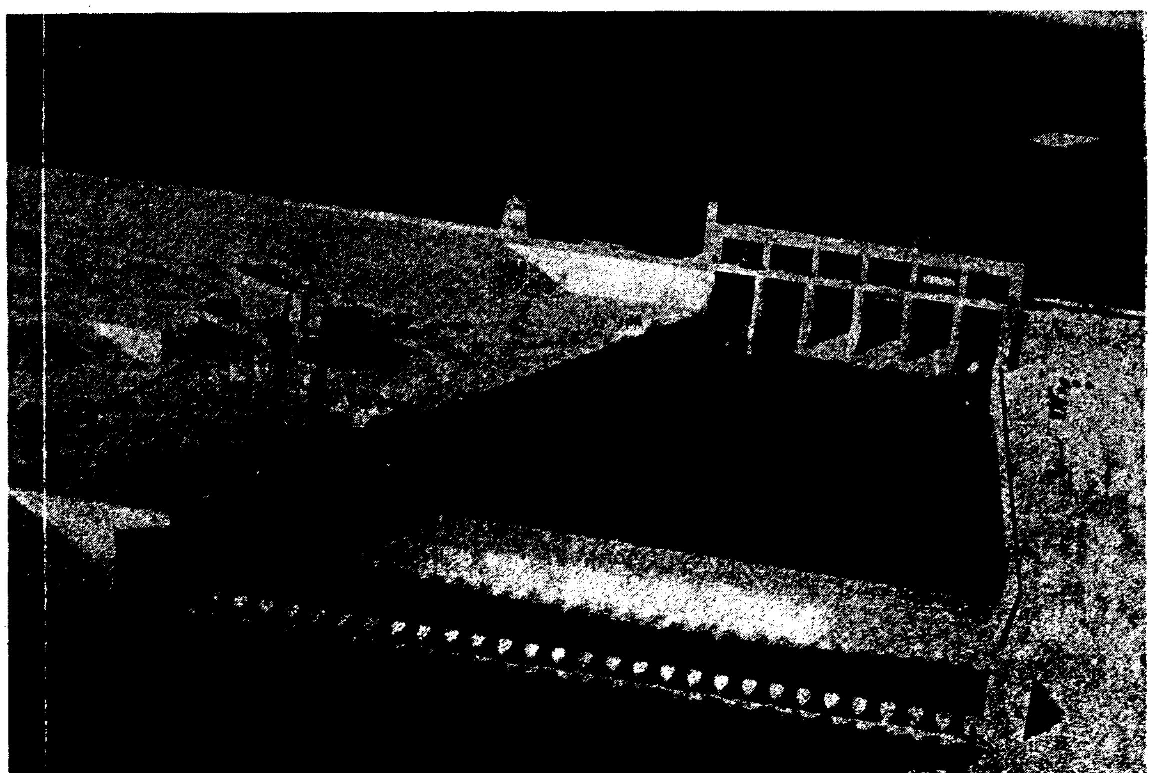
PROCEEDINGS

Of the Ninth Annual

RIO GRANDE VALLEY HORTICULTURAL INSTITUTE

Weslaco, Texas

January 25, 1955



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Presidential Address

Dr. E. O. Olson, *President, Rio Grande Valley Horticultural Club*

It is indeed a great privilege to welcome you to the Ninth Rio Grande Valley Horticultural Institute. We are especially glad to welcome those members of the Texas Growers and Shippers who are meeting with us this morning. We sincerely hope that today's program will be a source of new ideas for better farming and marketing of Valley produce.

Events of the past year have affected the manner in which Valley crops were grown and marketed. Water stored behind the newly-completed Falcon Dam has meant a more stable source of water for future irrigation and this assurance has resulted in an increase in the number of citrus trees planted. The "Wetback Roundup" by the U. S. Immigration Service has changed the outlook for seasonal labor, tending to discourage plantings of winter vegetables in late 1954 and increasing interest in chemical weed control and other labor-saving methods. Cotton acreage allotments left idle many acres of land. It is true that some of this land is being and will be planted to citrus. But on the other hand, this idle land presents the grower with a problem in what to plant.

Citrus orcharding continued its comeback in 1954. Many old trees set a normal crop, the first since the disastrous freeze in 1951. Approximately three million new trees have been set out since 1951, some in new groves and some as replacements in older groves. The new groves are expected to be more productive than those set out many years ago. Most of the new trees are red grapefruit, a variety which seems to do better in the Valley than in competing citrus areas. Nurserymen have had time to build up a supply of State Certified planting stock which is free of the tree-killing disease known as psorosis; this is the first year that these trees have been available in quantity for establishing new groves. Those growers who plant psorosis-free trees will avoid Scaley Bark disease, which weakens or kills trees at the time when they should bear heavy crops of fruit.

With the experience of the past as a guide, the new groves are being set on deep, well-drained soil, and much of the new acreage is on land which has been graded to slopes which permit more efficient use of water and labor during irrigation. An increased interest in drainage facilities is also apparent.

Some of the results of citrus research in 1954 are presented in the Proceedings and some will be reported on the program today. Probably the major citrus production problem is freeze damage. The two freezes in 1949 and 1951 demonstrated this point. Thus, an understanding of the factors which tend to increase freeze-injury is of great importance to the Valley. The work of Dr. W. C. Cooper with this problem may help our understanding of this problem.

Valley growers have feared that Tristeza disease would be introduced into the Valley. Research this past year has demonstrated that the virus causing this disease has been here for perhaps 30 years, but an epidemic has not materialized during that time. On the basis of these results, tristeza at present is considered a minor problem, but one which could become of major importance if circumstances for its spread should arise.

Some of the most significant citrus research in the Valley is still in its early stages. Work on biological control of insects, nematode control, Red grapefruit strain studies, new varieties, fertilizer management, fruit processing, and cultural methods has been started, but it will take years before these studies provide the information that will be the basis of the improved methods of the future. Research on marketing, a major problem, has to date received scant attention.

For some vegetable growers, 1954 might be remembered as the year of the price debacle on onions. Others might recall painful experiences with cantaloupe and watermelon crops. Others might remember the bright spots in the fall vegetable deal, when early cabbage brought good returns and cannery beans and field peas were in demand. However, carrots have developed into a profitable crop due in part to the development of chemical weed control and marketing in pliofilm bags. Those efficient growers who produced exceptional yields of tomatoes and peppers realized some profit, even though prices were not high throughout the harvesting season. In vegetable production, it is the efficient operator who is making the profit and it will be so in the future. The efficient grower is one who picks up new ideas and adapts them to his farming practices. The operator who cannot utilize new ideas will fall by the wayside. The purpose of this Institute is to present new ideas, and report progress toward the solution of horticultural problems in the Valley.

There are a number of new ideas in today's program and also in the Proceedings. We hope that they will be a source of new ideas for better farming and marketing of Valley produce.

Before closing, I would like to express the appreciation of the Rio Grande Horticultural Club to all those who have made this Institute possible. Our thanks to the Club membership, the Texas Agricultural Experiment Station, Texas A & I Training Center, the Valley newspapers, radio and TV stations. We are most grateful for the continued support of the Valley businesses that finance this Institute.

Again, may I extend our sincere welcome to all of you.

Preliminary Studies on Cold Hardiness in Citrus As Related to Cambial Activity and Bud Growth

WILLIAM C. COOPER, *Horticultural Crops Research Branch, A.R.S., U. S. Department of Agriculture, Weslaco, Texas;* SAM TAYLOE, *Rio Farms, Inc., Monte Alto, Texas;* and NORMAN MAXWELL, *Texas Agricultural Experiment Station, Substation #15, Weslaco, Texas.*

Introduction

When plants acquire increased resistance to freezing, the process is known as hardening, or becoming hardy. The term is usually associated with resistance to cold acquired by several days' or weeks' exposure to temperatures near the freezing point. However, many other environmental factors may induce changes in resistance to cold.

Ivanov (1939 b) established that lemon, orange, and mandarin trees on trifoliate-orange rootstock can be hardened by holding them in controlled temperature rooms at 36° and 28°F for eight successive nights. During the daytime of this hardening period, the plants were held under natural light and temperature conditions; natural temperatures ranged from 47° to 76°. Cold resistance was tested by placing the hardened and unhardened plants in controlled temperature rooms at freezing temperatures ranging from 20° to 14° and estimating the injury to leaves and branches. The lemons attained greatest cold hardiness when hardened at 36°, while the oranges and mandarins hardened less at 36° than at 28°.

In further experiments Ivanov (1939 c) again used lemon, orange, and mandarin plants grafted on trifoliate-orange stock. When these plants were shaded with three layers of gauze during the 8-day hardening period, their frost resistance increased. Likewise, Ivanov (1940) found that lemon and orange trees subject to an 8-hour day from mid-August until mid-December were more hardy than plants on the natural day length, while plants exposed to an 18-hour day were less hardy than plants on the natural day length.

Ivanov (1939 a) found that the content of water in the leaves, the amount of sugars, and the activity of catalase seemed not to be related to cold resistance. On the other hand, cold resistance was linked with a decrease in glutathione content of the tissue and with a depression of growth processes. Ivanov did not report specifically a depression in growth of the cambium, but he did show that glutathione content was a good measure of growth activity. Therefore, a decrease in glutathione content of the branches suggests induction of dormancy.

Since overwintering citrus trees in commercial groves of the United States become dormant as they develop hardiness, it is natural to seek some relation between the two phenomena. Citrus trees in active growth are more severely injured by freezing than those which are dormant; this conclusion is based on wide experience of growers and research workers in Florida (Wilder, 1948), California (Wilder, 1948), and Texas (Cooper, 1952). In tests conducted in Texas, grapefruit trees with no bud growth in early January could withstand temperatures as low as 24° F without injury, while similar trees with bud growth in mid-February were injured by 26° (Cooper et al, 1954).

In the Texas tests, buds were dormant, while the bark of twigs, large limbs, and the trunk peeled from the sapwood, indicating some cambial activity as early as January. In California there are winter periods when the cambium of citrus trees is inactive and the bark does not separate easily from the sapwood (Chandler, 1950). Such trees generally withstand temperatures as low as 20° or lower without severe wood injury. In Texas many orange and grapefruit trees of varying ages with no evidence of bud growth were killed by temperatures as low as 20° in early February, 1951. It is suspected that the cambium throughout these trees was active, and thus a layer of succulent cells separated the bark and sapwood.

The objectives of the present studies were to investigate bud growth and the state of cambial activity in the above-ground portion of the citrus tree in Texas during the winter under normal irrigation practice; to determine the relation of cold hardiness to cambial activity and bud growth; and to determine the influence of drought, salinity, rootstocks, growth-inhibiting substances, and length of day on cambial activity and bud growth.

Methods and Materials

Most of these studies were conducted in a block of sixty-two 3-year-old Webb Red Blush grapefruit trees on sour orange rootstock and six 3-year-old Meyer lemon on sour orange rootstock. The trees were grown at a 5-foot spacing and were located at Rio Farms, Inc., Monte Alto, Texas. The trunk diameter of these grapefruit and lemon trees was approximately 2 1/2 inches; the height of the trees was about 6 feet.

Fifty-six of the grapefruit trees were irrigated with water from the Rio Grande nine times during 1953. The irrigation dates were January 10, February 20, April 15, June 14, July 8, August 10, September 16, November 12 and December 4. Six grapefruit trees and six lemon trees, located in an outside row, were irrigated on the first eight irrigation dates, but were not irrigated on Decmber 4. The twelve trees not receiving the December 4 irrigation and twelve grapefruit trees receiving the December 4 irrigation were used for the experiments comparing the effects of winter irrigation and no-winter irrigation. The remaining trees irrigated on December 4 were used as follows: 4 grown on short day, 4 grown on natural day length, and 36 sprayed wth growth-inhibiting substances.

Control of length of day for four of the grapefruit trees was accomplished by the use of a 12-foot square light-tight compartment. This compartment was lowered over the trees each afternoon at 4 o'clock and raised each morning at 8 o'clock.

The following compounds were used in sprays applied to the foliage on December 4: alpha-naphthalene acetic acid; 2-4-6 trichlorophenoxy acetic acid; 2-4-dinitrophenol; maleic hydrazide; sodium arsenite; sodium arsenate; sodium flouride; y-phenylbutyric acid; isopropyl N-(3-methylphenyl)-carbamate; sec-butyl N-(3-chlorophenyl)-carbamate; isopropyl N-(2-methoxy-5-chlorophenyl)-carbamate; and tap water. The water sprays, with Dreft added as sticker, contained 100, 500 and 1000 mg. per liter of the chemicals. One grapefruit tree was sprayed with each solution. In addition, five 2-year-old sour-orange seedlings growing in a nearby nursery were sprayed with each solution.

Test of the influence of irrigation water quality on cambial activity was conducted on a 2-year-old Webb Red Blush trees on Cleopatra mandarin rootstock growing in a series of 3-tree plots at Rio Farms, Inc. The irrigation waters used for this test included Rio Grande water, Rio Farms well water, well water plus calcium sulfate, and well water plus calcium nitrate. The Rio Grande water contained less than 1000 p.p.m. of soluble salts and 0.5 p.p.m. of boron and had a sodium percentage of 60. The well water without amendments contained 3300 p.p.m. of soluble salts and 5.8 p.p.m. of boron and had a sodium percentage of 87. The addition of calcium sulfate and calcium nitrate to the well water lowered the sodium percentage to 60 but increased the soluble salt content to approximately 4000 p.p.m. Four replicate plots were irrigated with each kind of irrigation water nine times during 1953 including an irrigation on December 4.

The study of the influence of rootstock was made in a 6-year-old Webb Red Blush orchard planting at the Texas Agricultural Experiment Station, Weslaco, Texas. The planting comprised twelve trees of each of 33 rootstock varieties; 3-tree groups on each rootstock were replicated in each of four blocks. The trees were irrigated six times during 1953 with water from the Rio Grande; the last irrigation was made in early December.

Cambial activity of all trees in these tests was estimated by determining the ease with which the bark peeled from the sapwood. Two longitudinal cuts, about one inch long and one-eighth of an inch apart and joined at the bottom by a traverse cut, were made in the bark. A knife blade was inserted under the cut edge and the bark peeled from the sapwood. The ease of bark peeling was given a numerical score: 0, if the bark would not peel from the wood; 1, if the bark barely peeled; and 2, if the bark peeled easily. It is recognized by the writers that this bark-peeling test may give only a relative value for cambial activity. A study of the anatomical differences in cambium formation and the laying down of new cells as influenced by soil moisture and other treatments in these investigations has not been made.

Bud growth was estimated. The person making the estimate walked around the tree and estimated the average length of bud growth. The bud growth of each tree was given a numerical score: 0, if all buds were dormant; 0.5, if most of the buds were "breaking" and occasional buds were beginning to elongate; 1, if most of the buds had elongated one-fourth of an inch; and 2, if most of the buds had elongated two or more inches.

The minimum temperature at which tree injury was first apparent was determined in the freezing chamber (figure 1) used in earlier tests (Cooper, *et al*, 1945). In the present tests a standard three-hour exposure

Figure 1. The freezing Chamber in place over a 3-year old grapefruit tree. The door of the Chamber is open to expose the tree to view.

at the minimum temperature was used. Frequently, trees were exposed to several different low temperatures to determine the temperature causing incipient injury. Separate trees were used for each individual low-temperature exposure, since previous exposures might influence hardiness.

The temperatures of the leaves on the trees inside the freezing chamber were determined at 5-minute intervals during the low-temperature exposure by means of thermocouples. The leaf used for temperature measurement was folded over a thermocouple and clamped tight with a wooden clothes pin. The temperature of the leaves in the central area of the chamber was found to be fairly uniform and this area of the tree was used for tree-injury measurements following the cold treatment.

At the beginning of each test, the temperature of the interior of the chamber and of the leaves and branches of the tree was near that of the outside air. This temperature varied for different tests but was usually above 60°F. The rate of temperature drop under normal operation of the refrigeration equipment averaged 25 degrees per hour. It became progressively slower as the temperatures were lowered; below 32° it averaged 9 degrees per hour. This rate of drop is more rapid than normal in natural freezes. Cooper[1], however, found in preliminary experiments with grapefruit that injury was equal for slow and rapid rates of cooling; this observation is in agreement with the general one that cold-tender species are injured about equally by slow and rapid cooling (Levitt, 1941).

The extent of tree injury from low-temperature exposures was estimated from the appearance of the leaves, twigs, and bark one week following the exposure to cold. Although it is possible to detect severe injury to the tree immediately following a freeze, mild injury is not so easily detected, and observations made after one week were considered more reliable for determining incipient injury.

The daily minimum soil and air temperatures during the 3-month period of these tests are shown in figure 2. The air temperatures were obtained on a recording thermometer in a standard U. S. Weather Bureau shelter located three feet above the ground at a point 100 yards from the test plot. The soil temperatures were obtained by means of a recording thermometer located at a 9-inch depth in the center of the cold-hardiness test area. Soil temperatures, obtained at a 15-inch depth, are not shown in figure 2 but are summarized in table 1.

The minimum air temperature during the test period was 28°F, on December 26. On December 25 the minimum was 32° and on December 27 it was 48°. Thus the freezing weather was of short duration.

Air temperatures dropped below 40°F on 12 nights during the three months, but most of the periods of low temperatures were of short duration. The only sustained period of low temperatures was in late December, when the mean air temperature of the week was 49° (table 1).

[1]Unpublished data, 1954.

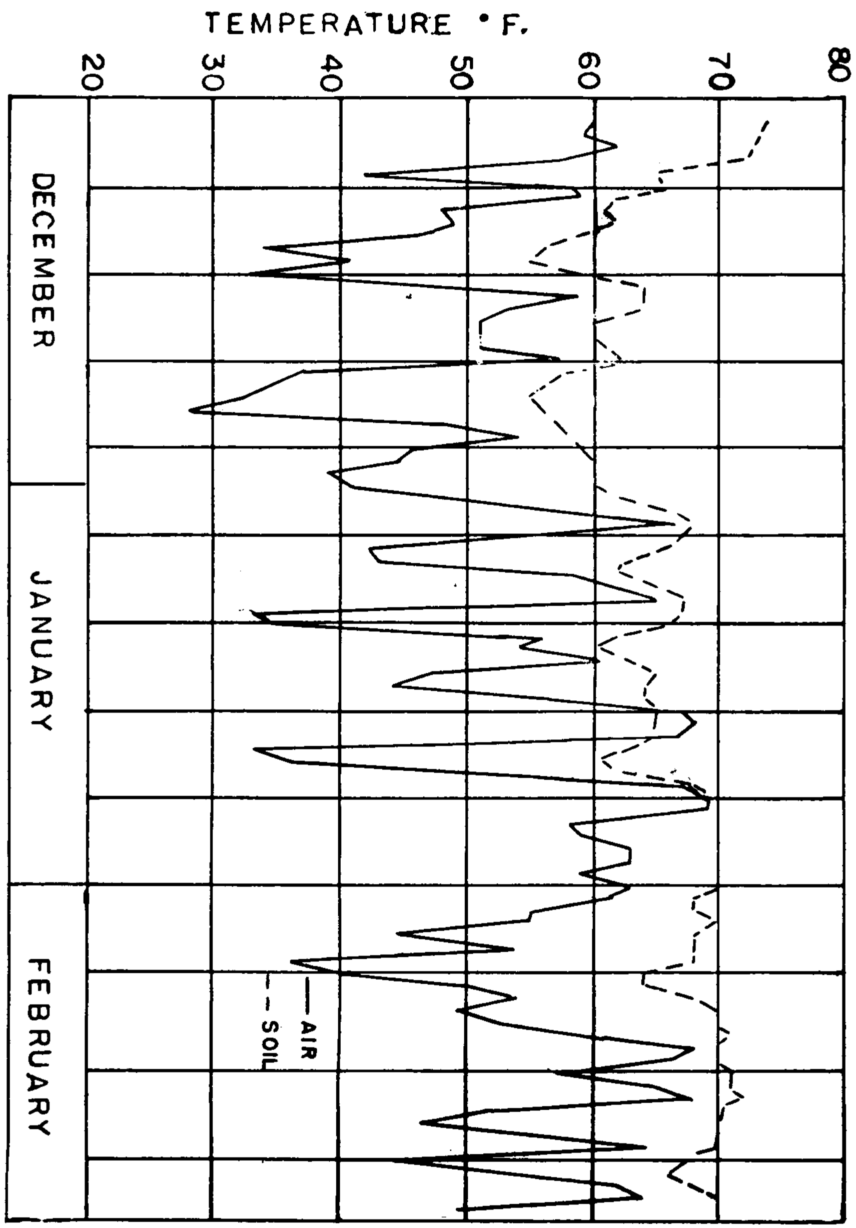

Figure 2. The daily minimum air and soil temperatures at Monte Alto, Texas, during December, January, and February. The soil thermometer was placed at a 9-inch depth.

Fluctuations in soil temperature nearly always occurred during a period of extreme fluctuations in air temperatures. The minimum soil temperature at a 9-inch depth for the 3-month period was 55°F, on two dates, December 14 and December 26, when minimum air temperatures were 32° and 28° respectively. Similar fluctuations occurred in maximum temperatures.

Except for 11 days in December, minimum soil temperatures at a 9-inch depth were above 60°F during the entire period. The weekly mean soil temperature (average of the daily maximum and minimum) during the last three weeks in December ranged from 60° to 63° at a depth of 9 inches and 60 to 64° at a depth of 15 inches (table 1). The means increased to 64 and 65° (9-inch depth) and 64 to 67° (15-inch depth) during January and to 69 to 74° and 69 to 72° during February.

Results

The cambial activity in grapefruit trees during the winter period as related to bud growth is shown in figure 3. These determinations were made on trees irrigated on December 4. On this date a November flush of bud growth had matured and all buds were dormant; the cambium, however, was highly active in all parts of the tree.

The buds remained dormant during all of December and the first half of January. They began to break during the third week in January and shoot elongation took place in late January and early February.

Cambial activity in the trunk remained at a high level all winter.

Table 1. Weekly Mean[1] soil and air temperatures in the test plot at Rio Farms during December 1953 and January and February 1954.

Week	*Soil at 9 inches* (°F)	*Soil at 15 inches* (°F)	*Outside air* (°F)
1 (Dec.)	68	70	68
2	60	64	57
3	63	63	59
4	60	60	49
5 (Jan.)	65	64	64
6	64	66	62
7	65	67	69
8	—	—	65
9 (Feb.)	71	69	67
10	69	69	67
11	74	72	70
12	69	71	69

[1]Average of minimum and maximum temperature for the week.

Activity in the twigs and large limbs decreased slightly during December and early January, but at no time did the cambium become completely dormant except in occasional limbs on two of the trees. In early February following the flush of bud growth, cambial activity in the twigs and large limbs increased to the same high level observed on December 4.

Until mid-January bud growth and cambial activity of grapefruit and Meyer lemon trees not irrgiated on December 4 followed the pattern

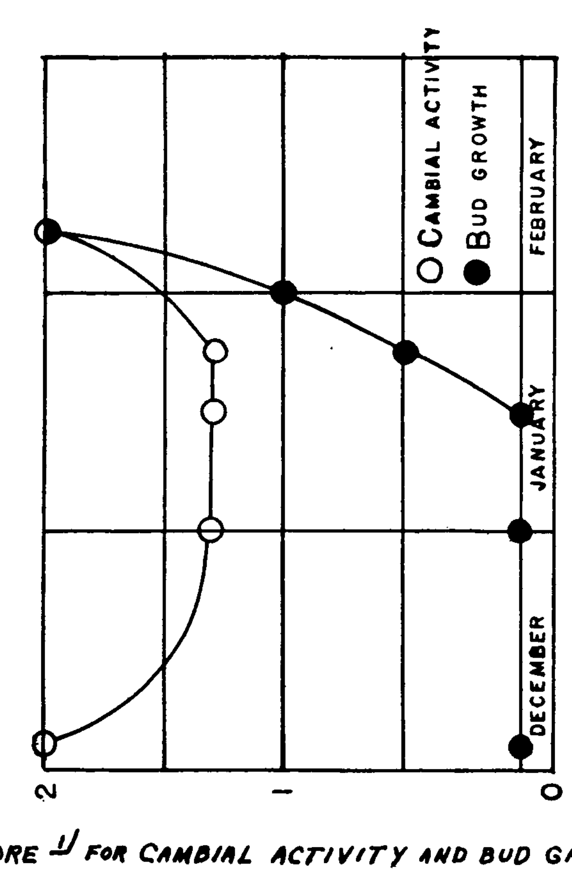

Figure 3. Bud growth and cambial activity in large limbs and twigs in 3-year old Webb Red Blush grapefruit during December, January, and February.

