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EFFECT OF GIBBERELLIC ACID ON INFLORESCENCE PHENOLOGY OF THE 'HASS' AVOCADO (*PERSEA AMERICANA* MILL.)

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Abstract

'Hass' avocado shoots (*Persea americana* Mill.) produced during the fall were observed to flower earlier than older shoots produced in the summer, but summer shoots flowered more intensively due to the production of a greater number of axillary inflorescences. Under California conditions, vegetative shoot development follows anthesis. To examine the effects of GA_3 on floral expression and inflorescence phenology, branches of avocado trees, on which summer and fall shoots were present, were sprayed with 0, *50,* 100 or 1000 mg GA_3/liter in November, December or January. All treatments were prior to budbreak. GA_3 stimulated apical growth of all shoots. Thus, if a floral shoot was already differentiated, the inflorescence developed in advance of inflorescences on branches not treated with GA_3. In addition GA_3, caused precocious development of the leaves relative to the flowers of indeterminate inflorescences and relative to the leaves of indeterminate inflorescences from untreated branches. November GA_3 treatments stimulated vegetative shoot growth and expansion of partially formed inflorescences with fewer secondary axes resulting in reduced floral intensity. Axillary growth was inhibited with increased GA_3 concentrations. Untreated branches flowered later than GA_3-treated branches.

1. Introduction

Gibberellins have been reported to inhibit flower initiation in deciduous perennial fruit crops (Sedgley, 1990) and some subtropical and tropical fruit trees such as citrus (Davenport, 1990) and mango (Kachru et al., 1972). The inhibition of flowering by GA_3 is normally associated with stimulation of vegetative growth. A delay in flowering of more than 4 weeks was obtained when deblossomed branches of mango were treated with a single spray of GA_3 at either 10 or 50 mg/liter (Nunez-Elisea and Davenport, 1991). On the other hand, gibberellins caused early anthesis in strawberry (Porlingis and Boynton, 1961) and coffee (Schuch et al., 1990). In each case, the effect of GA_3 was influenced by the concentration used and the stage of floral development at the time of application.

Recent research with container-grown 'Hass' avocado trees, 22 months from budding, provided evidence that the stage of floral development within the resting bud influenced its response to GA_3 (Salazar-Garcia et al., manuscript in prep.). Thus, the objective of this study

was to quantitatively evaluate the effects of applying GA_3 to the foliage of 'Hass' avocado branches on different calendar dates under field conditions on floral expression and inflorescence development. Our goal was to ascertain whether GA_3 applied to the canopy might have potential utility as a management strategy in the production of the 'Hass' avocado.

2. Material and methods

Forty 10-year-old 'Hass' on Duke-7 avocado trees growing in an irrigated commercial grove in southern California were used. The experimental trees were in an "off' year and in a similar phenological stage. On the south side (physiologically the most advanced) of each tree, four branches, 1 m long, were selected and their shoots classified according to the vegetative flush in which their growth was initiated (summer or fall). The branches were sprayed until run-off with a GA_3 solution (at pH 5.5) prepared from Progibb 4 % (Abbott Laboratories) plus 1 ml/liter Triton X-100 in water. Treatments consisted of a single application of one of four GA_3 concentrations (0, 50, 100, and 1000 mg/liter) and three application dates, 13 November or 13 December 1993, or 13 January 1994. Control branches received only water plus Triton X-100. All treatments were made prior to bud break. According to Davenports scale (Davenport, 1982) at the time of the first treatment in November, apical buds were at "zero" which corresponds to "bud in rest, bracts closed with no sign of growth." For control branches, elongation of secondary axes of the inflorescence was first observed on 27 January 1994; anthesis occurred during the third week of March through April, 1994.

The type of growth produced by both apical and axillary buds was recorded for both summer and fall shoots at the end of the flowering season. Flowering was defined as the time when the secondary axes of the inflorescence started to elongate. A randomized complete block design with ten replicates per treatment was used. Before statistical analysis, data were transformed by arcsin of the square root of the percentage. For means comparison, the Duncan's multiple range test at $P = 0.05$ was used.

