practical and in conformity with the citrus laws and regulations.

If you could spend a few months in the Commission office you would be amazed at the number of inquiries received from persons all over the country. Many of these persons request information concerning the citrus industry or its products. One party wants to know something about a new process for extracting citrus juices; another is interested in investing his life's savings in a grove and seeks advice and information. Quite a few people submit ideas, recipes, and sure-fire sales aids they wish to sell. Some of the most interesting letters we receive are from people commenting on the quality of our citrus fruits and products. These comments and observations cause those of us associated with the Commission to be quite conscious of the need for the industry to put great stress upon supplying consumers with *quality* products. We receive many letters commenting on the fine quality of our products, but we also receive some adverse comments. I think one of the biggest factors that will determine the eventual market for our frozen orange concentrate is QUALITY. Up to now quality has been good, with few complaints being received. It is my opinion that this is the principal reason for the tremendous expansion in the market for this product and we should all be a self-appointed committee of one to advocate and stress quality for *all* of our citrus products. The best advertising and promotion program in the world won't be much help in selling poor quality products.

The scope of activities of the Commission has expanded with the growth of the industry. When it was established in 1935, the Commission had only a few employees and the income that year was $550,000, the production being only 29.5 million boxes. The production is now ranging close to 100 million boxes with a resultant income in excess of $2,000,000.

The industry has been faced with the problem of marketing increasingly larger crops. This has been a problem that has been with us for many years. I believe most of you will agree that, in general, the problem has been met with success. It is true that there have been years of adversity and loss, but for the most part our groves have been a good investment. However, we can't rest on our laurels. We must continue aggressive advertising, merchandising and research programs. We must investigate and explore new ideas, new methods, new outlets. We must hold production costs to a minimum. We must do some aggressive consumer educational work. And above all we must produce good fruit and maintain a high standard of quality for our citrus products.

The Florida citrus industry does things in a big way. That is why we have weathered the economic storms in the past that have wreaked havoc among some of the other fruit industries. We must continue to do things in a big way if we are to prosper. Those of us associated with the Florida Citrus Commission are proud of the part it has played in the progress of this great citrus industry.

# OBSERVATIONS ON BORON DEFICIENCY IN CITRUS

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Although the presence of boron in plants was discovered nearly a century ago, it was not shown to be an essential element for the normal growth of plants until 1914[9]. The first demonstration of the essential nature of this element for the growth of citrus was made by Haas[7] in 1929, by the use of sand cultures. Grapefruit, lemon, and orange all failed to develop properly in those cultures from which boron was withheld. Several deficiency symtoms were described in detail by Haas and Klotz in 1931[8]. Roy[12] induced boron deficiency in grapefruit in sand culture in Florida in 1943 and found that arsenic induced deficiency symptoms even though boron was present in amounts that would seem adequate. During the past three years we have grown young Valencia trees under conditions of very limited boron supply and several symptoms have resulted which appear to have some diagnostic value in the field. Gumming of the fruit, lumpiness, and a hard, dry fruit are almost universally recognized as characters which result from the lack of an adequate supply of boron. Leaf symptoms, on the other hand, are not generally recognized. The present report lists the chief fruit and vegetative symptoms of boron deficiency from previous work and those found in our outdoor sand-culture experiments at Orlando (table 1). On the basis of these symptoms, or a large number of them, several groves in central Florida were suspected of showing varying degrees of stress due to lack of this element during the very dry winter and spring of 1948-49. One grove was selected for detailed study, and all of the available evidence seems to indicate that boron deficiency was present under field conditions. Since the only reported case of definite boron deficiency in a citrus orchard appears to be that described by Morris[10] in South Africa, the present findings are given in some detail.

Boron deficiency symptoms in the fruit have frequently appear in Florida in conjunction with application of lead arsenate, and boron sprays are helpful in remedying the situation. Similar symptoms have been noted[4,5] periodically in the absence of arsenic antagonism; but a response to soil applications of boron was not evident, while toxicity symptoms sometimes resulted and the deficiency symptoms usually disappeared regardless of whether boron was applied or not. A dry soil condition has been found to induce deficiency symptoms in apples[1] and other plants even though the soil is not necessarily deficient in boron. Citrus rootstocks have been shown[6,12,13] to influence the boron supply to the scion. Sour orange roots are relatively poor feeders for this element, while grapefruit, trifoliata, and Cleopatra mandarin are among the best of the tested rootstocks for supplying it. Sweet orange and Rough lemon are intermediate in this respect.

