EFFECTS OF PLANT GROWTH REGULATORS ON THE REPRODUCTIVE AND VEGETATIVE GROWTH OF THE 'HASS' AVOCADO

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ABSTRACT

Plant growth regulators (PGRs) are applied to the foliage of many commercial crops to increase yields, but research with avocado (*Persea americana* Mill.) is limited. Therefore, several PGRs were evaluated for their effects on growth of the 'Hass' avocado in California. Branches measuring one meter from the apex were sprayed with prohexadione-calcium (ProCa, 250 or 1000 $mg \cdot L^{-1}$), $Gibberellin_3$ (GA_3, 25 or 100 $mg \cdot L^{-1}$), amino-ethoxyvinylglycine (AVG, 250 or 2000 $mg \cdot L^{-1}$), 6-benzoyladenine (BA, 25 or 250 $mg \cdot L^{-1}$), DL-tryptophan (TRP, 10^{-10} or 10^{-4} M) or a combination of PGRs (25 $mg \cdot L^{-1}$ GA_3, 250 $mg \cdot L^{-1}$ AVG, 250 $mg \cdot L^{-1}$ BA, and 10^{-10} M TRP). Treatments were applied at full bloom (April), early drop (May), or June drop (June). In another set of treatments, each spray was followed with a second spray in August. An additional treatment was the application of 10^{-10} M TRP on each successive spray date. There were no significant differences in percent fruit set at harvest between the untreated control and any treatment. However, several treatments resulted in significant changes in pre-harvest fruit set, vegetative growth, and the persistence of the preceding year's crop to harvest. The results suggest that commercial PGR spray regimes can be developed to successfully manipulate avocado reproductive and vegetative growth.

INTRODUCTION

The avocado industry is an important part of California's agricultural economy with an annual wholesale value of more than a quarter million dollars (California Avocado Commission). However, avocados have extremely low fruit set (<<1%), even in healthy, well-managed orchards. Despite the successful use of PGR sprays to increase yields of many fruit tree crops, few studies reporting the use of this technique with avocado have been published. The objective of this experiment was to quantify the effects of several commercially available PGRs on reproductive and vegetative growth of the 'Hass' avocado in California. PGRs known to increase fruit set in other tree crops were tested. These included AVG, an inhibitor of ethylene biosynthesis; TRP, a precursor of indoleacetic acid; and BA, a cytokinin. In addition, PGRs with the potential to regulate growth of the vegetative apex of indeterminate floral shoots (>90% of floral shoots produced at bloom in California) were tested. GA_3 was used to advance development of the vegetative shoot, so that leaves of the indeterminate floral shoots would be sources to developing fruit rather than competing sinks (Salazar-Garcia and Lovatt, 1998; Salazar-Garcia and Lovatt, 2000). In contrast, ProCa, a GA biosynthesis inhibitor, was applied to suppress vegetative growth until fruit set had occurred. Use of foliar-applied paclobutrazol, a GA biosynthesis inhibitor now banned in California, retarded vegetative growth of 'Hass' avocado in South Africa and significantly increased both fruit number and size (Kremer-Köhne and Köhne, 1998).

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MATERIALS AND METHODS

A branch study was conducted in a commercial orchard of 'Hass' on Mexican rootstock in Carpinteria, California. Branches one meter in length were used in a randomized complete block design with 15 replications and 10-tree blocks.

The following PGRs were tested at the noted concentrations: AVG (250 or 2000 $mg \cdot L^{-1}$), TRP (10^{-10} or 10^{-4} M), BA (25 or 250 $mg \cdot L^{-1}$), GA_3 (25 or 100 $mg \cdot L^{-1}$), or ProCa (250 or 1000 $mg \cdot L^{-1}$). In addition, a "combination" treatment (GA_3, AVG, BA, and TRP; each at the lowest concentration given above) was used. Unless otherwise specified, PGRs were applied at full bloom (April); early drop (May); June drop (June); full bloom + August; early drop + August; or June drop + August. TRP 10^{-10} M was also applied in April, May, June and August. ProCa was applied in April only.