[1]The cambial activity was estimated by determining the ease with which bark was peeled from sapwood. A score of 0 indicates bark tight; 1, bark barely peels; 2, bark peels easily. The same numerical score was used for bud growth as follows: 0, buds dormant; 0.5 buds breaking; 1, buds one-fourth inches long; 2, buds two or more inches long.

described for the irrigated grapefruit. During the next three weeks the buds continued dormant and cambial activity in all parts of the tree decreased instead of increasing as in the irrigated trees. On February 7 the cambium of the Meyer lemon trees was completely dormant while that of the grapefruit was only slightly active. Thus, by withholding irrigation water during the winter period a low level of cambial activity in the top of the tree was induced during late January and early February.

The cold hardiness of the trees was not tested until early January. At this time the minimum temperature causing injury to both irrigated and non-irrigated grapefruit trees was 23°F. In early February following the flush of bud growth and increase in cambial activity in the top of the tree, the minimum temperature at which incipient injury to irrigated grapefruit trees occurred was 26 to 27°. At the same time the minimum temperature inducing incipient injury to the non-irrigated trees was 23° for grapefruit and 20.5° for the Meyer lemon. The cambium of the Meyer lemon was less active than that of the grapefruit. This may have been due to drier soil conditions for the Meyer lemon. The trees of these varieties were grown at opposite ends of the row and soil moisture conditions could have varied. However, no soil moisture determinations were made.

On February 12, three of the dry Meyer lemon trees were irrigated. One week later buds were beginning to grow and the cambium was highly active in all parts of the trees. The minimum temperature causing incipient injury was 27°.

These results indicate that cold hardiness of a tree is influenced by both cambial activity and bud growth. However, in the present tests the effects of bud growth and cambial activity were not entirely separated.

The small influence of rootstock on cambial activity of grapefruit is shown in table 2. On January 21 there were no difference in the cambial activity in the large limbs of trees on 33 different rootstocks and only a slight difference in cambial activity of the twigs. Because the trunks were banked with soil cambial activity determinations were confined to large limbs and twigs.

The largest difference between rootstocks occurred in bud growth. The buds were completely dormant on trees on satsuma rootstock and almost dormant (numerical score of 0.2 or less) on trees on Florida sour orange, Chu Koa mandarin, Clementine mandarin and Sunki mandarin. In contrast, buds on grapefruit on sweet orange seedling, Thong dee pummelo, Siam pummelo, and Thornton tangelo were about 2 inches long.

The rootstock effect on cambial activity and bud growth of grapefruit was of short duration. On February 12 bud growth was general throughout the orchard and the bark of all trees peeled easily. None of these trees were tested for cold hardiness.

The quality of the irrigation water caused no noticeable effect on cambial activity of the above ground parts of grapefruit trees (table 3).

Table 2. Cambial activity and bud growth on 6-year-old Webb Red Blush grapefruit trees in the Experiment Station rootstock planting on January 21, 1954.

Variety of rootstock	Score for ease of bark peeling[1] from: Large limbs	Score for ease of bark peeling[1] from: Terminal twigs	Score for bud growth[2]
Florida sour orange	1.7	1.5	0.1
Oklawaha sour orange	1.6	1.4	0.3
Sauvage sour orange	1.6	1.6	0.6
Bittersweet orange	1.6	1.6	0.5
Bergamont orange	1.9	1.4	0.5
Sweet orange seedling	2.0	1.8	2.2
Cleopatra mandarin	1.8	1.7	1.2
Dancy mandarin	1.7	1.3	0.3
Chu Koa mandarin	1.8	1.4	0.1
Clementine mandarin	1.6	1.8	0.2
Sunki mandarin	2.0	1.6	0.2
Satsuma mandarin	1.8	1.3	0
King (orange) mandarin	1.8	1.8	0.3
Calamondin	1.8	1.9	1.1
Duncan grapefruit	1.9	1.9	0.8
Leonardy grapefruit	1.8	1.7	1.0
Thong Dee pummelo	1.9	1.9	1.3
Siam pummelo	1.9	1.9	1.3
Minneola tangelo	1.9	1.9	1.2
Williams tangelo	1.8	1.5	0.7
Thornton tangelo	1.8	1.9	1.5
Suwanee tangelo	1.9	1.7	0.3
Sampson tangelo	1.9	1.4	0.3
Watt tangelo	1.9	1.6	0.8
Pina tangelo	2.0	1.9	1.1
Sunshine tangelo	1.8	1.6	0.8
Yalaha tangelo	1.8	1.4	0.4
Umatilla tangor	1.7	1.5	0.6
Rough lemon	1.7	1.5	0.7
Rangpur lime	1.8	1.5	0.3
Kalpi lime	1.7	1.9	0.9
Lempum	1.9	1.8	1.2
CPB. 4475 citrumelo	1.8	2.0	1.1
Significance of F value	None	**	**
L.S.D. at .05 level	—	0.3	0.7
L.S.D. at .01 level	—	0.4	0.9

[1]Numerical key used for classifying cambial activity: 0, bark tight; 1, bark barely peels; 2, bark peels easily.

[2]Numerical key used for bud growth: 0, buds dormant; 0.5 buds breaking; 1, buds one-fourth inch long; 2, buds two or more inches long.

The determinations of cambial activity were made on January 15, when there was no visible evidence of bud growth. The cambial activity was equal for all kinds of irrigation water tested. However, cambial activity of the bottom of the trunk was greater than that at the top of the trunk, large limbs, and twigs.

Bud growth on these trees began by January 23 and by February 12 the new shoots were 2 to 4 inches long. At this time cambial activity was at a high level in all parts of the trees and there were no differences among treatments.

Growth-inhibiting substances sprayed on the foliage on December 4 had no influence on either cambial activity or bud growth. Likewise, trees exposed to an 8-hour day from December 4 to January 4 showed the same cambial activity as trees exposed to a natural day length. The minimum temperature required to induce incipient injury was 23°F on January 4 and 26.5° on February 4 for both short-day and natural-day length trees.

Discussion

The experiments described indicate that there was no cessation of cambial activity in citrus trees even though they showed no visible bud

Table 3. Effect of irrigation water quality on cambial activity in 3-year-old Webb Red Blush grapefruit trees on Cleopatra mandarin rootstocks, January 15, 1954, before bud growth commenced.

Treatment	Score for ease of bark peeling[1] from: Bottom of trunk	Top of trunk	Large limb	Twig	Treatment mean
Canal water	1.5	1.3	1.1	1.2	1.3
Well water	1.8	0.9	1.3	0.9	1.2
Well water / $CaSo_4$	1.5	1.1	1.1	1.6	1.3
Well water / $Ca(No_3)_2$	1.5	1.5	1.3	1.1	1.4
Portion of tree mean	1.6	1.2	1.2	1.2	—

Significance of F value:
Treatment means – none.
Treatment X portion of tree interaction – none.
Portion of tree means – highly significant.
Least significant difference for portion of tree means:
.05 Level .215
.01 Level .287

[1]Numerical key used for classifying cambial activity: 0, bark tight; 1, bark barely peels; 2, bark peels easily.

growth during December and early January. The great influence of cambial activity on cold hardiness, indicated in these tests, makes it desirable to explore thoroughly factors influencing cambial activity in citrus.

Cambial activity in many decidious species has been associated with the presence of expanded buds (Coster, 1927). Subsequent work (Snow, 1935; Avery, *et al.* 1937) correlated the wave of cambial activity in the spring with a similar wave of high auxin (growth hormone) concentration moving down the cambium from expanding buds. In citrus the relations between cambial activity and growth of the terminal buds have not been investigated adequately. In the present experiments an increase in cambial activity followed the February flush of bud growth. However, the cambium was active for six to eight weeks prior to the February flush and during this period the buds were dormant. What stimulated the cambium to grow during this long period of bud dormancy?

Cooper (1939) investigated the auxin content of mature grapefruit terminal shoots with actively growing buds and with dormant buds. By ether extraction of fresh material he found auxin in the growing buds and in the cambium of shoots with growing buds, but not in mature leaves or in the cambium of shoots with dormant buds. The auxin production by the growing buds and its subsequent movement to the cambium would account for the observed increase in cambial activity in February, but not for cambial activity during a prolonged period of bud dormancy.

By using dried leaves instead of fresh leaves, Cooper[2] was able to extract auxin from mature grapefruit leaves on shoots with dormant buds. It is possible that the auxin in mature leaves occurs in a bound form, and there is a slow liberation of free, or active, auxin which might account for cambial activity during periods of bud dormancy.

Cambial activity during the long period of bud dormancy probably is associated with root activity. Reed and MacDougal (1938) found that cycles of root growth in citrus corresponded with cycles of cambial activity. Their experiments, however, were conducted in California where soil temperatures are approximately 10 degrees lower than in Texas and where shoot, root and cambial growth did not occur during the winter period.

Girton's (1927) investigations on root growth of citrus seedlings (grown in water culture) at various temperatures showed the optimum temperature for root growth to be 79°F and the minimum temperature to be 54°. In Palestine, where the soil temperature at 10 inches depth is 63°, citrus roots grow throughout the whole winter period (Cossman, 1947). The 63° soil temperature approximates the winter temperature of Texas soil. Considerable root activity would therefore be expected during the winter in Texas.

[2]Unpublished data, 1940.

Only small differences in cambial activity of the limbs of grapefruit trees on the various rootstocks were observed in mid-January in these tests. Perhaps greater differences might occur in older trees. The trifoliate-orange rootstock in Florida and California is known to induce a greater degree of dormancy in citrus than other varieties (Webber, 1948). This rootstock was not included in the rootstock orchard described in this paper. However, this rootstock and sour orange are planted in an experimental planting of Valencia oranges at Rio Farms, Inc. and no greater degree of dormancy was observed in these trees than in Valencia oranges on sour orange rootstock. The trifoliate orange, because of lack of salt tolerance, is not adapted to Texas soils and it is not used successfully in this area (Cooper, 1952).

Foliage sprays containing certain growth-inhibiting substances, are applied in these tests, were ineffective in inducing dormancy. Among the substances tested was maleic hydrazide, which delayed spring growth of Valencia orange and grapefruit trees when applied as a spray during the late winter in California (Erickson, *et al*, 1952). However, in the California experiments the cambium as well as buds was probably dormant when the spray was applied; the treatment prolonged dormancy. What is needed in Texas is a treatment to induce dormancy. Other compounds and other methods of application are being investigated.

All of the evidence that has been reported in the literature in regard to the effect of salinity of the substrate on cambial activity indicates that, as the concentration of the salts in the substrate increases, the rate of cambial activity decreases. (Hayward et al, 1941, 1942, 1943, 1944). In the case of citrus, Hayward and Blair (1942) found that increasing the salinity of the substrate decreased the activity of the terminal meristems (growing points) of the roots of Valencia orange seedlings. The evidence presented in the present paper is concerned with the lack of effect of soil salinity on the cambial activity of the above ground portions of the tree; no evidence was given on cambial activity of the roots. The problem requires further investigation before the findings of the present work on effect of irrigation water quality on cambial activity can be properly interpreted.

Other possible means of inhibiting cambial activity include lowering the soil temperature, decreasing soil mosture, and root pruning. Under Texas conditions lowering soil temperatures does not appear feasible, because of the warm temperatures of air and irrigation water.

Observations following the freezes of 1949 and 1951 indicated that root pruning is effective in inducing dormancy and cold hardiness. However, it has not been tested adequately to justify commercial trial.

Withholding irrigation water in the winter, as shown in these experiments will induce dormancy of the cambium and increase cold hardiness. This procedure, however, may be hazardous as citrus orchards have at times been severely injured by drought. There is also the possibility that the drought might be broken by an untimely rain which might result in very vigorous bud growth and cambial activity and less cold hardiness than trees that had been irrigated frequently. More experiments should be conducted before drought is used on a commercial scale to induce cold hardiness.

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Methods of Preventing Transit Losses

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Broadly speaking transit losses can be classified into two general categories, (1) Monetary loss in which the condition of the shipment is not involved such as market decline due to delay, and (2) damage to the shipment itself. We here are not interested greatly in the first category which after all cannot be classed as a waste as there is no actual damage. We are however very interested in the second category which causes waste and loss of food.

This waste can also be broken down into two general categories (1) Loss due to condition such as over-ripeness, decay, freezing, etc. and (2) Physical loss due to bruising and spilling.

Under the category of loss due to condition we have made improvements in train schedules so that food products reach their destination quicker and therefore fresher and with less deterioration. This is an operating department subject and involves better equipment that can be run faster with less delay for repairs, adjustment of train schedules so that connections can be made without lengthy layovers in freight yards enroute and the improvement of icing facilities so that this necessary function will not slow down the movement unnecessarily. The latest of such improvements was the "Expedited Train Service" put on early last summer by the AT & SF whereby shipments from certain points in California were given third day arrival in Chicago, $1.20 per C surcharge and normal service beyond. The only trouble with this service, judging from our Detroit experience, was that it was merely used to take advantage of beginning of season markets. The fruit in these shipments (plums) were picked and packed at the same stage of ripeness (or should I say greeness) as if they were to be shipped by regular freight that takes several days longer. As a result of the fast movemnt the fruit had less time to ripen in transit and arrived too green and at times did not sell as well as the riper fruit moving under regular freight service. Our observations on the cars shipped under this service were that the fruit arrived greener than fruit in conventional service and the damage from breakage was no more and possibly less than in conventional shipments. We believe that to properly utilize this service the fruit should be permitted to mature more fully on the trees and thereby obtain a product of higher quality that will ship without loss. This service could be very useful for end of the season produce which deteriorates rapidly and would be greatly helped by shortening the transit period. This expedited service was however not used for such shipments.

Another improvement to help condition would be improvements in the refrigerator car. Some of these improvements are quite old. Among the first were the use of floor racks to allow circulation of air underneath the load and thereby retard freezing in the winter and help circulate refrigerated air in the summer. Another such early improvement

was the basket type bunker which greatly increased the efficiency of bunker ice. Other improvements have been made in the doors which close more securely, in plugs which seal tighter, in drain pipes which seal more completely and in insulation which is more effective. Floors are treated and prepared so that body ice may be used without impairing the effectiveness of the insulation and new sheathing materials are used which are more airtight. Most recently cars have been equipped with flue walls which keep the lading from direct contact with the outer walls and provide a positive air circulation to prevent direct heat absorption by conduction from the car walls. Equally recent are circulating fans built into the equipment whereby normal air circulation is reversed and made positive so that maximum efficiency is obtained from the bunker ice. Another improvement not visible but very important is the standardization of refrigerator car size. It is now possible for car loaders to load any of the newer refrigerator cars in the same manner without serious thought of how the load will fit. It enables the package men to design their package to fit the car as well as the commodity. There have been some attempts to improve on the floor racks without much success. There is one item that has been so called "improved" of which inspectors have no use. I refer to the new sliding doors. Theoretically the idea sounds good. A nice big door is obtained with no obstructions through which pallett loading and unloading may be accomplished with the greatest of ease. Also the door closes the opening as a cork stops a bottle, theoretically air tight. Practically however the door is so big that when it is opened it lets the whole outside into the car; it cannot as old type doors could, be practically closed after entering the car, neither can it be partially opened when only a small opening is desired. I might also mention the difficulty in opening and closing such doors under conditions when ice forms on the tracks, also the susceptability of such tracks to damage from backing trucks which could prevent their proper closure.

Since the beginnings of refrigerator car use, refrigerants have been thought up to aid the insulation in keeping temperatures down. For years ice has been accepted as the most desirable medium and by the use of ice alone or with proper proportions of rock salt, we have been able, within certain limitations, to obtain desired temperatures. There are however too many variables and it is obvious that a given ice or ice and salt combination suitable for a 90° outside temperature might be entirely unsuitable at a 40° outside temperature; still cars of produce have to run through even greater ranges of temperature. Carriers have provided for this by permitting definite instructions to be given so that the type of service can be varied to better suit the changing conditions encountered enroute but even this is not entirely satisfactory. To remedy this we have now a few cars with thermostatically controlled refrigeration so that any desired temperature can be maintained. These cars however are based on mechanical refrigeration and are very costly; in addition their usefulness is limited to cars on which refrigeration service is desired and cannot be used under ventilation.

Another recent development is the thermostatically controlled car heater. This replaces the old oil and charcoal heaters which had very limited control and required much servicing. While this will be of little use to cars requiring intensive refrigeration or ventilaton it has possibilities in cars using limited refrigeration or ventilation and will prove very valuable for shipments requiring protection from freezing or low temperatures but prevention from overheating.

All this brings us down to the last category of physical loss due to breakage of packages and the resulting damage due to bruising and spilling. This damage I believe causes more loss than any other, if Tom Bell were here he probably could give you actual figures. The loss from breakage on any one shipment is seldom as great as that experienced because of poor condition or loss of market but the number of shipments containing damage due to breakage is so much greater than those damaged by other causes that their total becomes very important. What to me seems a shame is that most of these losses could be eliminated by the use of suitable packages and suitable and proper loading.

I have been active in inspection for the past 30 years. When I inspected my first car of California oranges I found it to contain identically the same box as used today, our FCB #635, the first car grapefruit I inspected was packed in what is still used today as container #675. Grapes were then packed in lugs and 4 basket crates, today they are still packed in lugs. Peaches, apples, and other fruits and vegetables were packed in bushel baskets and many still are. Some packages have disappeared, barrels are completely gone, many of the types of hampers have dropped by the wayside, the Owosso and Cummer folding crates are no longer used in rail shipments and numerous boxes and crates have come and gone. The packages that have remained through the years have had to have some merit, these merits are sturdiness, attractiveness, convenience and I am sorry to say cheapness. Some of these old packages were good and after the proper loading combination was found they performed adequately.

California and Arizona oranges are still mostly packed in boxes, container #635. The old loose stripped load has however long been forgotten. Now boxes are loaded without strips but they are tightly loaded in the cars with hydraulic squeezes long since paid for by the savings in strips and the excess space not taken up by boxes is taken up by the spacefillers. Upon perfection of this method of loading, breakage was greatly reduced. Now experimentation is going on with fiberboard boxes of half bax capacity (reflecting the general trend toward smaller packages) and preliminary work indicates that when a more suitable loading method is worked out, the breakage will be reduced to a very small amount.

I might add here that lemons in #625 boxes have had a similar history but that the #625 box is now little more than a memory having been almost entirely displaced by a fiberboard box which has practically no damage.

The grape lug and the 4 basket crate now used more for commodities other than grapes have been turned around from the original lengthwise loading plan to a crosswise loading plan with almost miraculous results. In addition patented loading methods such as the Hoak load, Fence load, Superior Block load and Martin Spacer load have reduced damage still further.

The story of the Honeydew crate is a repetition of that of the lugs and crates. By turning the package from lengthwise to crosswise the terrific breakage was reduced to normal and after the use of patented loads (Hoak and Pierce) was started the breakage dropped still more.

Unfortunately we have not such a rosy picture of the 1 4/5 bushel nailed citrus box #675. This has been the subject of exprimentation for years and it is true that some progress has been made. Personally I believe the greatest progress was made by those sections that discarded it completely and now use the wirebound container 5004 of the same capacity. There are however a few sections that still use this package 100%. In these sections we have varying results. Due to this package being one of those that was not designed to fit a standard car it is too wide to load 7 wide and not wide enough to be tight 6 wide. In addition it has to be loaded 3 high. Today, strange to say the best load is one not shown in the loading tariffs and the load contained in the tariff is a pain in the neck. Here our trouble is entirely a package not designed to fit the car. It is true that strict attention to ordinary good loading practices such as taking up of all lengthwise slack does reduce the breakage to a tolerable point but even then it could be greatly reduced by redesigning to fit the car. The substitute container 5004 had a different history. As originally designed this container required an end gate in standard length cars. When this endgate was omitted as it frequently was, severe racking took place in the bottom layer because of the lengthwise slack and other boxes sheared their sides where out of vertical alignment. By slightly redesigning the crate to 1/16 inch less width and depth and 1/8 inch greater length, 2 inches of lengthwise slack was taken up and the severe breakage ended.

Sorry as the 675 box record is, it is still better than that of the bushel basket. The basket has changed but little in 30 years. It now has a crowned cover to better protect the bulge pack and it has side hooks to fasten the cover at 4 instead of 2 points. The bushel basket however is another package which was not designed to fit in the car. As a result the loading pattern used is the end to end offset load or other names affecting the same pattern; this consists of 6 rows which provide only single contact points with adjacent baskets in the row and there only at the basket and cover rim. It also leaves alternate upper layer baskets next bunkers only half supported at the bottom by baskets below. Nothing has been done to redesign this container to fit the car. We have however done a little experimenting in loading. Three cars were loaded by the alternate inverted crosswise offset method, all going to New York City. Their records were 0 - 3 and 9 packages requiring recoopering service. There is considerable hesitancy on the part of the trade to adopt this load for fear of bruising in the face of inverted baskets. The test cars however indicate that this fear is unfounded, that the cushion pads now used under the covers absorb all pressure and actually form individual cells for each contacting peach and thereby reduce rolling tendency and provide better protection than that afforded in the upright baskets.

Realizing the shortcomings of the bushel basket there was introduced in 1952 a new basket of three fourth bushel capacity. This basket was designed to fit a standard bar, the width being such that 6 rows could be placed across the car tightly. The loading plan devised was the 6x5 crosswise offset which eliminated the half supported baskets from next to the bunker and provided twice as many contact points with adjacent baskets. The results of this package was a reduction of 1/3 in the total number of broken packages per car as compared with the bushel basket and an actual reduction of about 1/2 based on the actual number of packages involved. Since the three fourths bushel basket is made exactly like the bushel basket except for size the improvement must be attributed to (1) slightly greater strength because of smaller size with same weight of materials but (2) mostly to the better loading pattern made possible by designing the basket to fit the car.

For years shippers assumed that carrot consumers were relatives of rabbits and had use for carrot tops, consequently they insisted on shipping carrots with tops using a nailed vegetable crate shown in the tariff as 926, 929 and 930 the different numbers representing slight differences in dimensions. These crates were not too satisfactory and became the subject of experimentation although I must admit it was with lettuce requirements in mind that the experiments were made. Several years ago the specifications of a new crate were agreed upon after many trial shipments and the WGA crate was born, now in the tariff as #935. No sooner was it in the tariff than grumbling began. More experimentation, more people interested. Then along comes the pliofilm bag and the discovery that consumers do not use carrot tops. Carrots began to have their tops clipped at origin instead at the grocery store, they were placed in pliofilm bags and these in turn in a master container. This is where we now stand. No one knows which will be the eventual master container. At present shipments are being made in nailed crates, wirebound crates and fiberboard boxes. Strange as it may seem the breakage in the test cars all seems to be less than in the old nailed crate. Wirebound and fiberboard are the most popular and have the best breakage record.

The discovery that lettuce could be successfully shipped without package and body ice completely upset the lettuce industry and again opened the way for superior packages to replace the old nailed L&V crate. In this picture fiberboard pulled to the front rapidly. In spite of hurried field operations resulting in sloppy closure, designing the package to fit the commodity rather than the car, questionable loading care and other vices; this package outturns much less breakage than any other

package. I wish to advise all present however that these questionable packing and loading practices result in a package, while not broken, is at least unkept and unattractive. There is still much room for improvement in this package before it will equal the nailed crate in attractiveness. Actually its freedom from damage has been greatly responsible for its acceptance. Other factors are its smaller capacity and its cleanliness.

The vegetable industry probably shows the greatest turnover of packages as any. The changes here are so numerous that it would be impossible to begin to discuss them in this limited time. One of the general trends however is the abandonment of large overpacked nailed crates in favor of smaller nailed crates with less bulge and an increasing percentage of wirebound crates. All this ends up in less damage. In this connection I might point out the change in cabbage containers from the mesh sack to the wirebound crate. The reduction in damage here is not one of breakage because sacks seldom broke. The damage reduction here is in condition. Regardless of how they were loaded, sacks were a very solid load which cooled slowly. Any weakness in the cabbage would break down and many cars arrived at destination showing deterioration from decay or yellowing. Wirebound crates do not load as solidly and permit sufficient air and ice water circulation to better cool the product and thereby retard deterioration and consequently loss.

This brings us up to a subject which is at present quite active. This is the new loading method of cantaloupe crates. Here again is a package, although well designed to fit in a car, has for years been loaded with it weakest dimension subject to the greatest strains which is lengthwise. When packed, the cantaloupe crate has a decided top and bottom bulge and a slight side bulge. All slats are then in a bowed position which can be compared with a bend in a nail. Everyone has tried to drive a bent nail and knows that even when hit lightly it will bend more. The same is true of the slats on cantaloupe crates. Under lengthwise load shocks they bend more and break. The problem then is to load these crates so as to eliminate the load shocks from the side slats. The on end load is the answer. The on end load provides for withstanding the load shocks through the straight thick ends and provides relief for the side bulge by the side stripping or stripping units. The adoption of the on end cantaloupe load as mandatory will reduce cantaloupe breakage the same as honeydew breakage was reduced by the mandatory crosswise loading.