The grove selected for study consists of about 10 acres on Lakeland (formerly classified as Norfolk) sandy soil near Eutis, Florida. The pH of the topsoil is about 5.5. It is planted almost equally to three orange varieties (Washington Navel, Hamlin, and Temple), all on sour orange stock. The trees are about 9 years old and have received uni-

TABLE 1.
GROSS SYMPTOMS OF BORON DEFICIENCY IN CITRUS AS NOTED BY VARIOUS WORKERS

| Symptoms | Haas | Roy | Morris | Smith & Reuther |
|---|---|---|---|---|
| 1. Curling, or buckling, of leaves, either upward or downward (fig. 1) | Yes | Yes | — | Yes |
| 2. Yellowing along midrib and lateral veins; normal thickness; tendency to abscise prematurely (fig. 1) | Yes | — | — | Yes |
| 3. Enlargement of midrib and lateral veins (fig. 1) | Yes | Yes | — | Yes |
| 4. Splitting and corking of veins on upper (ventral) side of leaf | Yes | Yes | No | Yes* |
| 5. Some leaves thickened; somewhat leathery, but brittle and persistent | Yes | — | — | Yes |
| 6. Some deformities of thickened leaves, such as blunt, notched, and heart-shaped apices | — | — | — | Yes |
| 7. Rosetting or whorled clusters of leaves due to shortened internodes of stem | — | — | — | Yes |
| 8. Brownish green leaf color, lack of luster | Yes | — | — | Yes |
| 9. Multiple buds | Yes | — | — | Yes |
| 10. Premature defoliation of some stems | Yes | Yes | Yes | Yes |
| 11. Dieback of young, defoliated stems | Yes | Yes | Yes | Yes |
| 12. Gum pockets in internodes of stem | Yes | — | — | Yes |
| 13. Normal to heavy blossoming | No | Yes | — | Yes |
| 14. Excessive fall of young fruit | Yes | Yes | — | Yes |
| 15. Gumming of albedo layer of rind (fig. 3) | Yes | Yes | Yes | Yes |
| 16. Gumming of inner tips of fruit locules (fig. 3) | No | — | Yes | Yes |
| 17. Gumming of core, or axle, of fruit | Yes | No | Yes | Yes |
| 18. Misshapen, hard, or dry fruit | Yes | Yes | Yes | Yes |
| 19. Shriveled, darkened, or undeveloped seed | No | — | Yes | Yes |
| 20. General tree resemblance to exanthema, or copper deficiency** | Yes | Yes | Yes | Yes |

*Infrequently found.
**Twisting and downward drooping of vigorous shoots, and symptoms 9, 10, and 11.

form cultural treatment, which included no boron fertilization insofar as it is possible to ascertain. When first seen early in March 1949 the trees were still dormant and the Washington Navels showed rather severe distress symptoms in the foliage (only a few scattered fruits were present) that appeared identical to those in the young Valencia trees on a low-boron ration in sand cultures. About 50 to 60 percent of the leaves were affected. The principal symptoms present were: (a) yellowing along midrib and lateral veins (fig. 2, B and C), (b) veins somewhat swollen on upper surface of the leaf with occasional splitting and corking, (c) some leaves (non-chlorotic ones) thickened and somewhat brittle, (d) buckling of the leaves which throws the internal area of the leaf blade either upward or downward in relation to the margin (fig. 2, A and C), (e) some terminals rosetted as a result of shortened internodal areas of the stem, (f) dead areas of bark on some of the younger twigs and (g) a dull, lusterless appearance of the foliage in general. The youngest leaves on the trees were the most severely affected ones (about 8-month-old leaves from the 1948 summer growth cycle). Those leaves with the yellowish veins abscised soon after this condition developed, leaving areas of bare branches on the trees (fig. 3, 4). The thickened leaves (non-chlorotic) are rather persistent and do not appear to show a shortened life. The symptoms were somewhat worse on the south and southwest exposures, although they could be found on all portions of the tree.

The crop of fruit had been picked, but an occasional off-bloom fruit was present. A few of these showed a lumpy contour and gum deposits in the albedo layer of the peel (fig. 3, G and H).

