HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

Table 6. **Effect of seedling variability on tissue element content of *Brassaia actinophylla* receiving the recommended rate of N-P-K fertilizer.**

Element	% dry weight[z] Mean x̄	Range
Calcium	1.28	1.00 to 1.50
Magnesium	0.37	0.28 to 0.50
Nitrogen	3.37	2.70 to 4.40
Phosphorus	0.55	0.45 to 0.76
Potassium	2.98	2.60 to 3.70
Sodium	0.09	0.04 to 0.14
Sulfur	0.22	0.16 to 0.37

Element	ppm Mean x̄	Range
Aluminum	115	60 to 190
Boron	26	17 to 35
Copper	14	10 to 18
Iron	17	72 to 110
Manganese	597	360 to 860
Zinc	241	138 to 388

[z]Means are given for 15 plants.

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Chemically Induced Branching of Woody Landscape Plants[1]

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Abstract

Axillary budbreak of *Ilex crenata* Thunb. 'Helleri' and *Ilex vomitoria* Ait. 'Stoke's Dwarf' hollies was promoted by a single BA (N-(phenylmethyl)-1H-purin-6-amine) application of 125–1000 ppm compared to an unpruned control. Budbreak of *Photinia* x *Fraseri* Dress was stimulated by 500–2500 ppm BA and 2000–5000 ppm Promalin (BA + GA_{4+7}). Budbreak in *Nandina domestica* Thunb. 'Harbour Dwarf' increased with 1000–2500 ppm BA and 2000–5000 ppm Promalin application. Budbreak of *Rhododendron* x 'Formosa' azalea was promoted by 2000 and 2500 ppm BA and 2000–5000 ppm Promalin. Axillary budbreak of *Ternstroemia gymnanthera* (Wight & Arn.) T. Sprague) and *Raphiolepis indica* (L.) Lindl. was not affected by BA or Promalin application.

Index Words: cytokinin, gibberellins, Promalin, growth regulators, BA

Growth Regulators Used in This Study: BA (N-(phenylmethyl)-1H-purin-6-amine); Promalin (BA + GA_{4+7}).

Species Used in This Study: Helleri holly (*Ilex crenata* Thunb. 'Helleri'); Stoke's Dwarf holly (*Ilex vomitoria* Ait. 'Stoke's Dwarf'); Fraser photinia (*Photinia* x *Fraseri* Dress); Indian hawthorn (*Raphiolepis indica* (L.) Lindl.); Formosa azalea (*Rhododendron* x 'Formosa'); cleyera (*Ternstroemia gymnanthera* (Wight & Arn.) T. Sprague); Harbour Dwarf nandina (*Nandina domestica* Thunb. 'Harbour Dwarf')

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Significance to the Nursery Industry

Plant species used in this study typically require multiple prunings during production for the development of a well-branched, compact plant. On the other hand, chemical stimulation of axillary budbreak potentially can reduce the number of mechanical prunings necessary to produce a well-branched, marketable plant. However, species do respond differently to rates of BA and Promalin. Results with Helleri and Stoke's Dwarf hollies, Fraser photinia, Formosa azalea, and Harbour Dwarf nandina are promising. However, it is suggested that before committing to large scale use of plant growth regulators for lateral branch induction, an evaluation with a few plants first be conducted. Promalin appears also to have merit in increasing cuttage of Harbour Dwarf nandina stock plants.

Introduction

Repeated pruning of many woody landscape species is a labor-intensive practice required to produce well-branched, marketable materials. Shoot tip pruning removes the source of apical dominace, a process controlled by a balance between auxin and cytokinin levels (4, 6), and stimulates lateral bud development. Exogenously applied cytokinins, including BA, promote axillary bud growth and branching of woody plants (3, 5, 7). Synthetic cytokinins may induce only a partial release from apical dominance (1); further growth of released axillary buds requires treatment with a synthetic auxin or gibberellin (2, 6). Two experiments were conducted to determine if axillary growth of several woody landscape species could be promoted by exogenous cytokinin and gibberellin application. Species used in the tests typically require multiple prunings during production for the development of a well-branched, compact plant.

