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EFFICACY STUDIES ON PREBLOOM CANOPY APPLICATIONS OF BORON AND/OR UREA TO 'HASS' AVOCADOS IN CALIFORNIA

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Abstract

Results of four bloom studies (two glasshouse and two field experiments) demonstrated the efficacy of applying boron or urea sprays to 'Hass' avocado inflorescences during early expansion (cauliflower stage) but prior to full panicle expansion and anthesis. Anatomical analysis of the flowers provided evidence that the boron prebloom spray increased the number of pollen tubes that reached the ovule ($p<0.05$) and also increased ovule viability, but to a lesser degree than urea. The urea prebloom spray increased ovule viability compared to boron-treated or untreated flowers ($p<0.05$). Urea also increased the number of pollen tubes that reached the ovule ($p<0.05$), but to a lesser degree than boron. However, combining boron and urea resulted in double pistils ($p<0.05$), even when the urea was applied 8 days after the boron.

The efficacy of using boron and/or urea as a prebloom canopy spray to increase fruit set and yield is under continued testing in commercial 'Hass' avocado orchards in southern and coastal California with low, moderate, and high leaf boron concentrations, for years when anthesis, pollination, fertilization and fruit set occur under optimal versus less than optimal climatic conditions, and for both "on" and "off years of the alternate bearing cycle. The objective of the research is to determine, on the basis of benefit to cost, under what conditions this management strategy should or should not be utilized in California.

1. Introduction

The most successful fruit set occurs at temperatures between 20 to 25°C. At these temperatures, female and male floral stages overlap for several hours (Sedgely, 1977). Warm temperatures during flowering increase both ovule longevity and the growth rate of the pollen tube, and thus increase fruit set by increasing the effective pollination period (Williams, 1965). The longevity of the ovule minus the length of time necessary for the pollen tube to reach the ovule to deliver the sperm to the egg is the effective pollination period. Cool temperatures during the flowering period decrease the viability of the ovule and increase the length of time it takes for the pollen tube to grow from the stigma to the ovule. Thus, the duration of the effective pollination period is significantly shortened and fruit set is reduced.

It is well established that boron is essential for pollen germination, for successful growth of the pollen tube through the stigma, style, and ovary to the ovule, and for the mitotic divisions necessary to produce the sperm (reviewed in Lovatt and Dugger, 1984). Boron sprays applied either during fall or spring to trees not deficient in boron (based on leaf analyses) have been effective in increasing fruit set in a number of deciduous tree fruit and nut crops (Batjer and Thompson, 1949; Degman, 1953; Bramlage and Thompson, 1962; Davison, 1971; Baron, 1973; Chaplin et al., 1977; Callan et al., 1978; Crassweller et al., 1981; Yogaratnam and Greenham, 1982; Hanson and Breen, 1985; Shrestha et al., 1987) and in avocado (Robbertse et al., 1990, 1992). Boron sprays are more effective during seasons when cool, overcast and wet weather predominate during bloom (Callan et al., 1978; Hanson and Breen, 1985). Benefits from boron sprays are less likely when conditions are optimal for fruit set (Degman, 1953).

Ovule longevity has been improved in deciduous tree crops by a summer application of nitrogen (Williams, 1965).

On the basis of these findings, we established and are continuing to conduct field experiments to test the hypothesis that fruit set and yield of the 'Hass' avocado can be increased by increasing the effective pollination period (i) by prolonging ovule viability with a bloom application of nitrogen and *(ii)* by accelerating pollen tube growth rate with a bloom application of boron.

2. Material and methods

The research was conducted at two mature commercial orchards of 'Hass' avocado on Duke 7 rootstock. One orchard was boron deficient at the start of the experiment with average leaf analyses of 18 jug B per g dry weight leaf tissue. Subsequently, all trees were brought into the adequate range (>25 ug B per g dry weight leaf tissue), because it was not the objective of the research to study the effect of boron deficiency on avocado fruit set and yield. The second orchard had high to excess leaf boron concentrations, >180 /*g B per g dry weight. Treatments were applied to 16 individual tree replicates in a randomized block design in 15 liters of H_2O per tree to give full canopy coverage. Boron was applied at a rate of 6.15 g B as $Na_2B_4O_7$ and nitrogen at 0.16 kg N as low-biuret urea prebloom, i. e., during the cauliflower stage of inflorescence development, which occurred about mid-March to mid-April depending upon the site and year.

