Growth Response of Seedlings of Flame Azalea to Manual and Chemical Pinching[1]

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Abstract

Seedlings of flame azalea [*Rhododendron calendulaceum* (Michx.) Torr] were subjected to the following manual pinching treatments at the 10-, 12-, 14-, or 16-leaf stage: no pinching, removal of the terminal two nodes [approximately 1.25 cm (0.5 in)] and removal of terminal growth [approximately 2.5-5.0 cm (1-2 in)] leaving six nodes. The greatest number of lateral shoots (5.3) was produced by removing the terminal two nodes at the 16-leaf stage. Generally, the number of lateral shoots increased with the leaf stage at which manual pinching was imposed. Removal of terminal growth, leaving six nodes, resulted in the lowest leaf, stem and root dry weights at each leaf stage. In a second experiment, dikegulac [Atrimmec; sodium salt of 2,3:4,6-bis-0-(1-methylethylidene)-α-L-xylo-2-hexulofuranosonic acid], at 0, 2000, 4000, 6000 or 8000 ppm, was applied to both nonpinched and manually-pinched plants (removal of the terminal two nodes at the 16-leaf stage). Dikegulac (Atrimmec) treatment significantly affected the number of lateral shoots and dry weights of leaves, stems and roots. The number of lateral shoots increased linearly with concentration up to 4000 ppm. At 6000 and 8000 ppm, the average number of shoots produced (9.4 and 9.6, respectively) was similar to 4000 ppm. Both pinched and nonpinched plants treated with dikegulac (Atrimmec) produced more lateral shoots than manual pinching alone. Dry weights of leaves, stems and roots decreased as the concentration increased. However, the number of lateral shoots and dry weights of leaves, stems and roots of pinched and nonpinched plants were not significantly different when treated with dikegulac (Atrimmec).

Index words: *Rhododendron calendulaceum*, native plants, chemical pinching agent, growth regulator, axillary shoot, dikegulac

Significance to the Nursery Industry

Lack of branching is a problem during production of flame azalea. These studies showed that lateral shoot development in seedlings may be stimulated by either manual or chemical pinching. Generally, the number of lateral shoots increases with the leaf stage at which manual pinching is imposed. The highest number of shoots results by removing the terminal two nodes at the 16-leaf stage. Both pinched and nonpinched plants treated with dikegulac (Atrimmec) produce more lateral shoots than manual pinching alone. The number of shoots increases linearly with increasing concentration of dikegulac (Atrimmec) over a range of 0 to 4000 ppm whereas responses to 4000, 6000 and 8000 ppm are comparable. However, considerable reduction in leaf, stem and root dry weights occurs with increasing concentration. This research also demonstrates that pinching the seedlings manually prior to dikegulac (Atrimmec) treatment does not result in a significantly greater number of lateral shoots compared to dikegulac (Atrimmec) treatment of nonpinched plants.

Introduction

Flame azalea (*Rhododendron calendulaceum*) is a deciduous species indigenous to the Appalachian region of the United States, extending from southwestern Pennsylvania to northern Georgia (8, 9). It blooms in late spring and is considered one of the most striking native flowering shrubs with flower color ranging from orange-yellow to scarlet (9). The commerical potential of this outstanding species has long been recognized. However, it has not been widely utilized due in part to lack of information regarding production.

A problem during production of flame azalea by sexual means (by seeds) is lack of branching. Well-branched plants, preferred by consumers, are what nurserymen attempt to produce but is often difficult to accomplish. Seedlings generally grow as a single stem and removal of the terminal bud only, results in little or no branching (personal observation by authors). Blazich and Acedo (2) have also reported lack of branching of plants propagated by micropropagation (tissue culture).

To produce well-branched plants, nurserymen often allow seedlings to grow from 1 to 3 years, followed by removal of top growth within a few cm (1 in = 2.5 cm) of the soil surface. Although this practice stimulates branching, several years' top growth is sacrificed, resulting in increased production costs. Thus, it would be highly desirable to develop techniques for manual and/or chemical pinching that induce branching in seedlings of flame azalea.