The prevention of transit losses then is everybody's business. Carriers must constantly improve their services. Car companies must keep their equipment in good repair, modernize old equipment and improve new equipment. Package manufacturers must seek to improve existing containers and design new and better containers. Growers and shippers must seek to improve packing processes, adopt improved containers and loading methods and do all in their power to see that only good merchandise is shipped. Government agencies must experiment and then disseminate their findings on improved varieties, improved cultural practices, fertilization, disease and insect control, maturity tests and transit tests. The receivers should insist on use of superior containers loaded by the best methods and shipped under the transit service that best protects the shipment.

Destination Findings – Citrus

Today we find that there is still some experimenting going on in Citrus containers, this is however not as extensive as in the case of lettuce. The trend is toward smaller packages and to packages requiring less lumber.

We have three citrus sections. Florida, Texas and the far West taking in Arizona and California. The Texas section is temporarily out of the picture for reasons well known, therefore our findings are necessarily limited to Florida and the far West sections.

Currently, shipments from Florida are made in 5 and 8 lb. mesh sacks and containers No. 5004, 4016, 3702, 3677, 675 and 690. We had a few shipments in fiberboard boxes No. 7575 and 7580 while these containers were being tested but none are now being received.

Comments on these containers are as follows: 5 and 8 lb. sacks are limited to chain store trade. Damage does occur in the form of crushing due to overhead weight but this is not classified as bad order, therefore our breakage experience on this container is very good.

Container No. 5004 carries the bulk of the oranges and grapefruit and carries quite well. We feel that the double crosswise offset loading method is superior to the single crosswise offset method but the difference is slight and has never been proven. Using the figures for Detroit in January 1954 we find an average outturn of 4.2 RRS and 1.8 B/O in the orange cars and 5.9 RRS and 2.7 B/O in the grapefruit cars. The difference is probably due to the tighter pack in the oranges.

Containers No. 4016, 3702, 3677 and 690 carry the tangerines, tangelos, satsuma and temple oranges. So few No. 690 are used that they may be disregarded. All these are half box (4/5 bushel) capacity packages. Since the material used in these packages is the same as used in the full size packages except for length, it makes a very strong package with an outturn average of 0.6 packages RRS and 0.5 B/O.

This leaves container No. 675. This is an old established package over 30 years ago when I started inspection work and has changed little. It is used chiefly in the Indian River District in Florida, probably to identify their product. It is used both for oranges and grapefruit but in Detroit only grapefruit come from this section in quantity and therefore our performance figures are limited to this commodity and are an average of 35.7 RRS and 2.3 B/O in January 1954. This container does not fit the car and allows too much crosswise space when 6 wide and will not go 7 wide without Largo rows. The stripped 6 wide load is susceptible to sprung covers because of the row spacing and broken corners because of the strips. The 7 wide load with Largo rows is superior but the Largo

rows tilt readily ripping off bulge bands and rack the boxes. Extensive study has gone into this load but nothing worthwhile has been found.

Currently shipments from the far West are in No. 635 for grapefruit and most oranges and fiberboard boxes for lemons and few oranges.

The lemon story is an interesting one. In 1952 94% of all lemon cars (Detroit) were No. 625 boxes, 6% were test cars with a third layer of fiberboard boxes. In January 1953 only 20% of the lemon cars were No. 625 boxes and 80% were fiberboard boxes. In January 1954 all cars were loaded in fiberboard boxes. I might add that during this time, and even now, experimentation is being conducted with a 1/2 box wooden and WKV boxes but they are too few to average. The performance of the No. 625 box in 1952 was 26.0 RRS and 2.1 B/O, in 1953 30.0 RRS and 1.0 B/O. The fiberboard boxes in January 1953 average 0.4 RRS and 0.2 B/O and in January 1954 average 0.5 RRS and 0.5 B/O, 45% of these being bad order because of being wet from melted bunker ice. In 1953 the R.P.I.A. made a survey for June, July, August and September which showed No. 625 boxes averaging 39.5 RRS and 3.0 B/O as compared with fiberboard boxes averaging 2.7 RRS and 1.2 B/O.

Although grapefruit move from this section in No. 635 boxes their number is so small that no figures were worked up. I may say however that our experience has been that the breakage is greater than in oranges using the same container.

Oranges still move mostly in container No. 635 but the trend to use of fiberboard is increasing. During June through September 1953 only 5% of the oranges moved in fiberboard but in January 1954 this figure had risen to 10% and another 5% contained both No. 625 and fiberboard. In the June through September period No. 635 boxes averaged 35.7 packages RRS and 4.3 B/O, in the January 1954 period the average was 30.8 RRS and 2.1 B/O. In comparison during the June through September period fiberboard boxes averaged 3.0 RRS and 1.9 B/O and the January 1954 period averaged 0.9 RRS and 0.9 B/O. In the June through September figures 30% of the B/O were ice water wets. The improvement in January figure is partly due to improved loading pattern and partly to more direct shipment.

Something new has been added in the wooden package line. This is the substitution of WKV slats for wooden slats. So far this substitution has been observed on containers No. 675, 635 and 4016. On container No. 635 it appeared very good except for slight excess flexibility of the cover slats. On container 675 sides, bottoms and covers bulged excessively. On No. 4016 the slats were entirely too flexible, the container shortened by bulging between the binding wires.

Destination Finding – Lettuce

Lettuce packaging has undergone a tremendous revolution in the past year. Previous to 1953 practically all lettuce moved in nailed crates. It is true that a few experimental loads were shipped in fiberboard and other experimental shipments were made on dry pack lettuce in wooden crates, but these were too few to even create a percentage in the total number of cars shipped.

In 1953 the R.P.I.A. made a survey covering all card lettuce received in their territory during June, July, August and September. This survey showed that out of 9402 cars lettuce inspected during this period 5265 cars or 56% of the total were in fiberboard boxes and 4137 cars or 44% were in wooden crates. The fiberboard boxes averaged 7.3 R.R.S., 0.9 Full B/O, 0.6 P/O & Empty, 0.7 Wet from ice water, a total of 2.2 for all types of B/O. The cars of wooden crates during this period averaged 26.7 R.R.S. and 7.5 B/O.

In this survey the figures for Detroit are 739 cars inspected of which 284 or 38% were fiberboard boxes and 455 or 62% were nailed crates. The Detroit breakage records were 3.5 R.R.S., 0.6 Full B/O, 1.6 P/O or Empty, no ice water wets for a total of 212 per car in the fiberboard boxes and 23.0 R.R.S. and 7.0 B/O for the nailed crates.

Since this survey the picture has changed very rapidly, in fact so rapidly that no overall picture can be obtained to keep up with the trend. I have however worked up the Detroit figures for January 1954 and these show that out of 221 cars inspected 214 or 97% were fiberboard boxes and 7 or 3% were nailed crates. I might add here that of these 7 cars crates, 6 were W.G.A. Crates and only one was 409 M crates which were designed as competition for fiberboard boxes. From a breakage standpoint the record for fiberboard boxes has improved from our previous survey, the figure for R.R.S. in January being 2.7 per car a reduction of 0.8 and the B/O were 1.7 per car a reduction of 0.5. The figures on nailed crates is not so rosy, the 7 cars averaged 40.1 R.R.S. and 10.3 B/O, an increase of 17.1 R.R.S. and 3.3 B/O.

So much for the breakage picture so now we will take up the question of condition factors readily determined, namely decay and freezing. Many factors affect decay so this picture may be somewhat clouded due to different sections with lettuce in different conditions using different packages, different methods of precooling and by shipment under various types of refrigeration with or without the use of salt. Freezing likewise might be affected variously by loading methods, methods of precooling and by types of refrigeration used. I might add that the variables in loading, precooling and refrigeration are limited to the fiberboard boxes and small size nailed boxes.

We have worked up consition figures only on January Detroit receipts and only on cars which all information was available. These totaled 149 cars of which 7 were nailed crates previously mentioned and 142 were fiberboard boxes included in those mentioned previously. In none of the cars was there sufficient decay to merit a protest. In none of the cars was there freezing. For the record however 14.3% of nailed crates and 6.3% of fiberboard boxes showed slight freezing. No wooden crates and only 5.6 of fiberboard boxes showed any decay whatever.

In this connection I might add that these cars were shipped under varying instructions 77% with half-stage refrigeration, with reicing, no salt, 2% half stage refrigeration with reicing, with salt in initial ice, 4% full bunker refrigeration regular or modified without salt, 16% full or modfied refrigeration with salt in initial ice. I might add that I recall one car shipped with 3% salt in initial ice and 2% in added ice received before this survey. This car checked over 300 boxes frozen.

In connection with the shipping of fiberboard boxes it must be understood that all Field heat must be removed as soon as possible. To this end a number of methods are used which fall into two general categories (1) Removal of heat before loading in the car by vacuum cooling or otherwise, (2) by removal of heat after loading but before car is shipped by either the ice in the car bunkers, which is then replenished, or by outside refrigerated air forced through the lading. It is in connection with the removal of heat after loading that many variables occur. Initial ice in these shipments is usually salted and the loading method provides for some sort of row spacing maintained by car strips. These factors, however, did not seem to affect the delivery conditions observed in Detroit.

Destination Findings — Peaches

Any list of peach containers would include the following containers, the peach box No. 775 and 777, the lug FCB No. 1025 and 1026 which would be classed as rigid, the wirebound Universal crate and half crates FCB No. 5045 and 5046 which would be classed as semi-rigid, and one half bushel baskets FCB 8028, 0837 and 8052, three fourths bushel baskets No. 8055 and one bushel baskets No. 8026, 8035 and 8050 which are flexible containers. Of these containers only the Universal crates and three fourths bushel baskets are new or reasonably new. The Universal crate was adopted for peaches displacing a very satisfactory earlier crate the Spartan Box FCB 3936 and 3937 which was more costly to manufacture.

Most peaches from the west come in containers No. 775, 777 soft fruit boxes or No. 1025, 1026, 1028 lugs. These are rigid containers and contain placed, wrapped, fruit. These should be satisfactory containers and they probably would be if given a chance. Unfortunately loading rules permit these containers to be loaded either lengthwise or crosswise or there is no penalty for lengthwise loading and the weak, damage provoking, lengthwise, load is chosen by 85% of the loaders for the soft fruit boxes and by 9% of the loaders for the lugs.

The results of the 1953 peach survey covering all stations showed the soft fruit box cars loaded lengthwise averaged a disgraceful 67.7 packages RRS and 33.5 B/O, whereas cars loaded by one of three crosswise methods used averaged 36.0 packages RRS and 10.4 B/O. The lugs made a similar showing, those loaded lengthwise averaged 72.7 packages RRS and 28.8 B/O whereas those loaded by one of the three crosswise methods used averaged 23.1 packages RRS and 8.2 packages B/O.

The only argument ever advanced for lengthwise loading is that lengthwise loads would secure better air circulation. Since better air circulation would show up as lower commodity temperatures, one would expect lower commodity temperatures in lengthwise loads provided the argument were valid. In 1952 the RPIA included in their survey, commodity temperatures. This survey showed the commodity temperatures slightly lower in the crosswise loads, thereby refuting the only argument for the lengthwise load.

In addition to the breakage record there are other reasons for the superiority of the crosswise over the lengthwise load. When loaded lengthwise all packages have their thin 1/4 inch side slats lengthwise or the car so that all lengthwise load strains are borne by these thin slats. The weight of the pack alone bulges these toward and at each load shock these slats bulge outward more and then return when the strain is released. When bowed outward the contained fruit settles to fill the greater crosswise space and when the side slats return to their original position there is side pressure on the fruit: often times fruit projects slightly at the crack between the bottom and side when these members bow outward and upon returning to normal the projecting fruit is pinched. Another item overlooked is the tendency to roll inside the package. All packs settle after packing and transit shocks tend to move the contents from one end of the container to the other much as a person leans backward or forward in an automobile when accelerating or braking. When these containers are loaded lengthwise there is a distance of 16/18 inches inside the container on which this action can take place. When loaded crosswise this distance is only 11 1/2 inches in the soft fruit box and 13 1/2 inches in lugs. This shorter distance materially reduces the rolling and settling tendency.

The RPIA goes on record as recommending that these containers be loaded by one of the crosswise loading methods.

In the other sections peaches are packed in the half, three quarters and one bushel baskets and in wirebound half crates and crates. The bushel basket has been with us more years than I care to talk about and its record after all these years is as poor as it always was: in 1953 the average RRS was 32.3 packages per car and the B/O was 20.7. In spite of educational programs at loading point to eliminate excessive bulge packs and secure better cover closure the damage figures remain practically unchanged year after year.

Probably our next oldest container is the half bushel basket. This has been in use for some time and their use has increased until in 1951 when 26.7% of all basket shipments were half bushel baskets, this trend however remained stationary and in 1953 again 26.7% of all basket shipments were half bushels. Obviously the use of half bushel baskets doubles the number of containers in a carload, still the 1953 RPIA breakage record stands at 28.5 RRS and 16.3 B/O packages per car.

The three quarters bushel basket was introduced experimentally in 1952 when we checked the outturn on 39 cars. In 1953 shipments increased 225 cars inspected by us. In 1953 the damage record was 26.0

RRS and 14.8 B/O per car which was substantially the same as the experimental cars in 1952. I might add however that the three quarter bushel basket was used by relatively few shippers and these shippers could probably all be classed as better shippers. What this record would be in general usage by all types of shippers is still a question.

Due to the variable size of these baskets a fairer comparison of their breakage record would be by comparing the records for 100 packages. On this basis the record is as follows:

Bushel baskets RRS per 100 pkgs. 8.2	B/O per 100 pkgs. 5.6
1/2 Bushel baskets RRS per 100 pkgs. 3.1	B/O per 100 pkgs. 1.8
3/4 Bushel baskets RRS per 100 pkgs. 4.4	B/O per 100 pkgs. 2.6

The remaining packages for discussion are the Universal crate both full and half size although not yet very popular because of their newness they did constitute 209 of the shipments inspected or approximately 5%. Their outturn record is excellent: on the full crate 1 1/9 bushel size the average was 4.0 RRS and 1.5 B/O per car; on the half crate 5/9 bushel size the average was 11.9 RRS and 3.4 B/O per car.

The RPIA goes on record as considering the bushel basket as an unsuitable container for the shipping of peaches by rail because it is too flexible and easily compressed and no efficient method of loading has been developed.

The RPIA recommends:

1. Further testing of the crosswise offset 6x5 alternately inverted method of loading for bushel baskets.

2. Encourage the use of the half and three quarters bushel when baskets are to be used.

3. Encourage the use of the 1 1/9 and 5/9 wirebound crate for utmost efficiency and freedom of breakage.

Suggested research is the use of a blanket of snow ice over the load similar to that now used on cantaloupes. Such a blanket would quickly remove orchard heat so that ripening and Rhizopus decay would be practically eliminated and Brown Rot decay checked. The blanket of snow would knit together and stabilize the load and the wetting of the veneer of the baskets would make them tougher and therefore less liable to split, crack or break.

Effect of Salt Content of Irrigation Water on the Growth of Pepper and the Magnitude of the Serpentine Leaf Miner Infestation

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The Lower Rio Grande Valley suffered from an acute shortage of irrigation water during July and August of 1952. As there was little or no available irrigation water in the Rio Grande River, farmers were attempting to raise pepper plants with well water, which in many instances had a total salt content of 2000 ppm or more. The pepper seedling grew very slowly and were heavily infested with the serpentine leaf miner *Liriomyza subpusilla* (Meig.). Growers complained that this leaf miner was actually stunting the growth of small pepper plants. However, in two experiments where the leaf miner was controlled with 2 percent parathion dust (Wene 1953) the pepper plants did not make much growth until rains fell in October. Hayward (1947) classified peppers as being moderately salt tolerant, indicating that the amount of total salts in the irrigation may influence the growth of peppers.

An experiment was designed to compare the effect of salty water and good irrigation water on the growth of various seedlings.

Procedure

Pepper, cotton, carrots, sweet corn, tomatoes, and cantaloupes were planted in rows spaced 3 feet apart and 25 feet long on January 18, 1954. Fifteen of these plots were irrigated with well water that had a total salt content of between 2400-2700 ppm. Another series of 15 plots were irrigated with river water that had a total salt content of between 420 and 600 parts ppm. The plots were irrigated on January 19, February 1, 12 and March 17. On March 23, 1954 the soil solution was analyzed and that of the river water varied between 812-912 ppm of total salts while those plots irrigated with the well water were between 2660 and 3843 ppm of total salts.

Plants emerged in 13 plots irrigated by well water and also in 13 of the plots irrigated with river water. On March 31 observations indicated that leaf miner damage was more severe on the well water plots; so ten plants were selected at random in each plot and data were taken on plant height, number of leaves per plant, and the number of leaves infested by leaf miners on each plant.

Results

Table 1 summarized the growth that the pepper seedling made in the plots irrigated with the two types of water. It is also interesting to note that approximately the same number of leaves per plant were infected by the serpentine leaf miner on plants growing in both the well

Table 1. Effect of water quality on the growth and degree of the leaf miner infestation of peppers.

	Source of Water	
	2400-2700 ppm Well; salt	*420-600 ppm River; salt*
Ave. Height of Pepper Plants	1.8 in.	4.3 in.
Ave. No. Leaves per Plant	8.2	15.3
Ave. No. Leaves Per Plant Infested by Leaf Miners	2.6	2.8
Percent Leaves Per Plant Infested by Leaf Miners	32	18

water (high salt content) and the river water (low salt content) plots. The plants growing in the well water plots average 8.2 leaves per plant while those growing in the river water plots averaged 15.3; therefore since about the same number of leaves per plant were infested with the serpentine leaf miner, the plants in the well water plots had the highest percentage of infested leaves which in turn resulted in their appearing to be more heavily infested to the casual observer. Those plants on the well water plots were much smaller and also had smaller leaves, so again, a single serpentine leaf miner infestation would do more apparent damage to the smaller leaves of the well water plants than on the larger leaves of the plants irrigated with river water. These data indicate that water quality and not leaf miner infestations was the principal limiting factor in the growth of pepper seedlings.

Summary

Pepper plants were grown in plots irrigated with well water containing 2400 to 2700 ppm of total salts and with river water containing 420-600 ppm. The serpentine leaf miner infested the same number of leaves per plant in both the river and well water plots but the plants irrigated with good water (low salt content) had a greater number of leaves and a lower percentage of leaves infested by the serpentine leaf miner. The data indicate that the high salt content of irrigation water is a greater factor in stunting peppr seedling growth than is the serpentine leaf miner.

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Control of the Bean Leafhopper

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The leafhopper, *Empoasca solana* DeL., has been found in destructive numbers on southern peas, castor beans, and cantaloupes. In the Lower Rio Grande Valley this insect is commonly called the bean leafhopper. Three experimnts were conducted in order to test the efficiency of the locally available insecticides for the control of this insect.

Materials and Methods

A severe leafhopper infestation was located in a field of purple hull peas that were just beginning to bloom. Each treatment plot was 0.02 acre in size. Each treatment was replicated three times. The treatments were applied with rotary hand dusters at approximately 15 pounds per acre.

The efficiency of the various insecticides was determined by selecting ten leaves at random from each plot and counting the surviving nymphal and adult leafhoppers.

Discussion

The data in Table 1 show that the best leafhopper control was obtained with a mixture of 5 percent DDT and 82 percent sulphur. Dusting sulphur also gave good control, being better than 5 percent DDT which had talc instead of sulphur as a diluent. Sulphur used alone was much slower than DDT in reaching its maximum effectiveness. The data in

Table 1. Insecticidal dusts for the control of the leafhopper, *Empoasca solana* DeL., attacking blackeyed peas (1950).

	Ave. No. Leafhoppers per Leaf After					
	1 Day		*4 Days*		*8 Days*	
Treatment	*No.*	*Percent Control*	*No.*	*Percent Control*	*No.*	*Percent Control*
1% Lindane	4.1	29	3.1	38	3.0	25
5% DDT	2.2	64	1.4	72	1.4	65
5% DDT + 82% Sulphur	1.2	79	0.3	94	0.3	93
Sulphur	2.6	40	2.1	58	0.8	80
1% EPN	1.3	75	1.5	70	1.4	65
1% Parathion	1.3	75	1.4	72	2.1	53
Untreated	5.8	—	5.0	—	4.0	—

Table 1 show that the use of sulphur instead of talc increased the efficiency of a 5 percent DDT dust. One percent concentrates of parathion and EPN were about as effective as the DDT-sulphur mixture, but did not have the residual effectiveness of the DDT-sulphur mixture or of the dusting sulphur. Lindane, used at a 1 percent concentration, was not effective in controlling this species of leafhopper.

Aldrin, chlordane, and heptachlor failed to control the leafhopper attacking purple hull peas, as shown by the data in Table 2. The data also show that 5 percent concentrations of methoxychlor and TDE were almost as effective as the mixture of 5 percent DDT and 82 percent sulphur. The data in Table 3 show that 10 and 20 percent concentrations

Table 2. Insecticidal dusts for the control of the leafhopper, *Empoasca solana* DeL., attacking blackeyed peas (1950).

	Ave. No. Leafhoppers per Leaf After			
	2 Days		*6 Days*	
Treatments	*No.*	*Percent Control*	*No.*	*Percent Control*
5% Heptachlor	5.3	9	6.9	14
5% Chlordane	2.0	66	4.0	50
2.5% Aldrin	5.7	2	5.1	36
5% Methoxychlor	0.8	86	2.0	75
5% TDE	2.1	64	3.1	61
5% DDT + 82% Sulphur	1.3	76	2.2	83
Untreated	5.8	—	8.0	—

Table 3. Insecticidal dusts for the control of the leafhopper, *Empoasca solana*, DeL., attacking blackeyed peas (1950).

	Ave. No. Leafhoppers per Leaf After			
	1 Day		*3 Days*	
Treatments	*No.*	*Percent Control*	*No.*	*Percent Control*
20% Toxaphene	0.7	77	0.0	100
10% Toxaphene	0.3	90	0.5	79
10% Toxaphene + 40% Sulphur	0.7	77	0.0	100
5% DDT + 82% Sulphur	0.6	80	0.4	83
2.5% Aldrin	1.9	37	1.8	25
1% Dieldrin	1.9	37	1.6	33
Untreated	3.0	—	2.4	—

of toxaphene were slightly more effective than the DDT-sulphur mixture. The data in Table 3 show that the addition of sulphur to the 10 percent toxaphene dust increased the effectiveness of the toxaphene dust. Dieldrin, used at a 1 percent concentration, failed to control this leafhopper.

Only two insecticides which gave good leafhopper control can be used on cantaloupes. Methoxychlor can be used safely on cantaloupes, while parathion dust can be applied safely only in absence of dew and when the application rate does not exceed 20 pounds of dust per acre.

Summary

A leafhopper, *Empoasca solána* DeL., was found in destructive numbers on southern peas. Good control was obtained with the following dusts: 5 per cent DDT; 5 percent DDT plus 82 percent sulphur; 5 percent methoxychlor; 5 percent TDE; 1 percent parathion; 1 percent EPN; 10 percent toxaphene; 20 percent toxaphene; and sulphur. Sulphur is a much slower killer than either DDT or parathion, requiring at least 5 days to reach maximum effectiveness. The use of sulphur as a diluent will increase the effectivness of DDT and toxaphene.

Aldrin, chlordane, heptachlor and lindane failed to control the bean leafhopper.

Control of Cabbage and Carrot Loopers

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The cabbage looper, *Trichoplusia ni* (Hubner), is the most destructive insect on cabbage. Wene (1954) reported that 20 percent toxaphene dust was more effective than 5 or 10 percent DDT dust. He also stated that 1 percent endrin failed to give commercial looper control. Since new formulations of endrin dust have been developed a series of experiences were conducted in order to compare the recently developed endrin formulations and perthane with toxaphene as a control for cabbage loopers.

A dark green looper, identified as *Rachiplusia ou* Gn. by Paul Riherd, was found feeding on carrot tops. Since this looper found on carrot is a different species to that of the cabbage looper it has been given the common name, "carrot looper" in this paper.

Cabbage Looper

Three experiments were conducted in order to test the efficiency of insecticidal dusts for the control of the cabbage looper. Each plot was 0.02 acre in size, with each treatment being replicated four times. The treatments, shown in Table 1, were applied with rotary hand dusters at approximately 20 pounds per acre. Three days after treatment applications 25 plants were selected at random in each plot and the surviving number of cabbage loopers counted. The first experiment was conducted in December 1953, while the other two were conducted in January 1954.

