extent on most varieties but was severe (75 percent or more of the trees showing the disorder) on Choo Chou Tien Chieh, P. I. 117477, Lau Chang, Calashu, Oneco, Kara and Suenkat mandarins; Hamlin and Precoce sweet oranges; Savage, Rustic, Saunders and Troyer citranges; citremon; and Webb (Red Blush) grapefruit. Tip or marginal

Table 3. Recovery from freeze damage and leaf symptoms of salt injury of Shary Red grapefruit on various rootstocks. (There were 12 trees of each rootstock in the planting before the 1951 freeze.)

Rootstock group and variety	*No. Trees That Grew New Top after 1951 Freeze*	*No. of Trees showing various Leaf Symptoms on May 30, 1952*		
		Leaf spot	*Tip burn*	*Defoliation*
Mandarin:				
Cleopatra	12	0	0	0
Sanguinea	8	5	0	0
Lau Chang	12	8	0	0
Oneco	11	9	0	0
Dancy	10	6	0	0
Choo Chou Tien Chieh	9	9	3	0
Pong Koa	10	7	0	0
Changsha	12	5	0	0
P. I. 117477	12	10	0	0
Ponkan	10	3	0	0
Suenkat	11	9	0	0
Clementine	12	6	0	0
Calamondin	11	5	0	0
Calashu	12	12	0	0
Kara	1	1	0	0
King	5	2	3	0
Sweet Orange:				
Avena Blood	12	11	0	0
Hamlin	12	12	0	0
Louisiana	12	6	0	2
Pineapple	12	3	0	0
Weldon	12	6	0	0
Gzel Gzel	12	6	0	0
Cadena panchosa	12	5	0	0
Precoce de Valence	12	9	0	0
Trifoliate orange hybrid:				
Citrumelo 4475	12	6	0	0
Highgrove citremon	10	8	3	0
Brownell citradia	11	5	9	11
Savage citrange	12	9	0	0
Rusk citrange	8	1	3	3
Rustic citrange	9	9	3	3
Uvaldi citrange	12	6	0	0
Saunders citrange	12	12	12	12
Troyer citrange	9	9	9	9
Citrangeor 43301-42	8	3	3	3
Thomasville citrangequat	7	0	6	3
Miscellaneous:				
sour orange	11	7	0	0
rough lemon	12	4	3	0
Webb (Red Blush) grapefruit	11	8	6	0
Webb (Red Blush) seedling	12	12	0	3
Rangpur lime	12	6	0	0
Sampson tangelo[1]	12	7	0	0

[1]Leaf symptoms and tree recovery were approximately the same for the Altoona, Minneola, Williams, San Jacinto, Webber, and Thornton tangelos as for Sampson tangelo.

leaf burn was noted on trees on 12 rootstocks and was severe on trees on Saunders and Troyer citranges, Brownell citradia, and Thomasville citrangequat.

Accumulation of Ions in Leaves

The sodium and chloride contents of the dry leaf tissue from grapefruit trees on 39 different rootstocks are presented in table 4; leaves from four replications of each rootstock were sampled at two different dates. Four replications of 11 additional rootstocks were sampled on May 30 (table 5). Determinations were also made on one or two replications of King and Kara mandarins and several other varieties on both sampling dates (table 5). Statistical analysis is given only for the data in table 4. In most instances a composite leaf sample from a three-tree plot was analyzed. However, leaf samples were collected from plots containing only one or two trees where certain trees did not recover from the January 1951 freeze; these varieties include the Troyer citrange, Thomasville citrangequat, and King and Kara mandarin rootstocks.

There were, in general, more sodium and chloride in the May leaf samples than in the January leaf samples (table 4). The leaves sampled on the two dates were of approximately the same age, but originated from different growth flushes. Thus the differences do not represent increased salt uptake by older leaves of the same flush, but differences in increased salt uptake by the later flush, probably because of more favorable conditions for sodium and chloride accumulation. Many of the leaves of the same age as those in the January sample had fallen off before samples of a different flush were collected in May.

The influence of rootstock on sodium and chloride accumulation in the leaves of two different flushes was relatively consistent. In general, trees which had high sodium and high chloride in the January sample had high values in the May sample. The few exceptions, notably the lower chloride content of Thomasville citrangequat, probably resulted from abscission and drop of leaves with high chlorides and from difficulties in sampling leaves of the same age on small trees that had six to eight growth flushes during a year.

The sodium and chloride accumulation among the groups of rootstock varieties varied greatly. The groups are considered only in a broad sense. For instance, the varieties listed in the mandarin group include sweet mandarins, sour mandarins, and tangors; some mandarin parentage is involved in each variety listed. Chloride concentrations generally increased in this order.

mandarin $<$ sweet orange $<$ trifoliate orange hybrid

Sodium concentrations, on the other hand, increased in this order:

sweet orange $<$ trifoliate orange hybrid $<$ mandarin

Thus, mandarins as a group were characterized by a marked capacity to exclude chloride irons and to accumulate sodium ions selectively. Sweet orange, on the other hand, accumulated chloride ions and excluded sodium ions selectively, while trifoliate orange hybrids accumulated high

Table 4. Sodium and Chloride contents of foliage of Shary Red grapefruit on various rootstocks in January and May, 1952.

	Chloride (% dry matter)			*Sodium (% dry matter)*		
Rootstock group and variety	*Jan.*	*May*	*Combined*[1]	*Jan.*	*May*	*Combined*[1]
Mandarin:						
Cleopatra	.095	.288	.191	.174	.243	.208
Sanguinea	.148	.290	.219	.334	.258	.296
Lau Chang	.140	.235	.188	.284	.288	.286
Oneco	.123	.253	.188	.293	.323	.307
Dancy	.093	.270	.181	.298	.278	.288
Choo Chou Tien Chieh	.205	.278	.241	.265	.315	.290
Pong Koa	.157	.305	.231	.244	.305	.274
Changsha	.145	.245	.195	.216	.243	.229
P. I. 117477	.128	.333	.230	221	.268	.244
Ponkan	.070	.335	.203	.276	.298	.287
Suenkat	.178	.280	.229	.293	.313	.303
Clementine	.265	.385	.325	.271	.270	.270
Calamondin	.288	.348	.318	.316	.310	.313
Calashu	.135	.303	.219	.271	.310	.290
Sweet orange:						
Avena Blood	.278	.393	.335	.224	.270	.247
Hamlin	.338	.420	.379	.196	.255	.226
Louisiana	.293	.395	.344	.199	.273	.236
Pineapple	.230	.365	.298	.181	.238	.209
Weldon	.315	.423	.369	.195	.250	.223
Gzel Gzel	.218	.345	.281	.191	.240	.216
Cadena panchosa	.338	.398	.368	.224	.255	.239
Precose de Valence	.288	.450	.369	.200	.263	.231
Trifoliate orange hybrid:						
Citrumelo 4475	.268	.435	.351	.203	.257	.230
Highgrove citremon	.313	.470	.391	.205	.248	.226
Brownell citradia	.250	.618	.438	.309	.388	.348
Savage citrange	.485	.575	.530	.240	.243	.241
Rusk citrange	.405	.605	.505	.211	.228	.219
Rustic citrange	.465	.595	.530	.234	.273	.255
Uvaldi citrange	.495	.755	.625	.250	.263	.255
Saunders citrange	.528	.808	.668	.226	.410	.318
Troyer citrange	.618	.890	.754	.233	.270	.251
Citrangeor 43301-A2	.578	.790	.684	.214	.205	.209
Thomasville citranequat	1.013	.845	.929	.236	.312	.274
Miscellaneous:						
Sour orange	.148	.293	.220	.175	.235	.205
Rough lemon	.138	.320	.229	.160	.245	.203
Webb (Red Blush) grapefruit	.303	.250	.276	.254	.275	.264
Webb (Red Blush) seedling	.170	.375	.273	.254	.343	.298
Rangpur lime	.100	.290	.195	.199	.270	.234
Sampson tangelo	.105	.270	.188	.231	.295	.263
L.S.D. @ 5%	.107		.076	.048		.034
L.S.D. @ 1%	.142		.101	.054		.045

[1]The mean of the combined January and May values.

L.S.D., Least significant difference between any two means.

concentrations of chloride ions and moderate concentrations of sodium ions. The sour orange and rough lemon varieties in general accumulated only small amounts of both sodium and chloride ion.

Ion accumulation also varied among the various varieties within a group. The Clementine and Calamondin (table 4) and Kara and King (table 5) accumulated sodium and chloride ions to a marked degree as compared with the other mandarin varieties. In the trifoliate orange hybrid group citrumelo, citremon and citradia accumulated the least chloride; the citranges, an intermediate amount; and the citrangequat, the most chloride. Among the citrange varieties the Savage, Rusk and Rustic accumulated less chloride than did the Saunders, Uvaldi and Troyer. The Saunders citrange accumulated more sodium than the other citranges. The variations among varieties in the sweet orange group were generally not significant at the one-percent level. The rootstock varieties which showed both low sodium and low chloride accumulation were sour orange, rough lemon, Rangpur lime, Cleopatra mandarin, Changsha mandarin and mandarin P. I. 117477.

Table 5. Sodium and Chloride contents of leaves of Shary Red grapefruit on rootstocks not included in table 4.

	Chloride (% dry matter)			Sodium (% dry matter)		
Rootstock Group and Variety	*Jan.*	*May*	*Combined*[1]	*Jan.*	*May*	*Combined*[1]
Mandarin:						
Sunki	.020	.200	.110	.230	.250	.240
Willow leaf	.155	—	—	.260	—	—
Betangas	.190	—	—	.380	—	—
Kinnow	.185	.240	.213	.320	.315	.318
Kara	.380	.460	.430	.380	.370	.375
King	.200	.350	.275	.315	.320	.318
Sweet Orange:						
Valencia	.280	—	—	.225	—	—
Trifoliate orange hybrid:						
Citraldin 50130	.120	—	—	.255	—	—
Citrandarin 4966	.120	—	—	.235	—	—
Cunningham citrange	.370	—	—	.270	—	—
Tangelo:						
Altoona	—	.320	—	—	.297	—
Minneola	—	.285	—	—	.280	—
Williams	—	.280	—	—	.288	—
San Jacinto	—	.280	—	—	.350	—
Webber	—	.220	—	—	.260	—
Thornton	—	.260	—	—	.300	—
Miscellaneous:						
Bergaldin 50359	—	.290	—	—	.265	—
Cuban shaddock	—	.410	—	—	.205	—
African pummelo	—	.427	—	—	.310	—
Duncan grapefruit	—	.275	—	—	.260	—
Palestine sweet lime	—	.420	—	—	.245	—
Kusaie lime	.135	—	—	.165	—	—

[1]The mean of the combined January and May values.

In the grapefruit group a comparison is shown between juvenile seedlings and an old line adult clone on the same rootstock. There was no difference in sodium in juvenile and adult tissue in January but the juvenile seedlings contained more sodium than the adult clone in May. There was less chloride in the juvenile seedlings in January and just the reverse in May.