Materials and Methods

In experiment 1, uniform 8.9 cm (3.5 in) liners of Helleri holly, Stoke's Dwarf holly, Fraser photinia, Indian hawthorn, Formosa azalea, and cleyera were grown in 7.6 cm (3 in) square containers in a glass greenhouse. Growth medium was milled pine bark-peat moss (4:1 by vol.) amended per m^3 (yd^3) with 3.6 kg (6 lb) dolomitic limestone, 1.2 kg (2 lb) gypsum, and 0.9 kg (1.5 lb) Micromax. Plants received 150 ppm N weekly from Peter's 20N-8.6P-16.6K (20-20-20) soluble fertilizer. On March 7, 1986, a single spray of BA at 0, 125, 250, 500, and 1000 ppm was applied to the foliage of all species. Foliar sprays included 0.2% (v/v) Buffer X, an ionic surfactant, and were applied with a compressed air sprayer equipped with a fan nozzle to the plant canopy just prior to runoff. A pruned control in which plants were cut to 5 cm (2 in) above the growth medium also was included. There were 5 replicates of 3 plants per treatment completely randomized within species. On April 29, 1986, newly developed lateral shoots longer than 1 cm (0.4 in) were counted.

Due to a minimal response to BA, the experiment was terminated in June 1986 for all species except Helleri and Stoke's Dwarf hollies. On June 9, 1986, Helleri and Stoke's Dwarf hollies were repotted into 2.8 liter (#1) containers of 100% milled pine bark amended with limestone, gypsum, and Micromax at the same rates added to the liner growth medium. In addition, Osmocote 17N-3P-10K (17-7-12) was added to the growth medium at 7.2 kg/m^3 (12 lb/yd^3). Plants were moved from the greenhouse to an outdoor production area in full sun, and treatments were reapplied. Growth indices ((height + width + width)/3) were measured on November 18, 1986. On January 28, 1987, lateral shoot length (5 longest shoots/plant), plant height, and relative root rating (1 = no roots on rootball surface; 2-5 = 25, 50, 75, and 100% coverage of rootball, respectively) were determined.

Because several species were not responsive to the BA rates applied, a second experiment was conducted using higher BA rates and several rates of Promalin. Promalin is a mixture of equal parts by weight of BA and GA_{4+7}. Species evaluated included Fraser photinia, cleyera, Formosa azalea, Indian hawthorn and Harbour Dwarf nandina, a species with little or no lateral branching that does not readily respond to mechanical pruning. Uniform liners were grown in 7.6 cm (3 in) containers of the same amended liner growth medium as in the first experiment. On November 4, 1987, BA treatments of 0, 1000, 1500, 2000, and 2500 ppm and Promalin treatments of 0, 2000, 3000, 4000, and 5000 ppm were applied. Foliar sprays with 0.2% Buffer X were applied with a compressed air sprayer just prior to runoff. A pruned control was included for comparison. The number of shoot apices were determined at this time so adjustments could be made for any initial differences among treatments.

Plants were maintained in a glass greenhouse with minimum day/night temperatures of 21°C (70°F)/17°C (62°F). Night interrupted lighting was provided from 10:00 pm to 2:00 am by 60 watt incandescent lamps spaced 1 m (1.1 yd) apart and 1 m (1.1 yd) above the plants. The experiment was completely randomized within species with 5 replicates of 3 plants per treatment.

On January 26, 1988, plant height and axillary budbreak were determined, and on February 8, treatments were reapplied. Plant height and axillary budbreak data were collected on April 1 from all species except Indian hawthorn which was collected May 13. On May 24, 1988, apical and subapical single-node cuttings were taken from Harbour Dwarf nandina to determine treatment effects on cuttage; cuttage production limits the availability of Harbour Dwarf nandina.

Results and Discussion

Experiment 1. Induction of axillary budbreak in response to BA application was species-dependent (Table 1). Bud-

Table 1. Effect of BA foliar sprays and hand pruning on axillary budbreak of 5 woody nursery crops, Experiment 1.

		Average number of new shoots/plant				
Treatment	BA rate	Cleyera	Formosa azalea	Helleri holly	Fraser photinia	Stoke's Dwarf holly
BA[z]	0 ppm	6.7	9.9*	6.8[y]	1.7	29.7
	125 ppm	6.3*[y]	11.2	11.5*	1.5	39.4
	250 ppm	6.8	10.6*	14.7	1.5	45.2
	500 ppm	6.5*	10.6*	20.9	4.4	35.0
	1000 ppm	5.9*	9.9*	42.1*	7.3[y]	63.4*
Hand pruned	—	9.5	13.7	19.1	2.5	35.4
	Significance[x]	Q	C	C	C	L

[z]Applied as a foliar spray with 0.2% Buffer X, a surfactant, added.

