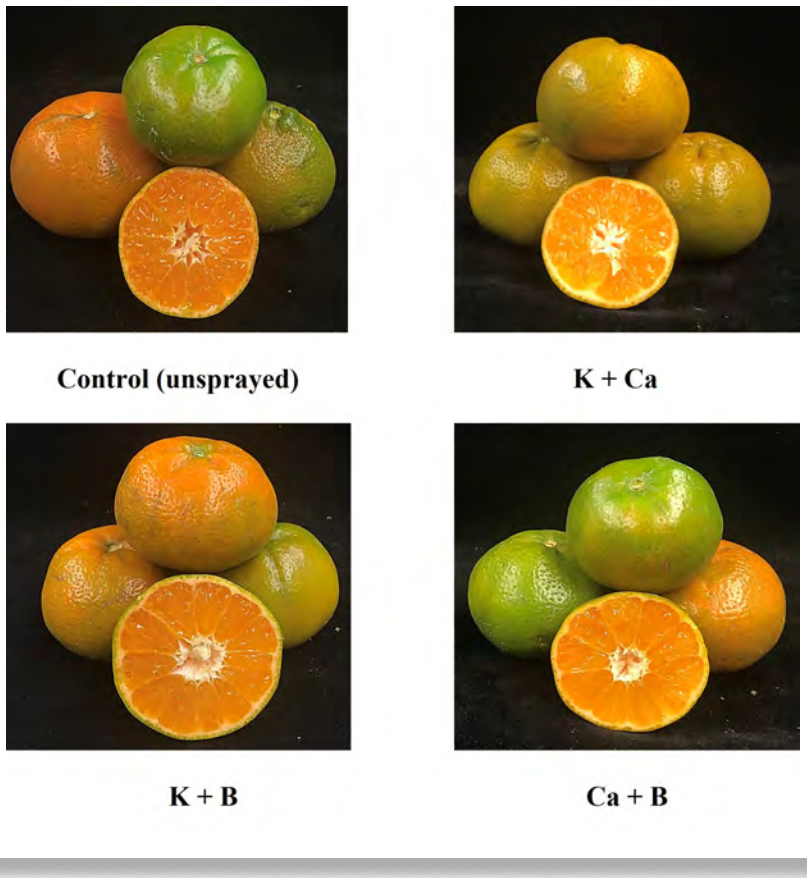

Figure 1. External and internal appearance at harvest of fruit from HLB-infected Tango trees as affected by nutrient treatments (control, K + Ca, K + B and Ca + B)

Foliar potassium and boron can improve mandarin yield and quality

By Tripti Vashisth and Faisal Shahzad

Mandarin production has been increasing in Florida since some mandarin varieties can potentially withstand HLB better than sweet orange varieties. Mandarin varieties such as Tango are popular among growers. However, Florida weather poses challenges for the external fruit quality; the peel color is often not satisfactory. Warm night temperatures in fall inhibit chlorophyll breakdown, which leads to poor peel color development.

To further complicate matters, HLB can result in poor internal and external fruit quality. HLB fruit is known to be small, lopsided, low in sugar and poor in flavor. In addition, the peel color remains green and blotchy. However, good quality mandarins can often be sold at premium value, thus making them potentially profitable to grow.

In the last decade, great progress has been made with citrus nutrition. HLB-affected trees require more nutrients than healthy trees. Possibly, nutrients are utilized constantly in the plant defense response. Currently, providing constant and all-nutrient fertilizer to the trees throughout the growing season is recommended.

The soil-applied fertilization method is the most efficient and suitable method of fertilization for long-term effects. Nonetheless, a supplemental foliar fertilization can be beneficial as foliar nutrients are readily available to the tree canopy (leaves or developing fruit) where it is needed. Developing fruit are a large sink of nutrients and energy; therefore, foliar fertilization can allow for better fruit development.

Literature supports that potassium, calcium and boron can improve fruit quality in different fruit crops. Potassium increases water uptake and sugar

Table 1. Tree yield and other parameters of fruit from HLB-infected Tango trees as affected by nutrient treatments (control, K + Ca, K + B and Ca + B).