DISCUSSION

The large accumulation of chloride ions and the accompanying tip burn of leaves eliminates most of the citranges from consideration as potential rootstocks for the Lower Rio Grande Valley. These observations substantiate the earlier findings of Cooper *et al* (1951) on the poor salt tolerance of the Rusk citrange when grown on plots salinized with an artificial salt solution containing a 50-50 mixture of NaCl and CaCl2.

There were, in general, more sodium and chloride ions in the May leaf samples than in the January samples. Leaf-tip burn, both in January and May, was associated with a large accumulation of chlorides but not with high sodium accumulation. Maximum sodium concentrations, however, were less than 0.5 percent while chloride concentrations reached as high as 1.013 percent in one variety.

A leaf spot, distinguishable from tip burn, was found to some extent on most rootstocks on May 30, but not on January 3. The general occurrence of this type of necrosis suggests the possibility that this symptom may be related to low soil moisture during the period of January 3 to May 30 rather than to specific toxicity of accumulated chloride or sodium, although the latter may have been a contributing factor. It is also possible that sulfate ions were involved in this type of necrosis.

The poor survival of cold-damaged trees on Kara and King mandarin, Rusk, Rustic, and Troyer citrange, citrangeor and citrangequat rootstocks was associated with high accumulation of either chloride or sodium ions. Poor recovery of King and Kara mandarin trees was associated with moderate chloride accumulation and high sodium accumulation. On the other hand, poor recovery of the Troyer citrange trees was associated with high chloride accumulation and moderate sodium accumulation. However, trees showing high chloride and sodium accumulation, such as Saunders citrange, showed good recovery. These irregularities might be expected since the tree recovery from cold injury is undoubtedly influenced by the inherent vigor of the rootstock and the degree of cold injury. The relation between salt injury, severity of cold injury, and the degree of tree recovery from cold injury is complex. Several factors may affect it. The high concentrations of sodium and chloride ions affect the moisture relations of the growing tissue. The generally weakened condition of trees injured by salt toxicity may also contribute to their poor recovery from cold injury.

When CaCl2 and NaCl were added to the irrigation water applied to young trees of the salt tolerance plots (Cooper *et al*, 1952), more chloride ions and less sodium ions accumulated in the leaves than were observed in the Delta Lake planting. Larger variations occurred in accumulation of chloride ions in the trees on various rootstocks in the salt plots than in the field planting. The order of the rootstocks as to ability to accumulate chlorides was similar in the two experiments except that sour orange, rough lemon, and tangelo varieties were more nearly intermediate in position between the Cleopatra mandarin and sweet orange than they were in the Delta Lake planting.

The reason is not fully understood for the greater facility with which sodium accumulates in the mandarins than in the citranges and in the trees of the field planting (of low salt content) as compared with the trees in the plots where CaCl2 and NaCl salts were added to irrigation water. The presence of sulfates in the soil solution of the field planting may have facilitated the absorption of sodium ions by certain rootstocks. Determinations made by L. V. Wilcox of the U. S. Salinity Laboratory on leaves from trees in the Delta Lake planting showed .064 percent sulfates for Troyer citrange and .178 percent for Oneco mandarin. Thus, the high-chloride, low-sodium accumulation by the Troyer citrange was associated with a low sulfate accumulation while the low-chloride, high-sodium accumulation of Oneco mandarin was associated with a higher sulfate accumulation.

SUMMARY

1. Shary Red grapefruit on 67 different rootstocks was grown in a commercial field planting irrigated with water from the Rio Grande containing sulfate, bicarbonate, and chloride salts of sodium, calcium and magnesium. The electrical conductivity of the saturation extract of the soil varied from 0.50 to 1.9 millimhos per cm.

2. Leaf samples were taken on two different dates and were analyzed for sodium and chloride ions.

3. The sodium and chloride accumulation among the groups of rootstock varieties varied greatly. Chloride concentrations were generally lowest for the mandarins, next for sweet oranges, and highest for trifoliate orange hybrids. Sodium concentrations, on the other hand, were lowest for the sweet orange, next for trifoliate orange hybrids and highest for mandarins.

4. Ionic accumulation also varied among the various varieties within a group. The Clementine, Calamondin, King, and Kara varieties accumulated more chloride than other mandarin varieties. The Troyer citrange and Thomasville citrangequat accumulated more chloride than other trifoliate orange hybrids.

5. Tip burn of leaves and defoliation of trees on certain of the trifoliate orange hybrid rootstocks were correlated with high chloride concentrations in the leaves. The cause of a necrotic leaf spot on trees on other rootstocks was not determined.

6. The poor survival of cold-damaged trees on Kara and King mandarin, Rusk, Rustic, and Troyer citrange, citrangeor and citrangequat rootstocks was associated with a high accumulation of chloride and sodium ions by those trees.

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Ornamental Horticulture In the Lower Rio Grande Valley

Mrs. D. W. Smith, *Harlingen*

With the present day trend in architecture – the patio, garden room, and modern home furnishings – the luxuriant ornamentals and exotic foliage plants have become of increasing horticultural importance. The jungles are again being searched, as in the days of Humbolt and Wallace for the more durable and less demanding plants to live with us, rather than in conservatory splendor.

The Valley is cactus country, without water, shade, and wind protection. Unless such protection is planned, utilize our neglected agava and cactus families. The early explorers realized their worth and carried them to many parts of the world. They contribute extensively to the beauty and charm of the Mediterranean shores.

PLANTS FOR WIND PROTECTION

A living wall of our cold-hardy native plants can be grown in two years. Seeds and small seedlings in a five foot strip must be heavily mulched, watered and fertilized. Interplantings of retama, anaqua, Brasil, ebony, wild olive, etc. can be strengthened with huisache, hackberry, Valley willow, Valley ash and palms. Our native vines further thicken the windbreak, and corona, cassia and beautiful flowering vines add color. The hardy bamboos can make an efficient and beautiful wall in two years. Rhizomes are planted a foot apart in a trench for deep mulching, since constant moisture and frequent fertilizing are necessary. Mature cones are useful and decorative for fencing, top shade for lounging areas, etc.

The masonry wall must have tall wind-lifting shrubs outside to prevent currents and eddies inside. This upward-moving wind from the windbreak can be further lifted and directed over the area by taller trees.

The central planting also furnishes shade and aids in preventing radiant heat loss. Tepehuaje, mesquite, huisache, Valley willow and Valley ash, if thinned, can be used.

EXOTICS FOR PLANTING IN THE SHELTERED AREA

(Plurals indicate more than one variety)

Large shrubs to small trees: Pachiras, tabebuias, spathodeas, brassia, cecropias, kapacs, teak, sandalwood, cucumber tree, tree tomato, guavas, yland-ylang, golden candle cassia. I have all of these growing from cuttings or seeds. To these should be added numerous varieties of banana, the papaya, and still others under investigation.

Herbaceous and small shrubs: Fatshedera, rice paper, jatrophas, stralitzias, pandanus, heliconias, epiphyllum cactus, rhipsalis, papyrus grasses and costus. A few of the gingers, calatheas, cordylines and peperomias.

The Aroids: An extensive order of herbaceaus plants, with many varieties of proved adaptation to our conditions. Hybridization is not difficult in some species. For this reason they hold my greatest interest. They include caladiums, elephant ears, alocasias, taros, dieffenbachias (newer, hardier imports and hybrids), aglaonemas (ornate, fast growing varieties of the well known Chinese evergreen), and philodendrons (from a few varieties, in the juvenile stage, come the majority of the house plants of today).

For sheltered area plantings the well known monstera big leaf ivy, green and varigated nephthitis and the Philodendrons are of proved value and the large leaves of the mature stage are indeed exotic. New varieties are appearing in the trade, from jungle collectors and busy hybridizers in this country. These must be tried under our conditions for both home and patio use. Soon the manufacturers will give us efficient light-bulbs to sustain health and growth in our house plants and a wide variety can be grown.

Public interest in the anthuriums is rapidly increasing, particularly in Florida. They are slow growers; therefore, expensive to produce. They are easy to grow from seed with proper care and the young plants ideal for terrerums. I have fifteen very promising varieties, plus numerous seedling from jungles of Panama and Peru and hybrids from my plants.

The exotic flowering andreanums are difficult to grow, but can be grown and kept flowering as a petted house-plant more easily than orchids. Good plants are very expensive.

SOIL, WATER, AND PEST PROBLEMS

A reasonable number of these plants in a sheltered outdoor living area require no more care than the usual yard. They are capable of returning to respectable size in six months after freeze. It must be borne in mind, however, that these plants are children of the tropics; they require warmth, humidity, shade and a constant source of nutrients from decaying organic matter. In the jungle they are shallow rooted. The numerous varieties in luxuriant growth, from the tangled root mat, are astounding to the uninitiated. Drainage is perfect in this jungle humus soil. Methods of creating and maintaining such conditions in our beds and potting mixtures are important problems.

Permanent porosity for root aeration and drainage is provided by charcoal, poultry gravel, coarse sand, pumis and the micaceous materials.

Humus supplies nutrients and aeration. Leaf mold, well rotted manure, pieces of bone, peat sphagnum and osmundum fiber, shreaded cane stalks, chips and chunks of slowly rotting woods are sources of humus. These ingredients can be varied to suit the demands of the specific plant and type of soil to be combined. The aroid root type lends itself to frequent repottings without growth retardation. From repotting one can learn much to prevent future mistakes on ingredient combinations.

Mulching provides constant nutrients and humidity. Hulls, straw, grass, leaves, cane fiber, peat, etc. can be used. The mulch can be replenished as necessary to maintain a moist decaying area to ground level and thick enough to aid humidity from frequent sprinklings in dry hot weather. Thus root damage is prevented from spade, hose stream, soil-drying with its humus destruction, concentration of undesirable chemicals, and freeze damage in winter. Ground covers may be grown in this mulch to add color and flowers. The tradescantia and Blackeyed clockvine are my choice.

Fertilizing is necessary and many of these plants are heavy feeders. I prefer a liquid or completely soluble fertilizer, easily applied and washed down from the mulch. Frequent weak applications are ideal but should be regulated to the growing season and plant health. An occasional manure mulch is excellent. Trace elements to prevent deficiencies are present in some liquids or can be purchased in bulk and applied at one ounce to square yard. Undesirable elements in the chemical formulae to be avoided are boron, sodium and chlorides.

Acidification with one-half pound of sulphur to square yard in the original mixing and a light sprinkling when mulch is replenished are practiced. An occasional application of ferrous sulphate and calcium sulphate twice a year (not advised during drought) may be helpful.

