calcium content and leaf content of potassium, phosphorus, nitrogen, and magnesium, in both Valencia orange and seedless grapefruit samples. Grapefruit leaf samples were higher in potassium and lower in nitrogen than Valencia orange leaf samples. Practical application of this information is discussed.

LITERATURE CITED

EFFECT OF COPPER AND LEAD ARSENATE SPRAYS ON THE TOTAL ACID AND MATURITY OF DUNCAN GRAPEFRUIT

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Lake Alfred

The use of copper compounds in the production of high quality citrus fruit as fungicidal and physiological sprays and as components in the fertilizer is a general practice in Florida. It has been observed frequently that grapefruit trees sprayed with copper sprays matured fruit a little later than fruit from unsprayed trees. This delay in maturity has resulted when copper sprays are used either as a fungicide applied at the post-bloom period, or as a physiological spray applied to dormant trees. Examination of the grapefruit from copper-sprayed trees showed that a higher total titratable acid content was responsible for the delay in maturity.

Fudge and Fehmerling (3) and Cowart and Steams (2) presented data showing the effect of copper fertilizers and sprays used in combinations with other elements on the acid and on the soluble solids to acid ratio in oranges and grapefruit. These authors reported no significant changes in the acid or the ratio values. Marloth and Stofberg (5) working in Africa found no effect of copper carbonate on the total acid of Valencia oranges. Reitz (6) found that an increase in the acid, and consequently a delay in maturity, of Duncan grapefruit resulted from a copper spray application followed by lead arsenate. Camp and Fudge (1) reported that a copper deficiency of oranges resulted in low acid fruit.

The purpose of this paper is to show the effect of copper sprays on the titratable acid content and on the maturity of Duncan grapefruit. Since lead arsenate sprays are used on grapefruit to reduce acidity and thus promote earliness of maturity, it is also of interest to the grower to know the effect of copper sprays when used in conjunction with lead arsenate.
Experimental

This investigation was conducted for three seasons, 1949-51, in a mature commercial Duncan grapefruit grove on rough lemon rootstock near Lake Alfred. The grove was in good condition and was fertilized according to a standard fertilizer program. In the first experiment, the effect of timing of lead arsenate sprays with or without copper was found by spraying lead arsenate in the postbloom spray and at intervals of three and six weeks following this spray. The copper was applied postbloom.

In the second experiment, the effect of timing of copper sprays in the presence or absence of lead arsenate was studied. The copper sprays were applied at dormant, postbloom, and at dormant plus postbloom periods, while the lead arsenate spray was applied three weeks after bloom. All copper sprays contained 3/4 pound equivalent copper per 100 gallons from a neutral copper source, while lead arsenate was used at the rate of 1 1/4 pounds. All sprays contained ten pounds wettable sulfur per 100 gallons. Samples of grapefruit were collected at regular intervals on the average of six times during each season. The total acid in the juice was found by titration, and total soluble solids were measured with a Brix spindle.

Results

Copper Sprays. — In general the total acid content of Duncan grapefruit juice increased following copper sprays (Tables 1, 2), and the increase was evident throughout the sampling season. Application of two copper sprays in the dormant and postbloom periods resulted in no significant differences as compared to a single copper application, although there were some exceptions within seasons (Table 2). There is some indication of an accumulative effect from copper sprays since the increment in acid increased slightly each season from 1949 to 1951 (Table 1).

Application of copper spray significantly decreased the ratio values of the juice (Tables 3, 4). Two applications of copper made no consistent significant differences in the ratio when compared to the single copper sprays (Table 4), although there were significant differences within seasons which were not consistent with the general trend.

Copper and Lead Arsenate Sprays. — When copper and lead arsenate were sprayed on the same trees, the total acid increased as compared to fruit from trees receiving the lead arsenate treatment alone (Tables 1, 2). In the two experiments, the increase in acid was significant, although in the lead arsenate experiment the increase was much smaller. A decrease in the ratio values of the juice was also evident when copper and lead arsenate were sprayed on the same grapefruit trees as compared to the fruit from trees receiving only the lead arsenate spray. This general trend held for both experiments over the three year period.