Symptoms as described, although somewhat more intense, were also found in a few sour orange trees that had developed after the Navel scions had died out several years previously. There was considerable fruit on these trees, most of which was undersized, hard, dry, and mummified in appearance. Gumming was very common in the albedo, in the inner tips of the locules near the central axis of the fruit, as well as in the axis (fig. 3, C, D, E, and F). Veinal chlorosis was very prominent. Since these sour orange sprouts appear to be even more sensitive to limited boron supply than budded varieties, they may prove to be useful indicators of boron deficiency when they happen to occur in an orchard.

The Hamlins showed slight, but similar, foliage symptoms but no fruit could be found to examine. The Temple trees showed no leaf symptoms at all and were carrying a good crop of normal fruit.

The three varieties are in separate areas of the planting; but the soil is quite uniform over the entire area, which suggests that the scion variety may be an important factor in the expression of deficiency symptoms.

On March 16, a borax spray (1 lb.:100 gal.) was applied to the Navels, one row being left unsprayed for further observation. This was applied with a liquid sulfur spray. One row was sprayed with the sulfur and then borax was added for the remainder of the grove. The one row which did not receive boron is hereafter referred to as "unsprayed." The spring growth had not yet appeared, being delayed by the drought. On March 29, new growth was present in profusion on the sprayed trees but virtually absent on the unsprayed trees. A similar delay in new growth has been reported in the case of apples that were under stress for boron[3]. Only 3 terminals of new growth could be found on the 17 unsprayed Navel trees. These young leaves were unduly yellowish in color and were removed for analysis, along with a set of comparable size from an adjacent sprayed row. Although the leaves were of nearly the same size, the leaves from the sprayed trees were much greener and somewhat thicker, as is indicated by their greater dry weight (table 2). Young Valencia leaves from trees receiving low and adequate amounts of boron (about 0.001 and 0.5 p.p.m. B in the culture solutinn, respectively) in sand cultures were taken for comparison (table 2).

The unsprayed Navel trees put out a bloom and flush of leaves about 8-10 days after the sprayed trees. No discernible difference in the number of flowers was evident in relation to the spray treatment. The bloom was very heavy throughout and flowers were frequently found on completely defoliated branches (fig. 2,B), indicating that the ability to flower was not impaired by the affliction. This same observation had previously been made with the Valencias under controlled conditions. Many of the defoliated branches that flowered did not produce new leaves and failed to set fruit. A gradual dying back of these young limbs followed.

Several additional samplings of this spring-growth flush were made during the spring and summer (table 2). In each case the trees that were sprayed produced slightly larger leaves and these had more boron in them than the untreated trees. The differences are not large but tend to substantiate the visible evidence that the sprayed trees are making the most rapid recovery. The fact that considerable defoliation had taken place at the time of treatment should be taken into consideration. It seems highly probable that the effect of the spray would have been much

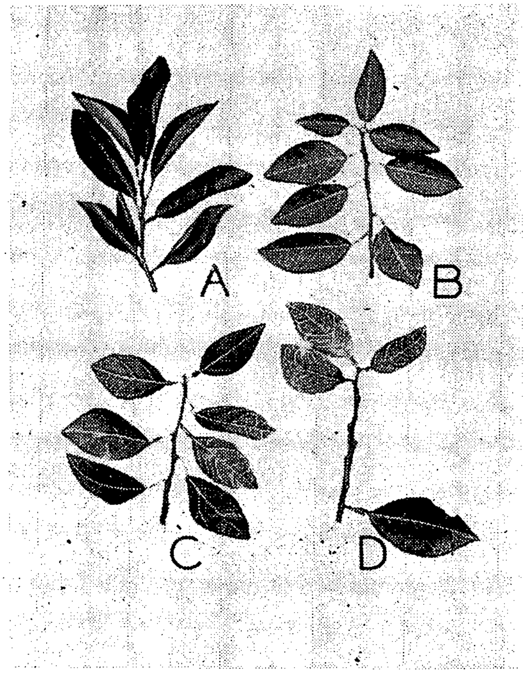


FIG. 1. Young (4-month-old) shoots of Valencia orange on Rough lemon stock (1/6 natural size; (A) Normal shoot from tree grown in sand culture with complete nutrients added; (B-D), shoots from trees grown with boron omitted from the culture solution. An early symptom of deficiency is the yellowing of midrib and lateral veins (B), followed by curling (C), accentuated veinal chlorosis, yellowing, and defoliation (D).