Watering depends on the soil consistency and temperature influencing transpiration. Thoroughly wetting the soil of the root zone and, during drought, flushing excess chemicals below the root zone are important. Wetting the leaves is damaging to some plants and to many during high temperature. Our strong alkali dust is probably a great factor in this damage but I feel thorough washing occasionally is necessary. The calcareous deposit from our alkaline water is probably damaging. A few potted plants can be watered with distilled or defrost water. Rain water should be utilized but the roof should be thoroughly washed. It requires at least an inch of water to remove the alkali from my composition roof and bring the pH to neutral. With the work being done on reclaiming sea water – possible soon – we can have inexpensive pure water for the home and garden.

Diseases and pests of the plants under discussion are not generally serious. Bacteria and fungi affect cuttings and tubers. Air-drying cut surfaces and allowing callous formation when feasible are important. Also, fungicide dust may be used. Antibiotics will soon be available for bacterial rots and some virus diseases. Moist potting media may be steam-sterilized in the oven or washtub.

For pests a handy windex spray bottle of nicotine solution and a small can of cat powder, Rotenone and pyrethrum, from pet shop suffice. Vigilance is necessary and hand picking early aphid colonies, cottony cushion scale and small worms prevents damage. The occasional large worm should be snipped and the night feeder looked for. Red spider mites are more of a problem in dry weather. Hosing leaves is an aid but the above spray and dust are effective. Sulphur damages many plants and some pest predators. Poison sweet bait of arsenic or Thallium aid greatly in

controlling scale-planting, predator-destroying ants. Special containers can be bought in California. I use small condensed cans for bait. Chlordane, BHC and DDT are seriously toxic to rots and leaves of many plants. The necessary frequent application for ant control soon gives damaging soil concentration, not only for roots, but nitrifying bacteria. Test plots, at end of six years, show almost no deterioration.

We have no chart of insecticide toxicity for ornamentals, as there is for field crops. The new chlorinated hydrocarbons, Aldrin and dieldrin, are highly toxic to warm blooded animals. 3/100,000 ounce aldrin will kill a quail. Parathion, of the organic phosphorus group, so highly toxic to the warm blooded animal, is inadvisable for use about the home and outdoor living area. Another (Octomethyl pyrophosphoramide) of this group shows promise as a systemic poison in the ornamentals and cotton.

Biological control is efficient, free, and the pest predators are fascinating to watch. The predators include lizards, toads, snakes, tunnel and web spiders, mantis, green lace wing and other flies, some wasps, dragon flies, lady bugs, etc., and birds so important for the larger insects and worms. In general the predators are more susceptible to insecticides than the pests. Even dead birds are common in the heavy dusting season, as are the fish in my pool. Clean water and washed berries, on their favorite shrubs, lessen the danger to birds nesting in the yard. The inconsiderate insecticide and herbicide dusters have caused much serious damage and the loss of many valuable plants in my house and yard, not to mention the public health hazard. With the increasing use of extremely toxic insecticides, herbicides and growth stunters in defoliation, control is vitally necessary.

FUTURE OF ORNAMENTAL HORTICULTURE

I would like to prophesy a bright future for ornamental horticulture in the Valley. Our assets balance favorably with California and Florida. Our delightful evening hours are unsurpassed and the intensively developed garden room for outdoor living will become very popular. Possibly the Tropical Plant Section of the Avocado Society can grow into an Ornamental Horticultural Society in which there is comparable earnest study, investigation and generous exchange of facts and ideas. Our good neighbor to the south can furnish a vast variety of material. I would greatly enjoy working on contributing projects.

Control of Corn Earworm On Sweet Corn In the Lower Rio Grande Valley

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In the Lower Rio Grande Valley the corn earworm causes severe damage to sweet corn every year. It also attacks sorghums, lettuce, peppers, and some other crops. In the Valley the earworm has seven or eight generations a year. Untreated fields of sweet corn are sometimes abandoned because most of the ears are so badly damaged as to be unmarketable. At least 30 percent of the crop is destroyed by earworms in the fields where nothing is done to control them. Damaged ears must be trimmed before they can be marketed; sometimes not more than 5 inches of an ear can be salvaged. The market price is usually about one dollar per 5-dozen package – lower for ears that have been trimmed than for whole, undamaged ears. Ears that have been trimmed are also less attractive to the consumer. Wormy or poor quality trimmed ears of sweet corn lower market prices for the crop in general and bad appearance has been one of the principal reasons why early sweet corn from the South has not been in greater demand.

No satisfactory control for the corn earworm was known until Barber (1941) developed a method of injecting mineral oil containing insecticides into the silk channels of the ears. Even control with this method was often disappointing, since considerable care was required to apply the oil properly. Moreover, the oil sometimes prevented development of kernels at the tips of the ears. Experiments carried out by Blanchard and Chamberlain (1948) indicated that an emulsion containing DDT and white mineral oil sprayed on the silks gave good earworm control. Such an emulsion did not interfere with development of the kernels at the tips of the ears, even when applied prior to pollination of the silks. It was thought that emulsion sprays might have possibilities for applications with large-scale machinery.

In 1948 the authors began an intensive research program in the Lower Rio Grande Valley to study this and other methods of controlling earworms with insecticides. This program was made possible by the wholehearted support of shippers and growers of sweet corn, who not only furnished materials and machinery for the tests but allowed unrestricted use of their corn fields for experimental purposes.

Altogether 21 insecticides or mixtures of insecticides have been tested. They include most of the organic compounds developed within the last seven years. However, since new compounds are still being developed at a rapid rate, there are several that have not yet been tested. A number of insecticides have been tested in both dusts and sprays.

Dusts applied in ordinary ways have not given satisfactory control

of the corn earworm in tests carried out by the authors. In cases where good control with dusts has been reported by others, either the infestation has been much lighter than that in the Valley or an excessive amount of dust has been applied. However, a method developed by Anderson *et al* (1950) in California, in which DDT dust is rubbed into the silks with a stipple brush, has given fair control in experiments conducted in the Valley. Airplane applications of dusts or sprays have not given satisfactory results in tests made in Texas.

The best control has been obtained with insecticides in mineral oil, either in solutions or in emulsions. Several methods of applying these insecticides have been used successfully in experiments and in actual field control by growers.

Two of the insecticides that have given the best earworm control are DDT and TDE, and they are now recommended for grower use. Both have been satisfactory in mineral oil solutions, although DDT has been used almost exclusively by growers. In emulsions containing mineral oil TDE has not given such consistently good control as DDT. Endrin and heptachlor have also given good control, but are still in the experimental stage and are therefore not yet recommended. Certain other insecticides have been effective in some tests but unsatisfactory in others.

Because of the danger of poisonous residues, husks or other parts of corn plants contaminated with DDT or TDE should not be fed to dairy animals or to meat animals being finished for slaughter.

Preparations of Insecticides

When the insecticide is applied by hand either a solution containing DDT or TDE or an emulsion of DDT may be used, but in machine application only an emulsion should be employed. A white mineral oil of 65 to 100 seconds Saybolt viscosity should be used for both preparations.

Oil Solution. The solution should contain 1 pound of the insecticide in 25 gallons of oil. It can be prepared by mixing ½ gallon of a 25-percent emulsifiable concentrate in the oil. If possible, a concentrate with xylene as the solvent should be used. A solution so prepared contains 0.5 percent of the insecticide.

Emulsion. To prepare the DDT emulsion, 3 quarts of a 25-percent emulsifiable concentrate and 7 quarts of oil should be mixed with water to make 25 gallons. Such an emulsion contains 0.75 percent of DDT and 7.5 percent of the oil. Either 2 or 3 gallons of water should be placed in a barrel or other suitable container, the DDT and oil added, and the mixture stirred vigorously while the remainder of the water is poured into it. A flat plunger with holes in it and a handle 3 or 4 feet long, or a cement mixing hoe, should be pushed up and down to mix the emulsion thoroughly. The mixture must also be kept agitated as it is being applied.

Hand Methods of Applications

In all hand methods the insecticide-oil solution or emulsion is applied to the individual ears. The application may be made with a sponge, a small compression sprayer, or from hoses attached to a horse-drawn sprayer. With the sponge method a synthetic-rubber sponge about 3 inches long, 1½ inches wide, and 1 inch thick is dipped into the solution or emulsion and then pressed on top of the silk. With the small compression sprayer or hoses attached to the horse-drawn sprayer, the nozzle is held 2 or 3 inches from the silk mass and a small squirt of the insecticide applied. In no case is more than 1 ml. applied. This is just enough to wet the silks with no run-off. Larger amounts not only waste material but may damage the ears by penetrating too deeply into them.

Oil Solution. If the soil solution is applied before pollination has taken place, it will prevent fertilization and development of the kernels. Tests have shown that 30 percent or more of the ears will be damaged seriously if it is applied as early as 5 days after the first silking of ears in a field. With the oil solution the grower must expect some ears with oil damage to their tips.

Excellent earworm control has been obtained with a minimum of oil injury by going through the field twice, each time treating only those ears sufficiently mature to resist injury by the oil. The first trip should be made 5 or 6 days after the first silks appear. By that time silks on the older ears will have wilted and turned light brown. Only ears in that condition should be treated. The second trip should be made 4 or 5 days later. Silks on the older ears will then be brown, and a slight stain remaining from the first application can be observed on the tips of the husks. The oil solution should be applied only to those ears not treated the first time. Usually 25 to 40 percent of the ears will be ready for treatment on the first time through the field, and 60 to 75 percent on the second trip.

Emulsion. Either two or three applications of the emulsion have given good control, although three applications have given better results. The first of two applications should be made 1 or 2 days after the first silks appear and the second 3 or 4 days later. If there are to be three applications, the first should be made the day the first silks appear or 1 day after and the others at intervals of 2 or 3 days. All ears in silk should be treated each time whether or not the silks have been pollinated.

Some yellowing of the outer husks may result from the treatment, but this has been found to have no commercial importance. Timing is very important, and if the first treatment cannot be applied as early as suggested, the grower should apply the oil solution.

The emulsion treatment has the advantage of providing ears as well filled as is possible with the particular hybrid and conditions under which it was grown.

Machine Application

A number of machines suitable for applying the DDT emulsion are now on the market and, although expensive, they have the advantage of being able to cover large acreages with little labor. A boom can some-

times be rigged on a conventional power sprayer provided a high-clearance tractor is used.

There are a number of requirements for a field sprayer for control of the corn earworm. It should have a minimum clearance of 5 feet, although in short corn a sprayer with less than 3 feet clearance has been used without causing serious damage. The sprayer should have a pump capable of producing a pressure of 100 pounds per square inch when in operation. It should have a means of keeping the liquid well agitated so that the oil in the emulsion will not separate. The liquid intake in the spray tank, as well as the line to the nozzles and the nozzles themselves, should have strainers for removing foreign matter. The strainer in the supply line must have holes large enough to allow easy flow of more than the maximum number of gallons of spray. The boom must be easily adjustable for height. The drops should be semi-rigid but capable of moving rather than breaking off in case they strike a solid object. A semi-rigid hose run through a hollow, stiff spring 6 or 8 inches long at the point of attachment allows the drop to maintain a vertical position except when it strikes a solid object. Either one pair of nozzles or two pairs, one pair 5 inches above the other, can be attached to each drop. However, two pairs of nozzles per row are preferred. The nozzles should be set above ear height, about 16 inches away from the stalks, and inclined downward to cover the silks and upper parts of the ears with spray. Better results have been obtained with nozzles putting out a flat fan-shaped spray than with those producing a hollow-cone spray. The flat fan nozzles should be adjusted to spread the spray vertically.