The data in Table 1 show that 20 percent toxaphene, 2 percent endrin, 5 percent perthane[1], and a mixture of 12 percent toxaphene with 8 percent DDT gave excellent looper control. The 2.5 percent dieldrin gave good control also. The 5 percent DDT dust was not as effective as the above mentioned dusts, whereas 40 percent cryolite gave good control in one test and failed in the other. The data in Table 1 show that a number of materials will give excellent looper control.

Carrot Looper

On December 7, 1953 a dark green looper was found feeding on carrot tops in the Pharr area. This looper was identified as *Rchiplusia ou* Gn. The type of damage resulting from the looper's feeding is illustrated in photograph 1. In a heavily infested carrot field handfulls of carrot tops were pulled at random and the amount of feeding damage estimated. A total of 120 carrot tops were examined with the following results: 10 percent of the carrot tops had 75 percent or more of the leaf area destroyed; 10 percent of the tops had 50 percent or more of the leaf area eaten; 56

[1]Bis (p-ethyl phenyl) dichloroethane, previously called Q-137.

Table 1. The effectiveness of various insecticidal dusts in controlling the cabbage looper.

Treatments	*Ave. No. Loopers per 25 Plant Sample*	*Percent Control*
Experiment No. 1		
2% Endrin	0	100
2.5% Dieldrin	1.0	90
20% Toxaphene	0.3	97
40% Cryolite	0.5	95
Untreated	10.1	—
Experiment No. 2		
12% Toxaphene + 8% DDT	0	100
2% Endrin	0	100
20% Toxaphene	0	100
5% DDT	0.8	82
40% Cryolite	4.0	36
Untreated	6.3	—
Experiment No. 3		
5% Perthane	0	100
2% Endrin	0	100
2.5% Dieldrin	0	100
20% Toxaphene	0	100
Untreated	7.3	—

percent of the tops had 25 percent of the leaf area destroyed; while only 24 percent of the tops showed little or no carrot looper feeding. Carrot looper infestations were found only in fields that were within two to three weeks of harvest. In order to pupate, mature larvae would fold the terminal leaflets of a carrot and form a cocoon. A number of Dipterous parasites were reared from these cocoons.

A low volume sprayer, applying 20 gallons per acre, was used in applying the insecticide treatments shown in Table 2. Each plot was approximately an acre in size with each treatment being replicated two times. Two days after treatment applications ten 4-foot samples of a carrot row was examined for the number of surviving carrot loopers. The data in Table 2 show that the carrot looper can be controlled with sprays of toxaphene at 3 pounds per acre and endrin at 0.3 pound per acre.

Photograph 1. *Carrot tops on left were eaten by the carrot looper.*

Table 2. The effectiveness of insecticidal sprays in controlling the carrot looper.

Treatments	*Ave. No. Carrot Loopers per 4-foot Row Sample*	*Percent Control*
Experiment No. 1		
0.2 lb. Endrin	1.5	59
3.0 lbs. Toxaphene	0.7	81
Untreated	3.7	—
Experiment No. 2		
0.3 lb. Endrin	0.2	90
3.0 lbs. Toxaphene	0.1	95
Untreated	2.0	—

Summary

Cabbage looper control was obtained with the following insecticidal dusts: 2 percent endrin; 2.5 percent dieldrin; 20 percent toxaphene; a mixture of 12 percent toxaphene with 8 percent DDT; and 5 percent perthane. A 5 percent DDT dust was not as effective as the toxaphene or endrin dust. A dust containing 40 percent cryolite failed to give effective looper control.

Control of the carrot looper was obtained with 0.3 pound endrin per acre and 3 pounds of toxaphene per acre applied as sprays.

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Response of the Yield of Turnip Greens to Various Fertilizer Treatments

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In the Lower Rio Grande Valley turnip greens are grown extensively for canning purposes, and to a lesser extent for the fresh market. The cash income from such a crop is generally low, but turnip greens can be grown in a short period. An experiment was designed to determine if yields could be profitably increased through the use of various fertilizers. The experiment was also designed to determine whether various fertilizer treatments would influence the abundance of the turnip aphid, *Rhopalosiphum pseudobrassicae* (Davis), a major pest of turnips. Unfortunately the expected aphid infestation did not develop.

Material and Methods

Fertilizer treatments shown in Table 1, were applied by hand in bands at a depth of three inches in the center of the 38 inch beds on December 8, 1953. The plots were 25 feet long. Each treatment was replicated 4 times. On December 16, the turnip variety, Purple Top Milan, was planted at the rate of 2 pounds per acre in a double row, space 12 inches apart, on each bed. The plots were irrigated the following day,

Table 1. Effect of various fertilizer treatments on the yield of turnip greens.

Lbs. fertilizer per acre		*Tons per Acre*			
Nitrogen	*P_2O5*	*1st cutting*	*2nd cutting*	*Total*	*Tons increase*
0	0	4.09	2.70	8.79	
0	100	4.54	4.88	9.42	0.63
0	200	4.12	4.65	8.77	0.02
100	0	4.63	5.32	9.95	1.16
100	100	5.06	5.12	10.18	1.39
100	200	5.28	5.52	10.80	2.01
200	0	5.09	5.63	10.72	1.93
200	100	4.21	5.37	9.58	1.21
200	200	4.58	5.51	10.09	1.30

		Date	*Nitrogen*	*P_2O_5*
L. S. D.	0.1% Level	0.3038	0.6397	No Significance
	0.5% Level	0.2205	0.4643	No Significance

and again on January 15, 1954. On February 10, 1954, the turnip greens or tops were cut at the ground level and the yield of each plot determined by weights. The plots were irrigated the following day, and again on February 28, 1954. Yield records were again taken on March 9, 1954.

Discussion

The yield of turnip greens, expressed in tons per acre, for the various fertilizer treatments is shown in Table 1. The data, when analyzed statistically, show that applications of phosphoric acid did not increase the yield of turnip greens. Applications of nitrogen at both levels of 100 and 200 pounds per acre gave significant increases of 1.16 to 1.93 tons per acre, although there was no difference in response at these two rates.

Summary

Yields of turnip greens were increased between 1.16 to 2.01 tons per acre with applications of 100 and 200 pounds of nitrogen in the fertilizer treatments. Applications of phosphoric acid to the fertilizer mixture did not increase the amount of turnip greens harvested.

At the low prices paid for turnip greens during the 1954 harvest season, the increased yields obtained by the application of nitrogen were too small to justify the use of fertilizer.

Some Effects of Maleic Hydrazide as a Preharvest Foliage Spray on the Storage Behavior of Onions

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Since the Texas onion grower usually markets his crop soon after harvest, he is not directly concerned with a sprouting loss in this commodity. However, recent attempts to prolong the relatively short marketing season of Texas onions by the use of cold storage facilities immediately confronts the local grower, shipper and cold storage operator with the prospect of serious losses from sprouting of his stored onion bulbs.

Some realization of the extent of these losses can be obtained by studying those experienced by northern onion growers. Depending on variety, location and weather conditions, commercial onion producers in the North must expect a 5 to 50 percent loss in the storage of their harvested crop (Foskett and Peterson, 1950; Gaylord, 1927; and Magruder *et al*, 1941). Sprouting and rooting account for approximately 85 percent of this loss according to a survey by Gaylord (1927).

Recent work by Wilson (1953) in the Horticulture Department of the Texas Agricultural Experiment Station indicates that approximately 55 percent of the variety Excel sprouted under simulated retail store conditions after three months storage at 35°F, while 84 percent of the bulbs of this variety sprouted after four months and 100 percent sprouted after five months storage at this same temperature.

Although Wilson reported the variety Granex to be a better storage onion than Excel, still the Granex variety sprouted approximately 81 per cent under retail store conditions after five months storage at 35°F.

While both sprouting and rooting of onions can be kept at a minimum by holding the bulbs at a temperature of 32°F and a relative humidity of 64 percent, (Wright *et al*, 1935), this is an expensive practice and as indicated above, the onions start to sprout as soon as they are moved from cold storage into ordinary trade channels.

The problem of retarding roots and sprouts on onion bulbs would be greatly simplified if some growth inhibiting substance could be sprayed on the foliage while the plants were still growing in the field.

Utilizing this possibility, Paterson and Wittwer (1953), Wittwer and Sharma (1950) and Wittwer and Paterson (1951) have shown that the chemical maleic hydrazide, when used at the rate of 2 or 5 pounds of the actual chemical per acre as a foliage spray ten days to two weeks before harvest, resulted in nearly complete elimination of sprouting of onions in storage for all major onion varieties grown in Michigan.

As the effectiveness of the chemical is dependent upon its absorption

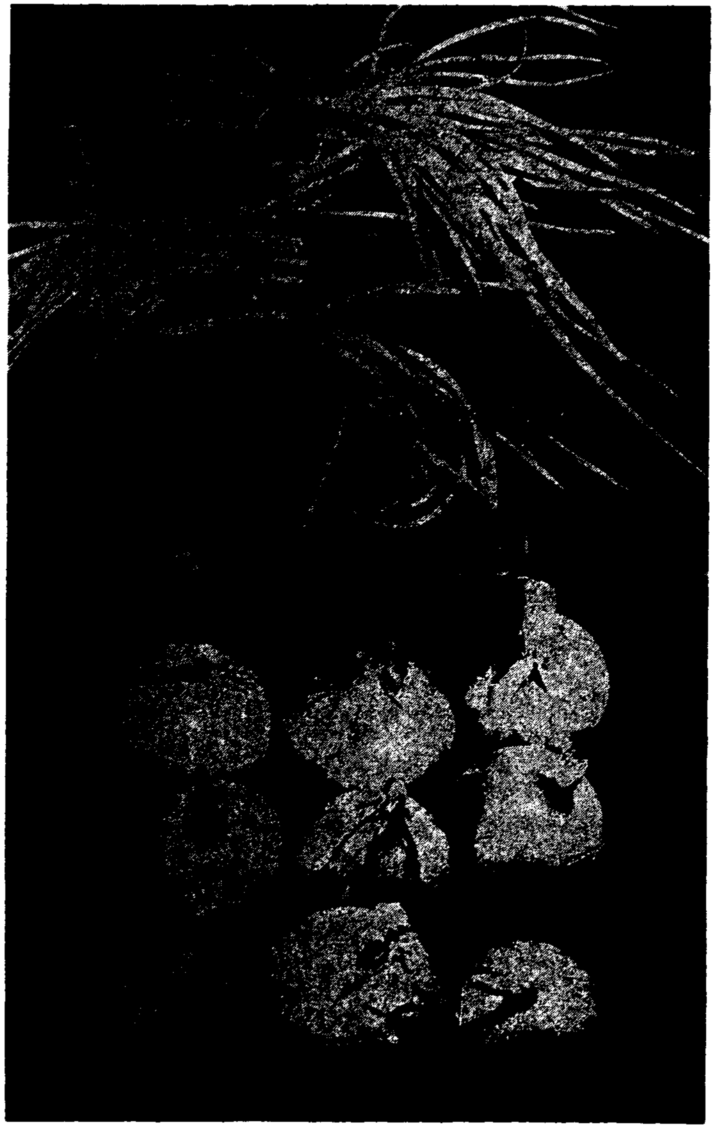

Figure 1. **The effects of maleic hydrazide in controlling sprout and root growth of Y-40 onions following 4 1/2 months in common storage and 3 months at 55 degrees F. Above, non-treated controls; below bulbs harvested from plants sprayed with 2500 ppm of maleic hydrazide.**

by the leaves and translocation to the bulb, the onion leaves must be alive and green at the time of spray application. Usually the best time for the application of maleic hydrazide occurs just as the tops of the onion plant start to fall over one to two weeks before harvest.

If the maleic hydrazide spray is applied before the onions mature, hollow or puffy bulbs result which are unmarketable and keep very poorly in storage.

As shown in figure 1, maleic hydrazide prevents the rooting as well as the sprouting of stored onion bulbs. This chemical has been shown to have no apparent effect on the flavor, color, odor or general appearance of onions (Wittwer and Paterson, 1951). Also, maleic hydrazide has neither altered the percent breakdown nor weight loss other than from sprouting of treated bulbs (Paterson and Wittwer, 1953).

Isenberg *et al* (1951) have shown that maleic hydrazide affects respiration of the onion plant through the partial inactivation or inhibition of one or more of the dehydrogenases.

Wittwer observed an increase of approximately 10 percent in the sucrose content of stored sugar beets treated before harvest with foliar sprays of maleic hydrazide in comparison with untreated controls (Wittwer and Hansen, 1951), while approximately six percent more total sugars were lost by untreated than by maleic hydrazide treated Y-40 onion bulbs held in common storage during the cold winter months in Michigan (Paterson and Wittwer, 1953).

Since respiration proceeds more rapidly at high than at low temperatures, the relatively high temperatures encountered in the Rio Grande Valley at the time of onion harvest, must result in a very real loss of sugar due to accelerated respiration in the onion crop of this area. Therefore, the slowing down or inhibition of respiration by the use of maleic hydrazide could result in an increase in sugar content of treated onions under these conditions.

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Damping-Off Control in Peppers

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One of the serious hazards of pepper production in the Lower Rio Grande Valley is damping-off. Emergence of peppers planted in July and August is usually satisfactory, although, preemergence losses may be high at times. Heavy post-emergence losses occur and entire fields are frequently plowed up because of low stand survival. These losses are caused by or associated with damping-off fungi such as *Pythium* and *Rhizoctonia,* excessive soil moisture, high humidity, high temperatures and a high soil salt content. Following the loss of a stand of peppers to post-emergence damping-off on the Station Farm a damping-off control test was set up. The results are reported herein.

Pepper seed, Rio Wonder variety, treated with Dithane Z-78, Arasan or phenyl mercuric salicylate, including control, were planted August 17, 1954, in 12 flats. Four rows, one row of each treatment and 100 seeds to a row, were planted to a flat. Six of the flats were filled with moist or pre-irrigated soil from beds in which damping-off had occurred. The other six flats were filled with dry soil from the non-planted area of the same field and within a few feet of the moist soil. Essentially the two soils represent a pre-irrigated or summer-cultivated soil which had been moist for three weeks or longer before planting and the dry soil a condition comparable to a summer-fallowed soil.

Emergence was nearly completed by August 28, 9 days after planting, and seedling damping-off losses had begun to occur. In an attempt to control this type of losses a drench of Dithane Z-78, 2 pounds per 100 gallons of water, was applied August 28, 30 and September 2 to six of the flats, as a split plot treatment. At the time of the first application the seedling mortality was comparable in the drenched and non-drenched flats.

Results

Seedling emergence 31 days after planting, was very good for all the treatments including the check. It ranged from 83.8 percent for non-treated seed to 88.5 percent for seed treated with phenyl mercuric salicylate. See Table 1. Even though the fungicidal seed treatments increased emergence, the increase was not sufficient to be considered of any great importance. Under less favorable conditions for emergence fungicidal seed treatments would be expected to give more striking benefits. On the other hand, the seed treatments tended to give some protection to the young seedlings against seedling damping-off. The seedling loss was 1/3 higher for non-treated seed than for seed treated with either Dithane Z-78 or Arasan and 1/5 higher than for phenyl mercuric salicylate treated seed.

Seedling mortality was effectively reduced by the 3 drenches of Dithane Z-78. The average seedling loss was twice as great for the non-drenched pepper plants as for the ones drenched with Dithane Z-78. The beneficial effect of the drench was evident in all of the seed treatments and the two soil classes. It should be pointed out that the dosage rate may have been a little high or that the number of applications excessive, since there was a tendency for the tips of the leaves to be slightly yellowed. No definite stunting was observed.

The most interesting and perhaps the most practical of the results obtained in the test was the effect of pre-irrigated or cultivated soil on reducing seedling losses. The results with seed treatments and seedling drenching were not surprising since these are common recommended practices and results may be variable. The seedling mortality was slightly more than 50 percent greater in the flats filled with the dry summer-fallowed soil than for the pre-irrigated or summer-cropped soil. This difference between the two soils was a consistent one. The cause for the lower damping-off losses in the pre-irrigated soil is believed to be attributable to biotic activity. A partial soil sterilization apparently takes place durng the hot dry summer period when the soil is allowed to lie fallow between spring and fall crops. When such a summer fallowed soil is irrigated there occurs an intensive growth activity on the part of the surviving soil organisms. Competition being low at first, the fast growing pathogenic fungi, such as *Pythium*, rapidly spreads through the soil and become a threat to any susceptible plant. After 3 or 4 weeks under favorable soil conditions the biotic activity of the slower growing soil organisms increases and a condition develops that retards and tends to inhibit the growth and actually reduces quantitatively the damping-off organisms, which in turn reduces damping-off losses. Conditions similar to this have been observed in the use of sterilized soil in green-house tests where losses are higher in sterilized soil infested with damping-off organisms than in non-sterilized soil similarly treated.

Table 1. Effect of seed, soil and seedling treatments on emergence and mortality of peppers.

Seed Treatments	*Emergence*[1]		*Mortality*[2]
	Number	*Percent*	*Percent*
Dithane Z-78	1034	86.1	33.5
Arasan	1061	88.4	33.4
Phenyl mercuric salicylate	1062	88.5	37.5
Check	1006	83.8	45.5
Total	4163	86.3	37.4
Seedling Drench[3]			
Dithane Z-78	2127	88.6	24.3
Check	2036	84.8	51.0
Soil[4]			
Dry, fallow	2055	85.6	45.7
Moist, 14-21 days	2108	87.8	29.7

[1]Emerged plants 31 days after planting, based on number of seed sown.

[2]Mortality, seedlings killed by damping-off, based on number of emerged plants, 31 days after seeding.

[3]Emerged plants were drenched with Dithane Z-78 on August 28, August 30 and September 2. Dosage: 2 pounds Dithane Z-78 to 100 gallons water or 1 g. per sq. ft. of Dithane Z-78.

[4]The dry soil represents a summer fallow condition. The moist soil came from beds in which serious losses from damping-off had occurred.

Summary

Fungicidal seed treatment of pepper seed with Arasan, Dithane Z-78 and phenyl mercuric salicylate increased seedling emergence slightly over non-treated seed, 5 percent and less.

Three applications of Dithane Z-78 as a drench were effective in reducing pepper seedling losses from 51.0 percent to 24.7 percent.

Seedling losses were 50 percent higher in flats filled with dry summer-fallowed soil than in soil that had been moist, pre-irrigated, for 2 to 3 weeks before planting.

The results of the test suggest that pepper seedling losses may be minimized in the Lower Rio Grande Valley by planting fungicidal treated pepper seed in soil that has been pre-irrigated and kept moist for 3 to 4 weeks prior to planting. Also, seedling losses can further be minimized by applying a fungicidal drench such as Dithane Z-78.

Red Grapefruit Strains as Symptomless Carriers of the Causal Agent of Cachexia, a Bud-Transmitted Disease[1]

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ART SHULL, *Rio Farms, Inc., Monte Alto*

Cachexia, a bud-transmitted disease, was first observed and described on Orlando tangelo trees in Florida. No insect vectors of the disease have been reported (Childs, 1950 and 1952). Characteristic and diagnostic symptoms of the disease are pitting of the stem and discoloration of the inner bark caused by gum impregnation. These symptoms have been observed on Orlando tangelo rootstock and certain other tangelo, mandarin and tangor rootstocks in Florida (Childs, 1951) and Texas (Olson, 1952, 1954).

Since in Texas cachexia occurred on susceptible rootstocks with Red Blush or Shary Red grapefruit tops, it seemed desirable to determine whether other strains of red grapefruit were free of the causal agent. A cachexia-free source of budwood would eliminate this disease as a hazard in future rootstock tests.

This article reports the present of the casual agent of cachexia in individual trees of 7 different commercial strains of red grapefruit and its absence in previously unbudded Red Blush grapefruit seedlings.

Materials and Methods

Orlando tangelo trees were grown on sour orange rootstock budded in late 1951 and early 1952. The Orlando tangelo buds were from a tree registered by the Texas Department of Agriculture as psorosis-free. This tree had shown no cachexia symptoms during 15 years of growth, and, since cachexia symptoms appear before the eighth year, was considered cachexia-free. Orlando tangelo seedlings were also lined-out in 1951.

With the assistance of Carl Waibel, at that time Citrus Nursery Inspector of the Texas Department of Agriculture, grapefruit budwood was collected from single trees of 7 strains of red grapefruit listed in table 1. The trees selected were among the first propagated in the Lower Rio Grande Valley from the bud sport from which each strain arose. Five of

[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 Agricultural Marketing Act (R.M.A. Title II). Rio Farms, Inc., Monte Alto, Texas, also cooperates in these studies.

the 7 trees had been registered as psorosis-free. The trees of Riddle Red Gold and the original Red Blush were considered psorosis-free but were not registered. The Red Blush budwood came from the original sport tree.

Budwood was collected at the same time from Red Blush grapefruit trees in a 4-year-old rootstock test planting at Weslaco; these trees had cachexia symptoms on rootstocks of Minneola and Thornton tangelos and Clementine tangerine. Grapefruit budwood was also taken from the Red Blush tops of trees on Rangpur lime rootstock; the rootstock showed gumming, bark-splitting and bark-shelling (Olson, 1952). For comparison, budwood was collected from year-old Red Blush seedlings that had never been grafted and hence were presumably free of bud-transmitted diseases.

Grapefruit buds from each source were inserted in seedlings or in psorosis-free budlings of Orlando tangelo in July, 1952, and no sprouts were permitted to develop from the bud. Thus, the tops of the test trees were Orlando tangelo, with a fragment of grapefruit tissue grafted to the trunk. The test trees were left in place in the nursery row, with approximately an 18-inch spacing between trees.

The test trees were examined for cachexia at intervals, starting in February, 1954. A bark patch, approximately 1/2 inch long and 1/8 inch wide, was removed from the Orlando tangelo trunk. Trees with the characteristic brown-stained inner bark and pitted wood were considered infected with cachexia.

Results

The first symptoms of cachexia were noted 20 months after bud inoculation. All 7 different commercial strains of red grapefruit yielded at least one positive test for cachexia (table 1), although not all test plants showed symptoms in 28 months. Orlando tangelo trees grafted with buds from year-old Red Blush seedlings have not developed cachexia symptoms, nor have unbudded Orlando tangelo trees shown symptoms. Cachexia symptoms developed in one instance where the inserted bud of Curry Red grapefruit had died within 19 days after budding. Symptoms occurred on both Orlando tangelo scions (on sour orange rootstock) and on seedlings. Both seemed equally suitable as disease indicators.

Discussion

The 7 red grapefruit strains included in these tests were the only ones propagated on a commercial scale in Texas in 1952. The results suggest that trees propagated from these strains probably carry the causal agent of cachexia. That the same disease-inducing agent is common to all the red grapefruit strains seems reasonable, since most of them originated as sport branches on trees of Pink Marsh grapefruit, which came to Texas from a single nursery in Florida. The occurrence of the causal agent of cachexia in the progeny of sport branches also suggests that the disease agent might also be present generally in the Pink Marsh and possibly in other grapefruit varieties. In Florida, Childs (1952) found that grapefruit trees (variety not specified) topworked to Orlando tangelo showed cachexia in Orlando tangelo scions, although the Orlando tangelo buds came from cachexia-free trees.

For several reasons the presence of the causal agent of cachexia in psorosis-free red grapefruit trees has definite implications for the present program to register psorosis-free budwood sources in Texas. First, trees which are free of psorosis are not necessarily free of the cause of other bud-transmitted diseases such as cachexia. In addition to the examples from red grapefruit, one Valencia orange tree registered as psorosis-free and one non-registered Joppa orange in Texas carry the causal agent of

Table 1. Transmission of cachexia to Orlando tangelo trees by means of buds from red grapefruit trees.[1]

Controls and source of grapefruit budwood from various scion-rootstock combinations	*Orlando tangelo test plants in each treatment*	*Test plants developing cachexia*
Controls:	*Number*	*Number*
Unbudded Orlando tangelo trees	8	0
Red Blush seedlings (year-old)	3	0
Rootstock with cachexia symptoms:		
Red Blush on Minneola tangelo	2	1
Red Blush on Thornton taneglo	1	1
Red Blush on Clementine tangerine	2	1
Rootstock with bark shelling:		
Red Blush on Rangpur lime	3	2
Rootstock without cachexia symptoms:		
Red Blush on sour orange	1	1
Riddle Red Gold on sour orange	2	2
Curry Red Radiance on sour orange	1	1
Shary Red on sour orange	2	1
Ballard Red on sour orange	2	1
Fawcett Red on sour orange	2	2
Henninger Ruby Red on sour orange	2	1

[1]Period from bud insertion to reading of symptoms: 28 months.

cachexia, as shown by bud-transmission tests which Orlando tangelo test plants. While cachexia symptoms have not been noted on grapefruit or orange trees on sour orange or Cleopatra mandarin rootstocks, it is possible that the causal agent of cachexia may cause a reduction of growth and fruit production of trees of these varieties. Second, if trees which are symptomless carriers of cachexia were to be excluded from registration, it seems probable that Texas nurserymen would not be able to register trees of the present commercial strains of red grapefruit. In Florida, buds from candidate trees are tested for cachexia (considered to be xyloporosis) on Orlando tangelo seedlings, which are inspected for symptoms of bark discoloration and stem pitting over a 4-year period. Under present regulations in Florida, Orlando tangelo test seedlings must not show symptoms of cachexia (xyloporosis) during the 4-year period of testing before the budwood source can be registered (Ayers, 1953). Third, it demonstrates the merit of Fawcett's recommendation (1948) that nucellar seedlings of each promising variety and strain be grown to obtain trees free of psorosis and other viruses.