Table 1

<table>
<thead>
<tr>
<th>Time of lead arsenate spray treatment</th>
<th>1949-50</th>
<th>1950-51</th>
<th>1951-52</th>
<th>Three Year Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cu</td>
<td>-Cu</td>
<td>Cu</td>
<td>-Cu</td>
</tr>
<tr>
<td>No lead arsenate</td>
<td>1.85</td>
<td>1.78</td>
<td>1.87</td>
<td>1.79</td>
</tr>
<tr>
<td>Postbloom</td>
<td>1.80</td>
<td>1.75</td>
<td>1.76</td>
<td>1.72</td>
</tr>
<tr>
<td>Three weeks</td>
<td>1.79</td>
<td>1.77</td>
<td>1.77</td>
<td>1.67</td>
</tr>
<tr>
<td>Postbloom</td>
<td>1.76</td>
<td>1.75</td>
<td>1.76</td>
<td>1.74</td>
</tr>
<tr>
<td>Average of three lead arsenate</td>
<td>1.78</td>
<td>1.76</td>
<td>1.76</td>
<td>1.71</td>
</tr>
<tr>
<td>treatments</td>
<td>L. S. D.</td>
<td>0.05</td>
<td>0.04</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>L. S. D.</td>
<td>0.01</td>
<td>0.06</td>
<td>0.07</td>
</tr>
</tbody>
</table>

*Each treatment consisted of triplicate plots.
1Sampled on five dates.
2Sampled on seven dates.
3Sampled on six dates.
COPPER TIMING. – The time of application of copper sprays resulted in no significant variations in the acid content of the juice in the presence or absence of lead arsenate (Table 2). There were, however, significant differences within seasons. In 1950-51 for example, the acid content of fruit from trees receiving the dormant and copper post-bloom sprays was significantly lower than that of fruit from trees sprayed during the dormant period, (Table 2), whereas the reverse was true in 1951-52. Copper timing in the presence or absence of lead arsenate also resulted in no apparent differences in the ratio values of Duncan grapefruit juice (Table 4). However, as with the acid, there were some variations within seasons between the copper treatments themselves.

LEAD ARSENATE TIMING. – Timing of lead arsenate resulted in significant variations in the total acid, when compared on the three year basis (Table 1). In the absence of copper sprays, the lead arsenate application three weeks after bloom resulted in the acid content being significantly lower than that resulting from the spray applied six weeks after bloom. There were also variations within seasons but no consistent pattern of variation was evident.

Timing of lead arsenate sprays affected the ratio values of the grapefruit juice (Table 3). The most outstanding difference was observed in the ratio of fruit from trees receiving the postbloom spray in the absence of copper, where significantly higher values were obtained as compared to the two later periods. The presence of copper sprays had some bearing on the effectiveness of lead arsenate, but these differences were generally very small (Table 3). There were some significant variations which were not consistent within seasons.

Discussion

In Florida, maturity regulations in effect since 1949 set minimum standards for the total soluble solids, juice content, and total soluble solids to total acid ratio which must be met before grapefruit can be shipped commercially. Since the soluble solids and the juice volume (4) are but slightly affected by lead arsenate sprays, the ratio values, and the consequent effect on time of legal maturity attainment of grapefruit are the chief concern in this paper.

Low ratio values usually limit commercial shipment of grapefruit early in the season. To improve the ratio, lead arsenate sprays are widely used to lower the acid content and advance the time of legal maturity. However, the effect of lead arsenate sprays in producing early legal maturity is not always constant, and varies with the time and rate of application, season or weather changes, and other unknown factors. In actual practice, the effect of lead arsenate sprays on the time of legal maturity attainment of grapefruit may vary considerably among groves and seasons. Although generally application of lead arsenate sprays hastens maturity, complete failures have been observed. All the reasons for these differences are not known.