Four spray nozzles per row with an output of 9 gallons per hour each at a pressure of 100 pounds per square inch have given excellent results where the machine has been operated at 3½ to 4 miles per hour. With only two nozzles per row, nozzles with capacities of 18 gallons each per hour at the same speed and pressure are required. Where four nozzles per row are used, the angle of spray should not be over 65 degrees at 100 pounds' pressure. There should be some overlapping of spray from the upper and lower nozzles. Where only two nozzles per row are used, the angle of spray should be 75 to 85 degrees at this pressure, in order to treat effectively all the ears, which vary somewhat in height on the plants.

The grower who applies DDT emulsion by machine according to recommended procedure can expect to harvest 80 to 90 percent of worm-free ears as compared with almost none in untreated fields in a heavily infested area.

Proper timing of the sprays is essential. Under Valley conditions not more than 3 days should be allowed between emergence of the first silks and the first spray application. The same holds true for the interval between sprays. At the high temperatures occurring in southern Texas earworm eggs hatch in 2 or 3 days after being laid and the larvae immediately go down into the silk channel. Although they usually do not penetrate deeply into the ear for several days, they are more easily reached before or very shortly after they enter the silk channels. Then too, the longer the silk mass grows the larger it becomes, and the less distance into it a given quantity of spray can penetrate. If all ears in a field could be sprayed when the silks are not more than 2½ inches long, earworm control could be nearly perfect. Three properly timed applications will not only do that but will cover some silks two or three times. Another important advantage of proper timing is that the oil in the spray will kill any eggs wet by it. Again the smaller the silk mass the more likely is the spray to reach the eggs.

Another important consideration is to provide proper agitation of the emulsion so that the oil does not separate. Several failures of a spray program to control the corn earworm have been traced to poor agitation. The pumps on many machines that depend upon overflow to keep the emulsion mixed actually do not have sufficient capacity to return enough liquid to the tank to provide proper agitation. A good mechanical agitator is best.

Under the heavy earworm infestation in southern Texas, at least three sprays applied after the corn has begun to silk are necessary for good control. The first fields to mature in any area will require an additional application to the immature shoots. This spray should be applied when most of the tassels have emerged but before any silks are present. Such a pre-silking application will destroy larvae from eggs laid on the immature shoots and will protect the shoots from larvae, or budworms, migrating from the tassels to the ears.

Other Aids to Earworm Control

To obtain the best possible control of the corn earworm in the Valley, consideration should be given several other factors. It is important to choose a hybrid that is as resistant to the corn earworm as possible. Hybrids with loose husks or other characteristics that allow the earworms to penetrate quickly and deeply into the ear are unsatisfactory. Hybrids that tiller excessively or have the leaves so arranged on the plant that the ears are protected from the spray are also unsatisfactory for machine spraying.

Planting the corn too thickly in the row, besides making spraying difficult, actually reduces the yield. Boswell (1952) in summarizing rates of planting found best by many horticulturists, stated that for drilled corn the plants should be at least 10 inches apart for any but the very small strains. For hybrids usually grown in south Texas the plants should be 12 to 14 inches apart to prevent undue masking of the ears by leaves or tillers. The rows should be 32 to 36 inches apart. These rates of planting make it possible to grow 14,500 to 15,000 plants with a minimum of 1200 dozen ears per acre. In some areas where sweet corn is grown for the early market, it is common practice to plant extra kernels and thin the plants when they are 6 to 10 inches high.

In planting the corn, care should be taken to avoid variations in row width. In some fields variations of 8 to 10 inches between rows have been observed. Since the nozzles on large sprayers are in fixed positions, they will be too close to the row in some places and too far away in others.

The necessity to irrigate fields while the spray program is being carried out is a serious handicap to machine spraying. This might be overcome by leaving unplanted spray rows which would not be irrigated or leaving rows dry when the field is being irrigated. For an eight-row machine one row out of the eight could be used as a spray row.

Summary

The corn earworm is a serious pest on sweet corn as well as on other field and vegetable crops grown in the Lower Rio Grande Valley. It was not until G. W. Barber developed the method of injecting oil containing insecticides into the silk channels of the ears that control of the earworm appeared to be possible. More recently much improved hand and machine methods of applying insecticides in oil solution or in emulsions containing oil have been developed.

Of 21 insecticides tested for earworm control in sweet corn, DDT, TDE, endrin, and heptachlor have given the best control. DDT and TDE are recommended for grower use. Endrin and heptachlor are still in the experimental stage and are not yet recommended. TDE has been more efficient in oil solutions than in emulsions.

For hand applications to individual ears, two formulations are recommended: (1) 0.5 percent of DDT or TDE in solution in mineral oil and (2) 0.75 percent of DDT in an emulsion containing water and 7.5 percent mineral oil. Both can be applied by hand as a spray to individual ears by dipping a sponge into the liquid and applying to the silk masses at the tips. The oil solution must not be applied before the silks have been fertilized. Only one application should be made to each ear, although two or more trips through the field should be made. At least two applications are necessary with the emulsion, and three are recommended – the first application 1 or 2 days after the first silks appear and later ones at intervals of not more than 3 days. Since the emulsion does not affect fertilization of the silks, all ears in silk should be treated each time through the field.

The oil solution cannot safely be applied by machine sprayers, but the emulsion can be applied by especially adapted machines. Three applications should be made, the first in less than 3 days after silks first appear in the field and the other two at intervals of not more than 3 days. For the first fields to begin silking in any area an additional application to the immature ear shoots should be made when tassels have emerged throughout the field but before any silks have appeared.

A well-planned program of earworm control should include (1) selection of a resistant hybrid in which the leaves or tillers do not prevent the spray from hitting the ars, (2) accurate spacing of the rows at planting time, and (3) a plant population not to exceed one plant every 10 inches.

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Weather Thinking in the Lower Rio Grande Valley

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Some parts of this discussion under the title "Weather Thinking in the Valley" is going to be a bit boring at times, as we are going to have to have to refer to numerous graphs and tables, or in other words just a review of a lot of Weather Statistics. The purpose of the review, is to try and bring about a new trend of thinking as far as weather is concerned. Mainly this has been brought about by the freezes of 1949 and 1951, which has changed the Valley from, you might say, a tree grown economy to a ground grown economy. Now from all indications, we are rapidly growing into a combination tree-ground economy.

Now before launching into that discussion. I would like to go into the various graphs and tables, so that we might understand more thoroughly what has happened in the past, in order that we might approach the future with more assurance.

The first figure is one for the daily rainfall normals for Brownsville as computed from the actual record for the years 1878 through 1927. Please note that great portion of the days throughout the year run less than .10 of an inch, and another important point is the uneven distribution of the rainfall. The range is wide, running from a mighty small .02 around the first of April to .30 in September. For a satisfactory agricultural economy about 40.0 inches, or more, are needed well regulated to growing seasons. It will be noted by comparison to the growing season needs in the curves, that our normal fails to meet any of the real needs of any season. That is the reason that actually our climate falls under a semi-desert classification.

The normal chart is also misleading in that it seems to peak at about the time that Citrus needs more water. These peaks from August through November cannot be depended on because they were built up by a few hurricanes passing near this area during those many years, and dropping rains like the 30.57 inches in September 1886, and the 11.91 inches in one day during that month.

Now it may seem superfluous that we have brought these figures on rainfall, because most of us already know that this is a Semi-Desert Climate, and that irrigation is essential for Agriculture. The reason that it is being brought out is that we must conserve those supplies that we do have, and even consider a better distribution of what is available. Agriculture is considerd by many as being the greatest gamble there is, but there is no need to make it a greater gamble by planting when you will be unable to supplement the rainfall with other water.

By checking Fig. 1, it will be found that there is no year with a really adequate rainfall for agriculture, and the up-Valley points have slightly less rainfall than the Brownsvile area, as shown on the first table. By direct comparison with the figures for the various cities in the Valley, you will arrive at a comparative figure for any point in the Valley.

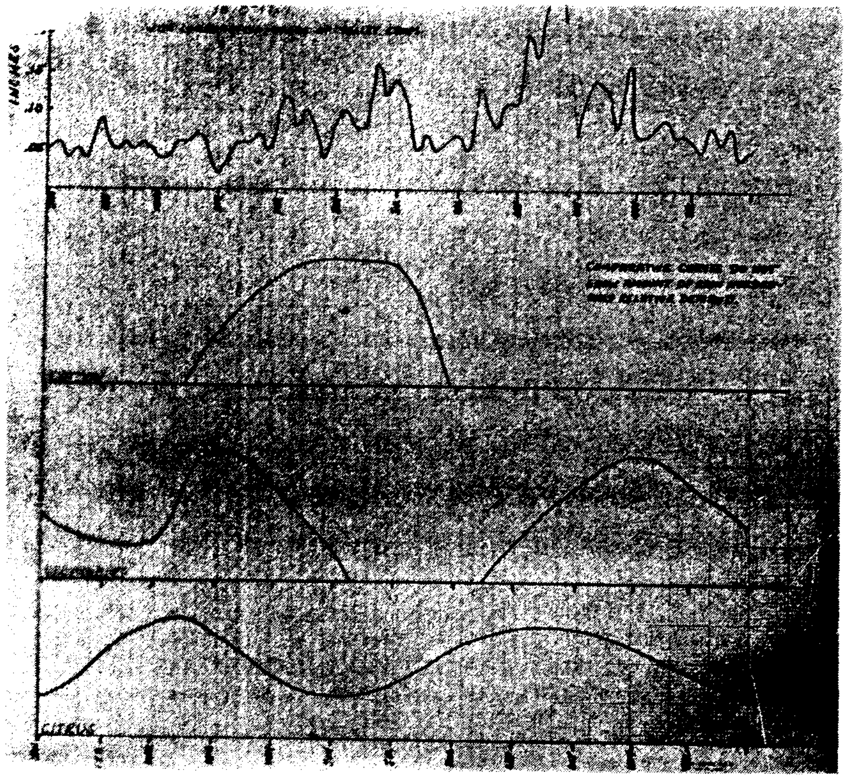

Fig. 1. Top line of chart shows daily rainfall normals for Brownsville as computed for the year 1878 through 1927. Lower lines show amount of water demand by cotton, vegetables and citrus during the year.

Now dropping the rainfall angle, we will take the temprature angle which is much more important to the Valley at the present time. From here on, we are going to appear as being pessimistic, but we are not, as we have a very optimistic view on the future. We feel that there are many things that you can do about the cold weather that we will have in the future.