For two reasons the occurrence of the causal agent of cachexia in commercial strains of red grapefruit also has implications for the rootstock studies now being conducted in Texas. First, many mandarin and mandarin-hybrid rootstocks are tolerant to saline soils and to tristeza, but 25 of these varieties have been found to be susceptible to cachexia (Olson, 1954). Unless budwood free of the causal agent of cachexia can be found or produced, many promising rootstocks appear unsuitable for red grapefruit. The most promising source of virus-free tops would appear to be nucellar trees that have never been budded with infected strains and varieties of citrus. Second, certain disorders limited to specific rootstocks may represent a different host reaction to the causal agent of cachexia. For example, the bark-shelling symptoms on Rangpur lime rootstock may be related to the presence of the causal agent of cachexia in the red grapefruit tops. Also, exocortis of *Poncirus trifoliata* rootstocks may be associated with cachexia, since buds from a Joppa orange tree dwarfed by exocortis caused cachexia in an Orlando tangelo test plant.

Summary

When psorosis-free red grapefruit buds were grafted on Orlando tangelo trees, phloem discoloration and stem-pitting symptoms of cachexia developed within 28 months in some Orlando tangelo test plants. Individual trees of 7 different commercial strains of red grapefruit yielded at least one positive test for cachexia. No symptoms occurred in test plants grafted with grapefruit buds from Red Blush seedlings, nor did they appear on unbudded Orlando tangelo scions. On the basis of this test, individual trees of 7 different strains of red grapefruit were shown to be symptomless carriers of the causal agent of cachexia, a bud-transmitted disorder.

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A Survey For Tristeza Virus In Texas Citrus

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During the early 1940's Texas citrus growers were greatly disturbed by reports of the killing of millions of citrus trees on sour orange rootstock by tristeza disease in South America and by the losses from "quick decline" of sweet orange on sour orange rootstock in California. Their concern is easily understood, since at that time 99 percent of Texas citrus trees were on sour orange rootstock. In 1946 Texas growers raised $20,000 to assist studies of tristeza in Argentina by Florida State Plant Board personnel.

In 1946 the U. S. Department of Agriculture began studies of tristeza disease in Brazil in cooperation with Brazilian investigators. In 1947 rootstock studies were started at Weslaco to test the adaptability to Texas conditions of rootstocks which proved tolerant to tristeza in Brazil.

The early studies established that tristeza, or "quick decline," was caused by a virus (Fawcett and Wallace, 1946), and was spread from tree to tree in South America by a species of black aphid, *Aphis citricidus* (Kirk), (Meneghini, 1946), which has not been found in the United States.

After the discovery of tristeza in Louisiana in 1950, the Texas Agricultural Experiment Station used funds supplied by the Texas Citrus Commission to build screenhouse facilities to be used in conjunction with field survey work to determine whether the Tristeza virus was present in Texas. The survey work was intensified after the discovery of tristeza in Florida (Grant and Schneider, 1953). Growers, nurserymen, state and federal inspectors, and citrus specialists at the Valley Experiment Station cooperated in the survey. Assistance was also given by Mortimer C. Cohen, of the Florida State Plant Board, and T. J. Grant, of the U. S. Department of Agriculture.

This report summarizes the results of the survey for Tristeza virus in Texas during 1953-54. Some of this information has already been published (Olson and McDonald, 1954; Olson and Sleeth, 1954).

Materials and Methods

Groves in every section of the Lower Rio Grande Valley, as well as a few plantings in the Winter Garden area near Carrizo Springs, were inspected. Trees suspected of carrying Tristeza virus were classified in one or more of the following groups.

[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 Agricultural Marketing Act (R.M.A. Title II).

a. Trees of varieties that had a history of poor performance on sour orange rootstock. Examples are Meyer lemon, satsumas and kumquat.

b. Trees of varieties growing on rootstock other than sour orange and introduced recently from citrus areas outside Texas. It was known that many citrus varieties on tolerant rootstocks could carry Tristeza virus without showing symptoms.

c. Citrus grove trees on sour orange rootstock that showed thin foliage and branch dieback with no obvious cause for the decline.

Budwood from each suspect tree was grafted to Mexican lime seedlings grown in gallon cans of soil in a screenhouse. The leaves on new growth on the lime plants were observed for a 3- to 6-month period. Grafted plants with young leaves showing a vein clearing that tended to persist until the leaves were mature and with pitting of the lime stem under the bark were considered to have tristeza (Costa, Grant and Moreira, 1950; Grant and Schneider, 1953; Hughes and Lister, 1949; McClean, 1950; Wallace and Drake, 1951).

Results

Tristeza Virus in Three Groups of Suspect Trees

Group a. Varieties with a history of poor performance on sour orange rootstock.

Meyer lemon: Tristeza was first found in Texas on certain Meyer lemon trees (Olson and Sleeth, 1954). Infected Meyer lemon trees have been found near La Feria, McAllen, Mercedes, Santa Monica, Santa Rosa and Weslaco on 11 different properties. Infected trees were also located near Carrizo Springs and Beeville. Thirty-four of 174 suspect trees were found to carry Tristeza virus.

Satsuma varieties: Tests in the screenhouse for presence of Tristeza virus showed that 17 of 26 satsuma varieties grown near Winter Haven carried Tristeza virus; Owari and Silverhill satsumas found free of the virus grew well on sour orange rootstock (Olson and McDonald, 1954). Additional infected trees of other satsuma varieties found at Winter Haven included the Hayashi, Moriya, Takegami, Tsuda and Yamada. A tree of Kawano Wase which grew well on sour orange rootstock was found free of Tristeza virus. One Silverhill satsuma had made weak growth on Cunningham citrange rootstock and had declined. This tree was found to be carrying Tristeza virus, but other trees of the same variety on sour orange rootstock were found to be free of the virus. The infected Silverhill tree was presumably infected by insects, by bud-transmission, or by root graft with adjacent infected trees. Two other satsuma trees, one near Beeville and one near La Feria, were tested but gave no indication of Tristeza virus.

Kumquat: Six kumquat trees showing decline or incompatibility on sour orange rootstock were found to be free of Tristeza virus. Those test-

ed were of the Nippon and Nagami varieties.

Group b. Introduced citrus varieties on various rootstocks.

The variety collection at the Valley Experiment Station at Weslaco included introductions from Florida, California and foreign countries. Many of the introduced varieties grew well on sour orange rootstock; others showed variable growth on assorted rootstocks: sweet orange, grapefruit, mandarin, rough lemon and others.

By use of the lime test, it was established that 14 trees of 8 varieties introduced from foreign countries carried Tristeza virus (Table 1). Except for the Meyer lemons, these infected introductions were scattered in a single 3-acre planting. Another tree, a Thompson grapefruit on Rusk citrange rootstock and planted in 1931, also carried Tristeza virus. The tree from which the grapefruit buds came is free of the virus; so it seems probable that the Rusk rootstock was infected accidentally by Meyer lemon buds during early propagation studies at Weslaco (Friend, 1931).

A 25-year-old Calamondin tree on Cleopatra mandarin rootstock, introduced as a budded tree from Florida and planted on another property near Weslaco, carried Tristeza virus. Progeny of this Calamondin tree, budded on Cleopatra mandarin rootstock and planted on the Station about 1947, also carried Tristeza virus. Except for trees grown in screenhouses under insect-free conditions, all tristeza-infected trees on Station grounds have been destroyed to eliminate them as a virus source for spread of the disease.

Group c. Commercial trees on sour orange rootstock.

Twigs collected from 136 grapefruit trees and 114 orange trees showing decline on sour orange rootstock were budded to lime test plants. Only 2 of the 250 suspect trees were found to carry Tristeza virus. The 2 infected trees were 25-year-old Valencia orange, located in a commercial grove planted with trees from Florida. One tree showed thin foliage and some branch dieback (Fig. 1); none of these symptoms were present in the second tree. Since trees were missing adjacent to the infected trees, which were approximately the size of nearby healthy trees, it seems possible that the virus may have spread from infected trees which died before 1954.

Twigs were collected also from grapefruit, orange and tangerine trees in commercial plantings adjacent to Meyer lemon trees known to be carrying Tristeza virus. Of 53 twig samples taken from adjacent plantings and grafted to lime test plants, only one carried the virus. This infected tree was a 1-year-old Mexican lime on sour orange rootstock grown in a nursery row adjacent to infected Meyer lemons on the same rootstock. Insect transfer of the virus from infected Meyer lemon to Mexican lime seem probable in this instance.

Symptoms of Tristeza Disease in Mexican Limes

When lime plants in the screenhouse became infected by Tristeza

Table 1. Trees from introductions from foreign countries found carrying Tristeza virus, Texas, 1954.

Kind of citrus and variety introduced	*Source country and year of introduction to the United States*[1]	*Trees found infected with Tristeza virus in 1954*		
		Number	*Rootstock*	*Year planted*
Meyer lemon	China (1909)	5	Trifoliata	1924
Mandarin:				
Beauty of Glen Retreat	Australia (1893)	2	Mandarin	1942
Richards	New Zealand (1935)	1	Swatow	1940
Grapefruit:				
Merthyr	Australia via New Zealand (1939)[2]	1	Rough lemon	1940
Wheeney	Australia via New Zealand (1939)[2]	1	Grapefruit	1942
Miscellaneous oranges:				
Daidai	Japan via New Zealand (1936)[2]	1	Grapefruit	1940
Yuzu	Japan via New Zealand (1936)[2]	1	Sour orange	1942
Mediterranean Blood[3]	India (date unknown)	1	Mandarin	1942
Mediterranean Blood[3]	India (date unknown)	1	Mandarin	1948[4]

[1]Information received by letters from Dr. W. E. Whitehouse, Plant Introduction Section, U. S. Department of Agriculture, Beltsville, Maryland.

[2]Introductions via New Zealand came from trees in the variety collection of one man, an ardent collector of plants from all parts of the world.

[3]Tristeza identified by Dr. Bailey Sleeth, who used lime plants to indicate presence of the causal virus.

[4]Propagated from the tree of the same variety planted in 1942.

Figure 1. This tree, a 25-year-old Valencia on sour orange rootstock, showed thin foliage, branch dieback and "honeycombing" of the sour orange bark below the bud union. This tree is infected with Tristeza virus. It is similar in appearance to many tristeza-free trees injured by cold, high water table, drouth or neglect. Picture by Bailey Sleeth.

virus, the leaf veins were clear and translucent when viewed by transmitted light. The vein clearing sometimes produced a vein flecking, or the cleared veins sometimes formed a network covering the whole leaf. These symptoms were apparent in the young mature leaf, but sometimes faded or disappeared as the leaf became older. A condition called "corky vein" on the Gold Coast (Hughes and Lister, 1953), consisting of a corky enation of the veins on the upper side of the leaf, also occurred in Texas. The symptoms on test plants in Texas were similar to those reported from New South Wales (Fraser, 1952) and South Africa (McClean, 1950). The "corky vein" symptom was noted on 2 dwarfed lime plants 3 months after tristeza symptoms had been noted. Both Mexican lime plants had been inoculated by buds from one source, Sueoka satsuma. The "corky vein" symptoms apparently developed on the cleared areas of the lime leaf. Since "corky vein" can occur on plants with boron or heavy metal deficiencies, symptoms may be caused by Tristeza virus in conjunction with either nutritional disturbances or another virus. With few exceptions, lime plants have grown vigorously after infection, suggesting that the infected trees so far studied were invaded by a mild rather than a severe strain of the virus.

Anatomical Disturbances Caused by Tristeza Virus

In Florida, Cohen and Knorr (1954b) noted that 90 percent of the trees injured by tristeza had minute holes in the inner surface of the bark of the sour orange rootstock just below the bud union. This symptom they named "honeycombing." Honeycombing was noted on the sour orange rootstock of infected one-year-old Meyer lemon trees and one infected 25-year-old Valencia orange tree in Texas. Mortimer Cohen, of the Florida State Plant Board, examined a bark patch from across the bud union of the infected Valencia orange tree and considered its anatomy to be positive indication of the presence of tristeza.

Stem pitting (McClean, 1950), characterized by pits or depressions in the wood, was not noted on the grapefruit rootstocks of the 2 infected trees listed in Table 1. Stem pitting was pronounced on a 25-year-old apparently healthy Calamondin tree that carried Tristeza virus, but not on its Cleopatra mandarin rootstock (Fig. 2). However, it is not known that tristeza-free Calamondin trees on Cleopatra mandarin rootstock are free of stem-pitting disorders. Cohen and Knorr (1954a) reported that stem pitting in the limequat apparently did not alter the healthy aspect of the infected trees. Both Calamondin and limequat are kumquat hybrids, which have shown a bud-union disorder when used as rootstocks for Red Blush grapefruit trees free of Tristeza virus but carrying the causal agent of cachexia disease (Olson, 1954).

Discussion

Tristeza Virus Introduced Repeatedly Into Texas

Present evidence indicates that there have been several different introductions of Tristeza virus into Texas. The Meyer lemon from China,

Figure 2. Stem pitting above the bud union of an apparently healthy Calamondin tree that carried Tristeza virus; no stem pitting occurred on the Cleopatra mandarin rootstock. The bud union is approximately level with the 1¾ inch mark on the ruler. Picture by Bailey Sleeth.

satsuma varieties from Japan, the Beauty of Glen Retreat mandarin from Australia, varieties introduced via New Zealand (Table 1), and Valencia orange and Calamondin from Florida represent different introductions by private and public sources. Tristeza is presumed to be present in China (Swingle, 1945) and is known to occur in Australia and New Zealand (McAlpin *et al*, 1948). It is perhaps significant that in Australia and New Zealand the mandarins have been grown on tristeza-tolerant mandarin rootstock, while sour orange and rough lemon rootstock are used for other citrus (Traub and Robinson, 1937). Satsumas in Japan are generally grown on trifoliate-orange rootstock, also tolerant to Tristeza virus. While tristeza-free satsumas grow well on sour orange rootstock, Tristeza virus is now known to be present in many satsuma varieties that were introduced from Japan. The incompatability between satsuma introductions and sour orange rootstock has been known in the United States since 1896 (Olson and McDonald, 1954). During the great satsuma boom in the Gulf States from 1908-1911, about one million budded trees were brought in from Japan (Webber, 1943). At the time the satsumas and other citrus varieties were introduced (prior to 1942), the virus nature of many citrus diseases, including tristeza, was not understood and precise detection techniques were not available. Citrus introduced into the United States now must be budded to lime test plants in quarantine screenhouses, and infected material is detected before distribution to citrus-growing areas (Whitehouse, 1954).

The Tristeza Threat to the Texas Industry

While Tristeza virus has been repeatedly introduced and infected Meyer lemon trees have been planted throughout south Texas, there is no present indication of economic losses from tristeza in commercial plantings of oranges and grapefruit on sour orange rootstock. Tristeza is a major hazard in areas where aphids easily transmit the disease from infected to healthy trees. Present indications are that insect transfer of the virus is not common in Texas, although it may occur to a limited extent. An epidemic such as occurred in South America has not developed in Texas citrus. The rapid spread of tristeza in South America was due to *Aphis citricidus* (Kirk), an aphid unknown in the United States. The aphids present in Texas include *A. gossypii* (Glover) and *A. spiraecola* (Patch), which in Florida are relatively inefficient vectors (Norman and Grant, 1954).

However, tristeza is still a hazard, since the causal virus is here and a majority of the citrus trees in Texas are still grown on sour orange rootstock. At present the most serious possibilities appear to be these: (a) the introduction into Texas of an efficient vector such as *A. citricidus,* (b) the introduction of a virus strain easily transmitted by aphids already here, and (c) development of favorable circumstances, such as a build-up of aphid population, for spread of present strains by insects already in Texas.

The most encouraging aspect of the present situation is that of 136 grapefruit trees on sour orange rootstock in a state of decline, not one

has shown tristeza symptoms when grafted to lime test plants in Texas. In Brazil, trees with grapefruit tops were less susceptible to infection by insects than were oranges and mandarins (Costa, Moreira and Grant, 1954).

Summary

With lime seedlings as indicator plants, a survey to detect Tristeza virus was conducted in South Texas. Infected citrus trees were located in the Lower Rio Grande Valley and in the Winter Garden district near Carrizo Springs. Infected trees were found in two varieties, Meyer lemon and satsuma, with a history of poor performance on sour orange rootstock. Other infected trees were introductions from other citrus areas. Two infected trees of Valencia on sour orange rootstock, and one infected Mexican lime tree on sour orange rootstock were located; insect transmission of the virus in these three cases and in one example of infected satsuma may have occurred.

Two lime seedlings grafted with Sueoka satsuma showed leaf symptoms similar to a "corky vein" symptom of tristeza in the Gold Coast; limes infected by buds from other tristeza-infected trees showed symptoms of a mild strain of tristeza.

Stem pitting was severe on the Calamondin top, but was absent on the Cleopatra mandarin rootstock of one infected tree.

Tristeza virus, while present in Texas, is not a cause of tree decline in commercial plantings at present, but is still a potential threat to millions of trees on sour orange rootstock especially if an efficient insect vector should be found or introduced into Texas.

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Soil Sterilization

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Growers and horticulturists have long sought more effective and less cumbersome means of protecting plants from damage by soil-borne pests. While much progress has been made in the selection of resistant varieties of field crops, and while the modern-chemical age has given us new and better compounds for disease and insect control generally, the practical grower knows only too well that many of his disease problems are yet to be solved. Soil sterilization, or disinfection, is one of these perplexing problems.

Technically speaking, soil sterilization is almost an impossibility, and, fortunately, it is neither necessary or desirable. Soil that has been steamed to the point of "near-sterilization" will not support normal plant growth until a favorable flora of soil microorganisms have re-established themselves. For optimum plant growth, a soil must be in balance microbiologically and, of course, there must be no plant root pests present. Therefore, if we can treat a soil in such manner that only the plant pests are removed, we will have accomplished our best objective with the least harm done.

Fortunately, many of the beneficial species of the flora are more resistant to heat and chemical action than are the plant pathogens. The latter are dependent for the most part upon the presence of a suitable host. This means that a mild chemical treatment or a mild heat treatment of the soil, resulting in partial sterilization (pasteurization) may be practical. Our ultimate purpose in perfecting soil treatments is to control undesirable species of all sorts that interfere with the crop.

One of the earliest methods of soil pasteurization was the use of heat either as steam or as dry heat. Tobacco seed beds even now are customarily treated for weeds and disease control by burning brush, limbs, and wood on the site. If a small potato buried in the soil at a depth of six inches is baked, then the treatment is considered to be a practical success. But the labor and quantity of fuel required is a serious limiting factor. In certain areas of the country, steam is used with considerable success. This process, however, requires a high pressure boiler and much equipment seldom found in Florida or outside of large greenhouse installations.

One of the first chemicals to be tried as a soil sterilant was carbon disulfide, a moderately effective fungicide and nematocide. The large quantities required together with its explosive nature has prevented its success as a soil disinfectant, particularly since better chemicals are now available.

Similarly, formaldehyde has enjoyed some use as a soil disinfectant and it is still used today in certain areas.

Very recently a new chemical became available to nurserymen for the control of soil-borne pests. This material, chlorobromopropene (CBP for short) is effective against most soil fungi, nematodes, and weed seeds. It is a heavy liquid containing an emulsifier so that it may be washed into the seed beds or soil to be treated; no fumigation covers or mechanical injectors need be used. This new compound may be applied with a sprinkling can, a hose-watering device, or by means of a small pump using a dosage rate of 2 or 3 gallons per 100 square yards of surface to be treated. For best results, the material should be applied so that 100 gallons of water is used to distribute the 2 or 3 gallons of chlorobromopropene over the entire 10 square-yard area. An additional 100 gallons of clear water must follow the treatment to wash the chemical into the soil. The use of a small motor-driven centrifugal pump which is designed so that 2 or 3 gallons of chlorobromopropene is put through a plastic garden hose with 100 gallons of water. After application of the chemical, an additional 100 gallons of water is pumped on to the treated area. Where city water pressure is available, a simple metering device costing about three dollars is available for the same work as the motor-driven pump. A typical example of this type of treatment on celery is the large clear white roots of the treated plants as compared to the small dark diseased roots of the untreated check plants (Florida results).

Chlorobromopropene is now available in limited supply for the control of soil-borne fungi, nematodes and weed seeds, where small quantities of soil or compost are used for potting and where a water drench is practical for the control of damping-off fungi.

Formaldehyde is not an effective nematocide except at very high dosages. The usual rate of application for control of damping-off is 1/2 to one gallon of a 1 to 50 solution of commercial formalin to each square foot of soil surface.

Urea and calcium cyanamide, two nitrogenous fertilizer materials, when mixed with the soil release ammonia which is destructive to weed seeds, and soil borne pests. These materials must be thoroughly mixed with the soil 60 to 90 days in advance of seeding to permit the escape of the ammonia vapor. At present, urea and calcium cyanamide are being used to some extent in tobacco seed beds. One pound of urea and 1/2 pound of calcium cyanamide per square yard of seed bed is the usual rate of application for a crop such as tobacco.

Chloropicrin, a product of gas warfare in World War I, is used successfully as a soil fumigant under certain conditions. This highly volatile liquid material is very irritating to the eyes and only a small quantity in a room renders it uninhabitable to man. The compound is therefore useful as a warning agent in methyl bromide. As a soil fumigant it is highly effective against weeds, nematodes and fungi at a dosage of 41 to 50 gallons per acre provided some sort of seal can be used to con-

fine the fumes to the site of action. Chloropicrin finds its best use in the fumigation of grain bins, warehouses, and similarly closed spaces. It is highly effective for the fumigation of potting soil in bins or boxes or where a cover may be placed over the soil to be treated.

Ethylene dibromide is one of the more recent soil fumigants to come into general commercial use. The material is available in several concentrations, a common one being 40 percent by weight in a petroleum solvent such as naphtha. It may be injected into the soil either by tractor drawn application equipment or by hand, using a mechanical device holding about one quart of material. Ethylene dibromide is effective against nematodes, weed seeds, and certain soil insects, particularly wireworms. A concentration of between 10 and 20 gallons per acre appears to be the effective dosage range of the 40 percent material. Unfortunately, ethylene dibromide is not highly effective against soil fungi directly. There is, however, an indirect effect through the control of nematodes and soil insects which appear to assist root invasion by soil fungi. Where only the control of soil insects is the object, much better materials than the soil fumigants are available at less cost and less trouble. As little as three pounds of aldrin dust or five pounds of chlordane mixed either with the soil or with the fertilizer is a highly effective soil insecticide. Unfortunately, neither of these materials will control soil fungi or nematodes.

Methylbromide is now widely used among nurserymen in Florida for the pasteurization of seed bed soils and potting soils. This compound is a heavy liquid becoming a gas upon opening the container. Because it is extremely poisonous, a small quantity of chloropicrin or tear gas is included as a warning agent. The fumigant, being highly volatile is applied under a plastic cover with a special device for opening the container and for distribution of the toxicant. It is a very effective compound, being destructive to weed seeds, soil fungi, nematodes and insects, at dosage rates of between one and four pounds per 100 cubic feet of soil. The higher dosage is required for the complete destruction of such soil-borne pests as the more resistant weed seeds and the sclerotia of certain plant pathogenic fungi. Great care should always be exercised with methylbromide, because it is extremely poisonous and odorless unless the manufacturer has incorporated a warning agent.

A liquid mixture of dichloropropene and dichloropropane (D-D for short) is in very general use throughout California and the East Coast area for the control of nematodes under field conditions. This material is injected into the soil with tractor drawn equipment. A dosage rate of from 15 to 40 gallons of the material per acre is required for the control of plant parasitic nematodes. The higher rates are used on organic soils, while the lower rate is effective in the southeast on sandy soils.