[y]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5% level.

[x]L = linear; Q = quadratic; C = cubic regression response, 1% level.

Table 2. Growth index, shoot length and plant height of 'Helleri' and 'Stoke's Dwarf' hollies treated with BA, Experiment 1.

Treatment	BA rate	Growth index[z] (cm)		Shoot length[y] (cm)		Plant height (cm)	
		Helleri	Stoke's Dwarf	Helleri	Stoke's Dwarf	Helleri	Stoke's Dwarf
BA	0 ppm	30.4	26.9	7.6	7.7	20.6	26.5*[x]
	125 ppm	28.8	27.6*[x]	6.9	7.3	19.9	25.5*
	250 ppm	26.9	29.2*	4.7*	7.3	19.4	25.2*
	500 ppm	29.8	27.2	6.1	7.9	19.3	26.5*
	1000 ppm	27.2	24.6	5.4	6.9	18.7	22.4
Hand pruned	—	27.1	25.5	7.4	6.9	18.2	22.2
	Significance[w]	NS	C	C	Q	NS	C

[z]Growth index = (height + width + width)/3.

[y]Shoot length = mean of 5 longest shoots/plant.

[x]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5% level.

[w]NS = not significant; Q = quadratic; C = cubic regression response, 1% level.

break of cleyera, Formosa azalea, and Indian hawthorn (data not significant and not shown) was marginally or not affected by BA, whereas hand pruning induced equal or greater branching than all rates of BA. Axillary budbreak of Helleri and Stoke's Dwarf hollies and Fraser photinia increased with increasing rates of BA and resulted in a greater number of new shoots at 1000 ppm than did hand pruning. Results with Helleri holly and Fraser photinia concur with previous research (5, 7).

Six months after repotting and a second BA application, little visual response was evident in the relative root rating for Helleri and Stoke's Dwarf hollies (data not shown). Growth indices, shoot length, and plant height measurements tended to decrease with increasing BA rates (Table 2). BA application, especially at the higher rates, resulted in dense and compact plants of Helleri and Stoke's Dwarf hollies (Figure 1). Phytotoxicity was not observed on any species.

Experiment 2. Axillary shoot number taken when treatments were first applied did not differ among treatments, so subsequent budbreak data were not adjusted. As in the first experiment, species responded differently to growth regulator application. Neither axillary budbreak nor plant height of cleyera was affected by BA or Promalin foliar sprays (data not shown).

Axillary budbreak of Formosa azalea, determined in January 1988, decreased at the lower BA rates before increasing at the highest rate (Table 3). By April, budbreak was positively correlated with BA rate, increasing from 9.1 breaks per plant for the unpruned control to 14.1 breaks per plant receiving 2000 ppm BA. Budbreak was not affected by Promalin in January, but by April 1988, budbreak increased linearly with increasing Promalin rate, from 9.1 breaks on the unpruned control to 22.1 breaks on plants treated with 5000 ppm. Pruning induced greater budbreak than all plant growth regulator (PGR) treatments except 2500 ppm BA in January and the lower 2 BA rates in April. Only the highest Promalin rate promoted greater budbreak than pruning. There was a decrease in plant height with increasing PGR rate; this trend was particularly evident in April.

Indian hawthorn responded minimally to both PGRs. With increasing BA and Promalin rates there was a slight increase in budbreak noted in January 1988, however this response was not evident in May (data not shown). Budbreak of pruned plants was significantly less in January than budbreak of plants treated with 3 rates of BA and Promalin and less in May than that of plants treated with all rates of both PGRs. Budbreak of pruned plants also was less than that of unpruned plants in May.