Now getting to what might appear to be a pessimistic angle, take a good look at Fig. 3. There are several points on these charts that should be carefully observed. The first one is that we have had a much colder weather prior to 1930 than after. The next reason for picking 1930 as a check point is that after that year there are as many years without freezes, as there were in the first 55 years. You might also note that there is a slight cycle appearance to the series above freezing and below, but don't let this mislead you, as it does not take on a definite cycle.

The fact that apparently the weather has been up during the past

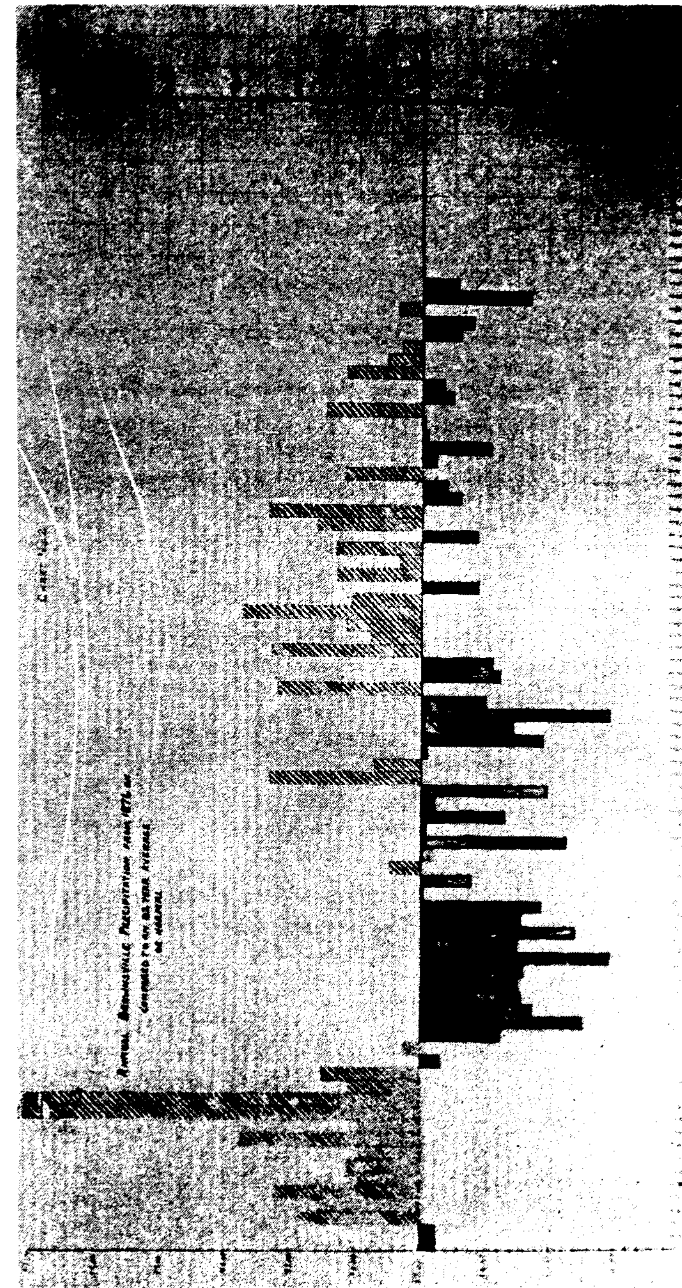

Fig. 2 Comparison of the annual rainfall from 1876 to 1951 with the normal expected rainfall.

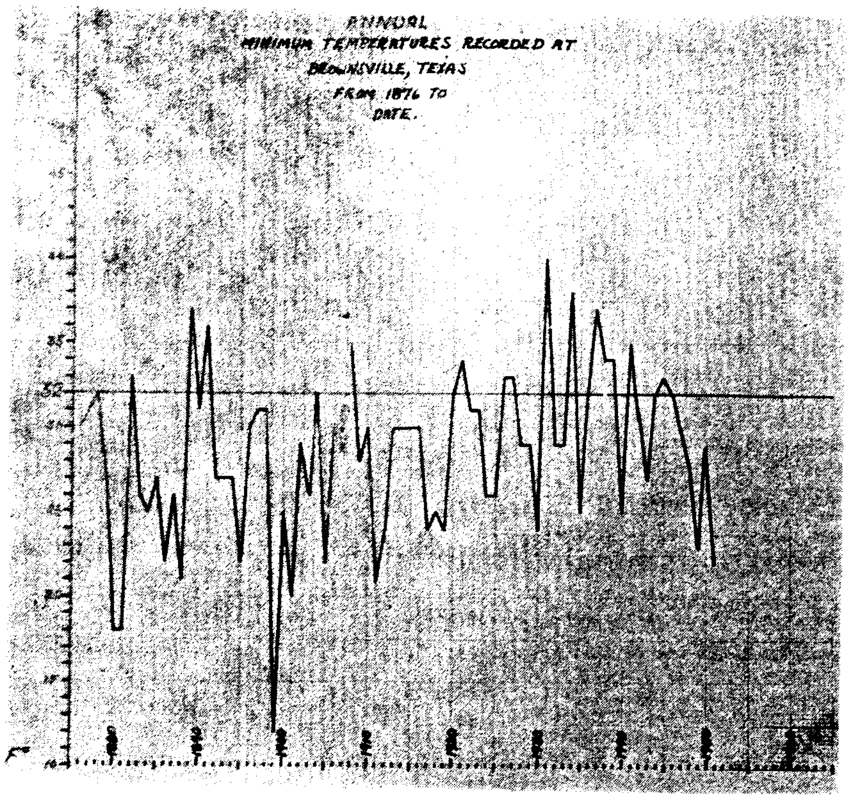

Fig. 3 Annual minimum temperatures at Brownsville from 1876 to 1951.

20 years has led some people to feel that little, or no precaution against cold is necessary. The chart bears out the fact that rather serious consideration should be given to some sort of protection year after year. Now as to the type of protection, that will have to be decided by you. There are several known methods of protection, such as heaters, wind-breaks, and large air-fans to keep the air stirred up on strong radiation nights. Your Agricultural Agents and the Experiment Station at Weslaco are working along that line and will be experimenting with different methods to determine what is best for your area. They will be seeking your aid in carrying out some of these experiments, so cooperate in trying to help everybody. Other sources of research aid will be that already done in California and Florida.

Before leaving the cold weather angle, let's look at several more tables that will be of considerable interest. Table No. 1, Temperature Section, will enable you to arrive at comparable lows for your section by direct comparison. It is not likely that they would be exact, but are of value for comparison.

Table No. 2 is self explanatory, and will give you a good look at past cold weather, and the number of days that it continued. Credit for this table goes to Mr. W. E. McDavitt of Brownsville, who has published this table for years for the benefit of the farmer.

Table No. 3 is the record lowest temperature recorded for each individual day of the cold season, along with the year. It would be well to note that the extreme cold is well divided with the months of December through February, and that these are the months for the greatest vigilance.

Table No. 4 shows 229 days with freezing or below for Brownsville for each year since 1876. It was also found in making this table that there were 171 days during that period when the Brownsville temperature was running from 33 to 35°. This brings up the assumption that the probable number of days with freezing temperature up the Valley will total near 400 days, or about 5 days per year.

Now we have given you quiet a few statistics, what is the part of the Weather Bureau in the future. Here is a brief outline of the Weather Bureau functions in the Valley, and these are not new, but have been growing ever since the establishment of the Fruit Frost work in the Valley during the 1920's.

The Brownsville Office of the U. S. Weather Bureau completes four surface charts and six upper air charts daily to keep up a current picture of the weather. The surface maps are drawn every six hours, and new forecasts are made from each of these maps. Each map gives a different picture of the weather as it progresses. So each forecast is not a revision of the last one, but a new one based on new facts, just the same as the

Table 1. Established Rainfall and Temperature Normals for Valley Cities.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann.
RAINFALL													
Brownsville	1.81	1.49	1.57	1.73	2.58	3.17	2.27	2.86	5.82	3.60	2.28	1.87	31.05
Port Isabel	1.40	0.84	1.12	1.63	2.61	2.18	0.98	1.67	4.70	3.00	2.03	2.64	24.80
San Benito	1.32	1.19	1.20	1.30	3.72	3.56	2.05	2.22	5.85	2.72	1.34	2.14	28.63
Harlingen	1.67	1.12	1.31	1.27	3.54	2.94	2.27	2.35	5.07	2.46	1.57	1.80	27.37
Mission	1.33	0.83	1.18	1.35	2.61	2.35	1.91	1.41	3.79	1.76	1.24	1.43	21.19
Raymondville	1.78	0.88	1.52	1.21	3.96	3.02	2.42	1.92	4.73	2.75	1.51	1.69	27.39
Rio Grande City	0.95	0.78	0.88	1.06	2.37	2.11	1.50	1.67	3.07	1.55	0.93	0.83	17.69
MINIMUM TEMPERATURES													
Brownsville	51.2	54.0	59.3	65.7	69.9	74.5	75.5	75.4	72.6	66.3	58.9	53.0	64.7
Harlingen	49.8	51.4	57.2	63.1	68.4	72.3	73.0	73.0	70.8	63.7	56.2	50.6	62.5
Mercedes	49.7	52.8	57.9	64.5	69.4	72.9	73.8	73.6	72.9	64.1	56.2	51.0	63.2
Mission	48.8	51.9	57.3	64.2	69.1	72.8	73.8	73.7	71.4	63.7	55.4	50.2	62.7
Port Isabel	55.1	56.8	61.9	67.8	73.6	76.8	77.7	77.6	76.1	70.4	62.8	56.1	67.7
Raymondville	48.8	51.8	56.6	63.3	68.7	72.4	73.6	73.2	70.5	63.4	53.9	50.8	62.2
San Benito	50.5	52.8	58.0	64.4	68.5	72.0	73.2	73.3	71.4	64.1	56.3	52.6	63.1

Table 2. The years and dates of freezes in Brownsville, Texas, when temperatures went 32° or lower and annual precipitation for the past 76 years; also, frost dates since 1925.