3. Results

3.1. Type of growth produced

By 26 March 1994, 100% of the apical buds home on untreated (control) summer shoots produced inflorescences. A November application of either 100 or 1000 mg GA_3 /liter to summer shoots significantly reduced inflorescence production (Table 1). A similar response was obtained for fall shoots treated in November with 1000 mg GA_3/liter. In each case, the reduction in inflorescence number was associated with an increase in vegetative shoots (Table 1). However, the number of vegetative shoots produced by apical buds of summer shoots decreased in response to progressively later GA_3 applications, e.g., December and January. For fall shoots, there was always a small population of apical buds that responded to GA_3 by producing vegetative shoots.

Regardless of the treatment, determinate inflorescences were the only type of growth produced by axillary buds on both summer and fall shoots. In general, summer shoots flowered more intensely due to the production of a greater number of axillary inflorescences. The number of axillary buds producing inflorescences decreased with increasing GA_3 concentrations. For some application dates, flowering of axillary buds of fall shoots could be totally inhibited with any GA_3 concentration. However, for summer shoots, inhibition of flowering only occurred

when GA_3 at 1000 mg/liter was applied in either November or December. Inhibition of inflorescence development from axillary buds resulted in a concomitant increase in number of resting buds (data not shown).

3.2. Inflorescence development

By 13 January, the control had not started budbreak, whereas 8 and 18% of the buds on summer or fall shoots treated with 50 mg GA_3/liter in November or December exhibited elongation of the secondary axes, respectively. Two weeks later, 23% of the inflorescences on the untreated control shoots exhibited elongation of the secondary axes. However, all concentrations of GA_3, regardless of application date, increased the proportion of inflorescences that had reached this or a more advanced stage of development (data not shown). GA_3 at 100 mg/liter applied in November or December stimulated the elongation of secondary axes of inflorescences 4 and 2 weeks, respectively, earlier than the control (Fig. 1). Advancement of inflorescence development was greatest in response to 1000 mg GA_3/liter applied in November or December (more than 75% of the total inflorescences had initiated elongation of the secondary axes by January 13).

The degree of floral advancement resulting from each GA_3 treatment persisted such that maximum flower opening was precocious to the same degree. Thus, maximum flower opening was 37 days earlier than the control for shoots treated with 100 or 1000 mg GA_3/liter in November or 1000 mg GA_3/liter in December and 23 days earlier in response to 50 or 100 mg GA_3/liter applied in December or January.

3.4. Precocious vegetative growth of indeterminate inflorescences

For 'Hass' avocados under southern California conditions, vegetative shoot growth and leaf expansion are delayed relative to elongation of the inflorescence axes of indeterminate inflorescences. Thus, by 5 March, when 100% of total inflorescences of the untreated control had reached elongation of secondary axes or a later stage of development only 11% of total indeterminate inflorescences from the control had initiated the first leaves of the vegetative shoot. However, GA_3 at 1000 mg/liter applied in November, December or January caused precocious development of the vegetative shoot (up to 80% of inflorescences had initiated vegetative growth 37 days earlier than the control). GA_3 at 100 mg/liter applied in January was equally effective (Fig. 2). Earlier application dates were less effective with a maximum of 22% of the indeterminate inflorescences initiating vegetative shoot growth 37 days before the control. GA_3 at 50 mg/liter had a significant effect only when applied in January. With this treatment, by 5 March, 68% of inflorescences exhibited vegetative growth (data not shown).