TABLE 2.
LEAF WEIGHT AND BORON CONTENT OF VALENCIA AND NAVEL ORANGE LEAVES OF DIFFERENT AGES AND WITH DIFFERENT BORON TREATMENTS

| Variety, leaf age, and treatment | Date sampled | Mean leaf wt. mgm. | p.p.m. Boron in dry leaves | Micrograms Boron per leaf |
|---|---|---|---|---|
| Valencia, 1 week, low boron(a) | 3-29-49 | 34 | 6 | 0.2 |
| Valencia, 1 week, — boron(b) | 3-29-49 | 35 | 28 | 1.0 |
| Valencia, 18 weeks, low boron(a) | 7-10-48 | 274 | 14 | 3.8 |
| Valencia, 18 weeks, — boron(b) | 7-10-48 | 283 | 140 | 39.3 |
| Navel, 1 week, Unsprayed | 3-29-49 | 50 | 4(d) | 0.2 |
| Navel, 1 week, Sprayed(c) | 3-29-49 | 80 | 21(d) | 1.7 |
| Navel, 5 weeks, Unsprayed | 4-29-49 | 196 | 12 | 2.4 |
| Navel, 5 weeks, Sprayed | 4-29-49 | 214 | 17 | 3.6 |
| Navel, 10 weeks, Unsprayed | 6-14-49 | 274 | 15 | 4.1 |
| Navel, 10 weeks, Sprayed | 6-14-49 | 297 | 26 | 7.7 |
| Navel, 18 weeks, Unsprayed | 7-29-49 | 294 | 22 | 6.5 |
| Navel, 18 weeks, Sprayed | 7-29-49 | 300 | 33 | 9.9 |
| Navel, 1 week, Unsprayed | 8-24-49 | 89 | 29 | 2.6 |
| Navel, 1 week, Sprayed | 8-24-49 | 81 | 37 | 3.0 |
| Navel, 6 weeks, Unsprayed | 9-29-49 | 325 | 24 | 7.8 |
| Navel, 6 weeks, Sprayed | 9-29-49 | 311 | 26 | 8.1 |
| Navel, 6 weeks, Unsprayed(e) | 9-29-49 | 318 | 48 | 15.7 |
| Navel, 6 weeks, Sprayed(e) | 9-29-49 | 300 | 47 | 14.1 |
| Valencia, 18 weeks, Mean, 29 mature Florida groves | | | 92 | |

(a) 2-year-old Valencia/RL in sand culture with about 0.001 p.p.m. B. Deficiency symptoms were present but affected leaves were not included in the samples.
(b) 2-year-old Valencia/RL in sand culture with about 0.50 p.p.m. B.
(c) Trees sprayed with 1 lb. borax per 100 gal. on March 16, 1949, before the appearance of these leaves.
(d) Single sample. All Valencia values are the mean of four samples; all other navels the mean of three.
(e) 3 ounces of borax applied to soil around each tree on 8-24-49.

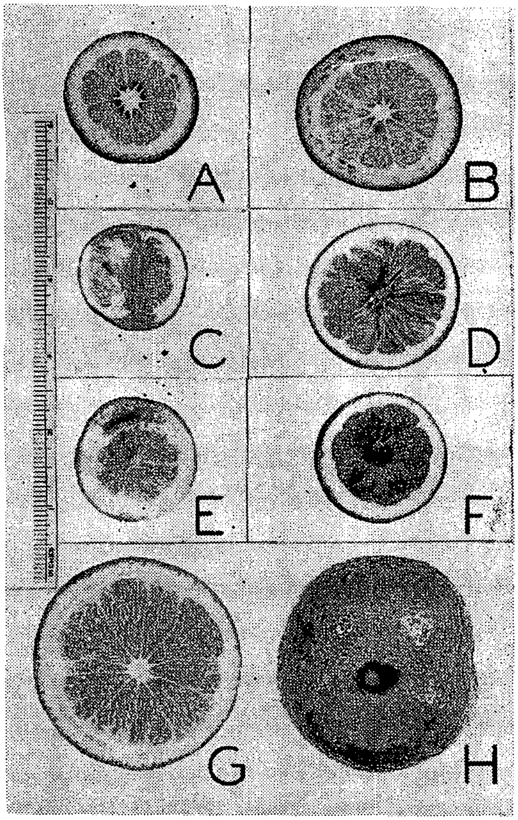


FIG. 3 Typical boron deficiency symptoms in fruits: A and B, Immature Valencia fruits from controlled sand cultures showing gum formation in the albedo and inner tips of the locules; C-F, various views of sour orange fruits from sour orange sprouts in the Navel grove. Note gumming in various portions of the fruits and the lack of seed development. A shriveled seed may be seen in C. These were mature, hardened and mummified fruits. Gumming of the albedo and lumpy contour of Navel fruits are shown in G and H.

greater if it had been applied earlier when all of the older leaves were still on the trees. About 40 to 50 percent of the leaves had fallen when the spray was applied.