NOVEMBER		DECEMBER		JANUARY		FEBRUARY		MARCH		Annual Precipitation		FROST Light	FROST Heavy	FROST Killing
1880-81:	18th 30°	1876-77:	26th 30°	1876-77:	1st 31°	1882-83:	4th 29°	1889-90:	1st 31°	Year	Inches	2/12/25	12/22/25	12/23/29
	19th 31°		29th 30°		2nd 32°		5th 27°	1916-17:	5th 30°	1876	25.81	12/5/25	12/30/26	3/14/32
1896-97:	29th 31°		30th 31°	1878-79:	6th 27°		6th 29°	1919-20:	8th 32°	1877	25.86	12/19/25	12/22/28	2/8/33
	30th 30°	1878-79:	25th 32°		9th 29°		18th 30°	1921-22:	1st 31°	1878	36.35	12/23/25	12/23/28	1/22/35
1911-12:	29th 29°		26th 32°	1880-81:	1st 18°	1893-94:	22nd 27°		2nd 32°	1879	34.73	1/10/26	12/4/29	2/27/35
	30th 27°		27th 32°		9th 32°		25th 28°		3rd 32°	1880	38.14	11/18/26	12/22/29	1/19/36
1920-21:	16th 32°	1879-80:	25th 27°		10th 28°	1894-95:	7th 27°		4th 31°	1881	31.74	12/29/26	12/17/32	2/18/36
			26th 30°		11th 32°		8th 22°	1931-32:	11th 32°	1882	32.56	1/1/27	1/1/33	1/23/40
		1880-81:	29th 23°	1882-83:	9th 29°		9th 24°		13th 32°	1883	31.05	1/11/27	1/23/35	1/24/40
			30th 18°		20th 27°		13th 31°	1948	11th 32°	1884	40.88	12/3/27	1/19/41	1/15/44
			31st 21°		21st 26°		14th 22°			1885	31.73	1/28/28	12/18/43	1/31/48
		1884-85:	25th 31°		22nd 32°		15th 25°			1886	60.06	2/18/28	1/10/44	1/30/49
			26th 30°	1883-84:	2nd 27°		16th 22°			1887	59.82	3/18/28	12/11/44	
		1886-87:	5th 26°		3rd 32°		17th 22°			1888	32.53	12/21/28		
			6th 29°		5th 31°		18th 30°			1889	34.61	12/24/28		
		1887-88:	21st 31°		6th 25°	1898-99:	7th 29°			1890	25.55	1/2/29		
			22nd 26°		8th 27°		8th 24°			1891	28.25	12/24/29		
			23rd 30°		25th 29°		9th 25°			1892	20.83	3/30/30		
			24th 32°	1884-85:	1st 32°		12th 16°			1893	14.36	12/23/30		
		1892-93:	27th 29°		2nd 28°		13th 12°			1894	18.36	12/29/30		
		1894-95:	28th 27°		17th 27°		14th 18°			1895	19.20	1/21/31		
			29th 27°	1885-86:	8th 23°	1899-00:	17th 31°			1896	19.40	3/3/31		
		1895-96:	30th 32°		9th 22°		18th 27°			1897	18.99	3/9/31		
		1897-98:	4th 31°		12th 30°	1900-01:	12th 28°			1898	12.31	1/9/32		
			27th 31°		13th 31°		13th 30°			1899	19.50	3/6/32		
			31st 30°	1886-87:	3rd 30°		14th 25°			1900	14.99	11/19/32		
		1898-99:	5th 32°		9th 32°		23rd 25°			1901	19.20	11/25/32		
			6th 32°		10th 28°	1901-02:	1st 29°			1902	17.62	12/7/33		
			10th 31°	1887-88:	15th 23°		2nd 30°			1903	26.78	12/19/33		
			11th 31°		16th 21°		6th 30°			1904	23.10	3/19/34		
			12th 32°		17th 27°	1902-03:	16th 26°			1905	29.35	12/12/34		
		1900-01:	29th 32°	1892-93:	19th 27°	1904-05:	13th 22°			1906	26.12	1/22/35		
			31st 25°		20th 29°		14th 28°			1907	15.68	2/18/35		
		1917-18:	9th 32°	1893-94:	23rd 31°	1905-06:	8th 32°			1908	26.62	2/27/35		
			30th 24°		24th 31°	1908-09:	16th 29°			1909	20.46	1/23/36		
			31st 31°		25th 31°	1909-10:	17th 32°			1910	25.86	12/15/36		
		1919-20:	10th 32°	1894-95:	10th 32°		18th 32°			1911	17.12	12/20/36		
			14th 32°	1898-99:	1st 32°	1911-12:	4th 29°			1912	38.82	1/26/38		
		1920-21:	28th 32°		2nd 32°		5th 30°			1913	30.64	4/10/38		
		1924-25:	19th 31°	1900-01:	1st 20°		6th 27°			1914	26.50	11/25/38		
			20th 27°		2nd 27°		7th 30°			1915	17.45	2/4/39		
			21st 26°		16th 30°	1913-14:	25th 30°			1916	19.78	4/8/39		
			22nd 31°		17th 29°	1915-16:	2nd 30°			1917	12.15	12/30/39		
			25th 28°		18th 32°	1916-17:	2nd 24°	ADD TO FEB.		1918	21.91	12/31/39		
		1925-26:	27th 31°		30th 32°	1917-18:	2nd 31°			1919	38.19	2/10/40		
			28th 26°	1903-04:	28th 32°	1922-23:	4th 32°	1951	1st 22°	1920	20.79	3/3/42		
			29th 26°	1904-05:	14th 32°		5th 31°		2nd 27°	1921	21.36	3/9/42		
			30th 31°		15th 30°		6th 32°		3rd 25°	1922	38.69	12/29/42		
		1929-30:	19th 32°	1905-06:	23rd 30°	1932-33:	8th 29°			1923	30.97	2/12/43		
			21st 32°	1908-09:	12th 28°	1935-36:	18th 28°			1924	32.77	11/9/43		
			22nd 29°		13th 30°					1925	40.98	12/16/43		
			23rd 32°	1909-10:	7th 30°	(Jan. Con't.)				1926	32.43	12/17/43		
		1932-33:	17th 29°	1910-11:	3rd 28°		18th 24°			1927	22.66	1/9/44		
		1943	29th 31°		4th 21°		19th 32°			1928	33.66	12/13/44		
		1946	31st 32°	1911-12:	7th 31°		22nd 28°			1929	28.72	12/15/44		
		1947	15th 32°		8th 32°		23rd 24°			1930	33.71	12/5/45		
		1950	6th 29°		9th 32°	1932-33:	1st 30°			1931	22.66	1/23/46		
			7th 29°		12th 30°	1935-36:	19th 32°			1932	35.17	12/15/47		
					13th 24°	1940	18th 28°			1933	38.96	1/21/48		
				1912-13:	7th 30°	1940	19th 26°			1934	23.92	1/24/48		
					8th 31°	1940	20th 29°			1935	25.05	2/14/48		
				1913-14:	31st 30°	1940	22nd 30°			1936	33.03	11/30/48		
				1914-15:	25th 30°	1940	23rd 25°			1937	25.89			
				1915-16:	17th 30°	1940	26th 32°			1938	21.54			
				1917-18:	11th 25°	1943	19th 27°			1939	26.53			
					12th 26°	1944	14th 32°			1940	26.81			
					21st 30°	1947	1st 32°			1941	34.49			
					22nd 30°	1947	4th 30°			1942	24.61			
				1918-19:	3rd 32°	1948	24th 31°	Add to JAN.		1943	25.31			
					4th 24°	1948	27th 32°	1951	29th 30°	1944	32.87			
					5th 30°	1948	28th 28°		30th 25°	1945	29.73			
					9th 30°	1948	29th 28°		31st 27°	1946	28.53			
				1924-25:	28th 30°	1948	31st 32°			1947	23.98			
				1927-28:	1st 29°	1949	29th 28°			1948	22.99			
					2nd 30°	1949	30th 25°			1949	28.85			
				1929-30:	17th 31°	1949	31st 23°			1950	18.45			
										1951	[illegible]			

price of grain on the market. The price of grain changes as new facts come to light, and wouldn't necessarily be called a revision. The Upper Air Charts are prepared for three levels, 5000, 10,000, and 18,000 feet, and are 12 hours apart.

Now you might ask why not just one map per day, and one forecast. There are several reasons for this. One is that Meterology is not an exact science, such as Mathematics, Chemistry, etc. Weather Forecasters make poor forecasts occasionally, because their average accuracy runs from about 87 to 95%. Weather changes are much more rapid, and sometimes quiet irregular than the average person assumes. Another special reason for keeping a special look at the region down in this section is that it is

Table 3. Lowest temperatures ever recorded on the individual days, and year of occurrence, for the period from 1876 through 1952; months, November through March.

	January	*February*	*March*	*November*	*December*
1.	18 – 1881	22 – 1951	31 – 1922	43 – 1949	34 – 1911
2.	27 – 1884	24 – 1917	32 – 1922	43 – 1951°	35 – 1902
3.	28 – 1911	25 – 1951	32 – 1922	38 – 1951	34 – 1897
4.	21 – 1911	29 – 1912°	31 – 1922	42 – 1950°	31 – 1897
5.	30 – 1919	27 – 1883	30 – 1917	42 – 1950	26 – 1886
6.	25 – 1884	27 – 1912	40 – 1902	48 – 1951	29 – 1950°
7.	30 – 1913	27 – 1895	37 – 1920	47 – 1951°	29 – 1950°
8.	23 – 1886	22 – 1895	32 – 1920	42 – 1938	34 – 1882
9.	22 – 1886	24 – 1895	36 – 1932	39 – 1942	32 – 1917
10.	28 – 1881	34 – 1929	33 – 1932	41 – 1948	31 – 1898
11.	25 – 1918	33 – 1929	32 – 1932	36 – 1907	31 – 1898
12.	26 – 1918	16 – 1899	33 – 1948	36 – 1907	32 – 1898
13.	24 – 1912	12 – 1899	32 – 1932	40 – 1920	36 – 1909
14.	32 – 1905	18 – 1899	35 – 1932	36 – 1916	32 – 1919
15.	23 – 1888	25 – 1895	35 – 1880	37 – 1916	32 – 1947
16.	21 – 1888	22 – 1895	36 – 1913	32 – 1920	34 – 1943
17.	27 – 1885	22 – 1895	33 – 1913	35 – 1920	29 – 1932
18.	24 – 1930	27 – 1900	38 – 1934	37 – 1886	34 – 1927
19.	26 – 1940	34 – 1942	39 – 1934°	39 – 1878	31 – 1924
20.	27 – 1883	34 – 1895	38 – 1914	39 – 1937°	27 – 1924
21.	26 – 1883	34 – 1921	40 – 1915	38 – 1906	26 – 1924
22.	25 – 1935	27 – 1894	39 – 1898	40 – 1929	26 – 1887
23.	24 – 1930	33 – 1894	40 – 1914	37 – 1938	30 – 1887
24.	31 – 1894	34 – 1914	41 – 1952	37 – 1938°	32 – 1887
25.	29 – 1884	28 – 1894	40 – 1912	35 – 1881	27 – 1879
26.	32 – 1940	33 – 1894	40 – 1894	40 – 1893	30 – 1884°
27.	32 – 1948	35 – 1935°	40 – 1913	38 – 1902	29 – 1892
28.	28 – 1948	36 – 1890	41 – 1913	37 – 1896	26 – 1925
29.	28 – 1948	44 – 1920	39 – 1894	29 – 1911	23 – 1880
30.	25 – 1949		38 – 1930	27 – 1911	18 – 1880
31.	23 – 1949		42 – 1937		21 – 1880

°and earlier years.

a region of dissipating, or dying, cool fronts, plus a region where warm ones are developing, or being born. If the weather was a stable factor, then one forecast per day would be satisfactory for the entire nation.

