EFFECT OF VARYING AMOUNTS OF POTASH ON YIELD AND QUALITY OF VALENCIA AND HAMLIN ORANGES

John W. Sites and Edward J. Deszyck

Florida Citrus Experiment Station
Lake Alfred

The advent of "frozen concentrate" has resulted in new problems for the Florida citrus grower. He may now decide to grow fruit expressly for concentrate use or try to produce fruit acceptable to any market outlet. This decision is perhaps more important to growers having Valencia oranges, but the same choice also applies to a certain extent for those who grow other varieties.

As long as the grower was concerned only with meeting the minimum standards required for the shipment of fresh fruit his problems were simplified; for this was critical only during the early part of the season. Once the crop reached legal maturity there was little interest in fruit quality for the remainder of the season. With fruit for the frozen concentrate market, a different situation prevails. Removing water from the juice in frozen concentrate preparation is costly, and producers of concentrate can afford to pay more for high-soluble-solids-content juice. In addition to the economy of plant operation, plant capacity is also increased by using higher solids juice and the general quality of the product is improved. All of these factors have focused attention on fruit quality as a prime objective in Florida citrus growing.

The importance of the fertilizer program on the quality of citrus fruit produced was demonstrated by early experiments with magnesium, zinc, copper and manganese. Subsequent work with phosphorus and potassium further emphasized the need for proper use of fertilizers. Fruit characteristics associated with a deficiency of potassium have been described by Bahrt and Roy (1) and by Roy (6), both working under Florida conditions. The recently published work of Reuther and Smith (5) has added to a better understanding of the relationship between nitrogen, potassium and magnesium. The work of Chapman et al (2,3) and that of Haas (4) have also been valuable in outlining the effect of potassium levels maintained under more carefully controlled conditions. Most of the experimental work conducted in Florida with potassium has been for comparatively short periods of time and largely only with Valencia oranges. The present paper is a report of progress of an experiment involving both Valencia and Hamlin oranges which has been in progress over a period of about 12 years.

Experimental Methods

Trees of Hamlin and Valencia oranges were set in new ground in 1937 for the above experiment. The soil is rather typical Lakeland fine sand. So far as is known, it had never been used as agricultural land. Plots were laid out containing eight trees of each variety, with duplicate plots for each treatment. Differential potash treatments were started in May, 1939, and included 0, 2, 5, 8, 10, 12 and 16 percent potash in a basic 4-6-x-4-1-1 mixture. The rate of application of the fertilizer has varied throughout the years, having been increased gradually as the trees increased in size. At the present time they receive 15 pounds of the above mixture per tree, per application, applied in February, June and October. Since 1948, only zinc has

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**Fig. 1.** Effect of varying the rate of potash supplied on the soluble solids content of Valencia and Hamlin oranges.
been applied in the dormant spray, but previously this spray also included copper and manganese.

Throughout the period of the experiment, nitrogen has been supplied as Uramon, ammonium sulfate, sodium nitrate, castor pomace, bone meal, tankage and milorganite; phosphate has been supplied as triple superphosphate, bone meal and milorganite; and potassium either as potassium sulfate or potassium chloride. (A very limited amount of potassium was also supplied in the castor pomace, but this amounts to only a very small percentage of the total potassium supply).

Sampling for fruit quality measurement was done at intervals of approximately three weeks, beginning usually the latter part of September and continuing through January for Hamlin oranges, while the Valencia oranges were sampled from February through May of each year.

All of the results in this paper are based upon sized fruit samples. Sampling by this method was used in preference to random sampling so that the effect of potassium on size of fruit would be eliminated, and so that differences in fruit quality which might be found would more nearly represent the effect of potassium itself on fruit characteristics, rather than the effects of potassium on size of fruit and the resultant effect of size on fruit quality.

Data on external quality are expressed as averages of all fruit harvested from plots from 1949 through 1951 for Hamlin and from 1948 through 1950 for Valencia oranges. Data are presented showing the relation of the various factors studied to the percentage potash in the fertilizer mixture, as well as to the pounds of K₂O supplied per box of oranges produced. Recently there has developed so much interest in the idea of supplying potash on a pounds-per-box basis that it was felt desirable to include these calculations in the presentation.

