

Improving Fruit Set and Yield of 'Hass' Avocado with a Spring Application of Boron and/or Urea to the Bloom

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Introduction

The CDFA Nitrate Working Group in their February, 1989, report to Director Parnell, stated that 12% of the wells of coastal Ventura, Orange, San Diego, and Riverside Counties exceed State MCL for nitrate and are no longer used as drinking water sources. The report stated that the loss of ground water production for domestic use from increased solids and nitrate is about 4% of the annual production of this area. This loss will increase, since numerous wells already have 20-44 mg nitrate/L. Avocado-growing areas of these counties correspond to the areas with high-nitrate wells. Avocado-growing areas of coastal San Luis Obispo and Santa Barbara Counties also correspond to the areas with wells that have 20-44 mg nitrate/L, or exceed the state MCL. There are 61,832 acres of bearing avocados in San Diego, Riverside, Ventura, and Santa Barbara Counties. Standard avocado fertilization is 150-175 lbs. ammonium nitrate to the soil/year. Many growers apply considerably more nitrogen to the soil annually. Thus, avocado production likely contributes to nitrate pollution of groundwater.

There is considerable interest among avocado growers in using boron to enhance pollen tube growth to increase fruit set and yield. It has been known for a long time 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 mitotic divisions necessary to produce the sperm (5). Boron sprays applied during either fall or spring to trees not deficient in boron, based on leaf analysis, have been effective in increasing fruit set in a number of deciduous fruit tree species (1, 2, 7), especially when cooler temperatures prevail during bloom (4).

The effect of boron on pollen germination and pollen tube growth has recently been studied in avocado (6). In most cases, when pistils harvested from avocado trees receiving a foliar application of boron were pollinated with pollen from trees also sprayed with boron, pollen germination and pollen tube growth were significantly better than in flowers from untreated trees. This difference occurred despite the fact that the leaves of the untreated trees contained "sufficient" boron, by leaf analysis, to sustain normal plant growth and yield. The effect of foliar-applied boron on avocado yield is not known.

The interest among California avocado growers in the use of boron to increase yield prompted the California Avocado Development Organization (CADO) to ask me to develop a project to test the efficacy of this treatment on avocados grown in southern California. It was of additional interest to me that ovule longevity was improved in

deciduous tree crops by a summer foliar application of nitrogen (8). Until our research, the use of nitrogen to enhance ovule longevity to increase fruit set and yield in avocado had not been investigated. We proposed that increasing the rate of pollen tube growth with boron and/or ovule longevity with urea would increase the effective pollination period and fertilization and increase fruit set and yield. Avocados are grown on steep slopes in southern California. Application of foliar sprays to these trees is difficult and is best accomplished by aerial sprays. Thus, it was important to determine whether it is only necessary to raise the tree nitrogen or boron status or whether it is essential to provide nitrogen or boron directly to the flower. Thus, in glasshouse studies and field trials on boron funded by CADO, we contrasted the effect of foliar vs. trunk-injected boron and/ or urea, applied during bloom to nitrogen-sufficient, boron-deficient trees, on pollen tube growth, ovule longevity, and yield. In addition, the efficacy of applying these treatments at three different stages of bloom was examined: budbreak, prebloom (cauliflower stage), or panicle expansion.

The specific objectives of the research are: (i) to test in a well-replicated field trial the results of the preliminary research suggesting that a single application of urea or boron to the canopy during prebloom of the 'Hass' avocado will increase yield and net return to the grower over untreated control trees at the 5% level; (ii) to determine if canopy-applied nitrogen can replace part of the nitrogen applied to the soil annually in avocado production; and (iii) to disseminate the results of this research to avocado growers through talks to growers and publications in grower magazines and the California Avocado Society Yearbook.

The project will determine the efficacy of canopy applications of low biuret urea *versus* boron during prebloom to increase yield and net dollar return of the 'Hass' avocado. In addition, the project will demonstrate whether or not foliar application of low biuret urea to the young spring flush is a more cost-effective management strategy than making a spring application of nitrogen to the soil. The barrier to adoption will be the perception that canopy applications of urea or boron made by helicopter may not be as effective and thus cost-prohibitive. If the results of the field research demonstrate that spring canopy applications of urea or boron increase fruit set and yield, we propose to test the efficacy of helicopter application. Avocado growers will know whether they should spend the extra money applying boron or urea to the canopy in the spring to improve fruit set and yield. Our research thus far has clearly shown that neither soil applications nor changing the boron or nitrogen status of the tree increased yield. In addition, our research will answer the question of whether there is a negative impact of using boron canopy sprays in orchards that have high levels of boron in the leaves. Our research will also demonstrate whether or not foliar urea fertilization in the spring has any benefit. This project will be completed with the final harvest in June of 1997. Support will be required in future years to test the efficacy of helicopter applications.

Procedures

Application of treatments will be made to 16 individual tree replicates/treatment in a randomized block design. The trees are mature, healthy commercially-producing 'Hass' avocados on Duke 7 rootstocks at two sites: one owned by Limoneira Co. in Santa Paula, California, (this orchard has very high levels of boron in the leaves, *i.e.*,

approaching toxic levels) and one by Agrispec in Temecula, California, (this orchard has very low levels of boron in the leaves, *i.e.*, bordering on deficient).