All of the trees showed increased boron in the leaves with the advent of the summer rains that started in June. The content, however, was still relatively low, indicating that the trees were getting boron from the soil only in limited amounts even in the rainy season. Healthy, mature orange leaves usually show from 40 to about 200 p.p.m. of boron[11]. By way of comparison, the mature Valencia leaves on low boron ration showed an average of 14 p.p.m. total boron and showed strong deficiency symptoms.

As the spring-flush leaves developed on the unsprayed trees, mild boron deficiency symptoms appeared (b, c, d, and e as listed in text). They were entirely absent on the comparable leaves of the sprayed Navel trees.

The main summer-flush of growth occurred in mid-August. No deficiency symptoms were found in the very young leaves, and they had (table 2) what would appear to be a normal amount of boron for week-old leaves. There was still some effect of the March spray treatment as the leaves from these trees showed over 25% more boron (compare 29 and 37 p.p.m. boron). These leaves appeared during the period of adequate moisture supply and differ sharply from leaves of a similar age from the same trees taken in March under drought conditions. The respective boron concentrations at that time were 4 and 21 p.p.m. This substantiates the evidence with other types of plants that soil moisture influences boron availibility.

The native boron supplying power of the soil in this particular grove is relatively low as shown by the following test. On August 24 three ounces of borax (18% $B_2O_3$) per tree was applied to the soil around each of five trees of the 17 unsprayed trees and to a like number of trees that had received the original boron spray. A hurricane, which occurred during the next few days, brought about four inches of rainfall. Five weeks later (September 29) the tree response was such that the treated trees were pointed out by an observer who did not know which trees had been given the soil application. A deeper green color and longer shoot growth served to distinguish the trees that had received the three ounces of borax from those that did not. Many of the six-week-old leaves on the trees that did not receive the three ounces of borax showed a whitish-yellow color of the midrib and a general off-green color. These symptoms of mild boron deficiency were present on both unsprayed and sprayed trees. The leaves of these two treatments were also nearly identical in their boron content (compare 24 and 26