**Results**

**Internal Fruit Quality** — Fruit quality data are presented as a series of curves showing the trends of results as represented by analyses made during the past five-year period. These curves are based on the seasonal averages taken during the period from 1947 through 1951 for Hamlin and 1947 through 1950 for Valencia oranges. Each point of the curves represents a total of more than 1800 fruits. The curves are used primarily to show general trends of the data rather than as a precise means of presenting the data.

**Total Soluble Solids** — The soluble solids content of both varieties of oranges decreased slightly as the amount of potash supplied in the fertilizer increased (Fig. 1). The highest soluble-solids content for each variety occurred where 2% potash was applied (equivalent to 0.15 and 0.28 pounds of K₂O per box for Hamlin and Valencia oranges, respectively). Soluble solids decreased gradually beyond this point as the rate of potash application increased. Thus high rates of potash application depress to some extent the development of soluble solids content of the juice.
Fig. 4. Effect of varying the rate of potash supplied on the percentage of U. S. No. 1 and No. 2 grade Hamlin oranges produced.

Percent Titratable Acid — Both varieties of oranges harvested from trees receiving high potash treatments were found to contain a slightly higher percentage of titratable acid, Fig. 2. This tendency for titratable acid to increase as the potash application increased was more pronounced in Hamlin than in Valencia oranges. An increase in the rate of application above 8% K₂O in the mixture appeared to result in little or no increase in acid content for either variety.

Ratio (Soluble Solids/Titratable Acid)—The trend for the ratio of the juice of Hamlin and Valencia oranges to decrease as the rate of potash application in the fertilizer increased is shown in Fig. 3. These data indicate that high rates of potash application tend to reduce the juice ratio and delay legal maturity.

Juice Content — The juice content of Hamlin orange has thus far been unaffected by the rate of application of potash, but Valencia oranges were influenced to some extent. With the latter variety, the percentage of juice by weight and the volume of juice per fruit tended to decrease to some extent as the rate of potash application increased.

Ascorbic Acid (Vitamin C) — Results to date show a slight, gradual increase in the vitamin C content of the juice of both varieties to be correlated with increases in the amount of potash supplied.

Size of Fruit — When the 1951-52 crop of Hamlin and Valencia oranges was harvested, random samples were collected from packing-house bins to ascertain the effect of size of fruit on juice quality. These fruits were all collected from trees that received 8% potash in the fertilizer. Although the amount of potash and other nutritional factors supplied were constant for both varieties, it is to be observed that the soluble solids and other juice constituents varied over a wide range as the sizes changed (Table 1). The effect of size on quality is an inverse relationship, with the desirable juice characteristics decreasing as the size increases.

External Fruit Quality — The effect of rate of potash application on the percentage of U. S. No. 1 grade fruit produced is shown in Figs. 4 and 5. The grade of Hamlin oranges produced was much less affected by the rate of potash application than that of Valencia. The percentage of U. S. No. 1 grade Valencia oranges produced decreased sharply as the rate of potash application increased up to about 8% K₂O in the mixture (1.20 pounds of K₂O per box of fruit produced), but beyond this rate there was no consistent change. The percentage of U. S. No. 1 Hamlin oranges, on the other hand, was highest at the 2% and 5% K₂O applications (0.15 and 0.39 pounds of K₂O per box of fruit produced) and decreased as the rate of application decreased below 2% or increased above the 5% rate.

It is apparent from the curve presented in Fig. 5 that the grade of Valencia oranges is affected to a considerable extent by the rate of potash application. The chief grade-low-
Table 1.
Effect of Size of Fruit on Juice Characteristics of Hamlin\(^1\) and Valencia\(^2\) Oranges.

