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Effect of gibberellic acid treatments on flower development of avocado

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ABSTRACT

The effect of gibberellic acid (GA_3) treatments on flowering was tested on three-year-old Hass trees. Two concentrations (50 or 250 ppm) and various application dates (March to May) were evaluated. Buds were collected from March to August and a microscopic study was undertaken to determine the effect of GA_3 treatments on flower development. Secondary inflorescence axis meristems, which are the first signs of floral development, were already present early in March. A single GA_3 treatment (50 or 250 ppm) applied in March therefore had no significant effect on flower development. However, GA_3 (250 ppm) applied three times (March + April + May) inhibited flower development for one season.

INTRODUCTION

Alternate bearing is a major problem facing the avocado industry. By reducing flowering during the 'on' year and thereby alleviating the alternate bearing pattern this problem may be solved. Gibberellin, a natural plant growth regulator, is known to influence flower development. Flowering was decreased in the 'on' year after gibberellin application to satsuma mandarins (Iwahori & Oohata, 1981) and *Citrus sinensis* (Lord & Eckard, 1987). According to Salazar-García and Lovatt (2000), GA_3 sprays applied at early stages of inflorescence bud development stimulated the production of vegetative shoots at the expense of inflorescences. Timing of GA_3 sprays is crucial with regard to the type of reaction that can be expected (Rossouw *et al.*, 2000). This study was undertaken to determine the stage of flower development at the time of GA_3 application and its effect on flowering.

MATERIALS AND METHODS

Gibberellic acid treatments

Twenty three-year-old Hass trees on Duke 7 rootstock, were treated with GA_3 at 50 or 250 ppm. Treatments were applied as single or multiple foliar sprays (GA_3 prepared from ProGibb® 4%, Abbott Laboratories) at various dates from March to May. Control trees were left untreated. Trees were evaluated from March to August for vegetative development on a scale of 1 - 5 (1 = unswollen vegetative bud, 5 = expanded flush) and for floral development on a scale of 6 – 10 (6 = swollen floral bud, 10 = expanded inflorescence). 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 (paramat extra pastillated) was used for infiltration and embedding. Buds were sectioned with a rotary microtome at 12µm 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 March, while most of the buds were still unswollen, some buds started to swell. A month later (early April) swelling was observed in most of the buds. By early July, bud burst had taken place and subsequent flowering was observed in August / September. Bud swelling on trees treated with a single GA_3 application (250 ppm) in early March, was delayed by one month when compared to the untreated control trees (Figure 1). Although bud burst was also delayed by one month until late July, the trees flowered at the same time as the control trees. Bud swelling on

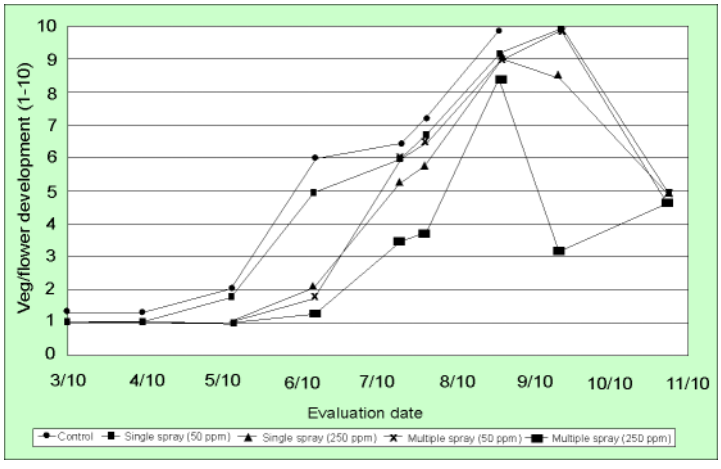


Figure 1 Vegetative and flower development as affected by GA_3 treatments (1 = unswollen vegetative bud, 5 = expanded flush, 6 = swollen floral bud, 10 = expanded inflorescence).

trees subjected to a multiple GA_3 treatment at the low concentration of 50 ppm, 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 to August) and then developed vegetative flushes in late September / October. However, the few flowers that did develop are reflected in Figure 1.

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. A 28% reduction in yield was obtained with a single treatment (50 ppm), whereas a multiple GA_3 treatment (250 ppm) showed an 87% reduction in yield compared to untreated control trees. The reduction in yield for the other two treatments (single treatment at 250 ppm; multiple treatment at 50 ppm) was 58% when compared to the untreated control trees (data not shown). Similar results were obtained by Salazar-García and Lovatt (1998). They reported that GA_3 applied at an early stage of inflorescence development resulted in a 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 (Figure 2). Already in early March, the first signs of flower development were observed in bud sections studied under the microscope. Secondary inflorescence axis meristems were observed as small axillary buds in the axils of the inner terminal bud bracts (Figure 3). These meristems developed during March to 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 micro-