In azaleas (*Rhododendron* L. spp), the number of shoots influences plant size and shape and often determines the number of flowers (11). To increase the number of shoots, growers usually hand-pinch terminal shoots of young plants or use chemical pinching agents. The type of manual pinching (based on the extent of terminal shoot removal) may influence the number (7) as well as the length (10) of lateral shoots, whereas, plant response to chemical pinching is partially cultivar dependent (7, 12).

To induce branching in flame azalea, information is needed

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regarding plant responses to both manual and chemical pinching. Hence, the objectives of this study were twofold; (A) to examine the effect of manual pinching conducted at different leaf stages and (B) to examine plant response to a chemical pinching agent applied to both nonpinched and manually pinched plants.

Materials and Methods

Seedling propagation and growth. On November 13, 1986 mature seed capsules were collected from a native stand of open-pollinated plants growing in Watauga County, North Carolina, at an elevation of 1400 m (4593 ft). Capsules were stored in a paper bag at 20°C (68°F) for 21 days. Seeds were then removed from the capsules and stored at a moisture content of 6% in a sealed bottle at 4°C (39°F).

Seeds were removed from storage on November 2, 1989 (Expt. 1) and April 18, 1990 (Expt. 2) and surface-sown in flats containing a medium of 4 pine bark:1 peat (v/v). Flats were placed under intermittent mist (Mist-A-Matic, E. C. Geiger, Harleysville, Pa.) in a greenhouse maintained at day/night temperatures of ≈ 24/16°C (75/61°F) with natural irradiance (light intensity) from 8:00 a.m. to 5:00 p.m. Incandescent lamps which provided a photosynthetic photon flux (PPF) of 3.6 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (0.2 klx) plus photomorphogenic radiation (PR) of 0.7 $W \cdot m^{-2}$ were used to interrupt the dark period between 11:00 p.m. and 2:00 a.m. daily [light measurements recorded with a cosine corrected LI-COR LI-185 quantum/radiometer/photometer (LI-COR, Lincoln, Neb.)].

Following germination, seedlings were fertilized weekly with 180 ppm N from a 15N-20P-4K (15-45-5) water soluble fertilizer [Rhododendron Special (Grace/Sierra, Fogelsville, Pa.)] also containing 200 ppm $CaCl_2$ and 75 ppm $MgSO_4$. When seedlings reached approximately 2.5 cm (1 in) in height they were transplanted into 1-liter (1.1 qt) containers (one per container) utilizing a medium of arcillite, a calcined clay. Arcillite was selected as a medium because it allows recovery of intact root systems at harvest (5). Plants were grown under the same temperature and light conditions as the seedlings in the flats and were fertilized weekly as previously described until transferred to the Southeastern Plant Environment Laboratory where Expts. 1 and 2 were conducted.

Manual pinching (Expt. 1). On January 23, 1990, when seedlings were at the 6–8 leaf stage, they were transferred to an unshaded, temperature-controlled greenhouse at the Southeastern Plant Environment Laboratory (4). The study was a 3 × 4 factorial in a randomized complete block design with 12 treatments and 12 single plant replications. The main factors were three manual pinching treatments [no pinching, removal of the terminal two nodes (approximately 1.25 cm [0.5 in]) and removal of terminal growth (approximately 2.5–5.0 cm [1–2 in]) leaving six nodes] and four leaf stages at which pinching treatments were imposed (10, 12, 14, or 16). Plants were pinched on February 23, February 23, March 9 and March 12, 1990 for the 10-, 12-, 14- and 16-leaf stages, respectively.

Day/night greenhouse temperatures were maintained at 26/22°C (79/72°F) and operated on a 9/15 hr cycle. Plants were subjected daily to long-day photoperiods by interrupting the dark period from 11:00 p.m. to 2:00 a.m. with 11–12 $\mu mol \cdot m^{-2} \cdot s^{-1}$ from incandescent lamps (4).

Initially, plants were fertilized twice weekly (Monday and Thursday) with the standard Phytotron nutrient solution (4). Beginning on week 4, fertilization was increased to thrice weekly (Monday, Wednesday and Friday). Plants were watered with deionized water on the remaining days.