<table>
<thead>
<tr>
<th>Size</th>
<th>Percent of Juice by weight</th>
<th>% Soluble Solids</th>
<th>% Titratable Acid</th>
<th>% Soluble Solids Ratio</th>
<th>% Acid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hamlin</td>
<td>Valencia</td>
<td>Hamlin</td>
<td>Valencia</td>
<td>Hamlin</td>
</tr>
<tr>
<td>324</td>
<td>54.11</td>
<td>54.28</td>
<td>10.95</td>
<td>10.30</td>
<td>.67</td>
</tr>
<tr>
<td>288</td>
<td>53.38</td>
<td>57.37</td>
<td>10.25</td>
<td>12.60</td>
<td>.70</td>
</tr>
<tr>
<td>250</td>
<td>53.01</td>
<td>56.71</td>
<td>10.10</td>
<td>12.19</td>
<td>.69</td>
</tr>
<tr>
<td>216</td>
<td>52.07</td>
<td>53.77</td>
<td>9.55</td>
<td>11.60</td>
<td>.66</td>
</tr>
<tr>
<td>176</td>
<td>49.47</td>
<td>51.58</td>
<td>8.75</td>
<td>10.90</td>
<td>.64</td>
</tr>
<tr>
<td>150</td>
<td>47.52</td>
<td>51.72</td>
<td>8.40</td>
<td>10.49</td>
<td>.66</td>
</tr>
<tr>
<td>126</td>
<td>45.88</td>
<td>47.73</td>
<td>7.95</td>
<td>9.90</td>
<td>.60</td>
</tr>
</tbody>
</table>

1 Hamlin oranges harvested January 24, 1952.
2 Valencia oranges harvested June 9, 1952.

Rind Color — The percent of green color in the rind of Valencia oranges was measured on samples picked June 17, 1952 from the trees in the potash plots. These data showed a highly significant positive correlation (r = .780) between the percentage K\(_2\)O in the fertilizer supplied to the trees and the percentage of green color in the rind of the fruit produced; trees supplied with large amounts of K\(_2\)O tended to produce a higher percentage of green, poorly colored fruits.

Creasing — When the 1951-52 Hamlin orange crop was harvested it was observed that much of this fruit was creased. As the fruit went through the packinghouse, randomly selected samples were collected from each plot and the amount of creased fruit ascertained. It was found that the percentage of creased fruit decreased sharply as the percentage of potash in the mixture increased to approximately 8% K\(_2\)O, but that potash applications in excess of 8% had little effect on creasing. Where no potash was supplied, approximately 22% of the fruit produced was thrown out of grade due to creasing. Figure 7 shows the effect of rates of potash application on the incidence of creasing in Hamlin oranges during a single season.

Table 2.
Average Amount of Potash Supplied in Fertilizer and Removed in Crop

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Avg. Boxes of Fruit per Year per Tree</th>
<th>Avg. Pounds of K(_2)O Supplied per Box per Yr.</th>
<th>Approx. Avg. Pounds K(_2)O Removed/Box/Yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hamlin</td>
<td>Valencia</td>
<td>Hamlin</td>
</tr>
<tr>
<td>0% K(_2)O</td>
<td>2.00</td>
<td>1.72</td>
<td>.14</td>
</tr>
<tr>
<td>2% K(_2)O</td>
<td>3.25</td>
<td>2.00</td>
<td>.19</td>
</tr>
<tr>
<td>5% K(_2)O</td>
<td>3.50</td>
<td>2.00</td>
<td>.30</td>
</tr>
<tr>
<td>8% K(_2)O</td>
<td>3.00</td>
<td>1.80</td>
<td>.80</td>
</tr>
<tr>
<td>10% K(_2)O</td>
<td>3.27</td>
<td>1.94</td>
<td>.93</td>
</tr>
<tr>
<td>12% K(_2)O</td>
<td>2.91</td>
<td>1.41</td>
<td>1.25</td>
</tr>
<tr>
<td>16% K(_2)O</td>
<td>2.98</td>
<td>1.69</td>
<td>1.63</td>
</tr>
</tbody>
</table>
Production—In order that a fair representation of the effect of varying potash fertilization on the production of Hamlin and Valencia oranges may be presented, production data during the six-year period from 1945 through 1950 are given in Table 2. These data show that the yield decreased where no potash was supplied, but no significant differences in yield have been found to be related to reasonable rates of potash application. Both varieties show a tendency for the yield to decrease to some extent as a result of the very high rates of application.

