toward higher quality from spring-fall applications.

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THE EFFECT OF BORAX AND LEAD ARSENATE SPRAYS ON THE TOTAL ACID AND MATURITY OF MARSH GRAPEFRUIT

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Recognized symptoms of boron deficiency, such as gumming, lumpiness and hard misshapen fruit appear occasionally on grapefruit in Florida (1). Such fruit is undesirable from the standpoint of production; therefore, some growers apply borax to grapefruit trees in the dormant or post-bloom spray, or as a component in the fertilizer. However, a recent survey indicates a tendency to supply too much boron in some groves in Florida (12).

Morris (5, 6) first described boron deficiency symptoms of Valencia late oranges in groves in Southern Rhodesia. He found that trees with boron deficiency produced low yields of oranges with a high amount of hard fruit. In addition, normal oranges grown on boron-deficient trees were low in soluble solids, acid, and juice contents. Reitz (8) found no apparent differences in fruit maturity or quality factors as a result of borax spray treatments. In sand cultures using soluble arsenic, Roy (9) produced grapefruit with boron-deficiency symptoms, even with apparently high boron levels in the leaves.

Use of lead arsenate in maturity sprays on grapefruit to reduce acidity and promote early legal maturity is common practice in Florida. However, these sprays often produce grapefruit with symptoms similar to boron deficiency. Sometimes these appear even though apparently adequate levels of boron are present in the leaves. It is not known definitely whether arsenic produces symptoms similar to boron deficiency or whether it is antagonistic to boron. When both lead arsenate and borax are used, boron deficiency of grapefruit may still occur, but in a less degree than fruit with no borax applications (2). Apparently there are still other unknown factors involved.

Under Florida maturity law, legally mature fruit must contain adequate juice and soluble solids contents, and must have the proper ratio of soluble solids to acid. Furthermore, this ratio must be maintained throughout the fruit season. For this reason, moderate rates of lead arsenate are used on grapefruit for early legal maturity, while low amounts are sprayed to insure passing ratios of the fruit in midseason.

Although lead arsenate sprays generally hasten legal maturity, there are certain other practices which delay it. For example, excessive use of potash in the fertilizer program raises the acid content of grapefruit (10), while improper timing of oil sprays lowers the soluble solids (11). Copper sprays (3), alone or in combination with lead arsenate, tend to raise the acidity of the juice and thus delay legal maturity. Experiments conducted for the past three years at the Citrus Experiment Station indicate that grapefruit from trees sprayed with borax matured somewhat later than fruit from unsprayed trees. The reason for the delay in maturity was found to be an increase in the acid content, which occurred even though no boron-deficiency symptoms of the leaves were apparent.

The purpose of this paper is to show the effect of borax spray on the total acid content and legal maturity of Marsh grapefruit. The grower is also interested in knowing the effect of borax on legal maturity when used in conjunction with lead arsenate sprays.

Experimental

The experiment was carried out during 1950-53 on mature Marsh grapefruit trees

Florida Agricultural Experiment Station, Journal Series No. 223.

grown on rough lemon rootstock in Block XI at the Citrus Experiment Station. The soil in the grove consists of well-drained, Lakeland fine sand with a water-soluble boron content of approximately 0.4 ppm. The grove received a complete fertilizer program with the exception of borax. Irrigation was also used whenever soil moisture was low.

The block of Marsh grapefruit trees was divided into six plots of three rows of five trees each, with single rows of buffer trees among the plots. The north two trees, or a total of six trees, of each plot received borax (36% B_2O_3) at one pound per 100 gal. in a post-bloom spray. Likewise, the south two trees of each plot were used as controls. A single buffer row separated the borax from the no borax treatments. Lead arsenate (26% As_2O_3) at 0, 0.4, and 1¼ lb. per 100 gal. was sprayed three to six weeks following the borax spray to the three rows of each plot. In this way each plot had two trees with and two trees without borax for each lead arsenate level.

Samples of grapefruit were collected at regular intervals beginning in September and ending in February of each year. The total acid content of the juice was found by titration, while the total soluble solids content was measured with a Brix spindle.