Ten weeks after treatments were initiated at each leaf stage, the total number of lateral shoots per plant was recorded. Plants were then divided into leaves, stems and roots which were dried at 70°C (158°F) for 72 hr and weighed. Shoot/root ratio (top dry weight/root dry weight) was also determined.

Manual pinching in combination with chemical pinching (Expt. 2). This experiment employed the pinching treatment from Expt. 1 which resulted in the greatest number of lateral shoots and spray treatments of dikegulac [Atrimmec; sodium salt of 2,3:4,6 bis-O-(1-methylethylidene)-α-L-xylo-2-hexulofuranosonic acid (Maag Agrochemicals, Inc., Vero Beach, Fla.)].

Seedlings were transferred to the same greenhouse used in Expt. 1 on July 5, 1990 and grown under shade cloth which reduced irradiance by 40%. Fertilization was as previously described for Expt. 1. The study was a 2 × 5 factorial in a randomized complete block design with 10 treatments and 10 single plant replications. The main factors were two pinching treatments (no pinching and removal of the terminal two nodes when seedlings reached the 16-leaf stage) and five concentrations of dikegulac (Atrimmec) sprayed to runoff (0, 2000, 4000, 6000 or 8000 ppm).

On August 7, 1990, 100 plants at the 16-leaf stage were selected. Half were manually pinched by removing the terminal two nodes. The other 50 plants were not pinched. Six days after pinching, both pinched and nonpinched plants were treated with the previously mentioned concentrations of dikegulac between 3:00 and 4:00 p.m. using a handsprayer. On November 7, 1990, 12 weeks after the experiment was initiated, data were recorded as in Expt. 1.

Statistical analysis. All data were subjected to analysis of variance and regression analysis.

Results and Discussion

Manual pinching (Expt. 1). Number of lateral shoots, dry weights of leaves, stems and roots and shoot/root ratio were affected by both manual pinching and the leaf stage at which pinching was imposed. In addition, there were significant interactions between pinching treatment and leaf stage for all dry weight parameters. There were no significant interactions for shoot/root ratio and number of lateral shoots.

Removal of the terminal two nodes produced more lateral shoots compared to removal of terminal growth leaving six nodes, for all leaf stages (Fig. 1). Nonpinched plants consistently produced the fewest lateral shoots (Fig. 1). Generally, the number of lateral shoots increased with leaf stage (Fig. 1). For plants in which the terminal two nodes were removed, the more leaves remaining on the pinched plants the more lateral shoots were formed (Fig. 1). Larson (7) reported that soft pinches [removal of 1 cm (0.4 in) or less of the shoot tip] produced more lateral shoots as more leaf axils remained from which lateral shoots emerged. For flame azalea, the greatest number of lateral shoots was produced by removing the terminal two nodes at the 16-leaf stage (Fig. 1). Generally, the shoots produced following manual

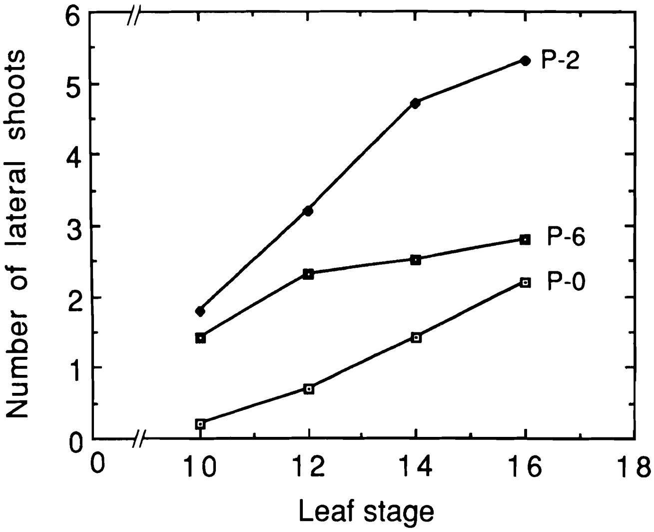

Fig. 1. Effects of manual pinching treatments and leaf stage on number of lateral shoots of seedlings of flame azalea (Expt. 1). P-0 = no pinching, P-2 = removal of the terminal two nodes and P-6 = removal of terminal growth leaving six nodes. Each datum is the mean for 12 observations.

pinching emerged from nodes near the shearing point. Similar observations for other species of azalea were also reported by Barrick and Sanderson (1) and Shu et al. (12).