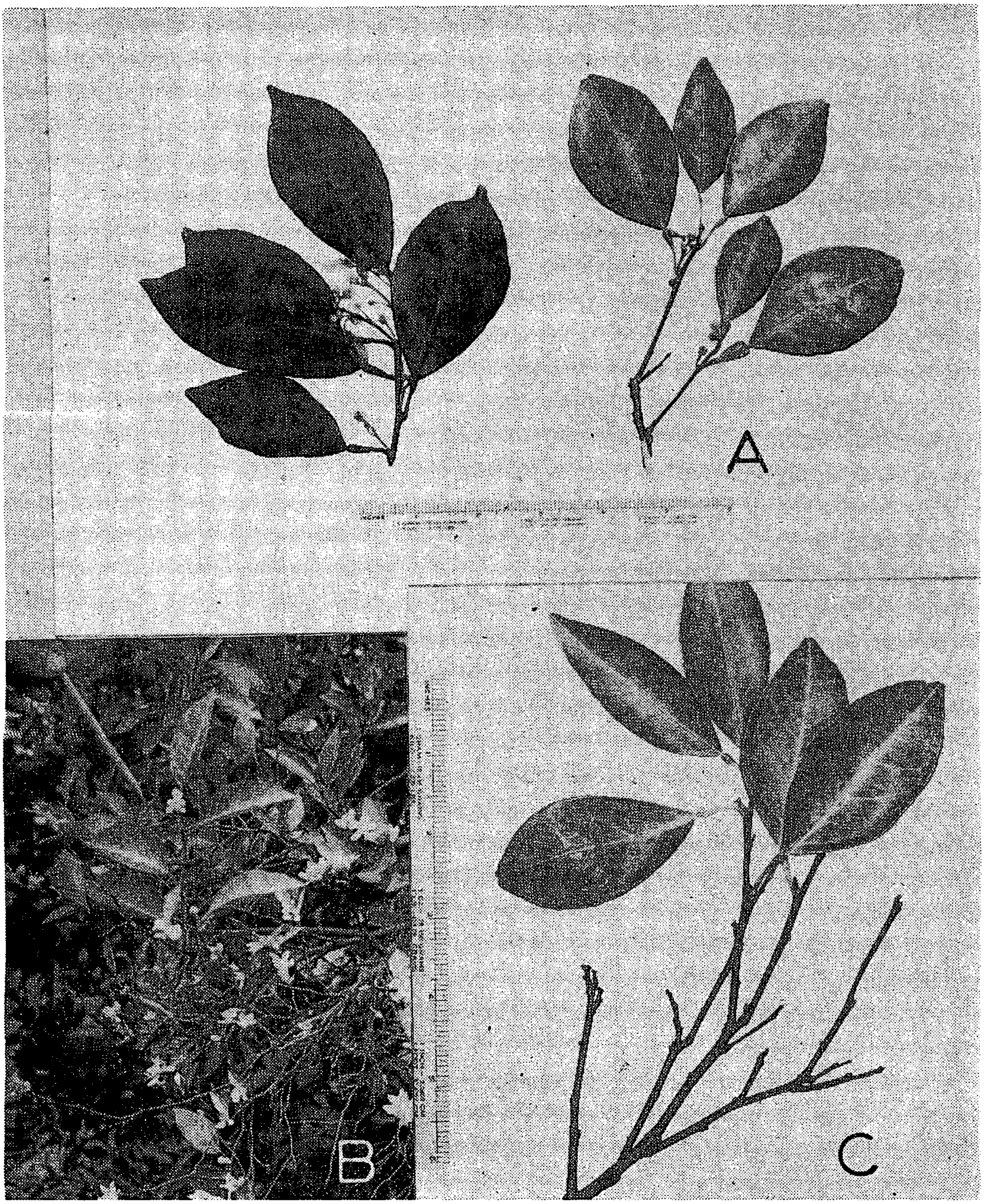


FIG. 2. Typical foliage, twig and flower condition as seen in early April 1949 in Washington Navel orange grove growing on sour orange stock near Eustis, Florida. Note veinal chlorosis in B and C and curling of leaves in A (right) and C. Defoliation is evident in B and C with flowers on the defoliated branches in B. The twig on the left in A is one that appeared to be normal.

p.p.m. for 9-29-49 in table 2). The leaves of a similar age from the trees which received the soil applications showed about 48 p.p.m. boron, and here again no difference was induced by the spray application of the previous March. The values of 24 and 26 p.p.m. are somewhat low for a nearly mature leaf. The better appearance of the trees as a result of the ground application suggests that even with abundant soil moisture the trees were limited in growth by the lack of adequate boron from the untreated soil.

Despite the poor condition of the foliage at the time of bloom and the relatively light set of fruit, it appeared that somewhat more fruit was set on the sprayed trees. To measure this response, counts were made of the fruit on each of ten sprayed trees and a like number of unsprayed trees on September 23, 1949. The sprayed trees averaged 277 fruits and the unsprayed 214 per tree. This difference of about 30 percent is suggestive that the spray treatment either enhanced the set of fruit or retarded subsequent droppage. Recent work[2] in Washington indicates that the set of pear fruit was increased by application of boron spray during the bloom period.

To summarize, it seems highly probable that boron deficiency occasionally exists in Florida citrus groves. The appearance of all of the listed (table 1) foliage and fruit symptoms in the Washington Navel orange trees on sour orange stock, together with the low boron content of leaves and the response to boron applications, leave little doubt of positive identification of boron deficiency in this one grove.

It is felt that a better appreciation of the various foliar symptoms that have not previously been associated with boron deficiency in the field, would be useful to growers in detecting early cases, and these could be quickly remedied by the insertion of boron in one of the dormant or (and) post-bloom spray applications. This is especially useful during periods of prolonged drought or in the absence of irrigation; otherwise soil applications should give a quick response under acid soil conditions. Dependence on fruit symptoms for diagnosis would probably result in a lightened crop, as it would then be too late for corrective measures that would influence the crop already on the trees.

The earliest symptoms noted, both in the sand cultures and the field, was the yellowing along the midrib and lateral veins. This symptoms developed quickly—in a matter of days—and defoliation of such twigs soon followed. The thickened, buckled type of leaf is slower to develop and of longer pesistence on the tree. The enlargement of the veins is also a gradual process. Periods of drought accentuate the expression of boron defiency symptoms.

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