In the production of grapefruit, certain cultural practices such as improper timing of

<table>
<thead>
<tr>
<th>Time of copper spray treatment</th>
<th>1949-50</th>
<th>1950-51</th>
<th>1951-52</th>
<th>Three Year Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As</td>
<td>-As</td>
<td>As</td>
<td>-As</td>
</tr>
<tr>
<td>No copper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dormant</td>
<td>1.63</td>
<td>1.77</td>
<td>1.65</td>
<td>1.84</td>
</tr>
<tr>
<td>Postbloom</td>
<td>1.75</td>
<td>1.83</td>
<td>1.76</td>
<td>1.99</td>
</tr>
<tr>
<td>Dormant and postbloom</td>
<td>1.76</td>
<td>1.84</td>
<td>1.71</td>
<td>1.93</td>
</tr>
<tr>
<td>Average of three copper</td>
<td>1.73</td>
<td>1.87</td>
<td>1.76</td>
<td>1.90</td>
</tr>
<tr>
<td>Percent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Each treatment consisted of triplicate plots.
†Sampled on five dates.
*Sampled on seven dates.
¶Sampled on six dates.
oil sprays, excessive use of potash, and other factors are known to retard maturity. Copper sprays, even where no apparent copper deficiency existed, were found to retard the time of legal maturity by increasing the total acid in the grapefruit juice. The delay of legal maturity due to the use of copper was consistent in these experiments.

The extent to which legal maturity was delayed with the use of copper sprays may be illustrated by comparing the effect of lead arsenate sprays used in the presence and absence of copper sprays. Lead arsenate spray alone produced an increase of 0.33 ratio units, while the addition of copper spray reduced the effectiveness of the lead arsenate by 0.16 units, or an approximate reduction of 50 percent. In other words the effectiveness of the lead arsenate spray was reduced nearly one-half where a copper spray was also included in the program.

The number of days delay in maturity due to copper cannot be stated exactly, but it was estimated from the daily increase in ratio that application of copper to lead arsenate sprayed grapefruit trees, did delay the probable date of maturity by approximately two weeks. Use of copper alone, however, delayed maturity by approximately five weeks. This delay was of considerable magnitude in a single grove which produced grapefruit with relatively high total acid as compared to other Florida groves (4). However, the authors believe that in most groves, the average delay would not be this long since the actual decrease in ratio due to copper was rather small.

Although copper sprays have been shown to delay legal maturity of grapefruit, it does not follow that these sprays should be omitted from the grapefruit spray program. Melanose is one of the important fungus diseases on both fruit and leaves of grapefruit trees, and omission of the postbloom melanose spray will usually result in loss due to grade. Especially in the light of the new grade regulations, omission of copper sprays as a fungicide cannot be recommended, since the delay in maturity due to copper applications may be less

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**TABLE 3**

Effect of Timing of Lead Arsenate Spray With or Without Copper on the Ratio Values of Duncan Grapefruit Juice for Three Seasons.

<table>
<thead>
<tr>
<th>Time of copper arsenate spray treatment</th>
<th>1949-50</th>
<th>1950-51</th>
<th>1951-52</th>
<th>Three Year Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cu -Cu</td>
<td>Cu -Cu</td>
<td>Cu -Cu</td>
<td>Cu -Cu</td>
</tr>
<tr>
<td>No lead arsenate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postbloom</td>
<td>5.07</td>
<td>5.56</td>
<td>5.44</td>
<td>5.94</td>
</tr>
<tr>
<td>Three weeks postbloom</td>
<td>5.48</td>
<td>5.68</td>
<td>5.95</td>
<td>6.15</td>
</tr>
<tr>
<td>Six weeks postbloom</td>
<td>5.42</td>
<td>5.59</td>
<td>5.99</td>
<td>6.34</td>
</tr>
<tr>
<td>Average of three lead arsenate treatments</td>
<td>5.54</td>
<td>5.58</td>
<td>6.00</td>
<td>6.02</td>
</tr>
</tbody>
</table>

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**TABLE 4**

Effect of Timing of Copper Spray With or Without Lead Arsenate on the Ratio Values of Duncan Grapefruit Juice for Three Seasons.