Within each leaf stage, pinching treatment significantly affected both leaf and stem dry weight (Table 1). Ten weeks after treatment, nonpinched plants had the highest leaf and stem dry weight (Table 1). Plants in which the terminal two nodes were removed had significantly greater leaf and stem dry weight than those for which all terminal growth was removed leaving six nodes (Table 1). There was no significant difference in root dry weight between nonpinched plants and those in which the terminal two nodes were removed, excluding the 14-leaf stage. Removal of terminal growth leaving six nodes, however, significantly reduced root dry weight at each leaf stage (Table 1).

Shoot/root ratio was affected by both pinching treatment and the leaf stage at which pinching was implemented (Table 1). The highest shoot/root ratio (averaged over all pinching treatments) was at the 16-leaf stage (Table 1). Among pinching treatments, shoot/root ratio was lowest (2.7) in plants where the terminal two nodes were removed, and highest (3.3) in nonpinched plants (data not presented).

Manual pinching in combination with chemical pinching (Expt. 2). Dikegulac treatment significantly affected the number of lateral shoots and dry weights of leaves, stems and roots but not the shoot/root ratio. There were significant interactions between pinching treatment and dikegulac (Atrimmec) concentration for stem and root dry weight but no similar interactions for number of lateral shoots and leaf dry weight. The number of lateral shoots produced following dikegulac treatment increased with concentration up to 4000 ppm (Fig. 2). At 6000 and 8000 ppm, the number of new shoots was comparable to 4000 ppm (Fig. 2). For several cultivars of greenhouse azaleas, the greatest number of shoots was produced following treatment with 5000 ppm dikegulac (11, 12). De Silva et al. (3) found 4000 ppm to be the optimum concentration from September to May but for the warmer months of June through August, 6000 ppm was optimum.

For flame azalea, both nonpinched and pinched plants treated with concentrations of dikegulac (Atrimmec) $\geq$ 2000 ppm produced more lateral shoots than nonpinched or manually-pinched plants alone which produced an average of 1.7 and 3.9 lateral shoots per plant, respectively (data not presented). Other workers (3, 6, 11, 12) have also found

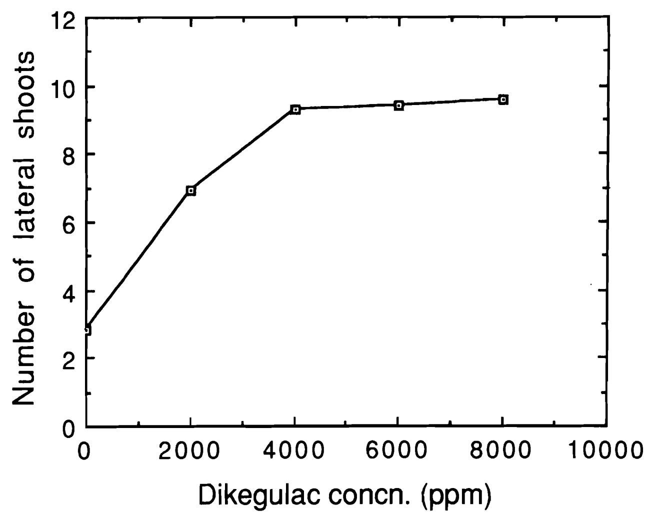

Fig. 2. Effects of chemical pinching (averaged over nonpinched and manually-pinched plants) on number of lateral shoots of seedlings of flame azalea (Expt. 2). Each datum is the mean for 20 observations.

Table 1. Dry weights of leaves, stems and roots and shoot/root ratio of seedlings of flame azalea as affected by manual pinching at different leaf stages (Expt. 1).

