tional saving and reduces the time factor, as it is moving of conductor line which is the bottleneck.

I think we are yet in the dark ages on Portable Irrigation. Much has been done in its development during the past two or three years. Yet more has to be done in lowering the cost per acre inch of water applied to the citrus groves. More Growers are thinking in terms of Water Conservation which is vitally necessary. More efficient facilities *will* have to be developed in reducing application costs. More research work is necessary in order that water is not wasted. This operation of Portable Irrigation will definitely develop fast if the next ten years are as generally dry as in the past ten. In closing, I urge you to start thinking and doing something about this all important problem of Portable Irrigation.

THE RESPONSE OF YOUNG VALENCIA ORANGE TREES TO DIFFERENTIAL BORON SUPPLY IN SAND CULTURE

PAUL F. SMITH AND WALTER REUTHER
U. S. Subtropical Fruit Field Station
Orlando

Previous reports on the boron nutrition of citrus have been concerned chiefly with deficiency and toxicity responses. The objective of the present study was to maintain trees at different levels of boron between these two extremes and to observe any differences that occurred in regard to general growth pattern, mineral composition of the leaves, and fruiting behavior.

Twelve young Valencia orange trees which were budded on Routh lemon stock, were planted into 50-gallon containers filled with white quartz sand.

Beginning May 28, 1947, complete nutrient solution was applied twice weekly at the rate of 2 to 3 liters per application. The rate of boron used in the nutrient feeding was the only differential variable for the succeeding three years. The lowest boron level was that which was supplied as impurities in the C.P. salts and the lake water used as a water source. A medium boron level of 0.5 p.p.m. and a high of 2.0 p.p.m. were maintained as the other two treatments. Four trees received each treatment. Water was applied between nutrient feedings in amounts that induced leaching Further details of the method of culture are presented in a previous article (6).

Leaf samples were collected each year and analyzed for various major and minor elements. Trunk diameter measurements were made semi-annually. Fruit was allowed to develop during the third year and was analyzed for total soluble solids, ascorbic acid, and citric acid.

Results and Discussion

In general, excellent growth was made by all trees. The size attained was equal to or greater than identical trees growing in soil adjacent to the plots. All growth was nearly normal in appearance except that the low-boron trees showed mild deficiency symptoms in the foliage (4) during the fall months of the second year, and the high-boron trees showed mild toxicity symptoms of occasional tip burn and yellow spots (1) throughout the test period. These symptoms were more pronounced during 1948, when the mean total boron content in dry leaf samples was 386 p.p.m., than in 1949 and 1950 when it was about 265.

The high boron trees showed some tendency toward forming a less compact top than the others. They had fewer, but larger, branches and a more open character. The mean tree size was nearly identical in all three treatments. This is indicated by the cross-sectional trunk area measurements in table 1.

The leaf samples collected on the first three and last sampling dates shown in table 1 were mature spring-flush leaves. A broad range in the B concentration within the leaf was induced and maintained. This range was over 24-fold in the summer of 1948 and over 10-fold in the summers of 1949 and 1950. The differences in the other elements in these mature samples are relatively small. Phosphorus tends to be present in slightly greater concentrations when B is low. Such a relationship has previously been found with sunflowers (2).

Three samplings were made from young leaves, which were developing in the fall at the time that a crop of fruit was maturing. Under these conditions the difference in the P concentration was greater than with mature leaves, although the difference appeared to diminish as the leaf approached maturity. The concentrations of the three base elements, K, Ca, and Mg were also influenced in these younger leaves. When B was supplied in a very limited amount Mg had a tendency to enter the leaf in greater amounts, and reciprocally, K in lesser amounts. Calcium appears to have been depressed at the highest boron level. Here again it appears that these differences are perhaps temporary and tend to diminish as the leaf grows older.

Nitrogen, manganese, copper, iron, and zinc do not appear to have been influenced in any way by the variation in boron supply. Sodium was determined on the same collections for which iron values are shown and showed no differences which were attributable to the rate of boron supply.

