California Avocado Society 2004-05 Yearbook 87: 111-116

Flowering of Avocado *(Persea americana* Mill.) As Influenced by Gibberellic Acid Treatments

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Summary

The effect of gibberellic acid (GA_3) treatments on the reproductive development of 'Hass' avocado trees was investigated at macroscopic and microscopic level. GA_3 (50 or 250 mg/L) was applied to three-year-old trees as single or multiple foliar sprays. On untreated trees, bud swelling was observed in early autumn (April) and flowering occurred four to five months later in late winter/spring (August/September). However, at microscopic level, secondary inflorescence axis meristems were already present in buds of untreated trees in late summer (early March). Single GA_3, treatments applied in late summer (March) had no significant effect on flower development, but multiple GA_3, treatments applied from late summer through early winter (March-May) inhibited flower development for one season.

Key words: Avocado, gibberellic acid, reproductive development.

Introduction

Avocado trees are prone to heavy flowering and fruit set in some years, followed by a very small crop the following year. By reducing flowering during the “on” year, the alternate bearing pattern may be alleviated. Gibberellins, a group of natural plant growth regulators, are involved in reproductive development which includes flower initiation, differentiation and all stages of the growth and development of the embryo, seed and fruit (Pharis & King, 1985). Gibberellin application to satsuma mandarins (Iwahori & Oohata, 1981) and *Citrus sinensis* (Lord & Eckard, 1987) decreased flowering in the “on” year following the application. According to Salazar-Garcia and Lovatt (2000), GA_3 sprays applied to avocado trees at early stages of inflorescence bud development, stimulated the production of vegetative shoots at the expense of inflorescences. Rossouw *et al.* (2000), observed varying reactions in potted avocado trees following GA_3, applications at different dates during the period of reproductive development. This study was undertaken to determine the stage of flower development at the time of GA_3, application and its effect on flowering.

Material and Methods

The trial was conducted at Westfalia Estates (24°S latitude) in the Limpopo Province of South Africa.

Gibberellic acid treatments.

Twenty three-year-old Hass trees on Duke 7 rootstock were treated with GA_3 (ProGibb® 4%, Abbott Laboratories). Treatments were applied as single (9/3) or multiple (9/3 + 7/4+13/5) foliar sprays at two concentrations (50 or 250 mg/L). Control trees were left untreated. Trees were evaluated from late summer (March) to early summer (October/ November) for vegetative development on a scale of 1 5 (1 = unswollen vegetative bud, 5 = expanded flush) and for floral development on a scale of 610 (6 = swollen floral bud, 10 = expanded inflorescence). Buds at a developmental stage of 1 -2 are referred to as swelling buds while a developmental stage of 6-7 is referred to as bud burst. Yield data were collected at harvest.

Anatomical study.

Five terminal buds from each tree were collected every third week from March to May and every second week from June to August. Buds were fixed in FAA (5 formalin: 5 acetic acid: 90 ethanol solution, by volume) and dehydrated via sequential transfer through a series of aqueous ethanol solutions (70%, 96%, 100% ethanol), followed by a series of ethanol / xylene solutions (25%, 50%, 75%, 100% xylene) (Johansen, 1940). Paraffin wax was used for infiltration and embedding.

Buds were sectioned with a rotary microtome at 12mm and stained with a safranin - fastgreen series. Sections were studied using a light microscope, and micrographs were taken with a Nikon DXM 1200 digital camera on a Nikon Optiphot microscope.

Results and Discussion

Flower development on the tree.

Early in autumn (April), bud swelling was observed in the untreated control trees (Figure 1). By early July, bud burst had taken place and subsequent flowering was observed in late winter/early spring (August/September). Bud swelling on trees treated with a single GA_3 application (250 mg/L) in early March was delayed by one month when compared to the untreated control trees. Although bud burst was also delayed by one month until late July/early August, the trees flowered at the same time as the control trees. Bud swelling on trees subjected to a multiple GA_3 treatment at the low concentration of 50 mg/L, was delayed until June. However from then on, bud development increased and by the end of July bud burst occurred, and anthesis (opening of flowers) started in August. GA_3 applied three times at the high concentration, almost completely inhibited flower development. Buds remained unswollen for the whole period (March August) and then developed vegetative flushes in late September/October. However, the few flowers that did develop are reflected in figure 1.