Since the Valley is an established Fruit Frost region, and incidentally the area that the Brownsville Office is now responsible for extends from the mouth of the Rio Grande to above Eagle Pass, thence to near La Pryor, then SE to Falfurrias, a special watch is made on weather conditions in the region, and special warnings are issued as needed. These warnings are issued to the Press Services, and all Radio Stations, plus about forty individuals and concerns, that give the warnings further dissemination to persons in their area.

The warnings generally contain the expected temperatures for the area in question, plus possible Frost conditions, and if colder weather is expected the second night. Warnings are begun when temperatures are expected to be below 40°, and the reason for this is because there are numerous soil formations over the Rio Grande Valley Area, which will have different heating absorbency and radiational cooling, which might show freezing temperatures at the surface while a nearby thermometer will show 40° five feet above the ground.

Now this brings us to the gist of the title of this talk "Weather Think-

Table 4. Number of days with temperature at 32°, or below, at Brownsville.

1876	– 3	1901	– 10	1926	– 0	1951	– 6
77	– 2	02	– 3	27	– 0	52	–
78	– 2	03	– 1	28	– 2	53	–
79	– 4	04	– 1	29	– 4	54	–
80	– 5	05	– 4	30	– 5	55	–
81	– 4	06	– 2	31	– 0	56	–
82	– 0	07	– Missing	32	– 3	57	–
83	– 8	08	– 0	33	– 11	58	–
84	– 10	09	– 3	34	– 0	59	–
85	– 12	10	– 3	35	– 0	1960	–
86	– 6	11	– 4	36	– 2		
87	– 7	12	– 9	37	– 0		
88	– 3	13	– 2	38	– 0		
89	– 0	14	– 2	39	– 0		
1890	– 1	1915	– 1	40	– 6		
91	– 0	16	– 2	41	– 0		
92	– 1	17	– 5	42	– 0		
93	– 2	18	– 5	43	– 2		
94	– 5	19	– 6	44	– 1		
95	– 2	20	– 3	45	– 0		
96	– 2	21	– 0	46	– 1		
97	– 3	22	– 4	47	– 3		
98	– 5	23	– 3	48	– 5		
99	– 8	24	– 5	49	– 3		
1900	– 4	1925	– 5	1950	– 2		

ing in the Lower Rio Grande Valley." Since we have had two rather severe freezes during the past few years, we have turned from the trees for a winter cash crop to the ground. Now with this change we have to change our weather thinking. In the past we have been mostly concerned with the temperatures from the Standard instrument shelters, which are usually about five feet above the ground, and around the lower fruit level. We have temporarily lost sight of the fact that sometimes the temperature may drop maybe 5 or 6° from five feet above ground to the surface. This is especially true on a clear still night.

Generally the readings expected that we will issue will be for the standard height thermometer, and we will also say frost when indicated. Now for example we might call for the temperatures to be around 38° and also call for frost. When you have frost, that means that you have to have freezing temperatures where that frost is forming, because it is the dew that is frozen that makes the frost. If you are interested in taking action to protect your crops against these conditions, then you should set up a series of thermometers near the surface of the ground and keep a continuous watch for the critical temperature to start your preventive measures. This watch should be started whenever temperature around 40°, or lower are forecast. This action will only hold true for those cold masses of air that roll in with dry air which will clear the skies and permit rapid radiation.

Preventive methods of fanning the air, or heating, are of little avail to some of those blustery northers that move in out of the north. They are usually accompanied by too much wind during the first couple of nights, but may settle down to still cold later. Some sort of wind-breaks might be of aid in some of the milder blustery northers.

The question has been brought up many times of just how cold does it have to be to frost. There is only one answer, at the point where the frost is forming either the object on which the frost is forming, or the air, or both, must be at a freezing temperature or below. If you have your thermometer several feet above the ground, it might register quiet a number of degrees above the freezing mark.

Several hours could be spent in discussing the different conditions of frost and the radiational affects of the grounds that leads to extreme cold next to the ground, but we are going to have to near a close, and shorten this considerably. We will say that the secret of the frost possibilities is in the amount of water vapor the air is holding.

If the air is holding a considerable amount of water vapor, then it will not lose its heat very rapidly. If it is rather dry, then it will lose its heat in a hurry on a still clear night. To know if the air is dry, you must either know its humidity, or dew point. The dew point is the more important to know as it tells you how low the temperature must go before the moisture in that particular parcel will begin to condense out, or the humidity becomes 100%.

Now the important thing about the dew point is to also know the actual temperature of the air. Using the two you can determine if the air is dry or moist, for example if the air temperature is 65°, and the dew point is 63°, then the air is rather moist. This type air will tend to hold its heat longer because of the moisture content releasing its latent heat of condensation on cooling. On the other hand, if the air was at 65°, and the dew point was 28°, there would be no release of the latent heat of condensation until the air temperature hit 28°, or a figure below the frost point, and frost would be very likely. Now this is all based on a clear still night. The farther apart the temperature and dew point are, the drier the air is.

The closing point that I would like to stress is that we cannot say that you are to start a certain type of preventive action, but can merely state the warning for a general condition, and hope that the individual farmers have acquainted themselves with their own terrain and have studied the experimental methods being carried on by the Experimental Station and other groups for their benefit.

Because of limited time at this meeting there are many things unsaid that are important, but I do want you to know that the U. S. Weather Bureau Staff at Brownsville is ready to meet with various farm groups to try to help solve weather problems. We may not be able to reach a solution but I know we may be able to help with the problems.

Sweet Corn Industry Depends On Earworm Control

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The year 1952 commemorates 25 years' effort to grow sweet corn commercially in Texas. It was in 1927 that C. P. Manglesdorf, agronomist at College Station, Tex., started a breeding program in which he attempted to produce adapted varieties of sweet corn that would be sufficiently resistant to the corn earworm that they could be grown commercially in the State. Northern varieties had been tried in gardens but were so badly injured by the earworm as to be unmarketable.

In 1927 Manglesdorf crossed two commonly grown and adapted varieties of field corn – Mexican June and Surecropper – with the sweet corn variety Country Gentleman. Through subsequent breeding and selection he was able in 1933 to release two sweet selections, which he called Honey June and Surecropper Sugar. These were both white strains having plants similar to the field-corn plants but typical sweet corn kernels. They would rate as poor to fair in quality by present standards. They were, however, fairly resistant to the earworm. A year or two later he released another sweet corn called Texas Evergreen, and still later a yellow strain called Mosshart Sugar produced in the same way as the others.

While Manglesdorf was working on this project in Texas, other breeders, principally in Georgia and Florida, were also trying to produce sweet corn adapted to the South. In 1935 Leslie R. Hawthorn, horticulturist at Winter Haven, Tex., reported on the performance of two varieties from Georgia and one from Florida among the 20 varieties tested.

In 1936 Hawthorn tried a number of the new northern hybrids. Among 13 hybrids from the Iowa station was one designated as Iogold P39.I45, which he described as "the most promising of all the crossbred inbred sweet corns including both white and yellow kerneled strains tried at Winter Haven in 1936." This hybrid was later named "Ioana" for the states Iowa and Indiana from which the parent inbreds came.

Ioana ranked tenth in Hawthorn's list in regard to earworm resistance, but when yield of marketable ears was considered it placed first in his over-all rating.

The first test of sweet corn as a commercial possibility in Texas seems to have been made by the Missouri Pacific Railroad under the direction of their agricultural agent, W. B. Cook. This test was made on the Adams Gardens subdivision in Cameron County in the spring of 1938. Three hybrids from the Iowa station – 04 x I45, P39 x I45, and P51 x I45 – were grown and given a yield and canning test. All three varieties were severely infested with earworms, but P51 x I45 was outstanding in showing the least damage. However, when total yield of ears and cut corn for the can was considered, P39 x I45 was by far the best.

The writer began his southern work on earworm resistance for the U. S. Bureau of Entomology and Plant Quarantine on the George Crockett farm near Weslaco, Tex., in the spring of 1938, with a planting of 79 varieties, single-cross hybrids, and inbreds. John Wood, agronomist at the Texas Agricultural Experiment Substation at Weslaco, put in a number of varieties for testing the same spring. When both the earworm resistance and agronomic characters were considered, Ioana ranked as the best and continued to hold this position for both Wood and the writer through several successive years.

While these tests were being conducted in Texas, George Barber, of the U. S. Bureau of Entomology and Plant Quarantine, was attacking the earworm problem in another way in the Eastern States. During the summer of 1936 he found that partial control of the earworm could be secured by injecting a small amount of highly refined white mineral oil in the tip of the ears shortly after fertilization. Then in 1939 he found that the addition of pyrethrins or dichloroethyl ether to the oil gave much better results.

During the early winter of 1940, Jim Barr, field superintendent for the Elsa, Tex., branch of the F. H. Vahlsing Company, came to the Agricultural Experiment Station at Weslaco for advice concerning sweet corn varieties or hybrids to grow for shipping as green corn. He was advised to try Ioana on a limited scale and to use the oil injection method for earworm control.

Four hundred acres were planted to Ioana that year as a trial. The plantings were in large fields scattered from Edinburg on the west to near Santa Rosa on the east. Another 40 acres were planted to Golden Cross Bantam near Elsa. This field was so badly injured by earworms that no attempt was made to salvage any of the crop.

The writer was called upon for advice and assistance in starting the oil treatment for earworm control. At the time, the corn was so far along that some of the larvae had already reached the ears, and the inexperienced labor considered the work "poco loco" anyway. Consequently there was considerable earworm injury in spite of the treatment. The damaged portion of the ears could be trimmed off, however, so that the corn could be shipped.

The company did so well on this venture that it put in 2,000 acres the next year. In 1942 other growers joined in, and about 4,000 acres of Ioana were grown. By 1945 about 10,000 acres were grown in the Lower Rio Grande Valley, and small plantings were being made farther north in the State. Other southern states, Florida and Mississippi in particular, were becoming interested.

At about this time Ralph Blanchard, of the U. S. Bureau of Entomology and Plant Quarantine, was testing the possibility of earworm control by spraying with a mineral oil emulsion to which an insecticide had been added. In 1944 he found that DDT gave the best results of any insecticide tried, and it is still the best. He enlarged his program, and

since 1946 has worked in cooperation with George P. Wene, entomologist of the experiment station at Weslaco, and various commercial growers in the Valley.

Blanchard and Wene's work with emulsion sprays made commercial spraying practical, and several companies soon began building or adapting spraying equipment for use in the corn fields. In the spring of 1948 the F. H. Vahlsing Company built a high-clearance motor-driven sprayer in their shops at Elsa, Tex. Blanchard and O. B. Wooten, then agricultural engineer, U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, at the Mississippi Agricultural Experiment Station, gave technical advice in its construction. This was perhaps the first such machine made. Other designs soon followed. Now very little sweet corn is grown in the South for the commercial green corn market that is not either dusted or sprayed in some manner to control the earworm.