Results

Borax Sprays. In general the total acid content of Marsh grapefruit was higher following a borax spray than that of fruit from the control or unsprayed trees (Table 1). The difference in acid was significant with some exceptions within seasons, especially in 1950-51, at which period the acid content in a few cases was the same or less than in fruit from unsprayed trees. Trees treated only with borax produced fruit with the highest acid content of any of the spray treatments. The average total acid content in fruit from the borax sprayed and unsprayed plots was 1.44 percent and 1.38 percent, respectively.

Application of borax, however produced lower ratio values of grapefruit than those of fruit from the control trees (Table 2). This variation was significant only during the last season; furthermore, the lack of significance in the difference in the ratios may be due in part to slight increases of the soluble solids whenever followed by borax sprays only. Even so this variation of the ratios was highly significant on a three year basis.

Lead Arsenate Sprays. As expected, spraying Marsh grapefruit trees with lead arsenate yielded fruit with lower acid content than that of fruit from untreated trees (Table 1). However, there were some exceptions to this general trend in the case of the low rate treatment during 1950-51. On the average the low amount of lead arsenate was about half as effective in decreasing the amount of acid in the fruit as the high rate. Likewise, the 1¼ lb. rate of lead arsenate produced fruit with the lowest acid content of all the treatments. The total acid content of fruit from the lead arsenate (1¼ lb. rate) sprayed and unsprayed plots was 1.26 percent and 1.38 percent, respec-

Table 1.- Summary of the effect of borax and lead arsenate sprays on the total acid of Marsh grapefruit for 1950-53.

Lead arsenate in spray	1950-51*		1951-52*		1952-53**		Three year averages		
	B	-B	B	-B	B	-B	B	-B	Treatment Av.
lb./100 gal.	Per cent total acid in fruit								
0	1.51	1.44	1.35	1.32	1.45	1.37	1.44	1.38	1.41
0.4	1.47	1.42	1.27	1.21	1.37	1.29	1.37	1.31	1.34
1 1/4	1.40	1.38	1.21	1.18	1.29	1.22	1.30	1.26	1.28
Treatment Av.	1.46	1.41	1.28	1.24	1.37	1.29	1.37	1.32	
L.S.D. for boron 5% level	0.04		0.02		0.03		0.018		
1% level	N.S.		0.03		0.04		0.024		
L.S.D. for arsenic 5% level	0.07		0.04		0.05		0.032		0.022
1% level	0.09		0.06		0.07		0.042		0.029

*Average of 6 replicates sampled on 7 dates.

**Average of 6 replicates sampled on 6 dates.

Table 2.- Summary of the effect of borax and lead arsenate sprays on the ratio of Marsh grapefruit for 1950-53.

Lead arsenate in spray lb./100 gal.	1950-51		1951-52		1952-53		Three year averages		
	B	-B	B	-B	B	-B	B	-B	Treatment Av.
	Ratio								
0	5.94	6.11	6.96	7.08	6.42	6.57	6.44	6.59	6.52
0.4	6.05	6.23	7.50	7.74	6.77	7.02	6.77	7.00	6.89
1 1/4	6.42	6.54	7.89	8.02	7.19	7.54	7.17	7.37	7.27
Treatment Av.	6.14	6.29	7.45	7.61	6.79	7.04	6.79	6.99	
L.S.D. for boron 5% level	N.S.		0.17		0.15		0.109		
1% level	N.S.		0.22		0.21		0.144		
L.S.D. for arsenic 5% level	0.26		0.21		0.21		0.188		0.130
1% level	0.35		0.28		0.28		0.249		0.175

tively. During the three seasons of this experiment, the high level of lead arsenate sprays did not reduce the acidity of grapefruit to the same extent as has been reported previously (4).

Marsh grapefruit from trees sprayed only with lead arsenate contained significantly higher ratios than did those of fruit from unsprayed trees (Table 2). This difference in the ratios was consistent with the exception of the low rate of lead arsenate for 1950-51. Trees sprayed with the high level of lead arsenate produced fruit with the highest ratio values.

Borax and Lead Arsenate Sprays. Marsh grapefruit trees that received both borax and lead arsenate sprays produced fruit with a higher acid content than did trees sprayed only with lead arsenate (Table 1). Although there were some exceptions within seasons, this variation was significant. From the standpoint of the amount of acid in the juice, the 1¼ lb. rate of lead arsenate with borax treatment was comparable to the low rate of lead arsenate (compare 1.30 percent and 1.31 percent).

