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Manipulating Primocane Architecture in Thornless Blackberry with Uniconazole, GA_3, and BA

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Abstract. **The potential for plant growth regulator (PGR) manipulation of 'Chester Thornless' blackberry (fibus spp.) primocane growth was evaluated. PGR treatments included combinations of soil-applied uniconazole at 1, 5, 25, and 125 mg/plant and GA_3, foliar-applied one or two times at 100 ppm 3 and 4 weeks after a 25-mg/plant uniconazole application. Also, GA_3 and BA were applied at 100 ppm alone or in combination one, two, or three times. Increasing rates of uniconazole reduced primocane length, leaflet count, and leaf, cane, and root dry weights. GA, applications reduced primocane length and increased branch elongation but failed to reverse the effects of uniconazole at 25 mg/plant, except those on branch length, leaflet count, and primocane dry weight. Only applications of BA + GA, increased both branch production and elongation and dry weights of some component tissues, while BA alone generally had no effects. Chemical names used: (E)-1-(p-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl)-1-penten-3-ol (uniconazole); N-(phenylmethyl)-1H-purin-6-amine (benzyladenine, BA); gibberellic acid (GA_3).**

Managing vegetative growth in *Rubus* spp. with plant growth regulators (PGRs) has not been developed to the extent used in tree fruit production. Primary objectives have been the control of raspberry primocane production, usually suppression (Dale, 1989), and uniform fruit ripening and abscission for efficient machine-harvesting of blackberry (Lipe, 1980; Morris et al., 1978; Sims and Morris, 1982; Takeda and Peterson, 1988). While vegetative growth control of red raspberry has been attempted (Antognozzi et al., 1989; Braun and Garth, 1984, 1986; Crandall and Garth, 1981; Radelan, 1980), there have been no reported attempts to manipulate vegetative growth of thorny or thornless blackberry. In contrast to red raspberry, thornless blackberry is a larger plant that requires more effort to train to conform to a given trellis design. Thus, the need to control growth assumes substantial importance.

The growth retardants daminozide and paclobutrazol have reduced red raspberry primocane length (Antognozzi et al., 1989; Braun and Garth, 1984, 1986; Crandall and Garth, 1981; Radelan, 1980). Growth retardation by these chemicals in fruit trees has been reversed by the application of GA, since the retardants' mode of action is to inhibit GA biosynthesis in treated tissues (Casper and Taylor, 1989; Curry and Williams, 1983; Steffens et al., 1985). Thus, excessive inhibitory effects of the growth retardants have been alleviated. The potential for release of growth inhibition using GA has not been assessed in *Rubus* spp.

Cane length, or height, is not the only concern in thornless blackberry management. Yield has been positively correlated with branch number per cane (Archbold et al., 1989). Not all nodes produce branches, so increasing secondary branch production may increase yield per plant. Branching has been promoted in fruit trees by the application of cytokinins such as BA, while the addition of GA has occasionally given a greater response than BA alone, although GA_{4+7} has been used more often than GA_3 (Miller, 1988).

Due to the lack of information on the potential for manipulation of primocane architecture in thornless blackberry, the response of thornless blackberry primocane growth to the triazole growth retardant uniconazole, to GA, alone or applied to alleviate retardant effects, and to BA was evaluated in three experiments.

One-year-old 'Chester Thornless' blackberry plants were obtained from a commercial nursery and planted in Promix BX (Premier Brands, Stamford, Conn.) in pots on 26 Apr. 1988 and 5 June 1989. The top diameters and volumes of the pots were 27 cm and 15 liters in 1988 and 17 cm and 3.9 liters in 1989. The potted plants were set outdoors and watered daily when rainfall was not adequate. Plants were fertilized weekly with a 100-ppm solution of 20N-20P-20K in 1988; in 1989, each plant received one application of 25 g Osmocote slow-release fertilizer (19N-6P-12K). For the second and third experiments, plants were pruned to one unbranched primocane on 17 July 1989 and blocked by node counts of seven to 12.

In the first experiment, on 11 May 1988, plants received soil drench applications of uniconazole (50% wettable powder) at rates of 0, 1, 5, 25, and 125 mg a.i./plant in 500 ml water. Plants were arranged in a completely randomized design with five replications of each treatment. A single primocane was allowed to grow on each plant by removing emerging primocanes. On 14 Oct. 1988, plants were harvested for data collection.

In the second experiment, on 17 July 1989, one-half of the plants received uniconazole at 25 mg a.i./plant in 250 ml water as a soil drench, while the remainder were untreated. On 7 Aug. or both 7 and 28 Aug. 1989, a 100-ppm solution of GA_3 plus 0.01% Tween 80 was foliar-applied to drip to subgroups of both uniconazole-treated and control plants. The apical internode was then tagged. Six replications of a factorial set of treatments were arranged in a randomized complete block, blocks determined by node count.