Soil fumigation has become a very special subject of research by both industrial and public research agencies. It is, of course, not possible here to discuss the many details associated with the various chemicals and their application to specific crops and problems.

What Is Happening To Our Citrus Soils?

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In our preoccupation with the immediate problem of how to attain the highest possible production from soils and the development of diagnostic criteria and methods for determining nutritional status and fertilizer requirements, soil scientists have sometimes lost sight of what has always been a second great objective, namely, how to *maintain* soil productivity. In California we are becoming increasingly conscious of the maintenance aspect. This stems from a number of observations: (1) the slow decline of many of our older citrus orchards; (2) difficulties in replanting citrus orchards in old citrus lands; (3) decreasing permeability of water, and (4) the encroachment of urban and industrial development on to our best agricultural lands. All of these observations underscore the need to examine critically the impact of a wide range of management operations on soils.

Recognizing in a somewhat more limited way than at present the importance of this problem, we began some salinity (Kelly et al, 1949) and fertility trend investigations 20 years ago. Sample data from these experiments will be presented, together with examples of more recent findings, all for the purpose of illustrating some of the chemical, physical and biological changes occurring in soils under the influence of cultural operations.

Chemical Changes

The two systematic investigations referred to as having been started some time ago were: (1) a salinity trend study in which we wanted to determine both short and long term changes of salinity in a variety of soils under the influence of several kinds of irrigation water, cropping practices and climatic situations, and (2) a long time lysimeter trial to determine the trend not only of salinity but the directional change of individual chemical components. Supplementing this have been special studies to determine the phosphate, potash, nitrogen, organic matter and exchangeable base status of a variety of soils in citrus orchards.

Phosphorus

In an attempt to evaluate the phosphorus status of California citrus orchards, a detailed study was undertaken some years ago in which was compared the total acid soluble and water soluble phosphorus in citrus orchards and adjacent nonfertilized areas.

These data showed that in many of the older orchards where manure, and in many cases mixed fertilizers, had been consistently used, phos-

phorus had greatly increased, particularly in the upper foot of soil. The extent of phosphorus buildup in some of the more striking cases is shown by the data of table 1. A partial summary of this investigation was published (Chapman, 1934).

A more recent investigation of the phosphate situation in a group of 45 top producing orchards and 34 poor orchards showed that only about 20 per cent of the 79 orchards examined had less than 500 ppm. acid soluble PO_4, whereas 80 percent showed more than this amount in the 0-6″ layer (Harding, 1953) thus confirming that phosphorus has accumulated markedly in many California citrus orchards.

In our lysimeter experiment where a strict account of additions and removals has been maintained, it is shown that the annual net loss to the soil where a heavy crop of Sudan grass has been harvested annually amounts to a maximum of only 16 lbs. phosphorus per acre annually. Leaching losses are almost nil. Sample data are shown in table 2. With relatively small annual crop removals and little leaching loss, it is easy to understand why most citrus orchards show marked gains; manure, both for nitrogen and organic matter, has been regarded as an indispensable and important component of the fertilizer program and additionally many growers in the past have applied mixed fertilizers regularly.

As a result of these studies, the present phosphorus situation in California citrus orchards appears about as follows: in a very small group of orchards where the soil was initially low in this element and where a program of straight inorganic nitrogen has been applied without manures, phosphorus deficiency has developed (Aldrich and Hass, 1949; Aldrich and Coony, 1952; Embleton et al, 1952). We believe that less than 10 per cent of our citrus orchards fall in this category. The remaining 90 per cent, either because of initial ample supplies or consistent programs of manuring, have sufficient phosphate for the present and in many we are sure that excessive amounts have accumulated. Increasing evidence is at

Table 1. Phosphate Accumulations in California Citrus Orchards[1].

Age Orchard Years	*Treatment*	*Acid Soluble PO_4 ppm Dry Soil* 0-6″	6-12″
23	None	370	342
	Manure	966	706
35	None	282	282
	Manure + Compl.	1680	1680
45	None	22	24
	Manure + Compl.	1430	920

[1]From Bul. 571 Univ. Calif. 1934.

hand to indicate that these excessive accumulations of phosphate exert a detrimental effect in some soils.

There is clear evidence that on some soils excessive phosphate will bring on or accentuate zinc deficiency of citrus. West (1938) in Australia observed this, as did Reuther and Crawford (1946) in a California experiment with young grapefruit. In further field fertilizer experiments in California, Aldrich (unpublished observations) has recently noted increased zinc deficiency where heavy annual phosphate applications were made. In water culture work Chapman et al (1937) found that high phosphorus aggravated zinc deficiency. Hence, it is certain that on some soils (though not necessarily all) excessive phosphate will bring on or aggravate zinc deficiency of citrus.

There is also clear evidence that on some soils excessive phosphorus will decrease copper absorption and produce copper deficiency. Forsee and Bair (1945) noted this on Florida everglade peat soils and more recently Martin and Bingham (unpublished data) of our own laboratory working in pot cultures have been able to induce severe copper deficiency by phosphate applications on a number of representative soils.

There is also evidence that high phosphate decreases nitrogen availability in some manner and the authors believe, but have no positive proof at present, that on some soils it decreases magnesium and iron availability.

With regard to fruit quality we have evidence both in controlled cultures (Chapman and Royner, 1951) and in field experiments (Aldrich — unpublished observations) that excessive phosphorus decreases fruit size. Increased puffiness has been noted in some years both in water cultures (Chapman and Royner, 1951) and in field experiments, and rind breakdown due to water spot was increased one year in our high

Table 2. Phosphorus Balance During 15 Years of Cropping in a Lysimeter Experiment.

	lbs/acre/15 years Treatment		
	Straw + 200 lbs. N	*Vetch + 200 lbs. N*	*Mustard + 200 lbs. N*
Added in Irrig. water	‹ 1	‹ 1	‹ 1
Added in Straw	38	—	—
Removed by Crop[1]	246	244	226
Lost by Leaching	‹ 1	‹ 1	1
Balance	—188	—244	—227

[1]Annual crop of Sudan grass.

phosphorus water cultures (Chapman and Royner, 1951). We likewise are sure that there are important insect infestation relationships to phosphorus status of citrus, high phosphorus favoring some insects.

While more work is needed, we are convinced that use of phosphate containing fertilizers on citrus orchards should be carefully watched. In fact, we have about come to the conclusion that unless there is positive evidence of incipient phosphate deficiency (and this can now be fairly reliably indicated by leaf and soil analyses plus visual symptoms) that *no* phosphate fertilizer should be added to citrus orchards because of possible adverse effects on nutrient availability and quality.

Potassium

The situation with this element is somewhat though not quite analogous to that of phosphorus. Both our early and more recent surveys show that potassium has built up substantially in many orchards. In table 3, are data to show the extent to which potassium has accumulated in some citrus orchards where manure and complete mixed fertilizers have been consistently used.

In a recent investigation of a citrus orchard suffering severely from iron chlorosis and general decline, and where heavy applications of Imperial Valley steer manure had been made annually, substantial accumulations of potassium and to a lesser extent sodium were found to have occurred. The percentage saturation of the exchange complex with these two elements in the surface compared with subsurface horizons is shown in table 4. The alluvial sandy loam soil of this orchard is fairly uniform depthwise, and it may be safely assumed that at the outset 95 per cent of the total exchangeable bases consisted of calcium and magnesium. Through continued manuring Ca + Mg have now decreased to 71.3 per cent in the surface with potassium and sodium proportion-

Table 3. Potassium Accumulation in California Orchards[1]

Age Orchard	*Treatment*	*Repl. + H_2O Sol. Potassium*	
		0-6″	6-12″
		ppm.	*ppm.*
40	None	86	—
	Manure + Compl.	1023	1023
27	None	78	89
	Manure + Compl.	472	425
22	None	90	90
	Manure + Compl.	617	562

[1]Unpublished data from H. D. Chapman files.

ately increasing. Martin, et al (1953) in pot culture studies with citrus seedlings have shown that with potassium percentages in the exchange complex beyond 15 per cent, growth reductions have occurred and that with sodium, growth reductions were quite pronounced when sodium was present to the extent of 14 per cent in the exchange complex.

Under field conditions, Aldrich (unpublished data) has clearly shown that magnesium deficiency is produced from heavy additions of potassium fertilizers and in some trials zinc deficiency has also been greatly aggravated.

Zinc and copper deficiencies are commonly very severe in old corral soils and we now believe that both the phosphate and potash accumulations in such areas are primarily responsible.

We have also noted in water culture experiments with high potassium that manganese deficiency is induced.

Although many old citrus orchards show accumulations of potassium, it is clear from our lysimeter trial that where no potash containing fertilizer is added, this element may decrease rather rapidly. Sample data drawn from our lysimeter experiment (Broadbent and Chapman, 1949) illustrate this (see table 5). Although leaching losses amount to

Table 4. Percentage Saturation of the Exchange Complex of a Citrus Orchard Soil Heavily Fertilized with Manure.

Inches	*Percentage Saturation*			*Exchange*
Depth	*Ca + Mg*	*K*	*Mn*	*Capacity*
0-6	71.3	22.6	6.1	9.7
6-18	83.7	11.9	4.4	7.8
18-36	90.7	2.6	6.7	9.2
36-48	95.2	1.8	3.0	7.4

Table 5. Potassium Gains, Losses and Balance During 15 Years of Irrigation and Cropping.

	lbs/acre/15 years Soil Treatment		
	Straw + 200 lbs/N	*Vetch + 200 lbs/N*	*Mustard + 200 lbs/N*
Added in Irrig. Water	157	248	243
Added in Straw	1,077	—	—
Removed in Crops	3,495	3,489	3,779
Lost in Leaching	38	24	16
Difference	—2,299	—3,265	—3,552

but 1 to 2 pounds of potassium per year, and irrigation water additions range from 10 to 16 pounds annually, net losses due to crop removal amounted to from 150 to 235 pounds potash per year.

These data illustrate that under some farming systems potassium may increase markedly, especially where heavy manuring is practiced; on the other hand, potassium may decrease rather rapidly where a crop which absorbs potash heavily is grown and where soil texture is such as to allow considerable leaching and where fertilization does not include potassium.

Thus, under continued citrus culture, potassium deficiency is likely to develop in some soils and under some systems of management and potash excess is likely to occur in others.

With present leaf analysis techniques, combined with soil and water analyses and an appraisal of the soil characteristics and the fertilizer program, one can decide which direction potash is going; it is important for growers to appraise this situation carefully for, as stated, excessive potassium will aggravate magnesium deficiency, and may also bring on zinc deficiency and iron chlorosis, and in addition adversely affect soil permeability. Conversely, too little potash will decrease fruit sizes as shown by Champman et al (1947).

Soil Salinity

A perennial problem in irrigated soils is salinity. There is still much we do not know about various aspects of this subject, despite the considerable amount of work which has been carried out and is still under way.

The sensitivity of citrus, and especially the lemon, to alkali salts has been recognized for many years. In California, Lougridge and later Kelley (1951) recognized this fact and the latter did a great deal of further research showing the essential nature of alkali soils, the principles of reclamation, and how alkali soils are formed.

Some of the things we still have insufficient information about are: (1) the concentration of various constituents individually and combined at which any given citrus specie and rootstock combination under a given climatic complex begin to be adversely affected; (2) the best way to irrigate and manage a soil under a given cropping-soil-fertilizer-water quality-climate situation, and (3) the secondary effects of salt buildup on soil-plant interrelations especially as it concerns the availability of essential elements, physical changes in the soil, and the biological complex.

In order to illustrate some of the findings which have emerged from the two aforementioned lines of work (i. e., lysimeter and salinity trend experiments), some sample data are presented in what follows.

Lysimeter Experiment: In this experiment, as already stated, we have measured all of the individual constituents added in irrigation water, fertilizer, seed and straw and measured crop removal and leaching losses, thus enabling us to determine the trend of each major constituent and the sum of these (Broadbent and Chapman, 1949). In table 6 is a 15-year summary showing the average for all lysimeters of (1) the total salts added, (2) the total removed, and (3) the balance. Under the conditions of this experiment, it will be noted that there has been a net gain amounting to about 1000 pounds of salt per year. The changes in individual constituents are shown in table 7. It is readily apparent that the 1000 pounds per year gain consists essentially of calcium and sodium bicarbonate, with smaller gains in sulfate and chloride. The irrigation water used in this experiment is comparatively pure mountain water containing about 350 ppm. total soluble solids, and the annual average rainfall is 11 inches. Fertilization was at an annual rate of 200 pounds nitrogen as calcium nitrate.

Table 6 Lysimeter Salt Balance After 15 Years of Cropping and Fertilization.

Soil Treatment	*lbs/acre* Added in Irrig. Water, Fertilizer and Seed	Removed by Crops and Leaching	Gain or Loss
Straw + 200 lbs. N	25,074	10,332	+14,742
Melilotus + 200 lbs. N	28,216	10,849	+17,367

Table 7. Soil Changes During 15 Years of Cropping and Fertilization Under Irrigation Agriculture.

Constituent	*Net Gain or Loss Lbs./Acre*	
	Vetch + 200 lbs. N	*Mustard + 200 lbs. N*
Calcium	+ 5,573	+ 6,189
Magnesium	− 194	− 17
Potassium	− 3,265	− 3,552
Sodium	+ 2,005	+ 1,913
Nitrogen	+ 853	− 448
Phosphorus	− 244	− 227
Sulfur	+ 382	+ 399
Chloride	+ 234	+ 119
Bicarbonate	+13,058	+12,203

The amounts of irrigation water applied were such as to meet crop needs only. It is well known that to keep the salts flushed out of an irrigated soil a certain surplus of water must be used. It has been estimated by us (Broadbent and Chapman, 1949) that water in excess of transparation-evaporation requirements in the amount of 9 per cent would have to percolate through this soil in order to keep salts from building up above a certain equilibrium level. This figure will vary depending upon the salt content of the water. Eaton (1954) has referred to this as the drainage requirement of a water and has set up formulas for calculation for any given water quality the percentage of applied irrigation water which must be wasted by drainage in order to assure reasonable yields. Also included in the formulas are the gypsum requirements. These formulas represent a significant advance and provide a type of guidance not hitherto available.

Salinity Trend: In this study we have determined yearly under a range of soil and cropping conditions the salinity status of the top 6 feet of soil bv one foot horizons. There is insufficient time to present a full account of this work and we will present only a small amount of data to show that the salt picture varies widely in different citrus groves and also from year to year.

Shown in tables 8 and 9 is the soluble salt situation in the first, sec-

Table 8. Salinity Trend — Orange Orchard, Santa Paula, Location 15. Irrigation Water Contains 1,481 ppm. Total Solids. Ground Water Below 6″.

Year Sampled	*Total Salt, ppm Soil* 0-1′	1-2′	2-3′	*Pounds Salt Acre 6′*	*Annual Rainfall Inches*
6- 5-36	683	825	741	17,976	14.8
6- 9-37	658	650	757	17,184	24.5
6- 9-38	951	1032	912	21,048	24.2
6-14-39	1257	1053	1045	24,672	13.2
6-11-40	955	1639	1629	29,928	14.3
6-25-41	530	605	622	14,880	35.7
6-18-42	1232	904	1102	26,640	13.0
6-22-43	1323	768	1080	27,648	17.2
6-22-44	941	1579	1964	39,336	
6-19-45	1113	982	1401	33,096	9.4
6-18-47	1075	1086	1570	38,376	
9- 1-48	2015	1828	2569	56,688	8.7
6-22-49	1576	2372	2416	50,688	9.6
6-19-50	1583	2552	3154	61,560	13.4
7- 6-53	1242	2414	2797	62,712	11.4

ond, and third foot of soil and the total found in the upper 6 feet of soil for two citrus groves over a 16-year period. The data of table 8 are from an orange orchard in Ventura County sampled first in 1936. From 1936 to 1953 it will be noted that total salt in the 6 feet of soil increased from about 18,000 to 63,000 pounds per acre. This large increase is due primarily to the years of lower-than-average rainfall we have had in California since 1942 and failure to keep the salts flushed out by increased irrigation. Note especially that in 1941 following the high seasonal rainfall of 35.7 inches that the total salt decreased from 29,928 pounds to 14,-880 pounds. This demonstrates the rapidity with which salt will move out of a well drained soil under the influence of leaching rains. The following year, however, the salt was back up to 26,640 pounds. It is certain that part of this increase was due to capillary movement upward from levels below 6 feet; in other words, it could not all have accrued from the irrigation water applied between June of 1941 to June of 1942.

In table 9 are similar type data on a lemon orchard in the Oxnard Plain area where high water table and high salt have been perennial problems. The water table at the time we started sampling was at 4.0 feet; later, through improved drainage, it dropped to below 5.5 feet and has stayed down. However, as may be seen from the data, there is an oscillation of salt from year to year in the various horizons. This up and down movement is in response to the combined influence of rainfall, irrigation and climatic conditions. The fact that after 16 years, salt is not much different than at the outset indicates that the drainage water is carrying away about as much salt as the irrigation water is bringing in but that no permanent gain is being made on the salt picture. In years of higher rainfall the salt is pushed out of the first 3 feet of soil into lower horizons, but moves back up by capillarity in succeeding years. This lemon orchard shows substantial salt injury all of the time as well as manganese and iron chlorosis. Despite this condition, fairly good yields of lemons are obtained. This orchard is located near the coast where temperatures are prevailing low and humidity high. In desert regions this much salt would probably render lemons completely unproductive.

Table 9. Salinity Trend — Lemon Orchard, Oxnard Plain, Location 18. Irrigation Water Contains 917 ppm Total Solids.

Year Sampled	*Total Salt ppm Soil*			*Pounds Salt*	*Annual Rainfall*	*Depth of Water*
	0-1′	*1-2′*	*2-3′*	*Acre 6′*	*Inches*	*Table*
6- 6-37	2376	5842	2879	167,400	20.7	4.0 ft.
6- 8-38	2772	2893	3552	162,456	19.7	4.5
6-16-39	1471	2529	1867	114,120	11.4	4.7
6-12-40	1024	7170	1829	158,184	14.4	7.0
6-28-41	838	1188	1585	125,400	36.0	> 5.5
6-18-42	943	846	2129	161,188	13.5	> 5.5
6-27-43	736	2494	3698	85,392	18.5	> 5.5
6-22-44	914	679	1893	118,512	23.8	> 5.5
6-21-45	1190	3059	1219	147,048	8.6	> 5.5
6-20-46	916	3121	1524	148,776	9.8	> 5.5
6-17-47	1056	1121	1697	89,736	12.1	> 5.5
6- 1-48	770	1138	1411	86,952	6.1	> 5.5
6-22-49	1000	1522	5161	176,880	7.5	> 5.5
6-21-50	937	1317	2258	129,576	11.4	> 5.5
7- 6-53	1877	2665	3464	148,296	9.3	> 5.5

These and other data point to the importance of securing much more data on the interrelations of irrigation practice, drainage performance, rainfall and other management practices as related to salt movement, accumulation, equilibrium levels, and the combined impact on citrus performance.

Another aspect of salinity to which we have given some attention is the accumulation of salts in furrow crests (Harding, 1954). This problem assumes special importance under non-cultivation. In table 10 is shown the concentration and character of salts which have accumulated in the furrow crests of one of our orchards. It is commonly noted in the fall after the first rain, that citrus trees often turn yellow. We think this is due to the leaching down to the upper root zone of these salts which have accumulated during the summer irrigation season. We believe that under non-cultivation, sprinkler irrigation may prove to be a better method of applying water; but in some areas we have actually seen more salt injury where sprinkler irrigation is practiced than under the furrow system. Special studies are now being made of this problem. A considerable amount of further data could be given to show something of the chemical changes which are taking place in citrus soils under the influence of fertilization, cropping, irrigation, etc., but the aforementioned examples will suffice to demonstrate the importance of this problem.

Table 10. Salt Accumulations in Furrow Cests of Citrus Soils[1]

Area	*Depth*	*Concentration (M.E. Sat. Extr.)*			
		Total Salt	*NO_3*	*Cl*	*Na*
Furrow Bottom	0-6″	55	5	4	8
Furrow Crest	0-1″	3040	2320	650	986
	0-6″	656	447	152	303

[1]Robert B. Harding. Proc. Soil Sci. Soc. 18:369-372.

No less important are physical and biological changes which will be briefly dealt with in the succeeding sections.

Physical Changes in Citrus Soils

Soils of the semi-arid regions where citrus is grown are commonly low in organic matter and in the loamy sands and heavier types are especially susceptible to physical deterioration.

In California and in many other regions where cultivation is practiced, compacted layers referred to as plow sole develop. These layers impede both water penetration and drainage. This is so well known that it need not be further discussed save to say that we do not know the importance of this as related to tree performance. We have come to feel that the improvement in tree condition which results from the practice of non-cultivation is due in part to the gradual disappearance of plow sole. However, much more information on this subject is needed.

In our long time soil fertility plots at Riverside we demonstrated a few years ago that heavy annual applications of sodium nitrate and ammonium sulfate had so deflocculated the soil of the cultivated layer that irrigation water was running off instead of penetrating, salts were building up, and the combined effect produced a marked decline in the trees of these plots. This work was published by Aldrich, et al (1945) and need not be elaborated upon here save to say that an increase of exchangeable sodium from 0.07 to 0.77 m.e./per 100 grams of soil with a resulting change of Ca:Na ratio from 93:1 to 8:1 was sufficient to bring about marked changes in permeability and other properties. These results illustrate the need for much more research to determine on a wide range of soils and under various fertilization, irrigation and management practices what the ultimate effect is on physical status and tree performance.

Biological Changes

About 20 years ago the director of our station, Dr. L. D. Batchelor, began calling the attention of a number of us to the poor growth of replanted citrus orchards on old citrus lands. This later culminated in the organization of a broad research program under his direction aimed at ascertaining both the causes and possible remedies. Among the lines of work started was a series of greenhouse field and laboratory experiments by Martin whose research published in a series of papers (Martin, 1948; Martin, 1950; Martin, 1950a; Martin, 1950b; Martin and Batchelor, 1952) has shown that the growth of citrus in many soils results in a buildup of a biological flora which unfavorably affect subsequent citrus growth; he has shown that not one but a considerable number of fungal species are involvd. This work also served to focus attention on the earlier work of Thomas (1923) who showed that the citrus nematode, ***Tylenchulus Semipenetrans***, was also a factor. Subsequent surveys by H. S. Reed and his associates (unpublished data) had shown that this nematode is universally present in California citrus orchards and more recently Baines (1950) has extended this work and confirmed the earlier

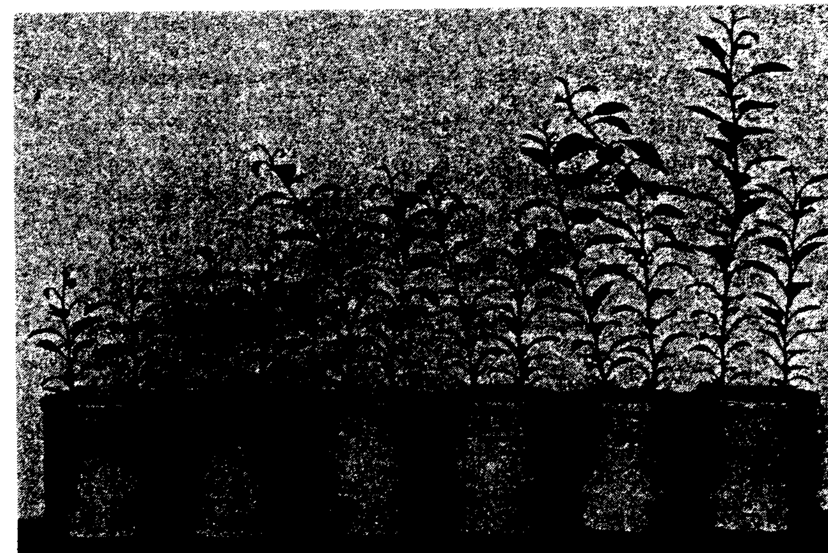

Figure 1. Relative growth of sweet orange seedlings in old citrus soil (first two pots on left); same soil fumigated (two pots in middle); and non-citrus soil comparable to that of citrus soil (two pots on right). Details first published by James P. Martin in Soil Science, Vol. 66, pp. 273-288.

work of Thomas. As a result of all these findings we are now convinced that a part of the replant difficulty is due to the development of this unfavorable flora; Martin also has produced evidence suggesting that possibly a slowly decomposable organic toxin specific for citrus also may accumulate in old citrus orchards. This unfavorable soil condition persists even when the soil is dug from the citrus orchard, potted and planted to citrus seedlings in the greenhouse. In comparisons of the growth of citrus in potted soils from old citrus soils and adjacent non-citrus soils, growth is frequently less than half of that of the non-citrus soil with a corresponding reduction in root development as shown in figures 1 and 2. Feeder root rotting is usually noted in the roots of seedlings grown in the old citrus soil.

