Application of GA₄₊₇ to Stem Enhances Carambola Seedling Growth

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Abstract. Growth response of containerized carambola (*Averrhoa carambola* L.) seedlings to GA₄₊₇ applied to trunks in lanolin paste were studied under glasshouse conditions. Gibberellic acid at 0, 250, 500, or 750 mg·liter⁻¹ and an untreated control (no lanolin) were used. Internode length and increases in plant height and trunk cross-sectional area (TCA) did not differ for control and 0 mg·liter⁻¹ plants, but mostly increased with concentration of GA. Increase in TCA was determined in a second study with control and treated plants, using 500 mg GA/liter. Mean recommended graftable size (7 mm) was reached in 47 days in plants that were GA treated, and 93 days in control plants, suggesting that GA may be used to shorten nursery time for producing graftable carambola seedlings. Chemical name used: gibberellic acid (GA₄₊₇).

Carambola has long been highly valued as an attractive dooryard fruit tree. Planting of commercial orchards in Florida began in the 1960s (Campbell et al., 1985). Commercial Florida plantings have grown from ≈4 ha in 1971 (Campbell, 1971) to > 175 ha reported in 1989 (Crane, 1989).

Cultural recommendations exist for ambola orchard management (Campbell

al., 1985; Campbell and Malo, 1984; Watson et al., 1988), but little information is available regarding the production of carambola nursery trees. Superior scion cultivars are typically propagated on open-pollinated seedlings with wedge, whip-and-tongue, or veneer grafts or budded with the chip or modified Forkert methods (Campbell and Malo, 1984; Campbell et al., 1985; Watson et al., 1988). A rootstock diameter of 6 to 8 mm is recommended for grafting (Campbell, 1989a, 1989b).

Stimulation of growth by gibberellins can be very dramatic in broad-leaved species (eopold and Kriedemann, 1975). Gibberellic acid-induced increases in stem diameter have been reported for diverse species (Brilinger and Storey, 1989; Hanna and Storey, 1972; Matta and Storey, 1981; Muller and

Young, 1982; Taylor, 1972).

Many tropical and subtropical fruit seedlings, but not carambola, reach graftable size relatively quickly. The objective of this study was to evaluate the use of GA for shortening carambola rootstock nursery production time by increasing stem growth rate.

Dose response. Seeds were extracted from 'Golden Star' carambola fruit 5 Jan. 1990 and planted in 3.1-liter clay containers in a whitewashed glasshouse. Seedlings were transplanted into individual 1-liter (11.5-cm diameter) containers on 20 Mar. and into 2.6-liter (15.5-cm diameter) containers on 5 July. The medium was 1 sand : 1 peat : 1 shredded pine bark : 1 perlite (by volume). Plants were watered daily and fertilized every 2 months. Fertilization consisted of a top dressing of 12N-2.6P-6.6K-2.4Mg-1.5Mn-0.1Cu-0.1Zn-1.3Fe granular fertilizer and a drench of 2.5 mM Fe (as FeEDDHA) solution. Rates were 2.5 g granular and 60 ml Fe solution for 1-liter containers, and 5.0 g granular and 125 ml solution for 2.6-liter containers.

Fifty uniform plants with a mean basal stem diameter (at 4.5 cm above crown) of 2.2 mm were chosen and spaced 35 cm on center on raised benches. Doses of GA₄₊₇ (ABG 3035, Abbott Laboratories, Chicago) were 0, 250, 500, and 750 mg GA/liter using lanolin paste as the carrier, and a no-lanolin control. Preparation was accomplished by adding GA to molten lanolin and stirring until the lanolin regained room-temperature consistency. Material was applied 6 and 27 July to seedling stems in a 4-cm band centered at 4.5 cm above the crown. Dual application was based on the methods of Muller and Young (1982). Ten single-plant replications were used in a completely randomized design.

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Table 1. Mean internode length and increase in plant height and trunk cross-sectional area (TCA) of carambola seedlings as influenced by GA₄₊₇ applied to stems in lanolin paste, n = 10.