In the third experiment, plants received BA and GA_3, separately or combined, at 100 ppm plus 0.01% Tween 80 on 8 July and 7 and 28 Aug. 1989. The GA, was applied on the first date only, while BA and the combination treatments were applied on the first

Table 1. Vegetative growth characteristics of 'Chester Thornless' blackberry plants as affected by uniconazole rate.

Uniconazole (mg/plant)	Total cane length (cm)	Leaflet count	Tissue dry wt (g) Cane	Leaf	Root
0	290	71	21	35	77
1	263	105	44	46	70
5	104	58	18	25	64
25	159	37	12	20	66
125	152	36	7	15	47
Significance[z]					
0 vs. uniconazole	*	**	*	*	**
Uniconazole					
Linear	NS	*	NS	*	**
Quadratic	NS	*	NS	NS	NS
Deviation	**	NS	NS	NS	NS

[z]Single degree-of-freedom contrasts for control vs. uniconazole treatment and for uniconazole rate excluding control values.
*,**,[NS]Significant at P = 0.05 or 0.01 or nonsignificant, respectively.

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Table 2. Vegetative growth characteristics of 'Chester Thornless' blackberry plants as affected by soil-applied uniconazole and foliar-applied antidotal GA_3.

Treatment	Cane count	Mean length (cm) Cane	Mean length (cm) Branch	Leaflet count	Tissue dry wt (g) Cane	Tissue dry wt (g) Leaf	Tissue dry wt (g) Root
Control	3.5	110	49	100	13.9	22.8	19.3
GA_3 1×[z]	2.7	57	58	82	11.5	20.5	21.2
GA_3 2×	2.3	62	63	88	11.7	20.8	18.5
Uniconazole[y]	1.2	98	11	42	4.8	14.0	14.7
Uniconazole + GA_3 1×	1.3	107	42	71	9.4	19.2	17.2
Uniconazole + GA_3 2×	1.3	80	37	60	8.5	18.3	14.6
Analysis of variance[x]							
Uniconazole (U)	*	NS	*	*	*	NS	*
GA_3	NS	*	*	NS	NS	NS	NS
Control vs. GA_3	NS	*	*	NS	NS	NS	NS
1× vs. 2×	NS	NS	NS	NS	NS	NS	NS
U × GA_3	NS	NS	NS	*	NS	NS	NS
U vs. U + GA_3	NS	NS	*	*	*	NS	NS
U × GA_3 1× vs. 2×	NS	NS	NS	NS	NS	NS	NS

[z]1 × = one application, 2× = two applications, 100 ppm each time.
[y]Uniconazole at 25 mg a.i./ plant.
[x]Significance of F for main effects (uniconazole and GA_3) and the interaction between uniconazole and GA_3 (U × GA), with single degree-of-freedom contrasts for selected comparisons.
*,[NS]Significant at P = 0.05 or nonsignificant, respectively.

Table 3. Vegetative growth characteristics of 'Chester Thornless' blackberry plants as affected by foliar-applied BA and GA_3.

Treatment	Branches/ cane	Mean branch length (cm)	Tissue dry wt (g) Cane	Tissue dry wt (g) Leaf	Tissue dry wt (g) Root
Control	2.6	28	13.0	26.8	23.0
GA_3 1×[z]	2.3	71	11.2	20.2	21.1
BA 1×	2.5	66	9.6	24.6	22.3
BA 2×	3.8	39	11.8	29.6	25.0
BA 3×	2.3	39	11.2	27.6	24.2
BA + GA_3 1×[y]	5.4	39	13.5	27.2	26.0
BA + GA_3 2×	3.4	53	17.0	29.2	29.7
BA + GA_3 3×	6.2	36	17.7	33.0	28.0
Contrasts[x]					
Control + GA_3 vs. rest	*	NS	NS	**	*
Control vs. GA_3	NS	**	NS	*	NS
1×–3× Linear	NS	**	*	*	NS
1×–3× Deviation	NS	NS	NS	NS	NS
BA vs. BA + GA_3	**	NS	**	NS	*
Linear × (BA vs. BA + GA_3)	*	NS	*	*	NS
Deviation × (BA vs. BA + GA_3)	**	**	NS	NS	NS

[z]1 × = one application, 2 × = two applications, 3 × = three applications, each at 100 ppm.
[y]BA and GA_3 each at 100 ppm.
[x]Significance of F for single degree-of-freedom contrasts.
*,**,[NS]Significant at *P* = 0.05 or 0.01 or nonsignificant, respectively.

date only, the first and second dates, or all three dates. Five replications per treatment were arranged in a randomized complete block; blocks were determined by node count. On 12 Oct. 1989, plants from both experiments were harvested.

