Inducement of Flowering in Taniers (*Xanthosoma* spp)[1]

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ABSTRACT

Tanier has not been improved through breeding because of a lack of uniform flowering in some clones or a lack of flowering in others. Flowering of taniers was induced by foliar application of gibberellic acid (GA_3). One foliar application of 250 p/m of GA_3 applied to 13-week-old plants induced 100% flowering within 19 weeks; three biweekly applications of 500 p/m induced 100% flowering within 15 weeks, and three biweekly applications of 100 p/m induced 88% flowering within 21 weeks of the first application. Both the white-fleshed and yellow-fleshed cultivars were induced to flower. More plants flowered, flowered sooner, and produced more flowers per plant when GA_3 plus 6-benzyladenine (BA) was used than when GA_3 was used alone. Flowers from the treated plants produced much pollen. Applications of GA_3 at 250 p/m or more, either alone or in combination with BA, promoted a branching effect on the cormels. The plant shape in all GA_3, and GA_3 plus BA treatments was altered. As a result, from three to more than eight auxiliary shoots developed per plant.

INTRODUCTION

Tanier is a staple crop in the American and African tropics (3). The 1977–78 crop was worth $12 million in Florida and $4.8 million in Puerto Rico (9, 12). Promotion of flowering in tanier is important from a breeding standpoint. Clones differ widely in their traits. Some produce only edible commercial cormels while others produce only edible commercial main corms. Breeding to combine favorable traits of the various clones would result in increased yields. However, if some specific sexual crosses are to be made to produce seeds, some cultivars must be induced to flower. For, although wild cones such as Valery generally flower profusely, some important cultivars do not flower under the environmental conditions of the Caribbean. The clones that flower naturally do not flower uniformly. In addition, a condition of protogyny exists in taniers, making the production of seeds under natural conditions rare. The first report of the production of seeds from a sexual cross was not made until 1975 (13, 14).

Gibberellic acid (GA_3) has been used to induce the flowering of grasses, tulips, Douglas fir, and *Cyclamen persicum* (5, 10, 11, 15). Both GA_3 and

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salicylic acid induced floral buds in *Impatiens balsamina* (8). Recently, GA_3 has been reported to induce flowering in taniers under the climatic conditions of Trinidad (1, 2, 6, 7).

MATERIALS AND METHODS

One trial and one experiment were conducted to determine the effect of growth regulators on flowering and other plant characters. The growth regulators, their concentrations, and the age of the white-fleshed or of the yellow-fleshed cultivar at the times of treatment applications in the trial and in the experiment are given in tables 1 and 2, respectively.

The trial was planted July 19, 1977, in a Rockdale fine sandy loam, a level phase-limestone complex soil (4) using nonapical main corm sections at a spacing of 91 cm between rows and 46 cm within the row. There were 10 plants per plot. The cultivars planted are locally known as Santo Domingo White (white-fleshed) and Malanga Amarilla (Yellow-fleshed). The experiment was planted January 15, 1978, in a Perrine marl soil (4). Apical main corm sections were planted at a spacing of 122 cm between the rows and 55 cm within the row. The cultivar used was Santo Domingo White. The plots in the experiment consisted of 10 treatments replicated four times in a randomized complete block design. Each plot was 4.9 m wide and 5.5 m long, and consisted of four rows which included 40 plants. Only the center 16 plants in the two middle rows were used for counts and experimental observations.

All growth regulators or chemicals in both the trial and the experiment were applied to the foliage with a hand sprayer pressurized with CO_2 gas. In the trial, the growth regulators were applied in 500 ml of water and 1 ml of wex, a wetting agent. In the experiment, treatments were applied at 2.81 kg/cm^2 pressure in 1 liter of water and in 1 liter of water plus 1 ml of wex per plot.

RESULTS AND DISCUSSION

In the trial the only treatments that flowered were those including or in excess of 250 p/m of GA_3 or a combination of gibberellin 4 and gibberellin 7 (GA 4/7). By April 3, 1978, 22 weeks after the first application to the trial, all plants in the 250 p/m or more GA_3 or $GA_{4/7}$ treatments were flowering except for treatments 5 and 11 (table 1), where 60% and 50% of the plants flowered, respectively. The 10 white-fleshed (table 1, treatment 7) and the 10 yellow-fleshed (table 1, treatment 8) plants, which received only one application of 250 p/m of GA_3 were all flowering by June 14, 1978, 19 weeks after treatment application.