The research was also replicated in the glasshouse using 'Hass' avocado scions on Duke 7 rootstock two years from budding. Treatments were applied at the same concentrations as in the field to the point of run-off.

To quantify the number of pollen tubes entering the ovule and the number of viable ovules, 20 to 30 flowers were collected for each analysis for each treatment 24 h after open-pollination in the field or hand-pollination in the glasshouse. Flowers were immediately fixed in 100% ethanol and concentrated glacial acetic acid (3:1, v/v) for 10 min and then washed 3 times in 70% ethanol. Samples were squashed in aniline blue to reveal pollen tubes; ovules were excised and stained with aniline blue. Observations were made with a Zeiss fluorescence microscope.

In the field experiments, all fruit were harvested on each tree and weighed to determine total kg fruit per tree. To determine packout, each of 200 randomly selected fruit per tree was weighed.

3. Results

The number of pollen tubes reaching the ovule averaged 0.77 for flowers collected in the field and approximately 1.0 for flowers from the glasshouse-grown trees. The application of boron to the canopy when the majority of the inflorescences were at the cauliflower stage of development increased this number more than 2.5-fold for flowers from both field and glasshouse trees ($p<0.05$). The number of pollen tubes reaching the ovule was also significantly increased by a canopy application of low-biuret urea at the cauliflower stage of inflorescence development to separate sets of trees. The greatest effect was for flowers collected from trees in the field experiment (approx. 2-fold, $p<0.05$).

Viable ovules were found in approx. 70% of the flowers collected from both the field and glasshouse-grown trees. The canopy application of low-biuret urea at the cauliflower stage of inflorescence development significantly increased the number of viable ovules by 25% for flowers collected from both sets of trees ($p<0.05$). Only the field trees benefited from the foliar application of boron; ovule viability was increased 16% ($p<0.05$).

In the orchard consisting of trees with low to adequate leaf boron concentrations, the cumulative average yield for the three years of the experiment at this site was 192 kg fruit per tree. Applications of boron or nitrogen to the canopy when the majority of inflorescences were at the cauliflower stage of inflorescence development increased the cumulative average yield for the three years of the experiment 25 and 23%, respectively. The orchard characterized by excess leaf boron concentrations consistently yielded better than the orchard with the low to adequate leaf concentrations of boron. The cumulative average yield for only two years at this site was 248 kg fruit per tree. In this orchard, yields tended to be reduced as a result of the boron or low-biuret urea treatments. However, the yield reductions were not statistically significant in any single year of the experiment or for the cumulative average yield.

Combining boron and low-biuret urea as a single treatment (despite the fact that low-biuret urea was applied as long as eight days after the boron) resulted in a reduction in yield in each year of the experiment and regardless of whether leaf boron concentrations were low, adequate or in excess. Flowers collected from trees in this treatment both in the field and in the glasshouse exhibited a significantly greater incidence of double pistils, which resulted in greater abscission of flowers and fruit.

4. Summary

While annual prebloom canopy applications of boron, or urea, provided some benefit in increasing yield over a period of several years in the orchard with low to adequate tree boron status (please note that a similar analysis for N in each orchard is not yet available and is equally important to evaluating the significance of these results), the fact that yield reductions were observed each year in the orchard characterized by excess leaf boron content suggests that strategy foliar applications of boron or urea during the bloom period should not be used indiscriminately or prophylactically. Further understanding of the interactions between prevailing environmental conditions and tree nutritional status during flowering and fruit set are required in order to know when either nutrient element can be used to successfully effect a significant increase in yield and profit.

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