Axillary budbreak of Fraser photinia was promoted by BA and Promalin on both sampling dates (Table 4). In January, budbreak of BA-treated plants increased from 1.8 for the

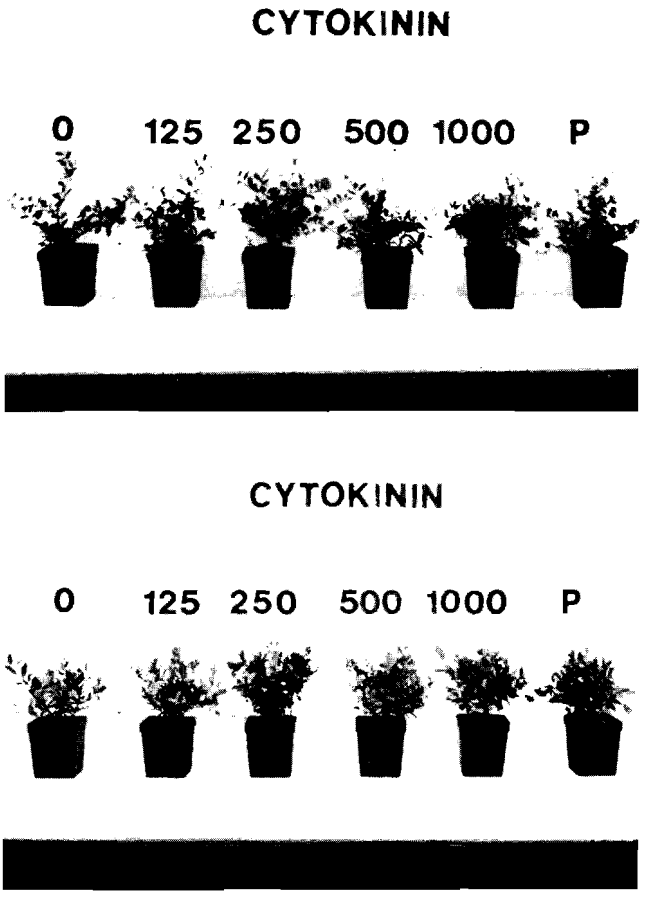

Fig. 1 Helleri (top) and Stoke's Dwarf hollies treated with BA (cytokinin) foliar sprays of 0, 125, 250, 500, and 1000 ppm.

Table 3. Effects of BA and Promalin on axillary budbreak and height of Formosa azalea, Experiment 2.

PGR	Rate (ppm)	Axillary budbreak no.		Plant height (cm)	
		January 26, 1988	April 1, 1988	January 26, 1988	April 1, 1988
BA	1000	5.5*[z]	8.1*	29.0*	49.7*
	1500	4.9*	8.7*	31.9*	53.3*
	2000	5.1*	14.1	28.9*	51.7*
	2500	6.1	13.6	27.1*	42.8*
Promalin	2000	5.5*	13.7	33.9*	46.4*
	3000	5.9*	15.9	28.6*	41.7*
	4000	5.5*	16.2	28.0*	37.6*
	5000	6.0*	22.1*	29.5*	38.4*
Pruned		7.7	15.3	16.0	14.5
Unpruned		6.9	9.1*	30.7*	49.3*
Comparison					
BA vs Promalin[y]		NS	**	NS	**
Sign. of rate[x]					
BA		Q	Q	Q	Q
Promalin		NS	L	C	L

[z]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5% level.
[y]NS = not significant or significant at the 1% (**) level.
[x]NS = not significant; L = linear; Q = quadratic; C = cubic regression response, 1% level; unpruned control included in regression analysis.

unpruned treatment to 6.9 breaks with 2500 ppm BA. In April the increase was from 11.0 to 23.8 breaks per plant. Budbreak increased to 9.6 in January and to 28.7 in April with the highest Promalin rate. Budbreak of pruned plants was twice that of unpruned plants in January but less in April. Pruning was less effective in inducing axillary budbreak than 2500 ppm BA and the 3 highest Promalin rates in January and all rates of both PGRs in April. Plant height, measured in January, was promoted by Promalin, but was not evident in April.

BA and Promalin increased axillary budbreak of Harbour Dwarf nandina compared to unpruned plants (Table 5). The BA-induced increase was from 1.1 breaks for unpruned plants to 3.9 breaks with 2000 ppm in January and from 1.3 to 7.4 breaks with 2000 ppm in April; Promalin promoted budbreak to 3.3 breaks in January and 5.5 breaks in April with 5000 ppm. Pruning induced more budbreaks compared to the unpruned control and was more effective than the 2 lowest Promalin rates in January but less effective than the 3 highest BA rates and the highest Promalin rate in April. Plant height of Promalin-treated plants was greater than height of unpruned plants on both sampling dates.