<table>
<thead>
<tr>
<th>Time of lead arsenate spray treatment</th>
<th>1949-50</th>
<th>1950-51</th>
<th>1951-52</th>
<th>Three Year Averages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As -As</td>
<td>As -As</td>
<td>As -As</td>
<td>As -As</td>
</tr>
<tr>
<td>No copper</td>
<td>5.98</td>
<td>5.50</td>
<td>6.33</td>
<td>6.70</td>
</tr>
<tr>
<td>Dormant</td>
<td>5.86</td>
<td>5.35</td>
<td>5.94</td>
<td>6.21</td>
</tr>
<tr>
<td>Postbloom</td>
<td>5.54</td>
<td>5.31</td>
<td>6.08</td>
<td>5.37</td>
</tr>
<tr>
<td>Dormant and postbloom</td>
<td>5.73</td>
<td>5.16</td>
<td>6.12</td>
<td>5.47</td>
</tr>
<tr>
<td>Average of three copper treatments</td>
<td>6.04</td>
<td>5.27</td>
<td>6.05</td>
<td>5.35</td>
</tr>
</tbody>
</table>

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L. S. D. 0.05 0.16 0.22 0.20 0.17 0.10 0.10 0.06 0.04
L. S. D. 0.01 0.21 0.26 0.23 0.13 0.08 0.08 0.04 0.04
serious than extensive loss by lowering of grade due to severe melanose damage.

SUMMARY AND CONCLUSIONS

The experiments reported in this paper consisted of a study of the effect of timing of copper and lead arsenate sprays, alone or in combination, on the total acid and ratio of fruit from mature Duncan grapefruit trees. Copper sprays when compared to no spray treatments increased the total acid, decreased the ratio and thus delayed the time of legal maturity attainment of grapefruit. Lead arsenate lowered the total acid and increased the ratio resulting in early maturity. However, when lead arsenate was used in a spray program which included copper, there was some delay in maturity as compared to lead arsenate applications used in the absence of copper. In other words, the effectiveness of lead arsenate in producing early maturity was somewhat decreased by copper sprays.

Timing of copper sprays apparently had no effect on the total acid or the ratio whether the copper was sprayed alone or sprayed with lead arsenate. Time of application of lead arsenate did affect the ratio values, since trees sprayed at postbloom produced grapefruit with the highest juice ratio. The order of effectiveness of the treatments in producing high ratio values—and consequently earliness of maturity of grapefruit—was lead arsenate, copper plus lead arsenate, no treatment, and copper alone.

LITERATURE CITED


METHOD OF APPLYING INSECTICIDES WITH DIFFERENT SPRAY MACHINES

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R. B. Johnson and E. J. Deszyck
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Lake Alfred

During the past few years many experiments, comparing dilute and concentrate sprays, have been carried on with the Speed Sprayer and Hardie Mist sprayers. Results of the early work were reported by Griffiths, et al., (1), in 1950. In 1951 Stearns et al. (2) reported the results of further work on the comparison of dilute and concentrate sprays. They also reported the results of dilute and concentrate sprays as applied by a commercial caretaker. In general, satisfactory results were obtained with most of the spray materials in both dilute and concentrate forms.

During the 1951-52 spray season concentrate sprays were again compared with dilute sprays. In addition, a preliminary test was made with concentrate sprays applied by the Myers Silver Cloud Sprayer and the Model 40 Speed Sprayer. These machines were compared with the Hardie Mist Sprayer and the Model 36L Speed Sprayer in one experiment on purple scale and rust mite control.

The work reported here deals with experiments conducted from October 15, 1951, through October 15, 1952. In all cases the sprays were applied at one-eighth of the normal gallonage and in most cases six times the concentration of materials normally used.

RESULTS

Comparison of Spray Machinery — On August 6, 1952, concentrate parathion — wettable sulfur sprays were applied with the following spray machines:

1. Model 40 Speed Sprayer, single head with a volute.
2. Model 40 Speed Sprayer, double head.
3. Model 36L Speed Sprayer, single head with a volute.