Discussion

The results presented in this paper show that the supply of potassium may have a pronounced effect on fruit quality. However, potassium is only one of many factors which affect fruit quality and cannot be considered a panacea for all quality troubles. Under certain conditions it is reasonable to assume that a reduced supply of potash will result in the production of better quality fruit, but it must also be remembered that potassium is an essential element for plant growth. A continued inadequate supply will result in a decreased yield and an increased percentage of small fruit.

The increase in soluble solids content of fruit attributed to a reduced supply of potash (based on data obtained from these experiments) appears to be due to a large extent to the effect of potassium on size of fruit produced. The effect of fruit size on quality is brought out clearly in Table 1. It becomes increasingly evident, from these data and from Fig. 1, that the optimum effect of a lower supply of potash on fruit quality will not be obtained until there is an appreciable reduction in the average size of fruit produced.

The question of markets and varietal characteristics, therefore, becomes of importance. Valencia oranges are most acceptable as fruit for concentrate production. This variety also often shows a tendency to bear light crops and produce a high percentage of large-size fruit. For these reasons, a minimum potash supply for this variety would appear to be logical. Smaller size fruit would be to the growers advantage if sale to concentrate plants is anticipated. Such fruit would also be largely acceptable on the fresh fruit market. The external quality of Valencia oranges would also improve (Fig. 5) in many cases if the potash supply was maintained at a comparatively low level.

However valid these arguments for maintaining a minimum potash supply for Valencia oranges may seem, they cannot be applied with the same logic to a variety like Hamlin oranges. The Hamlin orange is most valuable as a fresh fruit variety and, in addition, shows a marked tendency to produce a high percentage of small size fruit. Limiting the potash supply under these circumstances would appear to be the wrong approach. Small sizes are not accepted on the fresh fruit market and an inadequate supply of potash to Hamlin oranges may easily reduce the marketable crop by 10% to 15%.

In interpreting the data presented in this paper, the reader’s attention is called to the fact that the trees included in this experiment are young trees. Most of the production history has thus been obtained during the period when both trees and crops of fruit produced were comparatively small. Because the trees were young, they were fertilized proportionately heavier than trees in a bearing grove would have been.

The data obtained from the experiment to date indicate the amount of potassium supplied to Valencia trees from the 2% K2O treatment has resulted in production of fruit of the most desirable size and quality for this variety. The 2% treatment, at the poundage used, was sufficient to bring young trees into bearing without noticeable evidence of potassium de-

![Fig. 6. Effect of varying the rate of potash supplied on the average diameter of Hamlin and Valencia oranges produced.](image-url)
SITES AND DESZYCK: POTASH

Although potassium has been reduced to such an extent in these plots that native cover plants fail to grow and the soil is mostly bare. The average amount of potash supplied to Valencia oranges receiving the 2% potash treatment has been .31 pounds for each box of fruit produced during the six year period in question, (Table 2).

Analyses of whole fruit from trees receiving this treatment showed that the fruit contained potassium approximately equivalent to 0.23 pounds of potash per box. The ratio of potash supply to potash removal therefore has been 0.31/0.23 or approximately 1.35 to 1. Although this rather narrow ratio has apparently been adequate for young trees, it is likely too narrow for a mature bearing grove. Root systems of the trees in these experimental plots are still expanding and are probably extracting potassium from the soil over and above that supplied from the fertilizer mixture. Over any appreciable length of time, it would not seem desirable to reduce the ratio of potash supply to removal for bearing orange trees lower than approximately 1.5 to 1, based on a reasonable production capacity of the tree. This ratio may be insufficient for continuous operation in old heavily bearing groves.