At harvest, data collected included number and length of primocanes, number and length of lateral branches, leaflet count, and total leaf area measured with a LI-3000 (LI-COR, Lincoln, Neb.) leaf area meter. Node count and cane length above the tag were obtained from the tagged plants. From these values, mean cane and branch lengths and area per leaflet were calculated. Plants were separated into component tissues (roots, primocanes, and leaves) and oven-dried at 70C for a minimum of 3 days before weighing.

Data were analyzed by analysis of variance, with single degree-of-freedom contrasts used to determine uniconazole rate effects in the first experiment, GA_3 application effects and the effects of GA_3 on uniconazole-treated plants in the second experiment, and selected comparisons in the third experiment.

Primocane length was reduced by nearly 50% or more at uniconazole rates of 5 mg/plant or above (Table 1). Although area per leaflet was not affected by rate, leaflet count, and thus total leaf area per plant, was reduced at rates >1 mg (data not shown). A 36% reduction in primocane length was observed with field-grown red raspberry when the triazole retardant paclobutrazol was applied at 48 mg/plant as a soil drench (Braun and Garth, 1986). Less reduction was observed at 24 mg, while above 48 mg no further inhibition occurred. At rates > 2000 ppm, foliar-applied daminozide also inhibited primocane elongation (Braun and Garth, 1984; Crandall and Garth, 1981; Goulart, 1989).

As uniconazole rate was increased, the dry weights of the component tissues declined. Paclobutrazol similarly decreased red raspberry plant dry weight when foliar-applied at 1500 ppm (Maage, 1986) or soil-applied at 4 and 100 mg (Goulart, 1989). However, foliar-applied daminozide at 1000 and 5000 ppm had no effect on raspberry (Goulart, 1989).

While it is not known how much uniconazole the plants absorbed, their responses indicated progressively greater uptake with rates up to 25 mg, with minimal additional effects above 25 mg. Optimum application rates would need to be determined in field studies where higher rates than evaluated here may be required, and such tests should include measurement of yield. Uniconazole effectively reduced cane elongation, offering the potential for primocane growth control.

The application of GA_3 alone inhibited primocane elongation, increased branch elongation, but had no effect on tissue dry weights, cane count (Table 2), or branch number, which averaged 3.1 ± 0.5/primocane. When applied to uniconazole-treated plants, GA_3 increased leaflet count and cane dry weight over those treated with uniconazole alone. Branch count, reduced to 1.2 ± 0.3/cane by uniconazole, also increased to the control values of 3.1 ± 0.9 in response to GA_3. Area per leaflet, 22.5 ± 1.8 cm^2, was not influenced by the PGRs. However, since GA_3 increased leaflet count, leaf area of inhibitor-treated plants increased (data not shown). There were no differences between one or two GA_3 applications; neither were sufficient to alleviate all of the effects of uniconazole on primocane traits. Single GA_3 applications at similar rates have alleviated paclobutrazol inhibition in fruit trees, although the relative times of application of each PGR affects the responses (Casper and Taylor, 1989; Curry and Williams, 1983; Steffens et al., 1985). Leaf growth has generally been more responsive to GA than shoot growth in other studies, although leaflet size was not affected by uniconazole in this study.

Neither BA nor GA_3 application affected primocane production or mean primocane length, which averaged 2.8 ± 0.5/plant and 138 ± 26 cm, respectively. Branches per cane were increased by BA + GA_3 applications, though not linearly (Table 3). Branch length was increased by applications of GA_3, BA, and BA + GA_3. Thus, combining GA_3 with BA was critical to obtain both branch induction and elongation in thornless blackberry. This result is in contrast to the promotive effect of BA alone in fruit trees (Miller, 1988). Since GA_{4+7} more effectively promoted branch elongation than GA, in fruit trees, the response of thornless blackberry to GA_{4+7} should be evaluated. No effects on leaflet size or count were observed (data not shown). Leaf dry weight increased linearly with a greater response to BA + GA_3 than BA alone, while only BA + GA_3 increased primocane dry weight. GA_3 alone had no effect on root or primocane dry weight and reduced leaf dry weight.

It clearly is possible to manipulate thornless blackberry primocane architecture. Primocane count, elongation, and branching were altered in this study. Effects on yield components would be expected and need to be evaluated in field studies, as would additional rates and times of treatment. Due to the expense and effort needed to control vegetative growth of thornless blackberry, PGRs may provide a cost-efficient tool with which to manage that growth.

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