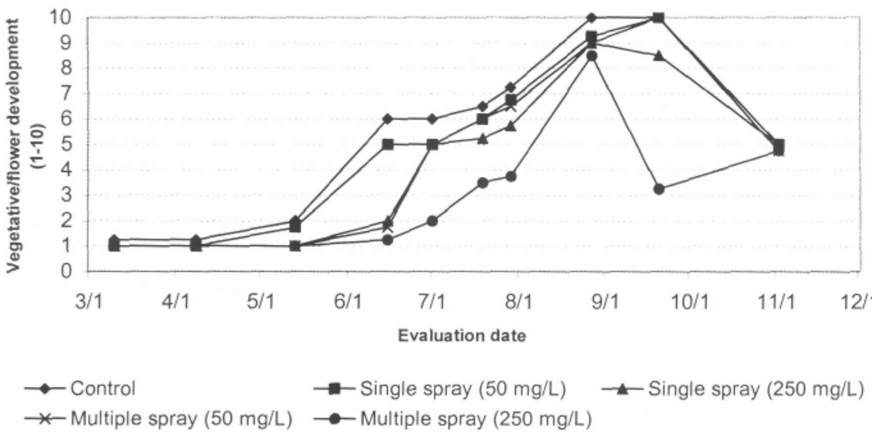

Figure 1. Vegetative and flower development of 'Hass' trees as affected by GA_3 treatments (1 = unswollen vegetative bud, 5 = expanded flush, 6 = swollen floral bud, 10 = expanded inflorescence).

Although time of flowering was not greatly affected by the GA_3 treatments, the intensity of flowering was reduced on the treated trees and this was reflected at harvest (data not shown). A 28% reduction in yield was obtained with a single treatment (50 mg/L), whereas a multiple GA_3 treatment (250 mg/L) showed an 87% reduction in yield compared to untreated control trees. The reduction in yield for the other two treatments (single treatment at 250 mg/L; multiple treatments at 50 mg/L) was 58% when compared to the untreated control trees. Similar results were obtained by Salazar-Garcia and Lovatt (1998). They reported that GA_3 applied at an early stage of inflorescence development resulted in reduced flower intensity due to the production of partially formed inflorescences, bearing fewer flowers.

Anatomical Study

The avocado has a compound inflorescence system, consisting of alternatingly borne secondary axes on a primary axis, with tertiary flower-bearing axes borne on the secondary axes. In most cases the primary axis does not end in a flower and retains its terminal bud, producing a vegetative flush. Already in early March, secondary inflorescence axis meristems (the first signs of flower development) were observed as small axillary buds in the axils of the inner terminal bud bracts of bud sections studied under the microscope. These meristems developed during March June forming the secondary axes of the inflorescence. By mid May the developing tertiary axes were visible under the microscope. The first developing flowers were observed by mid June and a month later the complete secondary axis with its flower buds could clearly be distinguished under the microscope. From then on, the individual flower parts developed and anthesis was in August/ September.

When GA_3 (50 mg/L) was applied as a single treatment in March, the development of the secondary inflorescence axis meristems present in the buds, was slowed down for one month until May / June. With GA_3 applied once at the high concentration (250 mg/L) this development was slowed down until early July. However from then on, flower development was quite rapid, and flowering coincided with that of control trees. Similar results were obtained in a trial on small trees (Rossouw *et al.,* 2000) where single applications of GA_3 (50 and 250 mg/L) delayed bud swelling when applied in mid March and early April, compared to the untreated control trees. Flower development was almost completely inhibited on trees treated with a multiple GA_3 treatment at the high concentration as only a few flowers formed while the rest of the buds remained unchanged.

Conclusions

It is evident from this study that flower development was delayed or reduced by GA_3 application depending on its timing. Due to the variation regarding the stage of flower development within an avocado tree's canopy, shoots differ in their response to GA_3 treatment. Multiple GA_3 applications to trees over a period of time thus affected a greater proportion of flower buds. As GA_3 sprays reduce flower intensity, they may be used to reduce flowering during the 'on' year, thereby alleviating the alternate bearing pattern of avocado trees.

Acknowledgements

The South African Avocado Growers' Association and the Hans Merensky Foundation are thanked for their financial support.

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