From 10 to 15 pounds of oranges were produced by each tree during 1949. These were picked and analyzed on February 6, 1950. No systematic differences were found in the yield, fruit size, rind thickness, juice content, or percentage of total soluble solids and citric acid in the juice. The only difference that was consistent in all four replications was a reduction in the ascorbic acid content of the juice in the low-boron trees. This treatment averaged 49.8 mg. per 100 ml., as against 57.0 and 54.9 for the medium and high boron treatments, respectively. This response may be indirectly attributable to the boron suply, however, and more closely associated with the higher level of phosphorus in the low-boron trees. This latter relationship was found to exist under orchard conditions when the leaf phosphorus was increased without changing the boron status of the trees (5).

The literature on boron nutrition shows several cases with various plants of a lack of growth response to a differential supply of this element between the limits of deficiency and toxicity levels. On the basis of this limited study with Valencia oranges, citrus seems to be no exception to that rule. Apparently normal trees can be grown with very limited applications of boron if it is supplied at frequent intervals. Likewise, applications of boron in amounts which produce mild toxicity symptoms do not seem to interfere appreciably with the functioning of the plant. The evidence presented is the first to show the relatively small effect of rather large variations in the boron content (maximum range 16 to 386 p.p.m.) of citrus on growth, fruiting, and the concentration of other mineral elements in the leaves. A similar range (30 to 305 p.p.m. boron) in mature Va-

TABLE 1

THE RELATION OF BORON LEVEL TO CROSS-SECTIONAL AREA OF THE TRUNK, AND DRY WEIGHT AND MINERAL COMPOSITION OF LEAVES OF YOUNG VALENCIA ORANGE TREES AT DIFFERENT INTERVALS OF A THREE-YEAR CULTURE PERIOD. TREES PLANTED APRIL 28, 1947

Sampling date and leaf age	Boron applied (p.p.m.)	Mean trunk X-section (cm. ^{2})	Mean leaf weight (mg.)	Percentage of leaf dry matter					P.p.m. in leaf dry matter				
				N	P	K	Ca	Mg	B	Mn	Cu	Zn	Fe
9-4-47	0.00	3.08	193	2.82	0.150	1.84	2.95	0.395	41	42	8	—	—
5 months	0.50	3.07	176	2.78	0.171	1.77	2.98	0.360	90	47	9	—	—
	2.00	2.73	193	2.71	0.136	1.79	2.98	0.352	117	41	8	—	—
7-10-48	0.00	4.89	274	2.91	0.164	2.86	2.42	0.194	16	33	8	—	74
6 months	0.50	4.75	272	2.89	0.156	2.84	2.55	0.194	144	44	9	—	80
	2.00	4.49	330	2.81	0.161	2.92	2.52	0.202	386	46	8	—	64
8-5-49	0.01	14.56	364	2.26	0.133*	1.84	2.68	0.288	25	31	14	47	83
6 months	0.50	14.77	358	2.25	0.121	1.72	2.84	0.242*	93	34	14	41	83
	2.00	13.89	389	2.15	0.112	1.99	2.70	0.267	263	30	13	43	76
8-30-49	0.01	—	414	2.15	0.178**	1.84**	2.61	0.512**	17	24	14	29	66
1 month	0.50	—	365	2.23	0.147	2.13	2.69	0.442	58	35	14	24	68
	2.00	—	379	2.12	0.146	2.15	2.20**	0.444	130	25	14	25	65
9-29-49	0.01	—	458	2.44	0.175**	1.82**	2.90	0.524**	20	28	13	29	—
2 months	0.50	—	419	2.38	0.140	2.04	2.74	0.435	67	32	15	36	—
	2.00	—	431	2.34	0.137	2.25	2.50**	0.421	158	29	14	36	—
12-5-49	0.01	18.13	506	2.30	0.157*	1.65	2.98	0.450*	24	44	13	29	—
4 months	0.50	18.18	454	2.35	0.133	1.68	2.98	0.400	78	45	14	28	—
	2.00	18.36	477	2.31	0.138	2.03**	2.55**	0.398	168	36	13	33	—
6-8-50	0.01	20.52	304	2.35	0.119	1.48**	2.46	0.349	25	43	12	34	—
5 months	0.50	20.67	314	2.20	0.117	1.80	2.54	0.312	104	38	12	33	—
	2.00	20.87	326	2.27	0.114	1.78	2.41	0.351	262	40	11	32	—
L.S.D. between any two means @	0.05	N.S.	N.S.	N.S.	0.020	0.22	0.27	0.040	2.7	N.S.	N.S.	N.S.	N.S.
@	0.01	—	—	—	0.027	0.30	0.36	0.053	3.6	—	—	—	—