Plants which received a combination of BA plus GA_3 appeared more vigorous and formed more flowers per plant than those sprayed with either GA_3 or BA. In treatment 6, the highest GA_3 level used, cormel

TABLE 1.—*Foliar growth regulator treatments to young tanier plants*

Treatment No.	Growth regulator[1]	Concentration—p/m					
		Weeks after planting					
		15	18	21	27	28	32
1	BA	10	40	40	40	0	40
2	BA	250	500	500	500	0	500
3	BA + GA_3	10 + 10	20 + 20	20 + 20	20 + 20	0	20 + 20
4	BA + GA_3	250 + 250	500 + 500	500 + 500	500 + 500	0	500 + 500
5	GA_3	250	500	500	500	0	500
6	GA_3	500	1000	1000	1000	0	1000
7	GA_3	0	0	0	0	250	0
8	GA_3[2]	0	0	0	0	250	0
9	AG50Y	0	10000	10000	10000	0	50000
10	AG50Y	0	0	0	0	1.2×10^6	0
11	BA + GA_3 + GA 4/7 + AG50Y	0	500 + 500 + 500 + 10000	500 + 500 + 0 + 10000	500 + 500 + 0 + 10000		500 + 500 + 0 + 50000
12	GA 4/7	0	250	0	0	0	0
13	Salicylic acid	1000	1000	0	4000	0	8000
14	Cytex[2]	20000	20000	20000	20000	0	10000
15	Maleic hydrazide[3]	2800	2800	2800	2800	0	0
16	Maleic hydrazide[4]	2800	2800	2800	2800	0	0

[1] The abbreviations refer to the following compounds: BA, 6-benzyladenine; GA_3, gibberellic acid; GA 4/7, a mixture of gibberelin 4 and giberellin 7; AG50Y, natural yeast concentrate of 2-ketoacid, cytex to mixed cytokinins (mostly zeatin-like), and maleic hydrazide to 1,2-dihydropyridazine-3,6-dione.

[2] Applied to a yellow-fleshed cultivar.

[3] Applied to yellow-fleshed plants stripped of suckers.

[4] Applied to yellow-fleshed plants with several suckers.

development was affected drastically. Several cormels per plant were initiated, but did not develop. At harvest, after the plants had grown for over 10 months, the average cormel weight was about 10 g in the highest GA_3 level treatment. The cormels did not show malformation except for their reduced size. The plants in the treatment with 250 or more p/m GA_3 produced a petiole-like bract or bladeless leaf prior to flowering. After flowering, axillary leaf systems began to develop. Tanier leaves in the higher GA_3 level turned yellowish-green from the time preceding flowering until harvest.

The salicylic acid-treated plants did not flower. Maleic hydrazide did not prevent suckering of the yellow-fleshed plants which had suckers, or from plants from which the suckers had been removed. Maleic hydrazide noticeably inhibited plant growth at the concentration used. Plants treated with AG50Y appeared no different from the control. Plots with white-fleshed cytex-treated plants appeared no different from the controls, while plots with the yellow-fleshed plants were larger and leafier. Yet the untreated yellow-fleshed plants surrounding the cytex-treated area were better developed than those in the rest of the experimental area, probably because of a more fertile soil.

In the experiment, 15 weeks after the first treatment application the 500 p/m BA plus 250 p/m GA_3 treatment, and the 1,000 p/m BA plus 500 p/m GA_3 treatment produced more bracts and more flowers per plot than the other treatments (table 2). The number of plants with bracts per plot was higher in the 250 or 500 p/m GA_3, in the 500 p/m BA plus 250 GA_3, and in the 1,000 p/m BA plus 500 p/m GA_3 treatments than in the other treatments. The number of plants with flowers per plot at 15 weeks after the first treatment application was significantly higher in the 500 p/m Ga_3, in the 500 p/m BA plus 250 p/m GA_3, and in the 1,000 p/m BA plus 500 p/m GA_3 treatment than in the other treatments.

Twenty-one weeks after the first treatment, the number of plants flowering per plot was significantly higher in the 250 or 500 p/m GA_3, in the 500 p/m BA plus 250 p/m GA_3, and in the 1,000 p/m BA plus 500 p/m GA_3 treatment than in the other treatments, except for the 100 p/m BA plus 100 p/m GA_3 treatment with which there was no difference. The 500 p/m GA_3, the 500 p/m BA plus 250 p/m BA_3, and the 1000 p/m BA plus 500 p/m GA_3 treatments produced significantly more axillary leaf systems per plant than the other treatments. The 500 p/m GA_3 or the 500 p/m BA plus 250 p/m GA_3 treatments produced plants with shorter petioles than those in the other treatments, except for the 250 p/m GA_3 and for the 1,000 p/m GA_3 treatments, with which there was no difference.