During year-one, voucher specimens were collected to insure that trees could be treated at the same stage of flower development in each subsequent year. At prebloom (cauliflower stage) [Fig. 1], trees will receive a canopy spray of 30 g Solubor (Solubor is 20.5% boron) in 4 gallons of water/ tree (all 4 gallons will be applied to the bloom and foliage to thoroughly cover the tree), 475 ml Unocal PLUS (Unocal PLUS is 20% nitrogen, 0.1% biuret) in 4 gallons of water/ tree, or 30 g Solubor plus 475 ml Unocal PLUS in 4 gallons of water/tree. In addition, two sets of trees will receive a foliar application of Unocal PLUS at the rate of 950 ml in 4 gallons of water/tree when the spring flush leaves are 2/3 fully expanded, alone or in combination with a prior bloom application of Unocal PLUS. The concentration used for the boron canopy spray is that of Robbertse *et al.* (6). The low biuret urea used in the bloom spray is the rate used in citrus production, but for the spring flush application it is two times this rate. Forty spring flush leaves from non-fruiting terminals will be collected at chest height around each data tree in September, 1995. In addition, leaves will be collected just before the 1995 spring flush urea application and one week after the application. The leaves will be immediately stored on ice, taken to UCR, washed thoroughly, oven-dried, ground, and sent to Albion Laboratories for analysis of total nitrogen and boron. Harvest data will include total lbs. of fruit/tree and the weight of 100 randomly selected individual fruit/tree, which will be used to calculate packout per tree, evaluation of internal fruit quality, and a cost/benefit analysis of each treatment.

Results

YEAR 1: Preliminary results from the glasshouse studies and the field trial screening the 24 treatments provided evidence that one application of urea to the canopy during early bloom significantly increased pollen tube growth and ovule longevity, compared with untreated control trees ($p < 0.05$). Boron increased the number of pollen tubes reaching the ovule to a greater degree than urea. Although not significant at the 5% level due to the limited number of replications in the screening trial, a single application of urea to the canopy during early bloom resulted in 65 lbs. more fruit/tree, approximately a 50% increase in yield over the untreated control trees. It took two sprays of boron to increase yield over the control, but the increase was only half that obtained with urea. Thus, the yield data were consistent with the results of the anatomical studies. Both studies clearly showed a negative interaction for trees treated with both nitrogen and boron, even when the treatments were made on separate days. There were no negative effects from any of the treatments on the quality of the ripe fruit. Results from both the glasshouse studies and field trial provided evidence that prebloom (cauliflower stage) was the best time to apply boron or urea [Fig. 1].

YEAR 2: In the second year of the study, we used this application time and tested the efficacy of boron and/or urea canopy sprays *versus* trunk injections with 16 individual tree replicates per treatment. The boron canopy spray significantly increased yield ($P < 0.05$), compared to all other treatments. The boron canopy spray significantly increased the number of fruit of size 70. There were no other statistically significant effects of any other treatment on fruit size. Boron trunk-injection significantly ($P < 0.05$) increased the boron content of the leaves (September leaf sample) over all treatments.

This result taken together with the yield data strongly suggests that boron must be provided directly to the developing flower (ovary). Neither nitrogen canopy sprays nor nitrogen trunk-injections had any effect on the nitrogen status of the trees. The nitrogen canopy sprays had no significant effect on yield in Year Two. There were no negative effects from any of the treatments on the quality of the ripe fruit.

Fig. 1. Results from glasshouse studies and field trial provided evidence that problem (cauliflower stage) was the best time to apply boron or urea.



YEAR 3: The third year of the project was conducted at the Santa Paula orchard, which has high leaf boron concentrations. While not statistically different at the 5% level, the yields of the boron- and urea-treated trees were lower than the controls. As seen in previous years, the combination of boron plus urea at prebloom significantly decreased yield compared to the control trees ($p < 0.05$). Additional years of yield data are required to determine if this result is due to the high boron status of the trees.

YEAR 4: The current project year was conducted at both the Rancho California orchard, which has low boron concentrations in the leaves, and the Santa Paula orchard, which has the high leaf boron concentrations. We will harvest the Rancho California site the first week of April, and the Santa Paula site in July, 1995.

Literature Cited

1. Batjer, L. P., and B. L. Rogers. 1953. "Blossom blast" of pears: an incipient boron deficiency. *Proc. Amer. Soc. Hort. Sci.* 62:119-122.
2. Chaplin, M. H., R. L. Stebbins, and M. N. Westwood. 1977. Effect of fall-applied boron sprays on fruit set of 'Italian' prune. *HortScience* 12:500-501.
3. Embleton, T. W., and W. W. Jones. 1974. Foliar-applied nitrogen for citrus fertilization. *J. Environ. Quality* 3:388-392.

4. Hanson, E. J., and P. J. Breen. 1985. Effects of fall boron sprays and environmental factors on fruit set and boron accumulation in 'Italian' prune flowers. *J. Amer. Soc. Hort. Sci.* 110:389-392.
5. Lovatt, C. J., and W. M. Bugger. 1984. Boron, pp. 389-421. In: E. Frieden (ed.), *Biochemistry of the Essential Ultratrace Elements*. Plenum Pub. Corp.
6. Robbertse, P. J., L. A. Coetzer, M. Slabbert, and J. J. Bezuidenhout. 1990. The influence of boron on fruit set in avocado. *ISHS Int. Symp. on the Culture of Subtropical and Tropical Fruits and Crops. Acta. Hort.* 2:587-594.
7. Thompson, A. H., and L. P. Batjer. 1950. The effect of boron in the germination medium on pollen germination and pollen tube growth of several deciduous tree fruits. *Proc. Amer. Soc. Hort. Sci.* 55:227-229.
8. Williams, R. R. 1965. The effect of summer nitrogen applications on the quality of apple blossom. *J. Hort. Sci.* 40: 31-41.