In contrast to the higher amount of acid of the fruit, the borax with lead arsenate spray treatment produced lower ratio values than did those of fruit sprayed only with lead arsenate (Table 2). This decrease in ratio was significant during the last two seasons, but was highly significant on a three-year basis.

Discussion

In Southern Rhodesia (6) orange trees grown under boron-deficiency conditions yielded small amounts of fruit with low soluble solids, acid, and juice content, and high amounts of hard fruit. Addition of borax to the soil had a very marked improvement on yield and fruit quality. This treatment was responsible for doubling fruit production and entirely eliminating hard fruit. The juice, soluble solids, and acid contents were considerably higher than in fruit from untreated trees. Although soluble solids were increased, the ratio values were lowered with subsequent delay in maturity. In the experiment reported in this paper, borax was applied only as a spray. However, there were no indications of larger yield or juice content of grapefruit because of this treatment (2). Of course, the soluble solids content of the fruit was slightly higher than that of untreated fruit, but this small difference was of no practical importance. The total acid of grapefruit was significantly higher than that of unsprayed fruit, while maturity was usually delayed.

When a grower includes borax in the lead arsenate spray, he is naturally interested in knowing whether or not it delays early legal maturity of grapefruit. This spray treatment does delay the date of legally mature fruit by an estimated ten days. In other words, grapefruit trees sprayed with both borax and lead arsenate produced fruit which matured ten days later than fruit from comparable trees sprayed only with lead arsenate. The extent of delay due to borax sprays was about the same whether used alone or in conjunction with lead arsenate.

As the new Florida Citrus Code provides for continuous inspection throughout the picking season, some growers find it necessary to

spray grapefruit trees with low amounts of lead arsenate for legal maturity of the fruit in midseason. These low rates of lead arsenate not only promote legal maturity in midseason but also produce sweeter and more palatable grapefruit than unsprayed fruit (4). In this experiment grapefruit trees sprayed with the low rate of lead arsenate were relatively effective in growing fruit with passing legal standards (7). From the viewpoint of maturity, the low rate produced fruit which matured about 1½ months earlier, while the high rate matured fruit about three months earlier than fruit from unsprayed trees. In other words the 0.4 lb. rate was about half as effective as the 1¼ lb. rate in producing fruit with passing ratios. Of course, the low rate sprays matured grapefruit during the midseason, while the high rate produced early legal maturity in the fall.

It does not follow that borax be omitted from a spray program since it delays maturity. In some groves where boron deficiency is suspected borax sprays should be used to correct this deficiency. It should be used also on trees producing gummed grapefruit. In this study borax sprays tended to reduce but not eliminate the amount of gummed fruit (2). For these two reasons leaving out borax from a spray program cannot be recommended.

Summary and Conclusions

This experiment consisted of a study of the effect of borax and lead arsenate sprays, alone and in combination, on the total acid content and the ratio values of Marsh grapefruit. Borax sprays raised the total acid content and lowered the ratio values and thus delayed the legal maturity of grapefruit. On the other hand lead arsenate sprays decreased the total acid content and increased the ratio values with consequent early maturity of the fruit. The 0.4 lb. rate of lead arsenate was efficient in producing legal maturity during midseason, while the 1¼ lb. rate was effective in hastening legal maturity in the early fruit season. When lead arsenate was used in a spray program with borax, grapefruit matured approximately 10 days later than fruit sprayed only with lead arsenate. In general lead arsenate sprays on Marsh grapefruit produced the highest ratio values of all the treatments, while borax sprays produced the lowest values. Borax and lead arsenate in combination produced fruit with ratios intermediate between these two extremes.

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SPRAY PROGRAMS, VARIETIES, AND WEATHER CONDITIONS IN RELATION TO SIX-SPOTTED MITE AND PURPLE MITE INFESTATIONS

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To be able to forecast scale and mite infestations, it is necessary to know as much as possible about the conditions which govern the severity of such infestations. Investigations into these factors are an important part of the survey and forecasting work in which the writers are engaged (1, 2). Some of the information which has been collected on the occurrence of major infestations was reviewed last year at this meeting (3), but no explanation of any of the conditions affecting the infestation cycles was offered.

Florida Agricultural Experiment Station Journal Series, No. 224.