4. Discussion

The inhibitory and promotive effects of exogenous application of GA_3 on flowering are well documented to be dependent on plant species, concentration and time of application (Porlingis and Boynton, 1961; Guardiola et al., 1977; Lord and Eckard, 1987; Schuch et al., 1990; Salazar-Garcia et al., manuscript in prep.). In the present study, application of GA_3 resulted in early budbreak and growth of the shoot apex at whatever stage of development it had reached at the time of application. Applications made prior to floral initiation resulted in the production of vegetative shoots. Application of GA_3 during early inflorescence development resulted in the growth of partially formed inflorescences lacking some secondary

axes and containing a reduced number of flowers per inflorescence. Application of GA_3 after the inflorescence was fully formed resulted in early flowering of normal inflorescences. Indeterminate inflorescences also exhibited precocious development of the vegetative shoot apex. Precocity was increased with increasing concentrations of GA_3 (50 to 1000 mg/liter). GA_3 at 50 and 100 mg/liter had no negative morphological effects. However, GA_3 at 1000 mg/liter applied at any time caused a remarkable elongation of inflorescence axes which, in general, appeared too weak to support setting fruit.

The results of this research suggest possible ways to use GA_3 to manipulate flowering in the 'Hass' avocado. November or earlier applications, when most buds are in a vegetative stage, would be expected to reduce flowering and might be used to increase the proportion of vegetative to reproductive growth prior to an "on" year. December application would be expected to have a dual effect. First, it should reduce floral intensity by stimulating resting buds not yet committed to flowering to produce vegetative shoots. Second, it would be expected to increase the earliness of flowering. January application should result in early flowering with full floral intensity. The fact that summer and fall shoots responded similarly to GA_3 suggests that a full canopy spray should produce uniform results.

As found by Salazar-Garcia et al. (manuscript in prep.), GA_3 caused precocious growth of the vegetative apex of indeterminate inflorescences. This result should prove advantageous. Competition between the developing vegetative shoot and setting fruit of indeterminate inflorescences has been cited as a cause of the low productivity of the avocado (Cutting and Bower, 1990; Whiley, 1990). The possibility of advancing the development of the vegetative shoot with GA_3 so that leaves are sources of photosynthate to setting fruit rather than competing sinks could have a positive effect on yield.

The results of this research provide evidence that GA_3 can reduce inflorescence number (inhibitory effect) or stimulate early flowering (promotive effect) depending upon time of application and concentration. The results suggest several possible strategies using GA_3 that may prove beneficial to avocado production.

5. Acknowledgments

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References

Cutting, J.G.M. and Bower, J.P. 1990. Relationship between auxin transport and calcium allocation in vegetative and reproductive flushes in avocado. Acta Hortic. 275:469-475.

Davenport, T.L. 1982. Avocado growth and development. Proc. Fla. State Hort. Soc. 95:92- 96.

Davenport, T.L. 1990. Citrus flowering. Hort. Rev. 12:349-408.

Guardiola, J.L., Agusti, M., and Garcia-Mari, F. 1977. Gibberellic acid and flower bud development in sweet orange. Proc. Int. Soc. Citriculture 2:696-699.

Kachru, R.B., Singh, R.N., and Chacko, E.K. 1972. Inhibition of flowering in *Mangifera indica* L. by gibberellic; acid. Acta Hortic. 24:206-209.

Lord, E.M. and Eckard, K.J. 1987. Shoot development in *Citrus sinensis* L. (Washington navel orange). II. Alteration of developmental fate of flowering shoots after GA_3 treatment. Bot. Gaz. 148:17-22.

Nunez-Elisea, R. and Davenport, T.L. 1991. Flowering of "Keitt" mango in response to deblossoming and gibberellic acid. Proc. Fla. State Hort. Soc. 104:41-43.

Porlingis, I.C. and Boynton, D. 1961. Growth responses of the strawberry plant, *Fragaria chiloensis* var. ananassa, to gibberellic acid and to environmental conditions. Proc. Amer. Soc. Hort. Sci. 78:261-269.

Salazar-Garcia, S., Lovatt, C.J., and Lord, E.M. Floral response of the 'Hass' avocado to gibberellic; acid applied at different stages of bud development. Manuscript in preparation.