	Leaf dry wt. (g)			Stem dry wt. (g)			Root dry wt. (g)			
Leaf stage	P-0[z]	P-2	P-6	P-0	P-2	P-6	P-0	P-2	P-6	Shoot/root ratio
10	1.8 a[y]	1.3 b	0.8 c	0.4 a	0.3 b	0.2 c	0.7 a	0.6 a	0.4 b	2.9
12	2.3 a	1.6 b	0.8 c	0.6 a	0.3 b	0.2 c	1.1 a	0.9 a	0.4 b	2.6
14	3.7 a	2.4 b	0.8 c	1.2 a	0.8 b	0.2 c	1.8 a	1.1 b	0.4 c	3.0
16	4.2 a	3.3 b	1.2 c	1.3 a	1.0 b	0.3 c	1.5 a	1.5 a	0.4 b	3.6
Significance										
Linear	**[x]	**	**	**	**	**	**	**	NS	**
Quadratic	NS	*	*	NS	NS	NS	*	NS	NS	**

[z]Pinching treatments: P-0 = no pinching, P-2 = removal of terminal two nodes, P-6 = removal of terminal growth leaving six nodes.

[y]Mean separation within rows for a dry weight parameter by LSD, 5% level.

[x]NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively.

Table 2. Dry weights of leaves, stems and roots of seedlings of flame azalea as affected by chemical pinching of nonpinched and manually pinched plants (Expt. 2).

Dikegulac concn. (ppm)	Leaf dry wt. (g)	Stem dry wt. (g)		Root dry wt. (g)	
		P-0[z]	P-2	P-0	P-2
0	2.1	0.7 a[y]	1.0 a	0.8 a	1.2 b
2000	1.9	0.7 a	0.6 a	0.8 a	0.7 a
4000	1.5	0.6 a	0.5 a	0.6 a	0.6 a
6000	1.5	0.5 a	0.5 a	0.5 a	0.6 a
8000	1.3	0.4 a	0.4 a	0.5 a	0.3 a
Significance					
Linear	**[x]	**	**	**	**
Quadratic	NS	NS	*	NS	NS

[z]Pinching treatments; P-0 = no pinching, P-2 = removal of the terminal two nodes at the 16-leaf stage.

[y]Mean separation within rows for a dry weight parameter by LSD, 5% level.

[x]NS, *, ** Nonsignificant or significant at P = 0.05 or 0.01, respectively.

that in general, dikegulac (Atrimmec) applied to either pinched or nonpinched plants produced more lateral shoots than manual pinching alone.

Dry weights of leaves (averaged over both pinched and nonpinched plants), stems and roots decreased linearly as dikegulac (Atrimmec) concentration increased (Table 2). Reduction in shoot growth was most pronounced at 8000 ppm as plants produced many short lateral shoots with narrow leaves. Inhibitory effects of dikegulac (Atrimmec) have also been observed by several workers (6, 11, 12) who reported a delay in shoot development for several weeks. In addition, our study showed that root growth was either directly or indirectly reduced by dikegulac (Atrimmec) treatment (Table 2). Thus, in selecting the appropriate concentration of dikegulac (Atrimmec), number of lateral shoots should not be the only concern. Retardation of shoot and root development should also be taken into consideration.

A common practice when using dikegulac (Atrimmec) to induce branching in azaleas is to pinch plants manually and then apply the compound 2 days later to stimulate lateral shoot development (7). In the current study, treatment of manually-pinched plants with dikegulac (Atrimmec) did not result in significantly different responses compared to dikegulac (Atrimmec) treatment of nonpinched plants (Table 2).

Within 2 weeks after dikegulac (Atrimmec) treatment, necrotic areas appeared at the tips and margins of upper leaves and newly expanded leaves of plants receiving concentrations ≥4000 ppm. The remainder of the foliage was unaffected. Temporary chlorosis was also observed following dikegulac (Atrimmec) application in greenhouse azaleas (3, 11). In contrast to manually pinched plants where most lateral shoots emerged from nodes close to the shearing point, new shoots of dikegulac (Atrimmec)-treated plants emerged from nodes along the stem, especially from lower nodes close to the base of the stem, as was reported by Shu et al. (12). This type of branching would be desirable for achieving an acceptable growth form.

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