Just prior to each spray application the number of inflorescences or fruit and the length of vegetative shoots were quantified on control branches and any branches to be treated at that time. The control mean values for fruit set and vegetative growth were therefore different for each application time. This allowed differences in early fruit set and vegetative growth to be compared between treated branches and the untreated control for each application time. Fruit set and vegetative growth were quantified on a monthly basis. Fruit set and size were also quantified at harvest (November). In addition, effects on fruit retention of the preceding year's crop were determined at harvest. Treatment differences were analyzed by Dunnett's two-tailed *t*-tests using SAS. Only treatment effects different from the untreated control at $\alpha \leq 0.10$ are reported.

RESULTS

Reproductive Growth

Early fruit set was quantified in August after June drop, as fruit remaining on the tree after June drop tend to persist to harvest. AVG (2000 $mg \cdot L^{-1}$) applied during early drop resulted in a significant increase in percent fruit set compared to the untreated control: 7.85 versus 3.04%, respectively ($\alpha = 0.10$). In contrast, BA (25 $mg \cdot L^{-1}$) applied during June drop resulted in a significant decrease in percent fruit set compared to the untreated control: 0.91 versus 8.76%, respectively ($\alpha = 0.05$).

There were no significant treatment effects on percent fruit set at harvest. Furthermore, there were no significant treatment effects on fruit weight, length, or diameter or on seed size at harvest.

In the production of the 'Hass' avocado in California, fruit from one season are still on the tree when the bloom of the next season begins. Thus the effect of the PGR sprays on the previous season's crop was quantified. AVG (2000 $mg \cdot L^{-1}$) applied at full bloom + August and TRP (10^{-10} or 10^{-4} M) applied during June drop + August resulted in a significant reduction in retention of fruit from the previous year. Each of these treatments resulted in the abscission of approximately 2 fruit per branch (2.18, 2.30 and 2.46, respectively) as compared to a mean loss of 0.36 fruit per untreated control branch ($\alpha = 0.05$).

Vegetative Growth

GA_3 (25 or 100 $mg \cdot L^{-1}$), AVG (2000 $mg \cdot L^{-1}$), TRP (10^{-4} M), and BA (250 $mg \cdot L^{-1}$) applications at full bloom resulted in a significant increase in seasonal vegetative growth compared to the untreated control. The mean change in vegetative growth from the time of treatment application to the end of the vegetative flush ranged from 7.76 to 8.86 cm for treated branches, compared to 6.04 cm for the untreated control. When applied at full bloom, the "combination" treatment, which was composed of GA_3, AVG, TRP, and BA, resulted in a highly significant increase in seasonal vegetative growth compared to the untreated control: 8.67 versus 6.04 cm, respectively ($\alpha = 0.01$).

DISCUSSION

Though none of the PGR treatments significantly changed percent fruit set or fruit size at harvest, several treatments resulted in significant changes in other aspects of reproductive and vegetative growth. AVG (2000 $mg \cdot L^{-1}$) applied at full bloom increased vegetative growth with no effect on fruit set but resulted in a significant reduction in the retention of mature fruit of the preceding year's crop. When AVG (2000 $mg \cdot L^{-1}$) was applied during early drop, early fruit set was significantly increased without a significant change in fruit set at harvest. This suggests that many of the fruit that survived through June drop did not persist until harvest and that an additional PGR treatment would be needed to increase yield. GA_3 sprays at full bloom increased vegetative growth, but did not increase fruit set. Different timing and application rates may be needed to push vegetative growth early and quickly so that leaves can act as sources for the fruit, not as competing sinks. Other research applying GA_3 at the cauliflower stage of floral shoot development showed promise (Salazar-Garcia and Lovatt, 2000). Several treatments had undesirable effects on avocado growth. BA (25 $mg \cdot L^{-1}$) applied during June drop significantly decreased early fruit set. TRP (10^{-10} or 10^{-4} M) applied during June drop significantly decreased the retention of the preceding year's crop. Increased auxin levels may have resulted in excessive levels of ethylene production (Bower and Cutting, 1988). The results demonstrate that with careful branch selection, a branch study is an efficient, cost-effective model system for testing a large number of PGRs, concentrations or application times to initiate PGR research in fruit tree crops. The study presented here provided the information requisite for whole tree studies currently being conducted to develop further strategies for using PGRs in commercial 'Hass' avocado orchards in California.

LITERATURE CITED

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