The results indicate that young tanier plants can be induced to flower by GA_3 application. The interval from the time of first application to 100% flowering was as low as 15 weeks when GA_3 was applied at 500 p/m

TABLE 2.—*Effect of phytohormones on flowering and plant characters*

Treatments	Concentration	Bracts/plot[1]	Flowers/plot[2]	Plants with bracts/plot[2]	Plants with flowers/plot[2]		Axillary leaf systems/plant	Petiole height
		Weeks after first treatment application						
			15				21	
	p/m	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*cm*
BA	100	0c[3]	0b	0b	0c	0c	1.4d	111ab
BA	500	1c	1b	0b	0c	1c	1.2d	116a
BA	1000	0c	0b	0b	0c	1c	1.2d	113ab
GA_3	100	2c	1b	1b	1c	14b	2.1bcd	111ab
GA_3	250	23b	6b	13a	5b	16a	3.6b	107abc
GA_3	500	49a	19a	16a	14a	16a	5.5a	92c
BA plus GA_3	100 + 100	7c	3b	3b	2bc	15ab	2.8bc	111ab
BA plus GA_3	500 + 250	47a	19a	15a	11a	16a	4.8a	91c
BA plus GA_3[4]	1000 + 500	47a	16a	15a	12a	16a	4.9a	95bc
Control	0	0c	0b	0b	0c	0c	1.4d	118a

[1] Applied at 13, 15, and 17 weeks after planting. The abbreviation BA stands for 6 benzyladenine; GA_3 for gibberellic acid.

[2] Sixteen experimental plants per plot.

[3] Means in columns followed by the same letter do not differ significantly at the 5% probability level according to Duncan's multiple range test.

[4] The third application was BA at 250 p/m plus GA_3 at 125 p/m.

in three biweekly applications, to 21 weeks for 88% flowering when it was applied at 100 p/m in three biweekly applications. One single application of GA_3 at 250 p/m produced 100% flowering 19 weeks after application. Generally, more plants flowered, flowered sooner, and produced more flowers per plant when GA_3 plus BA was used than when GA_3 was used alone at the same concentration. The flowers from the treated plants produced much pollen.

Although the youngest plants treated in the experiment were 13 weeks old, the same results could probably be obtained with plants 6 to 8 weeks old, or at the 1- to 2-leaf stage. However, unlike the results obtained by Alamu and McDavid (1) in Trinidad, presoaking of the seed pieces (sections or cormels) in solutions of GA_3 and planting in flats did not cause the production of flowers in two other trials and three experiments conducted by the authors of this article.

The application of GA_3 at 250 p/m or more, either by itself or in combination with BA, generally promoted cormel malformation. The malformed cormels had one or two characteristics in common. They tended to branch or they tended to elongate or become rhizome-like in form. Tanier cormels are normally mace-shaped, so at present the branched cormels would not be commercially acceptable. However, the cormels from the treated plants in the experiment were larger than those of the control plants.

In the trial, the treatment which included one application of GA_3 at 500 p/m and four applications at 1,000 p/m prevented initiated cormels from developing. Where lower rates of GA_3 were used, cormel malformation occurred. The malformed cormels showed several buds per cormel developing, but they had not reached the branching stage at harvest.

Gibberellic acid affected the plant shape and development. The apical bud turned into a flowering structure. As the flower died, axillary buds began to develop into axillary leaf systems. The higher the concentration of GA_3, and especially of GA_3 plus BA, the more axillary shoots developed. On the basis of the production of lateral-shoots and of the branching of the secondary cormels, it appears that GA_3 acts through a breaking of the apical dominance of the plant.

The practical and immediate significance of the trial and of the experiment is that they open the way for the systematic breeding of tanier. Clones can be forced to flower at the same time. Crosses which were either impossible, or very difficult, to make may now become a reality. The various desirable qualities of the different clones may be combined to improve crop yield and quality. The promotion of flowering would cut the time between planting and flowering, thus allowing for a quicker breeding program than if plants were allowed to flower naturally. Plants could be made to flower in about 21 weeks from planting.

RESUMEN

La yautía es una cosecha que forma parte de la dieta diaria de los países tropicales de América y Africa. Aunque existen grandes diferencias en los caracteres de distintas variedades, la yautía no se ha mejorado mediante cruzamiento genético porque los clones no florecen o no florecen uniformemente.

Se determinó que una aplicación de 250 ppm de ácido giberélico a plantas de 13 semanas de edad indujo 100% de floración a las 19 semanas después de aplicado. Cuando se aplicó tres veces cada dos semanas a 500 ppm se indujo 100% de floración a las 15 semanas, y cuando se aplicó tres veces a 100 ppm, se indujo 88% de floración a las 21 semanas después de la primera aplicación. Se indjueron a florecer tanto las plantas de carne blanca como las de carne amarilla.

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