For best results sweet corn should have rainfall or irrigation during the silking period. With soils such as are found in the Lower Rio Grande Valley, it is often almost impossible following irrigation to drive heavy power equpment for spraying or dusting through the fields at the proper time. Here it is still necessary to use more primitive hand methods of application.

While the insecticide method of control was being developed, the writer was continuing to search for a sweet corn resistant to the earworm. This work was being done in cooperation with practically all sweet corn breeders in the country. Inbreds and hybrids were sent in for testing almost as soon as they were developed. A great difference in resistance was found, but years of research are needed for the corn breeder to find the right combination of resistant characters together with the proper agronomic characters.

When sweet corn was first grown commercially in the South in 1940, Golden Cross Bantam was considered as average to slightly susceptible to the earworm. The writer's tests showed that it had an average of 22 damaged kernels per ear. Ioana had 18 damaged kernels and was considered the most resistant hybrid adapted for the Texas area. Most of the new hybrids coming on the market today give a test of about 10 to 12 injured kernels per ear, and some still in the experimental stage have tested from 3 to 5 injured kernels over a period of several years.

As a result of the research work conducted jointly by the plant breeders and entomologists, Ioana has now been largely replaced by the newer hybrids in Texas. Calumet seems to be the most popular hybrid in the Lower Rio Grande Valley at present, because of its natural resistance to the earworm and the long, slender ear which allows the grower to clip and sell untreated ears. Calumet also respond better to earworm treatments than Ioana. Other hybrids of better quality will probably soon replace Calumet.

At the present time, the planting of well-adapted sweet corn hybrids possessing some earworm resistance and the proper application of insecticides assure a high degree of corn earworm control. It is now possible to secure 75 to 90 percent or more worm-free ears in our commercial fields as compared with the 100 percent infestation of the ears common a few years ago.

In the Lower Rio Grande Valley of Texas today thousands of acres of sweet corn are being successfully grown for northern markets. Better hybrids and improved corn earworm control are important factors in this production.

Changes In Processing Methods To Avoid Darkening In Canned Texas Valley Beets

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In the Spring of 1952 a number of canners in the Lower Rio Grande Valley of Texas were troubled with darkening of their packs of sliced and whole beets. In many instances, this darkening was sufficient to reduce the grade from Fancy to Standard, or even to off-grade, making the product unacceptable to the Armed Forces, and causing a loss of 10 cents to 20 cents per dozen No. 2 cans.

When canners called the problem to the attention of this Laboratory, studies were undertaken to determine which factors during processing appeared to be related to the darkening of the canned beets, with the object of making practical suggestions to improve the situation. First, visits were made to plants having trouble with darkening of beets and to those having few complaints of darkening, and variations in each plant that might account for their different experiences were observed. Next, beet packs were prepared under different conditions and their color differences were compared.

Joslyn (1941) noted oxidative changes as causing darkening of fruit and vegetable pigments. Campbell (1950) and Gould (1951) ascribed the darkening of beets to the action of the enzyme tyrosinase in the presence of air, to iron contamination, and oxidative changes occasioned by residual oxygen in the headspace of the can. Cameron and his coworkers (1936), in their study of "black beets," found living bacteria in some of the cans of discolored beets.

In considering a connection between color changes and oxidative changes the chemical nature of the pigment has a bearing. Betanin is a nitrogenous anthocyanin, which degrades to glucose and anthocyanidin, or may form complexes with certain metals (Mayer 1943). These metal complexes may be more or less sensitive to air oxidation than the anthocyanin itself; while it is known that anthocyanidin oxidizes very easily. Oxidized derivatives of betanin are frequently brown or black in color.

It was kept in mind that the type of darkening occurring in the Texas plants was evidenced as definite areas of dark color in freshly processed packs or in those stored only a few days, whereas in packs that had been stored for several weeks the darkening had diffused throughout the can and there was only a slight, overall darkening, which was much less apparent to graders than the earlier spotted areas.

[1]A field station of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.

Methods and Results

Plant Visits. Observations were made in several plants in the area of the materials used for processing equipment, of the manner of exhausting, retorting, etc.

In nearly every plant visited in which darkening was a problem, it was found that processing lines included iron equipment – sidings of conveyor lines, sizers, for example, were usually either iron or galvanized, and in one plant iron baskets were used as containers in blanching whole beets.

Almost without exception, in plants which were having pronounced darkening in beet packs, the cans were sealed under steam closure without any provision for exhausting. In contrast, in every plant where darkening was not considered a problem, adequate steam exhaust boxes (hot water or steam boxes) were in use.

General Preparation for Experimental Packs. Detroit Dark Red beets were selected as the variety to be investigated, as being representative of the general plant run in the Valley.

Darkening was studied in beet packs that had been processed under these different conditions: (1) completely by laboratory processing; (2) completely in a plant by normal plant procedures; and (3) by blanching and peeling in the plant and then completing the processing in the laboratory.

Data were obtained on slices and whole beets with respect to can vacuum, total drained weights, and drained weights of darkened slices and whole beets. Darkening was expressed as percentage of drained weight.

Samples were examined after storage for 1 day, 3 to 6 days, 10 days, and 30 days. Results in table 1 show darkening and vacuum as measured after storage for 3 to 6 days.

Laboratory Processed Packs. Detroit Dark Red beets, of medium to large sizes, were obtained from the bins of a cannery, and 14 packs (slices or whole beets) in No. 2 cans were prepared in the laboratory, according to the general procedures for canning beets described by Campbell (1950) and Gould (1951) with several exceptions where modifications were made to study particular effects.

The recommended procedure calls for blanching in boiling water, the times of blanching varying from 10 to 30 minutes, exhausting in boiling water (for 6 or 7 minutes) before sealing, then sealing in the ordinary can closing machine, with no particular precautions for excluding air at this step; then retorting at 240° to 248°F. for 30 minutes.

Three packs were prepared with variation only of blanching time. Pack No. 4 (table 1) was blanched for 25 minutes and exhausted with lids on the cans.

The following variations in the other stages of processing were made

with different samples: In one experimental pack, one gram of iron filings was added to each can. In another, the blanched beets (slices) were held under cold water for 1 and for 2 hours. Blanched beets, in 6 runs, were exposed, respectively, to air on enamel pans for 30, 60, and 120 minutes, and on iron grating for the same lengths of time before filling. In another variation, the blanched samples were exposed to air on galvanized iron during processing, but were then immediately filled.

To some cans of light-colored Detroit Dark Red beets (whole), brine was added before exhausting; to others, beet juice concentrate was added.

Plant-Processed Packs: Sliced and whole Detroit Dark Red canned beets which had been sent through the regular processing line in a plant that had been having trouble with darkening were obtained and examined after 10 days of storage.

No exhaust of the cans was used in this plant other than that obtained

Table 1. Laboratory-Processed Detroit Dark Red Beets.

Pack No.	*Treatment**	*Vacuum Inches*	*Appearance after 3 to 6 Days Storage*
1	Blanched 10 min.	12	Slight darenking of 3 slices
2	Blanched 15 min.	12	Slight darkening of 4 slices
3	Blanched 20 min.	12	Slight darkening of 1 slice
4	Blanched 25 min., exhausted w/lids on.	14	No darkening
5	Blanched 30 min., 1 gm. iron filings added.	13	Immediate darkening after opening can
6a	Blanched 25 min., held on porcelain pans 30 min. before filling.	13	Slight darkening
6b	Same as 6a except held 30 min.	13	Slight darkening
6c	Same as 6a and b, except held 120 min.	13	Slightly darker than 6a and 6b
7a	Blanched 25 min. held on iron grate 30 min.	15	Slight darkening
7b	Same as 7a except held 60 min.	14	Slight darkening; grayish sheen on slices
7c	Same as 7a and b, except held 120 min.	14	Same as 7b
8	Blanched 25 min. held on galv. iron during process	13	No darkening; grayish sheen on slices
9	Blanched 25 min., held in cold water before filling.	12	No darkening; color leached out
10	Light colored beets; blanched 25 min., brine added.	13	Light colored; uneven
11	Light colored beets; blanched 25 min., beet juice concentrate added.	14	Deep color, even; much better than 10

*All cans exhausted 6 to 7 min. after filling. All beets were sliced prior to blanching.

by adding hot brine to the pack and sealing under steam closure varying from 4.8 to 7.5 inches of vacuum. The plant had retorted the sealed cans in large baskets, placed randomly, some upright, some horizontal, and others inclined. After retorting, the plant cooled cans in water before packaging. Plant equipment was of iron or galvanized materials, so that there was liability to metal contamination.

The conditions of processing and effects on darkening are given in table 2. These completely plant-processed beets all showed headspace darkening, which accounted for 57 to 86% or more of the total darkening.

Plant- and Laboratory-Processed Packs. Blanched and peeled samples taken from this cannery were further processed in this Laboratory by the same procedures used for the completely laboratory-processed samples, except that one sample (whole beets) was not exhausted.

The data obtained after 10 days storage are given in table 3.

Comparisons of results in tables 1 and 2 indicate the major difference occasioned by the differences in processing methods was the amount of vacuum in the canned beets. The oxygen retained in the headspace of the cans having the low vacuum presumably caused the more extensive darkening noted in table 2. Results in table 3 confirm this as only the pack which was not exhausted shows headspace darkening.

Table 2. Plant-Processed Pack of Detroit Dark Red Beets.

Pack No.	*Description*	*Can. Vac. Avg. In.*	*Darkening (% of Total)*	*Headspace Darkening(%)*
1	Whole beets, selected, peeled	4.8	15.7	9
2	Whole beets, selected culls	6.0	14.3	10
3	Sliced beets from (1)	7.5	8.2	6
4	Sliced beets from (2)	7.0	12.2	7
5	Sliced beets, random selection from delivery troughs	6.5	18.7	10
6	Sliced sized beets, random selection	6.3	20.7	10
7	Whole beets, random selection from holding containers	4.3	18.6	14
8	Sliced beets, random selection of plant product	7.5	23.4	20

Table 3. Laboratory-Processed Detroit Dark Red Beets.

Pack No.	*Description*	*Can. Vac. Avg. In.*	*Darkening (% of Total)*	*Headspace Darkening (%)*
1	Whole beets from plant bin, no exhaust	7.5	17.0	15
2	Sliced beets partially plant processed, exhausted, sealed, retorted at laboratory	12.3	0.0	0.0
3	Same as (9) except 7 min. exhaust in boiling water	12.3	0.9	0.9

Conclusions

Results of this study, taken in conjunction with observations of the general processing conditions observed in canning plants of this area, indicate the need for changes in processing equipment and procedures if darkening in canned beets is to be avoided.

This study suggests that darkening in canned beets can be reduced, and probably held within acceptable limits, by use of adequate steam exhaust. Quality of canned beets could also be improved by replacement of iron equipment with stainless steel or other suitable material, and by more expeditious handling during processing.

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