* Significant difference.

** Highly significant difference.

lencia orange leaves was found in a recent survey (3) of 75 commercial orchards in the major citrus producing areas of the United States.

Summary

Young Valencia orange trees were grown for three years in large outdoor sand cultures on complete nutrient solutions that varied differentially only in the amount of boron. Three rates of boron were applied to single-tree plots. The plots were replicated four times.

No difference in tree size resulted from the differential treatments.

Rather large differences in the boron content of the leaves were induced. The low-boron plants showed mild foliage deficiency symptoms during the second year but not in the first or third years of growth. The high-boron plants showed slight leaf symptoms of toxicity throughout the three-year period.

Mature leaves showed virtually no differences in mineral composition other than the 10- to 24-fold difference in boron. Phosphorus tended to be present in slightly greater concentration when boron was low.

Young leaves showed this same relationship with phosphorus in a more pronounced manner. When the boron supply was low, potassium accumulation in the leaf was retarded and magnesium accumulation accentuated. The rate of calcium accumulation was depressed at the highest boron level. These differences appear to diminish as the leaf approaches maturity.

The only consistent difference in the quality of the fruit produced during the third year was a slight reduction in the ascorbic acid content in the low-boron cultures.

LITERATURE CITED

1. Camp, A. F., and Fudge, B. R. Some symptoms of citrus malnutrition in Florida. *Fla. Agr. Exp. Sta. Bull.* 335. 1939.
2. Reed, H. S. A Physiological study of boron deficiency in plants. *Hilgardia* 17: 377-411. 1947.
3. Reuther, W., Smith, P. F., and Specht, A. W. A comparison of the mineral composition of Valencia orange leaves from the major producing areas of the United States. *Proc. Fla. State Hort. Soc.* 62: 38-45. 1949.
4. Smith, P. F. and Reuther, W. Observations on boron deficiency in citrus. *Proc. Fla. State Hort. Soc.* 62: 31-37. 1949.
5. Smith, P. F., Reuther, W., and Gardner, F. E. Phosphate fertilizer trials with oranges in Florida. II. Effect on some fruit qualities. *Proc. Amer. Soc. Hort. Sci.* 53: 85-90. 1949.
6. Smith, P. F., and Reuther, W. The response of young Valencia orange trees to differential boron supply in sand culture. *Plant Physiol.* 26: (In Press). 1951.

RIO GRANDE GUMMOSIS

Its Occurrence in Florida Citrus

J. F. L. Childs

Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture

Orlando

In 1945 G. H. Godfrey published an article entitled "A Gummosis Associated with Wood Necrosis" (4), in which he reported what was presumed to be a new disease attacking citrus trees, principally grapefruit, in the Rio Grande Valley of Texas. This disease is considered by the Valley growers to be their most serious citrus disease.

In November of 1949, in company with Dr. Godfrey and his former assistant Mr. Carl Waibel, I saw the Rio Grande Gummosis disease on the Experiment Station grounds at Weslaco. Several days later symptoms of the same disease were seen on grapefruit trees in the Coachella Valley area of California. Subsequently Mr. Waibel informed the writer that he had assisted Dr. Fawcett in identifying the disease