Treatment	Mean internode length (cm) ^a	Plant ht increase (cm)	TCA increase (mm ²)
Control	2.6	24.4	13.4
Lanolin (mg GA ₄₊₇ /liter)			
0	2.4	23.9	11.3
250	2.5	25.2	25.4
500	3.2	45.0	33.8
750	3.7	42.4	30.8
Significance	L***	L***,Q*	L***,Q**

^aMean of the terminal seven internodes.

*, **, ***Significant at P = 0.05, 0.01, or 0.001, respectively; L, Q = linear or quadratic trends, respectively.

Fig. 1. Change in trunk cross-sectional area of control (●) and GA-treated (▲) carambola seedlings with time. Treatment consisted of 500 mg GA₄₊₇/liter applied to trunks in lanolin paste. Vertical bars represent SE, n = 15. In most cases, SE bars were smaller than the symbols.

Plant height and trunk diameter at 4.5 cm above the crown were measured 6 July and 16 Aug. Trunk diameters were used to calculate trunk cross-sectional areas (TCA). In addition, the internode length of the terminal seven internodes of each plant was measured 16 Aug.

Mean internode length and the increase in plant height and TCA during the experimental period were subjected to analysis of variance. Following determination of significance, a two-tailed *t* test was used to test the difference between the two controls (no lanolin and lanolin with no GA). Regression analysis was used to determine the relationship between plant growth and GA levels among the lanolin-treated plants.

Dose-response differences in internode length and increase in plant height and TCA were highly significant ($P < 0.0001$) for all three growth variables (Table 1). Control plants did not differ in size from plants receiving lanolin without GA at 41 days after treatment. Internodes were longest in plants treated with the highest level of GA. Total plant height and TCA, however, were no larger at 750 than at 500 mg GA/liter. Thus, the 500 mg·liter⁻¹ dose level was the most efficient for increasing trunk diameter growth under our conditions.

Growth response. A second study was

conducted to determine how rapidly GA-treated seedlings would reach the mean recommended diameter for grafting, which is 7 mm (Campbell, 1989a, 1989b). Seeds from the same set as the previous study were planted 8 May 1990, transplanted to 1-liter containers 28 June, and to 2.6-liter containers 24 Sept. Container medium, plant spacing, watering, and fertilization were as described.

Thirty uniform plants were chosen with a mean basal diameter of 2.1 mm. Treatments consisted of a control and 500 mg GA/liter applied once on 6 Oct., as described. A completely randomized design was used with 15 replications. Trunk diameter was measured on 6 Oct. and, thereafter, at 1- to 2-week intervals beginning 2 Nov. and ending 18 Jan. 1991.

The response of TCA growth over time was determined with regression analysis. Models for the two treatment levels were then subjected to analysis of covariance for homogeneity. Number of days needed to reach the prespecified TCA of 38 mm² (7-mm diameter) was calculated from the models.

The difference in TCA between treated and control plants increased in magnitude throughout the study (Fig. 1). The two regression equations could not be used to estimate the same population according to the test of homogeneity. Mean graftable size

of treated plants was reached 47 days after GA application, at which time control plants were 40% the size of treated plants. Mean graftable size in control plants was reached on day 93, when TCA of these plants averaged 32% of treated plants.

Gibberellic acid increased trunk growth rate of carambola seedlings and shortened the time required to reach the recommended size for grafting. Hanna and Storey (1972) and Taylor (1972) reported similar results with pecan [*Carya illinoensis* (Wangenh.) K. Koch], where GA₃-treated container-grown seedlings were large enough to patch bud ≈2 to 3 months from emergence. Conventional field-grown seedlings typically require two seasons of growth before budding.

Our results suggest that the most efficient method of producing carambola nursery trees may include the use of GA for enhanced growth, leading to a more rapid turnaround of inventory. Other forms of GA, carriers, or application may be more effective or practical than our method. The amount of horticultural or economic importance of shortening production time may vary, depending on specific nursery practices.

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