More single-node apical and subapical cuttings were taken from Promalin-treated Harbour Dwarf nandina and more apical cuttings were taken from BA-treated plants than from unpruned plants (Table 6). This increase represents an im-

Table 4. Effects of BA and Promalin on axillary budbreak and height of Fraser photinia, Experiment 2.

PGR	Rate (ppm)	Axillary budbreak no.		Plant height (cm)	
		January 26, 1988	April 1, 1988	January 26, 1988	April 1, 1988
BA	1000	3.8	11.5*[z]	22.3*	33.7*
	1500	4.7	15.3*	25.7*	40.7*
	2000	4.9	18.1*	22.1*	32.2*
	2500	6.9*	23.8*	24.5*	36.0*
Promalin	2000	4.7	20.7*	29.3*	42.6*
	3000	5.9*	24.7*	29.3*	41.5*
	4000	6.3*	24.6*	30.3*	40.9*
	5000	9.6*	28.7*	36.9*	43.5*
Pruned		3.6	3.7	14.5	12.8
Unpruned		1.8*	11.0*	23.5*	38.1*
Comparison					
BA vs Promalin[y]		**	**	**	**
Sign. of rate[x]					
BA		Q	L	NS	NS
Promalin		C	L	C	NS

[z]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5% level.
[y]Significant at the 1% (**) level.
[x]NS = not significant; L = linear; Q = quadratic; C = cubic regression response, 1% level; unpruned control included in regression analysis.

Table 5. Effects of BA and Promalin on axillary budbreak and height of Harbour Dwarf nandina, Experiment 2.

PGR	Rate (ppm)	Axillary budbreak no.		Plant height (cm)	
		January 26, 1988	April 1, 1988	January 26, 1988	April 1, 1988
BA	1000	2.0	3.6	12.6	16.9
	1500	3.9	5.8*[z]	11.4	17.3
	2000	4.1	7.4*	13.5	18.6
	2500	3.8	7.4*	13.3	18.2
Promalin	2000	1.6*	3.5	18.0	27.2*
	3000	1.3*	2.4	18.5*	26.9*
	4000	1.9	3.5	22.4*	36.8*
	5000	3.3	5.5*	21.6*	43.3*
Pruned		3.4	2.9	11.3	15.7
Unpruned		1.1*	1.3	12.1	16.8
Comparison					
BA vs Promalin[y]		**	**	**	**
Sign. of rate[x]					
BA		C	L	NS	NS
Promalin		L	C	L	L

[z]Dunnett's test for least significant difference; means within a column followed by an asterisk differ from the mean of the pruned treatment, 5% level.
[y]Significant at the 1% (**) level.
[x]NS = not significant; L = linear; C = cubic regression responnse, 1% level; unpruned control included in regression analysis.

Table 6. Number of cuttings taken from Harbour Dwarf nandina sprayed with BA or Promalin, Experiment 2.

PGR and rate (ppm)		Cuttage (no.)[z]		
		Apical	Subapical	Total
BA	1000	1.6	0.0	1.6
	1500	3.0	0.0	3.0
	2000	3.4	0.0	3.4
	2500	4.8	0.4	5.2
Promalin	2000	1.8	2.2	4.0
	3000	2.0	1.2	3.2
	4000	2.2	2.4	4.6
	5000	3.2	4.6	7.8
Pruned		1.4	0.0	1.4
Unpruned		1.0	0.0	1.0

[z]Means of 5 single-plant replicates.

portant source of propagation material for the grower from a cultivar that does not naturally branch or form multi-node shoots.

BA promoted axillary budbreak of Fraser photinia, Harbour Dwarf nandina, Helleri holly, Stoke's Dwarf holly, and Formosa azalea, while budbreak of Harbour Dwarf nandina, Fraser photinia, and Formosa azalea was stimulated by Promalin. These responses were species and rate-dependent, with higher rates generally inducing more lateral budbreak than lower rates. Branching of cleyera and Indian hawthorn was not influenced by BA or Promalin application. BA and Promalin generally induced equivalent or greater numbers of axillary shoots compared to mechanical pruning. Plant height of all species and root rating, growth index, and shoot length of Helleri and Stoke's Dwarf hollies were minimally influenced by PGR application.

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