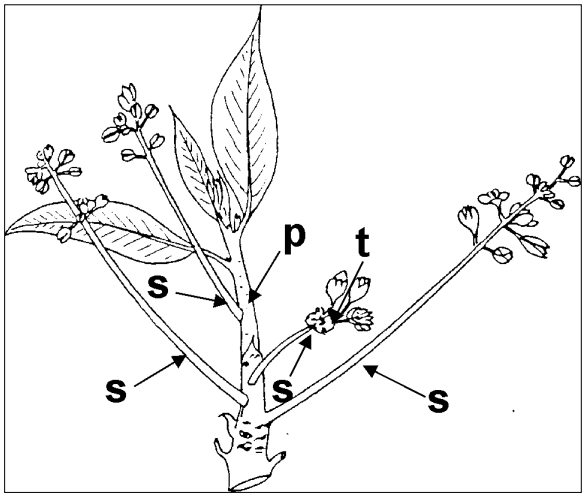


Figure 2 Diagram showing vegetative and reproductive growth of the avocado. Abbreviations: p = primary inflorescence axis; s = secondary inflorescence axis; t = tertiary inflorescence axis.

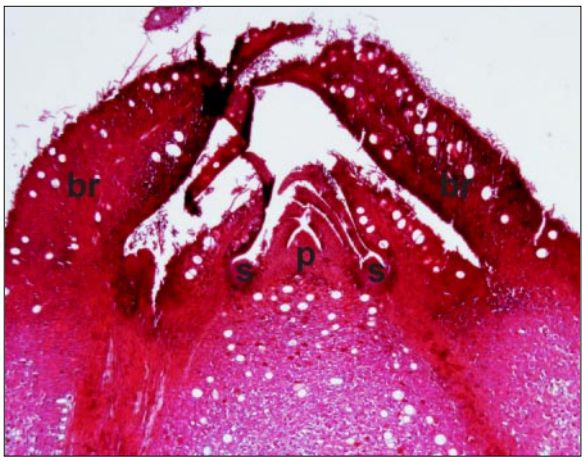


Figure 3 Two secondary inflorescence axis meristems present between the bracts of a bud sampled in mid March. Abbreviations: p = primary inflorescence axis meristem; s = secondary inflorescence axis meristem; br = bract.

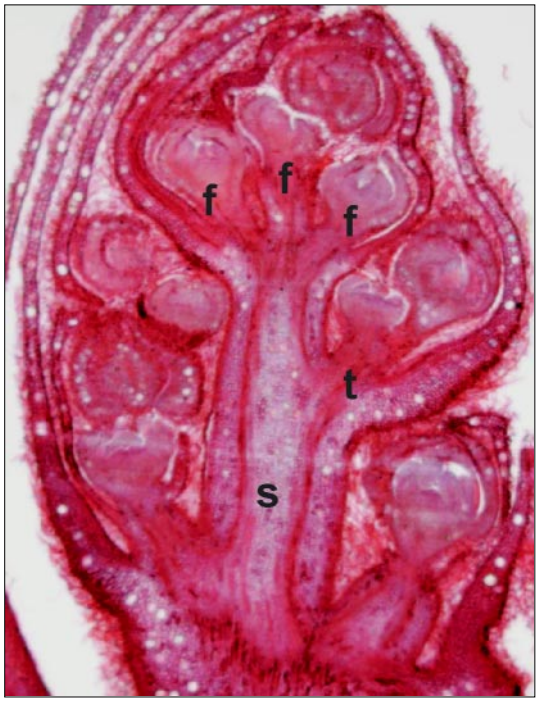
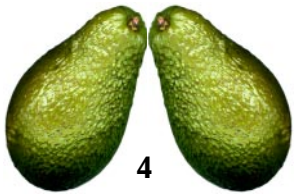


Figure 4 Elongated secondary inflorescence axis with tertiary inflorescence axes and developing flowers (mid July). Abbreviations: s = secondary inflorescence axis; t = tertiary inflorescence axis; f = flower.



scope (Figure 4). From then on, the individual flower parts developed and anthesis was in August / September.

When GA_3 (50 ppm) was applied as a single treatment in March, the development of the secondary inflorescence axis meristems present in buds, was slowed down for one month until May / June. With GA_3 applied once at the high concentration (250 ppm) 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 ppm) 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. Only a few flowers formed while the rest of the buds remained unchanged (Figure 5).

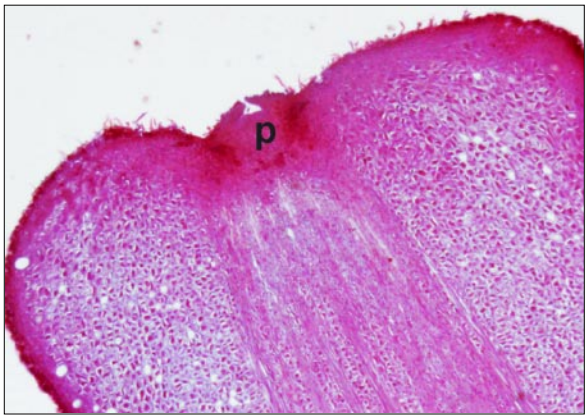


Figure 5 Vegetative bud collected early August from trees receiving a multiple GA_3 treatment (250 ppm). Abbreviation: p = primary inflorescence axis meristem.

CONCLUSIONS

It is evident from this study that flower development was delayed or reduced by GA_3 application. 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 was found in a previous study, timing of GA_3 application is extremely important. 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.

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