A further very significant finding is that the depressing effect found in old citrus soils is variable from soil to soil; on some there is virtually no effect, on others a pronounced effect. Ths indicates that soil conditions in some orchards are much *less* favorable for the development of an adverse flora than in others and one of our important objectives now is to find just what these soil conditions are.

As is well known, one of the important methods of making old citrus lands suitable for replanted citrus is soil fumigation. In this connection, however, it becomes important to determine the impact of this practice

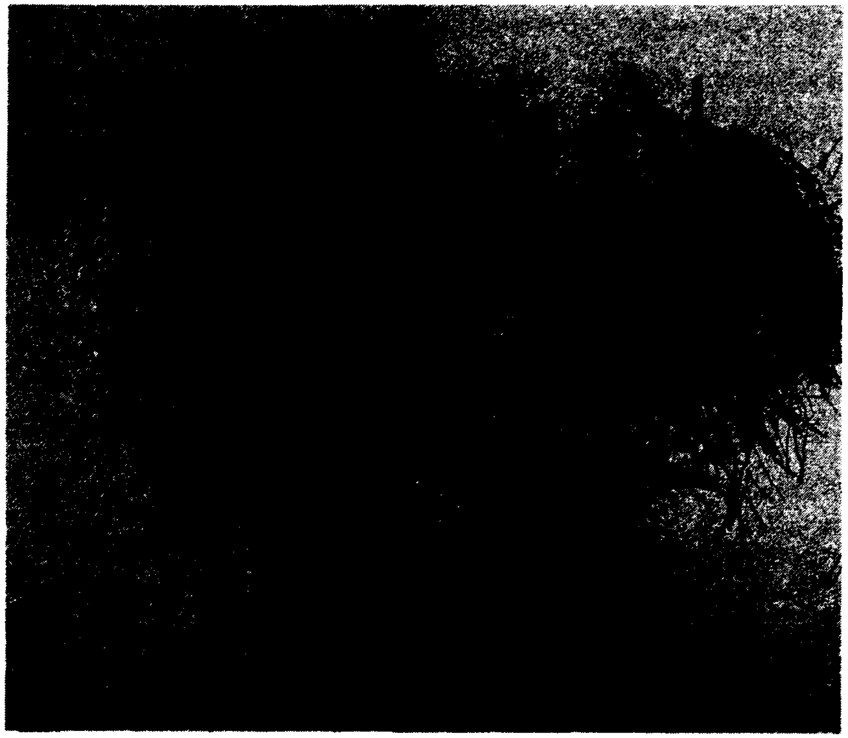

Figure 2. Root growth of sweet orange seedlings grown in non-citrus soil (left) and old citrus soil (right). (From Martin, James P. Soil Science 66:273-288.)

on long term soil productivity. Preliminary studies by Aldrich and Martin (1952) have been made to determine the chemical effects of several fumigants. These studies have shown increases in ammonia which then oxidizes to nitrate with an increase in soluble Ca, Mg, K, and Mn. In further investigations (Martin and Aldrich, 1952) little effect of fumigation was produced on soil aggregation, though there were large changes in microbial population and character.

With the increasing use of soil fumigants, fungicides, and pesticides it is evident that here is another area where we need to take account of possible soil changes, both short term and long term.

Discussion and Conclusion

From the foregoing, it is evident that in the culture of citrus, or of any other plant, profound changes in the chemical, physical and biological characteristics of soil take place as time goes on.

Fertilization, irrigation and cultural practices generally have been

more concerned with *immediate* performance than with the long time changes taking place. With decreasing land areas on the one hand and the need to both *attain* and *maintain* maximum production on the other, we must concern ourselves increasingly with the impact of a variety of fertilization, irrigation, and cultural practices on the soil in order to establish what is going on and avoid those practices which may in the end be very detrimental to soil productivity.

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Experimental Control of Iron Chlorosis of Citrus in Some Rio Grande Valley Soils with Chelated Iron and with Gypsum[1]

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Iron chlorosis of small grapefruit trees on Cleopatra mandarin rootstock growing in calcareous (containing calcium carbonate) soil is common in the Rio Grande Valley (Cooper and Peynado, 1953). Chelates of iron with ethylenediamine tetraacetic acid (EDTA), hydroxethylenediamine triacetic acid (EDTA-OH), and diethylenetriamine pentaacetic acid (DTPA), applied to the soil in the root zone of these chlorotic trees, corrected the iron chlorosis (Cooper and Peynado, 1954).

Additional trials were made during 1954 with both iron chelates and gypsum on chlorotic grapefruit trees on Cleopatra mandarin rootstock growing in a highly calcareous soil. Another trial with the same materials was conducted with chlorotic grapefruit on sour orange rootstock growing in a non-calcareous soil which was irrigated with residual-sodium-carbonate waters. The present paper presents data obtained from these trials.

Methods and Materials

The first test was made at Simon's orchard at Mission. The trees, Curry Red Radiance grapefruit on Cleopatra mandarin rootstock, were planted in the orchard in December 1952. At the time of this test, December 3, 1953, the trees, which had a trunk diameter of approximately 1 inch, were severely chlorotic. They had been irrigated exclusively with river water. The soil effervesced profusely when treated with dilute hydrochloric acid. The pH of the soil was 7.9 and the saturation extract of the soil contained no residual sodium carbonate. EDTA-OH at the rate of 13 grams of chelated iron per tree was applied to 20 trees in six holes around each tree. The holes were 18 inches from the trunk of the tree and were 12 inches deep. Gypsum, at the rate of 1/2 pound per tree, was applied to six trees in an adjacent row which had not been treated with EDTA-OH.

A second test was conducted on iron-chlorotic grapefruit trees in Kutzenberger's nursery at Harlingen, Texas. The Webb Red Blush grapefruit trees had been budded on sour orange rootstock in June 1953, and

[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. The cooperation of Mr. Simon, Mission; Howard Kutzenberger, Harlingen, and Dr. R. H. Cintron, Hoblitzelle Ranch, Mercedes, is greatly appreciated.

the trunks were approximately 1/4 inch in diameter at the time of this test. The trees were irrigated frequently during 1953 with well water which contained 0.70 equivalents per million (epm.) carbonates and 9.2 epm. bicarbonates (table 1). River water, by comparison, contained only a trace of carbonates and 2 to 3 epm. of bicarbonates. The soil was considered non-calcareous since it did not effervesce when dilute hydrochloric acid was applied to the moist soil. The soil pH was 8.2 and the saturation extract of the soil contained 3.6 epm. residual sodium carbonate. Three separate materials, EDTA-OH, DTPA, and gypsum, were applied on April 21, 1954 to the soil in furrows which were on both sides of the nursery row. The furrows were approximately 3 inches deep and 6 inches from the trunks of the trees. The iron chelates were applied at the rate of 1 to 3 grams of chelated iron per tree, while gypsum was applied at the rates of 1/4 and 1/2 pound per tree. The materials for each treatment were applied to ten trees.

Additional tests with EDTA-OH were made on iron-chlorotic grapefruit trees on Cleopatra mandarin rootstock growing in a calcareous soil and irrigated with river water at the Texas-Wesleyan farm at Monte Alto, the Hoblitzelle Ranch at Mercedes, and Ray Goodwin's at Mission. The tests at Hoblitzelle Ranch made on 1-year-old grapefruit trees included applications of EDTA, EDTA-OH, and DTPA at 5, 10 and 15 grams of chelated iron per tree spread on the surface of the soil and applied to furrows 4 inches deep.

Results and Discussion

Trees growing in a calcareous soil with no residual sodium carbonate.

The soil at Simon's orchard was calcareous but contained no residual sodium carbonate. EDTA-OH induced greening of all chlorotic foliage during the first eight weeks after treatment of the trees in the Simon's orchard (table 2). In addition, all new growth that developed on these trees following the treatment was green. During the same 8-week period untreated and gypsum-treated trees showed very little greening. The results confirm the earlier results with this iron-chelate on calcareous soils (Cooper and Peynado, 1954).

Observations in the earlier work, however, were incomplete as these trees were dug from the nursery eight weeks after treatment. In the present test at Simon's orchard, the experimental trees were observed for a year. The data in table 2 show that 16 weeks after treatment the appearance of the untreated trees had improved since most of the chlorotic old leaves had defoliated and new green foliage covered many of the trees. The chlorotic leaves persisted in only 2 of the 20 untreated trees in the test. The general appearance of the untreated trees at this time was nearly equal that of the treated; the treated trees, however, had retained the old foliage which remained green 16 weeks after treatment. Trunk circumference of the 20 treated and 20 untreated trees was measured at the beginning of the test and six months later. The treatments had no effect on rate of trunk growth during this period.

Table 1. Analyses of water from the Rio Grande and from the Kutzenberger well.

Kind of water	*EC. (millimhos per cm.)*	*Concentration of ions*							
		Cl (epm.)	*CO_3 (epm.)*	*HCO_3 (epm.)*	*Ca+Mg (epm.)*	*Na (epm.)*	*Residual Na_2CO_3 (epm.)*	*% Na*	
								Found	*possible*
Rio Grande water[1]	.52	1.2	.16	2.24	3.44	1.62	0	31	60
Well water	2.80	12.5	.70	9.20	7.50	20.50	1.70	73	100
Rio Grande water[2]	1.90	9.8	trace	3.50	9.9	13.9	0	58	68

[1]Report of water analysis on water sample No. 22652 from Rio Grande at Roma, Texas. Composite for the month of January 1954. Sample collected by International Boundary and Water Commission and analyzed by U. S. Salinity Laboratory.
[2]Water taken from the Mercedes canal January 23, 1953.

Table 2. Greening of chlorotic grapefruit trees[1] in the Simon orchard by soil applications of chelated iron and gypsum.

Material applied	*Chelated iron per tree (grams)*	*No. of trees treated*	*No. trees on which chlorotic foliage turned green at indicated intervals after treatment.*			*No. trees on which new green leaves developed at indicated intervals after treatment.*		
			0 week	*8 weeks*	*16 weeks*	*0 week*	*8 weeks*	*16 weeks*
None	0	20	0	5	D	0	8	18
EDTA-OH	13	20	0	20[4]	20[4]	0	20	20
Gypsum[2]	0	6	0	3	D	0	3	4

[1]1-year-old Curry Red Radiance on Cleopatra mandarin rootstock, treated December 3, 1953.
[2]1/2 pound gypsum per tree.
[4]Foliage shows chelated iron toxicity.
D It was not possible to make an accurate determination of greening of chlorotic old leaves on these trees as many of the chlorotic leaves had abscised and new foliage covered the trees.

Similar results were also obtained with untreated and EDTA-OH treated trees at the Texas-Wesleyan farm at Monte Alto, the nursery at Hoblitzelle Ranch at Mercedes, and a Cleopatra mandarin seedbed at Mission. The soil at these three locations was calcareous with no residual sodium carbonate. There was a tendency for most chlorotic trees to recover without treatment; the time required depended on a number of factors not clearly understood.

Over-irrigation or excessive rainfall frequently induces iron chlorosis on grapefruit on Cleopatra mandarin growing in a calcareous soil; drying out of the soil tends to correct this condition. In a seedbed on calcareous soil at Ray Goodwin's nursery at Mission, severe iron chlorosis developed on young Cleopatra mandarin seedlings growing in full sunlight, while partially shaded seedlings remained green. In other instances, an application of nitrogen to the soil induced chlorotic trees to develop a new flush of growth with green leaves. Although chelated iron will correct iron chlorosis on grapefruit on Cleopatra mandarin growing in a calcareous soil, it may not be necessary in many instances.

Trees growing in a non-calcareous soil with a residual sodium carbonate.

The iron chlorosis in the Kutzenberger nursery appears to have been induced by the use of irrigation water containing a high proportion of bicarbonate in the dissolved solids. Harley and Linder (1945) observed that application of irrigation waters relatively high in bicarbonate would induce chlorosis to apple and pear trees in Washington. Stabler (1911) predicted that the use of irrigation water containing appreciable bicarbonate could lead to the development of a "black alkali" soil. Eaton (1950) has recently given significant support to the above conclusion with his observations on "black alkali" soils in the Nile Valley. Analyses show that Nile river water contains residual sodium carbonate (1.44 epm.); that is, more bicarbonate and carbonate than calcium and magnesium. The analysis in table 1 shows that the irrigation water used on the trees in the Kutzenberger nursery contained 1.70 epm. residual sodium carbonate which is comparable to that found in the Nile river water. The obvious treatment for such soil is the application of gypsum.

Both EDTA-OH and DTPA were effective in a rapid greening of chlorotic grapefruit leaves on trees in the Kutzenberger nursery but were no more effective than gypsum (table 3). On the basis of these results, the owner of the nursery treated the entire 10-acre nursery with gypsum at the rate of 1 ton per acre and corrected the iron chlorosis.

Chelated iron toxicity.

In the Kutzenberger nursery, symptoms of apparent EDTA-OH toxicity (Fig. 1) were noted. These symptoms were not noted on trees treated with DTPA. In a test at Hoblitzelle Ranch where EDTA, EDTA-OH, and DTPA were tested on small grapefruit trees, it was found that EDTA was more toxic than EDTA-OH and there was no indication of toxicity from the use of DTPA at concentrations as high as 15 grams of

Table 3. Greening of chlorotic grapefruit trees[1] in the Kutzenberger nursery by soil application of chelated iron and gypsum.

Material applied	*Chelated iron per tree (grams)*	*No. of trees treated*	*No. trees on which chlorotic foliage turned green at indicated intervals after treatment.*			*No. trees on which new green leaves developed at indicated intervals after treatment.*		
			0 week	*8 weeks*	*16 weeks*	*0 week*	*8 weeks*	*16 weeks*
None	0	10	0	1	1	0	5	5
EDTA-OH	1	10	0	7[4]	7[4]	0	10	10
	2	10	0	10[4]	10[4]	0	10	10
	3	10	0	8[4]	8[4]	0	9	10
DTPA	1	10	0	8	9	0	10	10
	3	10	0	10	10	0	10	10
Gypsum[2]	0	10	0	5	10	0	10	10
[3]	0	10	0	9	10	0	10	10

[1]Webb Red Blush grapefruit on sour orange rootstock treated April 21, 1954.

[2]1/4 pound of gypsum.

[3]1/2 pound of gypsum.

[4]Foliage showed chelated iron toxicity.

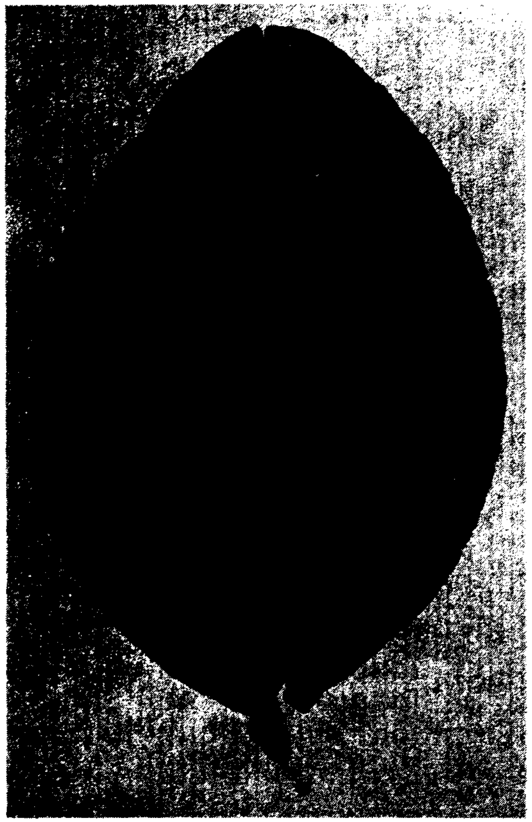

Figure 1. Injury to foliage of grapefruit on sour orange rootstock in the Kutzenberger nursery when EDTA-OH was applied at the rate of 3 grams of chelated iron per tree.

chelated iron per tree. EDTA and EDTA-OH were less toxic when chopped into the surface soil than when applied in furrows 4 inches deep. EDTA rates of 10 and 15 grams of chelated iron per tree occasionally killed the trees.

Toxicity symptoms were also observed on the large trees treated with EDTA-OH in the Simon's orchard, but these symptoms were mostly in the form of necrotic spots on the leaves.

Summary

Iron chlorosis on grapefruit, whether occurring in a calcareous soil or a residual-sodium-carbonate soil, was corrected by the application of EDTA-OH. However, iron chlorosis of grapefruit growing in a calcareous soil is mainly limited to small trees, and the trees frequently recover without the use of iron chelates.

Gypsum had no apparent corrective effect on iron chlorosis of grapefruit in calcareous soils, but was highly effective in non-calcareous soil containing residual-sodium carbonate.

Chelated-iron injury was observed on grapefruit leaves when EDTA and EDTA-OH was used, but not when DTPA was used.

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Boron Accumulation in Citrus as Influenced by Rootstock[1]

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Introduction

Roy (1943), Haas (1945), and Smith *et al* (1949) showed that rootstock tended to control the quantity of boron accumulated by the variety of citrus on them. Boron accumulation in citrus leaves in their experiments ranged from 14 to 88 ppm. and was in the deficient-to-optimum range for boron requirements of citrus (Reuther and Smith, 1954). In the Rio Grande Valley of Texas, where water containing 2 to 6 ppm. of boron is occasionally used for irrigation, citrus leaves frequently contain 300 to 1000 ppm. of boron (Wilcox, 1949, and Cooper *et al*, 1952) and boron-toxicity symptoms are common. Therefore, it seemed desirable to study the effect of rootstock on boron accumulation when high-to-excess amounts are present. Some information on sour orange and Cleopatra mandarin rootstock has been reported by Cooper *et al* (1952). The present paper presents additional information on boron uptake by these two rootstocks and 39 other kinds of rootstock.

Methods and Materials

The present study involved four experiments conducted from 1950 to 1954. The first experiment, identified as "Experiment A," was conducted on 2-year-old Shary red grapefruit trees on 20 different rootstocks in a series of Latin squares. Each Latin square contained 25 trees, planted 3 feet apart and comprised of 5 trees on each of 5 rootstocks. Two irrigation water treatments were tested: (a) the control, or base water supply, and (b) base water to which boric acid water was added to give an concentration of 6 ppm. boron (Table 1). Irrigation treatments began on May 31, 1950 and were repeated at 2-week intervals until December 1, 1950. Samples were collected from spring-flush leaves on all trees on July 21, 1950. On this date, the concentration of boron in the saturation extract of the top foot of soil was 0.15 and 2.61 ppm. for the control and boron-added plots, respectively (Table 2). Leaf symptoms of boron toxicity were observed on August 8, 1950, and trunk circumferences were measured on all trees on December 1, 1950.

[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. The cooperation of Rio Farms, Inc., Monte Alto, Texas, and Engelman Products Co., Elsa, Texas, is greatly appreciated.

Table 1. Analysis of water used for irrigating the four experiments on various dates.

Experiment	*Irrigation treatment*	*Date water used*	*Boron (ppm.)*[1]	*EC.*[2] *(millimhos per cm.)*	*Sodium (% of total bases)*
A	Control	May to Dec., 1950	0.2	1.2	60
	Boron added	May to Dec., 1950	6.0	1.2	60
B	Control	May 1953 to Dec. 1954	0.5	1.5	60
	Well water	May 1953 to Dec. 1954	5.8	5.0	87
C	Delta lake water	1950-1951[3]	0.3	1.0	60
	Delta lake water	1952[3]	1.3	2.9	60
	Delta lake water	March 6, 1953	1.3	3.4	58
	Delta lake water	May 4, 1953	4.6	4.6	67
	Delta lake water	June 4, 1953	1.0	2.5	58
	Well water	June 29, 1953	5.8	5.0	87
D[4]	Drainage water	March 24, 1952	4.1	7.4	72

[1]ppm. indicates parts per million.
[2]EC. indicates electrical conductivity. The EC. multiplied by 600 gives the approximate concentration of total salts in ppm.
[3]Mean value.
[4]Complete record on irrigation not available.

Table 2. Electrical conductivity and concentration of boron in the saturation[1] extract of the soil at various soil depths from the surface in three of the four experiments[2].

Experiment	*Irrigation treatment*	*Date of soil sample*	*Soil horizon (feet)*	*Boron (p.p.m.)*	*ECe.*[3] *(millimhos per cm.)*
A	Control	July 21, 1950	1	0.15	1.5
	Boron added	July 21, 1950	1	2.61	1.5
C	———	March 18, 1954	1	1.3	2.79
			2	0.8	2.71
			3	0.8	3.61
D	———	March 18, 1954	1	4.1	2.19
			2	2.2	2.61
			3	1.4	3.15

[1]The saturation extract is the solution obtained by vacuum filtration of soil made up to a saturated condition by adding distilled water while stirring.
[2]Soil analyses have not been made on "Experiment B."
[3]ECe. indicates electrical conductivity of saturation extract of soil. ECe. multiplied by 700 gives the approximate concentration of total salts in ppm.

The second experiment, referred to as "Experiment B," was also conducted on small Shary red grapefruit trees grown with a 3-foot spacing in soil plots but the rootstocks were sour orange and Cleopatra mandarin only. In this series, each plot contained 6 trees, 3 on sour orange rootstock and 3 on Cleopatra mandarin rootstock. The irrigation treatments consisted of a control, or base low-boron water, and 5 well-water treatments, each with 4 replicates. The well water contained 5.8 ppm. of boron (Table 1). The well-water treatments consisted of well water alone or combined with various chemical amendments. A description of the well-water amendments and their effect on boron accumulation by the trees will be given elsewhere (Cooper, 1955). The present paper presents data only on the effect of rootstock on boron accumulation by the tree. The irrigation treatments began in May 1953 and continued through December 1954. Four separate leaf collections were made from the trees in these plots: spring-flush and September-flush leaves collected November 11, 1953; spring-flush leaves collected May 4, 1954 and spring-flush leaves collected August 30, 1954.

The third experiment, identified as "Experiment C," was conducted at Rio Farms, Inc., Monte Alto, on 4-year-old Shary red grapefruit trees on 32 different rootstocks. The trees were grown at orchard spacing and were irrigated with natural waters of high boron content. The orchard consisted of 12 trees on each of 67 rootstocks arranged in 4 randomized replications of 3-tree plots. However, leaf collections for boron analysis were made only on trees on 32 rootstocks. The boron analysis of the irrigation water on various dates is given in Table 1. Twelve inches of rainfall occurred during the fall of 1953. September-flush leaves were collected from the trees March 18, 1954. Soil samples were taken on the same date from the first, the second and the third foot of soil from the surface at 8 locations in the orchard. The average boron concentrations of the 3 classes of soil samples are given in Table 2.

The fourth experiment, referred to as "Experiment D," was conducted at Engelman Products Co., Elsa, on 5-year-old Shary red grapefruit trees on 24 rootstocks and on an adjacent, separate block of Valencia orange trees on 14 rootstocks. The grapefruit and orange trees were planted in 4 randomized replications of 3-tree plots. These plantings were grown at orchard spacing and irrigated with drainage ditch water of high boron content. No record was made of the exact irrigation dates of the Engelman orchard. The only sample of irrigation water was secured on March 24, 1952, and its analysis is given in Table 1. However, irrigation water of similar quality was used repeatedly during 1952 and 1953 on this orchard. The boron analyses for the first, second, and the third foot of soil are given in Table 2. September-flush leaves were collected on March 18, 1954 from grapefruit trees on 14 rootstock varieties and from orange trees on 7 rootstock varieties.

The leaf collection procedure for all 4 experiments consisted of selecting 10 leaves from each tree of the indicated growth flush. Leaves from all five trees on each rootstock in "Experiment A" were combined

into a composite sample of analysis; therefore, only gross differences can be discussed. In the other 3 experiments, the leaves from the 3 trees on each rootstock in each of the 4 replications wer combined, giving a total of 4 separate lots of leaves for each rootstock for each sampling date. These data were analyzed for statistical significance.

The leaves in all instances were scrubbed with a moist cloth, rinsed 4 times in distilled water, dried at 75°C., and ground to a fine powder in a Wiley mill. Duplicate 500-milligram amounts of the sample were dry ashed with CaO, digested with 6N HCl, filtered, made up to 100 ml., and boron was determined colorimetrically by the carmine method (Hatcher and Wilcox, 1950).