Based on an average potash content per box of 0.23 to 0.25 pounds for Valencia oranges, this would mean a yearly supply of from 0.35 to 0.37 pounds of K₂O per box of anticipated fruit. Such a rate of supply of potash would also appear satisfactory for Hamlin orange trees; since, because of the lower potassium content of Hamlin oranges, such a rate of application would result in a potash supply to removal ratio of approximately 1.75 to 1. It would of course be necessary to increase accordingly the total quantity of potassium supplied to Hamlin trees, by comparison to Valencia trees of the same age and rootstock, because of the greater production capacity of Hamlin trees.

It should be made clear that the 2% treatment as discussed in some detail in this paper does not in any way represent a recommendation of 2% potash in the fertilizer program. The percentage potash included in the formulas in this experiment mean very little except as a way of ascertaining the amount of potassium supplied over a period of time. A formula containing 1% K₂O may be quite adequate, or one containing 10% K₂O may be inadequate — depending largely upon the number of pounds of the mixture used, the bearing capacity of the tree and the soil upon which they are growing.

Only time can ascertain whether the guides as suggested concerning rates of potash supply for Hamlin and Valencia oranges are adequate. These data are most applicable of course for young orange trees, whereas the estimates included for bearing groves will have to be verified by continued experimentation and observation.

**Summary**

A field experiment conducted on young Hamlin and Valencia orange trees, showing the effect of varying potash applications on the quality and quantity of fruit produced, is presented. The effects of potash variations from 0 percent to 16 percent, included in a 4-6-x-4-1 fertilizer mixture on the percent soluble solids, percent titratable acid, and ratio of the juice, as well as on the external grade, size, and yield of fruit are shown. The percentage soluble solids and ratio of the juice, as well as the incidence of creasing and percent of U. S. No. 1 grade fruit produced, were found to decrease as the rate of potash supply increased; whereas the percent titratable acid of the juice and average diameter of fruit increased as the rate of potash supply increased. The yield of fruit produced was not affected
by the rate of potash supply except at the very low and high levels.

LITERATURE CITED

OBSERVATIONS ON COVERAGE OF SPRAYS IN RELATION TO INSECT CONTROL IN COMMERCIAL OPERATIONS

Arthur F. Mathias
Entomologist,
Superior Fertilizer Company
Tampa

Today, in Florida citrus culture, there are employed many different types of sprayers, serviced and operated by a large army of workers with one object in mind — to get sufficient spray coverage to insure maximum control of insect pests. To be sure there are other factors that influence insect control such as weather and timing but the one that exerts the greatest influence is spray coverage. Fortunately it is also the one over which we have the greatest degree of control. It is therefore of paramount importance that each program be so carried out that best coverage is obtained.

During the past several years many individual spray operations by commercial operators have been checked and graded by using a check sheet designed for either a pressure sprayer or one of the mechanical sprayers now in use. However, except for a few instances most all of the work was done with the Speed Sprayer. The check sheet contained the following items:

(1) The Grove
   Size trees
   Variety
   Setting
   Condition of trees
   Insects to be controlled
   Degree of infestation

(2) Pressure Sprayer
   Pressure
   Condition of agitators
   Size disc
   Type gun

(3) Mechanical Sprayer
   Pressure
   Rate of operation
   Condition of agitators — condition of supply unit
   R. P. M.
   No. of nozzles
   Size nozzles.

(4) The Mixture
   Kind of mixture — Condition of mixture
   How mixed
   Gallons per tree
   Coverage

(5) Weather conditions
   Temperature
   Wind
   Cloud coverage

Each of the items applicable to the particular operation was filled out and if the actual operation differed from what was believed to be correct it was so entered. In all cases remarks were entered to indicate whether the coverage was felt to be sufficient. Approximately three to four weeks later each grove was checked to determine the degree of control.

Some very interesting information has been gotten from these checks plus some vivid illustrations that show the desirability of getting good spray coverage. On the initial check of Speed Sprayers it was found that sixty-seven per cent (67%) were traveling too fast for satisfactory application of the particular