Parameter	Control	K + Ca	K + B	Ca + B
Fruit yield (pounds/tree)	105±33 b	110±13 b	182±60 a	92±54 b
HLB-asymptomatic fruit (%)	70 b	75 ab	82 a	70 b
HLB-symptomatic fruit (%)	30 a	25 ab	18 b	30 a
Fruit size (%) < 2.1 inches	7 a	4 ab	2 b	5 ab
Fruit size (%) 2.1-2.5 inches	41 a	33 ab	24 b	38 ab
Fruit size (%) 2.5-3 inches	43	56	53	51
Fruit size (%) > 3 inches	9 b	7 b	21 a	6 b
Fruit weight (grams)	118 b	123 b	137 a	117 b
Peel thickness (millimeters)	2.0 b	2.1 ab	2.2 a	2.1 ab
Firmness (N)	16.0 c	18.6 a	16.5 b	17.8 ab

Different letters after the numbers indicate statistically significant differences among treatments.

translocation while also accelerating chlorophyll degradation. Boron contributes to fruit set and acts as a carbohydrate transporter through sieve tubes of phloem vessels. Calcium is an important component of the cell wall and can improve the integrity of fruit peel. However, the effect that supplemental foliar potassium, calcium and boron (directed at the fruit) has on the quality of HLB-affected mandarins has not previously been evaluated.

> *For two consecutive years, foliar K + B yielded approximately 80 pounds more fruit per tree than the control.*

STUDY SETUP

Ten-year-old Tango grafted on Swingle trees exhibiting mild HLB symptoms were used in a two-year study (2018 and 2019). All the trees received the same soil-applied fertilization program each year. Supplemental nutritional foliar treatments were applied at 45-day intervals six times (in April, May, June, September, October and November). This application pattern encompassed all the fruit growing stages.

All the foliar nutritional treatments included a surfactant (Induce, 0.15%) to improve nutrient absorption. The treatments were as follows:

1. Control (no spray)
2. Potassium (K, 40 pounds/acre/year) + Calcium (Ca, 60 pounds/acre/year)
3. Potassium (K, 40 pounds/acre/year) + Boron (B, 5 pounds/acre/year)
4. Calcium (Ca, 60 pounds/acre/year) + Boron (B, 5 pounds/acre/year)

RESEARCH RESULTS

For two consecutive years, foliar K + B yielded approximately 80 pounds more fruit per tree than the control (Table 1). Yields in the other two treatments were not statistically different from the control. At harvest, when fruit was categorized based on HLB symptoms (small and lopsided), the K + B treatment had the lowest (18%) HLB-symptomatic fruit in comparison to the control and Ca + B treatment, which both had 30% HLB-symptomatic fruit.

Based on fruit diameter classes, the K + B treated fruit had the lowest number of small fruit and the highest number of fruit that were larger than 3 inches. Across all the treatments, the majority of the fruit was in the 2.1-3 inches category, but the distribution varied. The individual fruit weight was highest for the trees receiving the K + B treatment.

Large fruit often has lower soluble solids as a result of the dilution effect. Nonetheless, no differences in soluble solids were found among the four treatments. The soluble solid content in K + B treated fruit and the control was the same. Acid (titratable acidity) was marginally lower for the K + B treatment than the control and Ca + B treatment. However, the sugar-to-acid ratio remained unchanged for all of the treatments.

Fruit firmness is an important parameter for the fresh market because buyers often consider a fruit's firmness an indicator of freshness. K +

Ca treated fruit showed the highest firmness when compared to the control. The other treatment including calcium, Ca + B, ranked second for fruit firmness, followed by the K + B treatment. Untreated fruit had the lowest firmness.

Figure 1 (page 10) shows external and internal appearance of fruit at harvest. Interestingly, the K + B treatment resulted in more uniform, orange-colored peel development, thus eliminating the need for degreening (postharvest ethylene) treatment. Ca + B retained green color more than the control, suggesting fruit firmness and peel color are linked. The internal pulp color was not affected by any of the treatments.

SUMMARY FINDINGS

In summary, the K + B treatment resulted in higher fruit yield, large fruit diameter and fewer HLB-symptomatic fruit in comparison to the control. Moreover, the increase in fruit size did not dilute the sugars, and the internal fruit quality was unaltered. The most prominent effect of the K + B treatment was on peel color development.

These findings suggest that K + B combination fertilizer (foliar applied) can substantially improve fruit growth when directly targeted to growing fruit. Supplementing soil-applied fertilizer with foliar potassium and boron can be a quick and readily applicable strategy to improve the quality and productivity of trees.

Historically, potassium has been known to increase fruit size, fruit weight, peel thickness and solids per acre in sweet oranges (refer to Nutrition of Florida Citrus Trees at edis.ifas.ufl.edu/publication/SS478). It is suggested to not use foliar calcium on any fruit where an orange-colored peel is desirable since foliar calcium may slow down color development. However, if physiological fruit softening is an issue, foliar calcium fertilization can be explored as an alternative.

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