Results

The boron contents of leaves from the grapefruit trees on 20 different rootstock varieties in "Experiment A" are presented in Table 3. In the control plot the contents ranged from 105 ppm. for the Duncan

Table 3. Effect of rootstock and boron treatment[1] on the boron content of leaves of Shary red grapefruit (Experiment A).

Rootstock	*Boron (ppm. in dried leaves) at indicated concentration of boron in irrigation water.*		
	0.5 ppm. (control)	6 ppm.	*Increase*
Cleopatra mandarin	300	500	200
Mandarin, *Citrus nobilis*	205	785	580
Calamondin	195	565	370
Sour orange	135	510	375
Rough lemon	170	310	140
Columbian sweet lime	305	845	540
Sweet lemon	170	620	450
Rangpur lime	210	535	325
Pineapple sweet orange	240	475	235
Florida sweet orange	285	680	395
Duncan grapefruit	105	365	260
Nakorn pummelo	236	730	494
Sampson tangelo	290	750	460
Williams tangelo	285	880	595
Minneola tangelo	295	415	120
Trifoliate orange	205	495	290
Rusk citrange	115	490	375
C.P.B. 4475 citrumelo	240	585	345
Etrog citron	185	515	330
Severinia buxifolia	175	345	170
Mean	217	570	

[1]Boron treatment began May 31, 1950 and the leaves were sampled July 21, 1950.

grapefruit rootstock to 305 ppm. for the Columbian sweet lime rootstock. Increases in the boron content of leaves induced by boron additions to the irrigation water averaged 353 ppm. for all rootstocks; small increases in boron occurred in trees on Minneola tangelo, rough lemon, *Severinia buxifolia,* Pineapple orange, and Cleopatra mandarin; large increases occurred in trees on *Citrus nobilis* mandarin, Columbian sweet lime, sweet lemon, Sampson tangelo, Williams tangelo, and Nakorn pummelo. The comparatively small increases for Cleopatra mandarin and Minneola tangelo were associated with a high boron content of trees on these rootstocks in the control plots.

While the boron content of the leaves increased during the 51 days of treatment, leaf symptoms of boron toxicity were slight. The principal foliage symptoms were numerous small yellow dots on the upper side of the older leaves, giving them a speckled appearance. On the under side of the leaf a tiny pustule or rough, resinous excrescence appeared at each yellow spot. The leaves of trees on *Citrus nobilis* mandarin and trifoliate-orange rootstocks showed an orange-colored mottling rather than the yellow scattered dots. Trees on *Citrus nobilis* also showed tip burn. There were no symptoms of boron toxicity on the leaves of trees on *Severinia buxifolia* rootstock. Six months of irrigation with 6 ppm. boron had no significant effect on trunk circumference increase for any rootstock. Since a freeze in early December 1950, killed most of the trees, the experiment was discontinued.

The data for boron accumulation in the grapefruit trees on sour orange and Cleopatra mandarin rootstock in "Experiment B" are given in Table 4. There was no significant difference in boron accumulation

Table 4. Boron content of leaves of Shary red grapefruit trees on Cleopatra mandarin and sour rootstocks in "Experiment B."

Rootstock	*Boron at indicated dates and time of growth flush (ppm. in dried leaves)*			
	Spring flush (Nov. 11, 1953)	*Sept. flush (Nov. 11, 1953)*	*Spring flush (May 4, 1954)*	*Spring flush (Aug. 30, 1954)*
Cleopatra mandarin	449.0	357.8	299.0	484.0
Sour orange	382.4	315.3	302.4	405.4
F value	Not significant	Not significant	Not significant	Highly significant
L.S.D. at .05 level	---	---	---	56.9
L.S.D. at .01 level	---	---	---	76.4

by leaves of grapefruit trees on sour orange and Cleopatra mandarin rootstocks in the first 3 leaf collections; however, in the August 30, 1954 collection, there was significantly more boron accumulated in trees on Cleopatra mandarin than in those on sour orange rootstock.

The boron contents of leaves of Shary red grapefruit trees in the Rio Farms orchard (Experiment C) are shown in Table 5. In this test, the effect of rootstock on boron uptake was highly significant. The boron contents of the leaves of trees on Clementine mandarin, Columbian sweet lime, Butnal sweet lime and Palestine sweet lime rootstocks were significantly higher than the content of leaves of trees on Cleopatra mandarin. There were no significant differences in the boron content of leaves of trees on the remaining rootstocks listed in Table 5, including the sour orange.

In the Engelman orchard (Experiment D), data were obtained for both Shary red grapefruit and Valencia orange scions on various rootstocks (Table 6). The boron contents for orange and grapefruit scions on the same rootstock were remarkably similar throughout. In the Pine-

Table 5. Boron content of leaves of Shary red grapefruit on various rootstocks in the Rio Farms orchard (Experiment C) on March 18, 1954.

Rootstock	*Boron (ppm. in dried leaves)*	*Rootstock*	*Boron (ppm. in dried leaves)*
Columbian sweet lime	425	Savage citrange	235
Palestine sweet lime	401	Rusk citrange	227
Clementine mandarin	354	Sampson tangelo	227
Butnal sweet lime	344	Ponkan mandarin	226
Cuban shaddock	324	Sanders citrange	225
Williams tangelo	319	C. P. B. 4475 citrumelo	215
Dancy mandarin	293	Cleopatra mandarin	213
Thomasville citrangequat	288	Webb Red Blush grapefruit	211
P. I. 117477 mandarin	285	Webb Red Blush grapefruit seedling	208
Lau Chang mandarin	278		
Sour orange	268	Rustic citrange	194
C.P.B. 43301-A2 citrangeor	266	Troyer citrange	190
Rough lemon	244	Calashu	186
Suenkat mandarin	244	Pineapple sweet orange	176
Lemonquat	241	Homosassa sweet orange	149
Rose (Rangpur) lime	240	Uvalde citrange	151
Duncan grapefruit	236		

L. S. D. at .05 level 122
L. S. D. at .01 level 161

apple orange rootstock, the greater accumulation of boron in the Valencia scion than in the grapefruit scion could be a real difference. However, comparison between boron accumulation of grapefruit and orange scions is not statistically valid, because the oranges were grown in a separate, though adjacent, area and soil differences may have influenced relative boron uptake.

The major factor influencing boron content of trees in the Engelman orchard was rootstock, not scion. The boron accumulation in grapefruit for the following rootstocks decreased in this order:

Sweet lemon.
Watt and Thornton tangelos, Cleopatra mandarin.
Columbian sweet lime and Pina tangelo.
Rough lemon and Rangpur lime.
Webber tangelo and sour orange.
Sunshine tangelo and Homosassa and Pineapple orange.
Severinia buxifolia.

Table 6. Boron content of leaves of Shary red grapefruit and Valencia oranges on various rootstocks in the Engelman planting (Experiment D) on March 18, 1954.

Rootstock	*Boron in indicated scion (ppm. in dried leaves)*	
	Shary red grapefruit	*Valencia orange*
Sweet lemon	519	518
Watt tangelo	470	470
Thornton tangelo	469	431
Cleopatra mandarin	463	
Columbian sweet lime	435	
Pina tangelo	422	420
Rough lemon	373	
Rangpur lime	350	
Webber tangelo	337	
Sour orange	324	284
Sunshine tangelo	269	
Homosassa sweet orange	300	
Pineapple sweet orange	263	338
Severinia buxifolia	64	61
L. S. D. at .05 level	32	34
L. S. D. at .01 level	43	48

The boron content of Valencia orange for the following rootstocks decreased in this order:

Sweet lemon.
Thornton, Watt and Pina tangelos.
Pineapple orange.
Sour orange.
Severinia buxifolia.

Discussion

In the present investigation, rootstock affected boron accumulation when high-to-excess boron concentrations occurred in the leaves. Boron uptake by trees on sweet lemon and sweet lime rootstocks was comparatively high in the 3 experiments in which these rootstocks were included, confirming a similar observation for these rootstocks when grown at lower levels of boron supply (Roy 1943). Boron uptake by *Severinia buxifolia* rootstock was comparatively low in the 2 experiments in which it was used, confirming a similar observation by Eaton and Blair (1935).

The comparative boron uptake by sour orange, Cleopatra mandarin, rough lemon, and sweet orange varied in the present experiments. In "Experiment C," there was no significant difference among these rootstock varieties, while in "Experiment D," a small but significant difference was found: the Cleopatra mandarin accumulated more than the rough lemon; rough lemon accumulated more than sour orange; and sour orange accumulated more than sweet orange.

On one of the 4 different leaf collections made from trees in "Experiment B," more boron accumulated in trees on Cleopatra mandarin rootstock than accumulated in trees on sour orange rootstock. This result, combined with that from the Engelman planting (Experiment D), tends to confirm a similar observation of these rootstocks when grown at lower levels of boron supply (Roy, 1943). However, the differences between the boron uptake by the two rootstocks is small and it is doubtful that the difference is of practical significance in the selection of rootstocks.

Boron toxicity symptoms were observed in the leaves of trees in the Rio Farms and Engelman orchards (Experiments C and D). In both locations, the boron toxicity symptoms were confounded by common occurrence of chloride toxicity symptoms. Although some of the symptoms of boron and chloride toxicity are distinctly different (Cooper and Edwards, 1950), the orange-yellow mottling of boron toxicity is frequently difficult to distinguish from the bronzing symptom of chloride toxicity. Tip burn also may be caused by either boron or chloride excess, and it is frequently impossible to determine by observation which is the cause.

In "Experiment B," chloride-excess symptoms were absent, while boron-excess symptoms were present. However, a difference in boron toxicity symptoms on trees on sour orange and Cleopatra mandarin rootstock was not observed; some defoliation occurred on trees on both rootstocks.

Summary

Analyses for boron were made on the leaves of grapefruit and orange trees grown on different rootstocks and irrigated with waters containing from 0.2 to 6.0 ppm. of boron. Data are given on four separate experiments with grapefruit trees in which 45 different rootstocks are represented and on one experiment with Valencia orange trees in which 7 different rootstocks are represented. In one experiment with grapefruit trees boric acid was added to a low-boron water supply to give 6 ppm. boron. In the other experiments, natural waters containing 0.5 to 5.8 ppm. boron were used for irrigation.

Boron concentrations in the leaves of the grapefruit ranging from 61 to 880 ppm. were influenced by rootstocks. Trees on sweet limes and sweet lemon accumulated large amounts of boron, while trees on Cleopatra mandarin, sour orange, sweet orange, and rough lemon accumulated lesser amounts, and trees on *Severina buxifolia* accumulated the least. The comparative boron uptake by sour orange and Cleopatra mandarin varied in the four experiments. In some instances, there were no significant differences; while in others, the uptake by Cleopatra was greater than by sour orange. However, the difference between the two rootstocks is small. The boron content for orange and grapefruit scions on the same rootstock were remarkably similar.

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Control of the Corn Earworm in Large Scale Field Experiments

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The corn earworm, *Heliothis armigera* (Hbn.), causes so much damage to sweet corn in the southern part of Texas that untreated fields are not even harvested. Good earworm control measures have increased yields up to 150 sacks per acre. The original work of Blanchard *et al.* (1951) showed that good corn earworm control on sweet corn could be obtained with 2 or 3 fixed boom applications of a DDT-oil emulsion, containing 1 percent DDT, 5 percent mineral oil, and water. In commercial sweet corn fields, growers usually irrigate their fields at the time when the fixed boom treatments should be applied and as a result sprayers could not be driven through the field to apply the required number of applications at the proper time. Growers therefore adopted the "sponge method" of earworm control as described by Wene and Blanchard (1953). This consisted of dipping a small synthetic rubber sponge in a solution of 1 percent DDT and 99 percent mineral oil and then pressing this sponge on individual silk masses until approximately one cc of DDT-oil had run into each silk mass. Best results were obtained when the treatment was applied 7 days after the first silk had appeared in the field. Although the sponge method is used extensively in the Lower Rio Grande Valley, this method of control is criticized for the following reasons: timing of the application is very critical; when appled too late the worm control is not satisfactory, and when applied too early the DDT-oil solution prevents as much as 2.5 inches of kernel development on the ear tip; and the tendency of laborers is to over-apply the amount of DDT-oil solution resulting in an objectionable oily taste to the ear. Wene (1954) showed that three applications of an emulsion of 1 percent DDT and 5 percent mineral oil in water applied by the sponge method gave excellent earworm control. When compared to the DDT-oil solution sponge applications of the DDT-oil emulsion also resulted in much less oil injury to the ear tips and also minimized the danger of oil contamination to the ear. Large scale field experiments were conducted to determine if three sponge applications of 1-percent DDT-5 percent oil-water emulsion could be applied for commercial earworm control, and if the fixed boom sprayer could be substituted for the first two sponge applications.

Commercial earworm control was obtained by Wene (1953) with 12 daily airplane applications of a 10 percent DDT dust. The DDT dust was applied at approximately 35 pounds per acre per application. Experiments were conducted with airplane applications of DDT dusts to

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determine if effective earworm control could be obtained with either a reduced dust poundage per application or with lengthening of the intervals between treatment applications.

Each experiment was conducted in a 20 acre field which had been planted with the hybrid, Calumet.

Individual Ear Treatment with a DDT-Oil Emulsion

The sponge method was used in applying a DDT-oil emulsion to individual ears in a 20 acre field of sweet corn. The DDT-oil emulsion was made by mixing 1 gallon of 25 percent emulsifiable DDT with 1.25 gallons of white oil (50 second Saybolt viscosity) in a 50 gallon drum, and then adding sufficient water to bring the volume up to 25 gallons. The emulsion was then thoroughly agitated.

Twenty laborers were used in applying the treatments each time. Each man carried his DDT-oil emulsion in a gallon can. He would dip a small synthetic rubber sponge, 3.75 inches long, 1.5 inches wide, and 1 inch in thickness, in the DDT-oil emulsion, and then press the sponge down on top of the silk mass until approximately 2 cc of the emulsion ran into the silk mass. Three or four silk masses were usually treated from each sponge dipping. The applicator would agitate the emulsion each time he dipped th sponge in the can. A laborer usually treated an acre of corn a day, using approximately 10 gallons of emulsion.

The field was divided into two sections. Section A was only an acre in size and received only two treatment applications whereas section B received three. The dates of treatment applications are shown in table 1. The first application treatment was applied when 75 per cent of the plants were silking. Two days before harvesting time 100 ears were examined at random in each plot for the percentage of worm-free ears.

The data in table 1 show that three applications of the DDT-oil emulsion were more effective than two. In the seventh experiment, shown in table 1, 70 percent worm-free ears were also obtained from three treatments of the DDT-oil emulsion. Furthermore, the sweet corn ears showed approximately 0.5 inch oil injury on the ear tips. Examination of the ears did not reveal any oil contamination which occurs when excess amounts of the DDT-oil solution (DDT in oil) is sponged on for earworm control. In both fields U. S. No. 1 crated corn was packed.

Combination of Fixed Boom Sprayer and Individual Ear Method

A Fordson tractor was mounted on tractor stilts and an eight row sprayer attached to the rear end of the tractor. The spray boom, arranged in the same manner as described by Blanchard *et al.* (1951), had four fan nozzles directed towards the ears of each row of corn (two for each side of the row). The sprayer was operated at a pressure of 150 pounds per square inch; and, when driven at the rate of four miles per hour, applied 35 gallons of spray to the acre. The spray tank had a capacity of 50 gallons. The DDT-oil emulsion was made in the following man-

ner: 1.75 gallons of a 50 second Saybolt viscosity white oil was poured into the spray tank; then, 1.4 gallons of a 25 percent emulsifiable DDT concentrate was added; and, while the agitator was working, sufficient water was added to bring the volume up to 50 gallons.

Before each experiment was started the percent of sweet corn plants in silk was determined. Five areas were selected at random in each field and the number of silks found on 100 plants in each area were counted. Immediately afterwards the first spray treatment was applied, and the second was applied 2 or three days later. After the second treatment application all the fields were irrigated. Three days after the second spray treatment laborers sponged a 1% DDT-5% oil emulsion to individual ears in the manner described previously.

The data in table 1 show that commercial earworm control was obtained by applying two treatments of a 0.75% DDT-3.5% oil emulsion with a fixed boom sprayer and a third treatment of 1% DDT-5% oil emulsion applied to individual ears by the sponge method. Table 1 shows that the percentage of worm-free ears varied from 38 to 100 per cent, depending upon the timing of the treatment applications in relation to the percent of stalks with silks.

The data in table 1 emphasizes the importance of timing the first spray application. The best earworm control was obtained when the first spray treatment was applied at the time when one percent of the corn stalks were silking. The data also show that sprays are of no value in this area if applied when 67 per cent of the plants are silking.

The data in experiment 8, shown in table 1, show that two spray treatments gave only 52 percent worm-free ears, but the addition of an extra sponge treatment increased the percentage of control to 100.

Very little oil injury was observed on the ear tips when a combination of fixed boom and sponge method was used in applying the three treatment applications.

Dusts for Earworm Control

The data in table 2 show that airplane applications of 10 percent DDT dusts gave erratic earworm control. In the Uvalde area 30 pounds of 10 percent DDT dust applied 11 times at daily intervals gave 80 percent worm-free ears whereas only 52 percent were obtained at Olmito. At Mercedes 10 percent DDT with 2 percent parathion applied daily at 20 pounds per acre gave 64 percent worm-free ears in the fourth experiment while only 18 percent was obtained in the fifth experiment. The work conducted at Uvalde show that daily applications were more effective than those applied at two day intervals. More research is needed before dusts can be recommended in this area.

Table 1. Control of the corn earworm with DDT-oil emulsions conducted on a field basis.

Expt. No.	% Silking at 1st. Application	Date of Applications: Sprayer: 35 Gal./A. 0.75 % DDT + 3.5 % Oil + water	Date of Applications: Sponge: 10 Gal./A 1% DDT + 5% Oil + water	Worm-free Ears %
1(A)	75		April 15, 17	60
(B)	75		April 15, 17, 20	70
2	67	April 20, 22	April 25	38
3	38	April 20, 22	April 25	70
4	14	April 22, 26	April 29	53
5	15	April 23, 16	April 29	62
6	1	April 24, 27	April 30	82
7	50		April 24, 27, 30	70
8(A)	1	May 3, 5	May 8	52
(B)	1	May 3, 5		100
9	—	----	----	6

Table 2. Earworm control with airplane applications of insecticides.

Expt. No.	Location	% Silking at 1st Application	Insecticide	Lbs. per acre per Application	Applications No.	Applications Interval	% Worm-free Ears
1	Mercedes	1	10% DDT	30	11	1 day	80
2	Mercedes	1	10% DDT	30	11	2 day	44
3	Mercedes	5	10% DDT	30	12	1 day	52
4	Mercedes	3	10% DDT + 1% Parathion	20	12	1 day	64
5	Uvalde	1	10% DDT + 1% Parathion	20	12	1 day	18
6	Uvalde	1	10% DDT + 1% Parathion	20	8	2 day	18
7	Olmito	—	------		—	----	6

Summary

Commercial corn earworm control was obtained by sponging three applications of a 1% DDT-5% oil water emulsion to individual ears at 2 or 3 day intervals. The first application was made when 50 to 75 per cent of the sweet corn plants were silking.

Good earworm control was also obtained by applying a 0.75% DDT-3.5% oil water emulsion twice with a fixed boom sprayer and sponging a third application of 1% DDT-5% oil water emulsion on individual ears at 2 and 3 day intervals. Best results were obtained by applying the sprays when only one percent of the corn plants were in silk.

Airplane applications of 10 percent DDT dusts resulted in erratic earworm control. The percentage of worm-free ears varied from 18 to 80 percent, indicating that more research should be done.

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Pruning Wound Paint for Budded Citrus Nursery Stock Wounds

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It is a common practice in citrus nurseries to cut off the stub or stem of the rootstock above the bud union after the bud shoot has reached a height of a foot or more and to paint the stock wound with an asphalt-type paint. The paint used should prevent the entry of pathogenic organisms through the stotck wound, be non-injurious to the exposed live wood and the bark tissues and not retard callusing-over of the wound. To check on the latter two qualities in four asphalt wound paints that appeared promising in preliminary citrus pruning work, 426 budded citrus stocks were pruned and the wounds painted in March 1953.

The budded citrus nursery trees used in the test consisted of grapefruit and orange budded on sour orange and Cleopatra mandarin rootstocks. Both the bud shoot and rootstock stub were somewhat larger than is usually the case when the stubs are cut off in most nurseries. The stubs were cut off with a smooth down-sloping cut, which started just above the bud shoot union. The slope varied with each cut; however, most of the cuts were in a 40 to 50 degree slope. Care was exercised to avoid loosening or peeling back of any bark below the cut. The stock wounds were painted immediately after the stubs were cut off. There were 10 replications of each plant treatment and each replicate consisted of all budded trees in 42 feet of nursery row.

The wound paints used and results obtained in the nursery stock wound test are given in table 1. Six weeks after the stubs were cut off and the wounds painted, good to excellent healing occurred in more than 60 percent of the stock wounds. In many instances the stock wounds were nearly one-half callused over. There was little or no difference in wound healing response to three of the paint treatments at the end of six weeks. However, initiation of callus tissue was delayed slightly in case of paint number 61. The most pronounced difference observed in wound healing was in the reaction of the two rootstocks in which callus initiation and wound overgrowth was slower in Cleopatra mandarin than in the sour orange. One year after treatment, 90 percent or more of all stock wounds in both rootstocks had healed over smoothly and no differences in paint treatments were noticeable.

The use of Penta (a trade product with a pentachlorophenol content of about 10 percent) as the fungicidal agent in three of the paints is of practical interest in the home preparation of a wound paint. In the fourth paint the pure or technical grade of pentachlorophenol was used. The same pentachlorophenol concentration, one percent, was used in all four paints. Penta has the district advantage over the technical form by having the pentachlorophenol in solution, which greatly faciiltates the

Table 1. Effect of asphalt wound paint on callus initiation and healing of stock wounds of budded sour orange and Cleopatra mandarin rootstocks, 6 weeks after treatment.

Number	*Wound paint materials* *Materials*	*Grams*[2]	*Rootstock*	*No. of Wounds*	*Wound healing response, in percent*[1] *Poor*	*Good*	*Excellent*
51	Asphalt	55.0	Sour	49	0.0	57.2	42.8
	Kerosene	34.3	Cleo	58	13.8	86.2	0.0
	Shell 9.4% Penta[3]	10.7					
54	Asphalt	55.0	Sour	48	4.1	50.0	45.9
	Carbolineum	34.3	Cleo	57	15.8	82.4	1.8
	Shell 9.4% Penta	10.7					
56	Asphalt	55.0	Sour	59	3.4	76.3	20.3
	Naphtha	34.3	Cleo	51	1.9	68.7	29.4
	Shell 9.4% Penta	10.7					
61	Asphalt	55.0	Sour	50	8.0	82.0	8.0
	Kerosene	44.0	Cleo	54	37.0	63.0	0.0
	Pentachlorophenol	1.0					

[1]Wound healing classes based on number of stock wounds in each paint treatment and healing response which ranged from a small area of callus initiation to wounds one-half healed over.

[2]Each formula is based on 100 grams of paint and the quantity of materials may also be read in percent by weight, if desired.

[3]Shell 9.4% Penta, a trade product, contains 9.4 percent pentachlorophenol in solution. Each paint formula is based on a one percent concentration of pentachlorophenol.

compounding of the paint. It is difficult to dissolve technical pentachlorophenol in the common solvents. The data in table 1 indicate that Penta as used did not adversely affect the healing of stock wounds.

The solvents, carbolineum, kerosene and naphtha, were apparently comparable in effectiveness in the three paints in which Penta was used as the source of pentachlorophenol. In this instance, the solvents in Penta were apparently non-injurious when incorporated in asphalt paint. However, it is highly advisable that when the first batch of wound paint is made from stock materials that it be tested for injurious properties by painting tender shoot growth or freshly cut pruning wounds. If pronounced injury occurs in a few days the paint should not be used. A change in the formula may correct the difficulty. This testing or cautious use is desirable because the manufacturer may change the chemical makeup of a product without changing the trade name. This applies to the use of solvents as well as the chemicals used as fungicides.

Summary

Four asphalt wound paints containing one percent of pentachlorophenol in which either kerosene, carbolineum or naphtha were used as the solvent gave satisfactory results when used to paint citrus nursery stock wounds. Callus initiation and healing over of the wounds developed rapidly and at about the same rate for three of the paint treatments but was slightly slower in case of the fourth paint. The different wound paints affected the wound healing response less than the rootstocks. Callus initiation and healing over of the stock wounds was slower in case of the Cleopatra mandarin rootstock than for the sour orange.