Schuch, U.K., Fuchigami, L.H., and Nagao, M.A. 1990. Gibberellic acid causes earlier flowering and synchronizes fimit ripening in coffee. Plant Growth Reg. 9:59-64.

Sedgley, M. 1990. Flowering of deciduous perennial fruit crops. Hort. Rev. 12:223-264.

Whiley, A.W. 1990- C02 assimilation of developing fruiting shoots of cv. Hass avocado (*Persea americana* Mill.)- A preliminary report. S. Aft. Avocado Grower's Assn. Yrbk. 13:28-30.

Table 1 – Effect of GA_3 applied in November 1993 on the growth of apical buds of summer and fall vegetative flush shoots of the 'Hass' avocado. Observations were made on 3/26/94.

Shoot type	GA_3 applied (mg/liter)	Type of growth (% of total number of buds)		
		Inflorescences	Vegetative shoots	Resting buds
Summer shoots:	0	100.0 a	0.0 c	0.0 a
	50	90.8 ab	9.2 c	0.0 a
	100	54.2 bc	33.3 b	12.5 a
	1000	34.2 c	63.3 a	2.5 a
Fall shoots:	0	92.9 a	5.7 a	1.4 a
	50	96.3 a	3.7 a	0.0 a
	100	71.4 ab	14.3 a	14.3 a
	1000	47.5 b	50.0 a	2.5 a

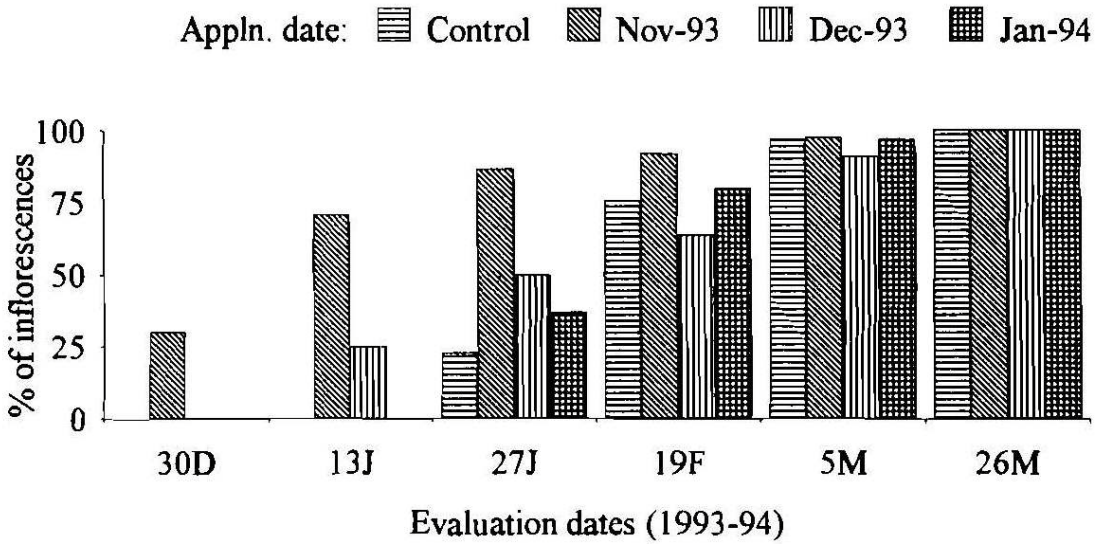

Figure 1. Effect of GA_3 (100 mg/liter) applied before budbreak (Nov -Jan) to summer and fall vegetative shoots (data pooled) on the percentage of total apical inflorescences exhibiting elongation of the secondary axes or a more advanced stage of development.

Figure 2. Control (untreated) indeterminate inflorescence exhibiting normal vegetative shoot development (left) and precocious vegetative growth of inflorescences produced by summer shoots treated with GA_3 (100 mg/liter) on January (right). Picture taken on 5 March 1994.