Response of Hosta to BA Crown Drenches Applied at Division and Establishment[1]

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Abstract

New offset formation in hosta in response to benzyladenine (BA) drenches applied at division and establishment was examined. *Hosta* Tratt. 'Frances Williams' and *H*. 'Francee' were separated into uniform single-bud divisions and drenched with 50 ml of 0, 100, 500, 1000, 2000 or 3000 ppm (mg/liter) BA just prior to potting (division) or two weeks later when substrate-container interface root development was evident (establishment). A 3000 ppm (mg/liter) foliar spray applied to established plants served as a standard. Offsets were counted in plants treated at division 14 days later at which time BA was applied to established plants. Offsets were counted on all plants 30 and 60 days after BA was applied to established plants and in spring of the following year. Offset counts increased rapidly in both cultivars following drench applications of increasing BA concentrations, whether applied at division or establishment. This positive response to increasing BA drench concentrations was evident 60 days after treatment (DAT) and the following spring, except in *H*. 'Frances Williams' drenched at division. However, benefits of either BA method or time of application were less pronounced in spring, following a period of dormancy.

Index words: plantain lily, hosta, offset, cytokinin, container production.

Species used in study: 'Frances Williams' hosta (*Hosta* Tratt. 'Frances Williams'), 'Francee' hosta (*Hosta* Tratt. 'Francee').

Plant growth regulator used in this study: benzyladenine (BA), N-(phenylmethyl)-1*H*-purine-6-amine.

Significance to the Nursery Industry

Hostas are propagated in the nursery industry by crown division. Because most cultivars are slow to develop new offsets during production, foliar sprays of benzyladenine (BA) have been applied to established plants to promote new offset formation. Our research showed crown drenches of 2000 or 3000 ppm (mg/liter) BA applied at either division or establishment were as effective as a foliar spray of 3000 ppm (mg/liter) BA and significantly more effective than an untreated control at 30 and 60 days after application. While these findings provide growers with additional options in the use of BA to promote offset development in hosta, material and labor costs of applying crown drenches are greater than those associated with foliar sprays.

Introduction

Hostas form rhizomic and lateral buds (14) that potentially develop into new shoots or offsets. Because many hosta cultivars form offsets slowly, growers may benefit from ways to hasten offset formation during production (9, 10). Benzyladenine, a synthetic cytokinin, is theorized to release apical dominance by altering auxin to cytokinin ratios in shoot tips (3). Benzyladenine (BA) has promoted lateral shoot development in several woody ornamental species, including Heller holly (*Ilex crenata* Thunb. 'Helleri'), Formosa azalea (*Rhododendron* x 'Formosa') and Harbour Dwarf nandina (*Nandina domestica* Thunb. 'Harbour Dwarf' (11). A foliar spray of 1000 ppm (mg/liter) BA applied to established *Photinia* x *fraseri* significantly increased branching as compared to untreated plants (12). Benzyladenine has also been used to induce shoot development on the lower nodes of pines grown as Christmas trees, resulting in denser trees. Boe (2) reported that 90 days after treatment (DAT) with 20 to 600 ppm (mg/liter) BA, three-month-old Scots pine (*Pinus sylvestris* L.) seedlings had more lateral branches than untreated trees. Benzyladenine applied as a foliar spray to mature herbaceous perennials, such as verbena (*Verbena* x *hybrida* Voss), enhanced lateral budbreak (17). In addition to positive results from BA application to temperate herbaceous and woody species, tropical foliage plants, including *Diffenbachia* Schott., *Peperomia obtusifolia* (L.) A. Dietr., and *Spathiphyllum* Schott., were stimulated to form more lateral shoots when BA was applied as a foliar spray (6, 7, 18).

Keever (8) examined the effects BA has on new offset formation in hosta when applied at concentrations ranging from 125 to 400 ppm (mg/liter). Offset counts at 30, 60, 90 and 300 DAT (following a period of dormancy) increased with increasing BA concentrations. Schultz et al. (16) found that a foliar application of 3000 ppm (mg/liter) BA to *H*. 'Frances Williams' and *H*. 'Francee' stimulated offset counts in both cultivars. Garner et al. (4, 5) reported increased offset production in 10 hosta cultivars at 60 DAT in response to applications of 1250, 2500 and 3750 ppm (mg/liter) BA. In this research and the majority of published literature, BA was applied as a foliar spray to established plants.

Altman and Moses (1) reported that BA was transported via the xylem, when applied to roots of young citrus (*Citrus* L.) seedlings. Uptake was dependent upon BA concentration, physiological state of the seedlings and duration of exposure. Benzyladenine applied as a drench to *Spathiphylum* 'Tasson' increased the number of visible basal shoots as concentration increased from 250 to 1000 ppm (mg/liter) (7). Soil drenches of BA have also been found to increase new offset formation in *Hosta sieboldiana* (Lodd.) Engl. when compared to plants not treated with BA. Increasing concentrations of BA applied as a soil drench to established plants increased new offset formation at 30, 60, and 90 DAT. However, higher concentrations of BA (80, 100, 120 mg a.i./pot) resulted in marginal necrosis, decreased growth index, and injury to new foliage by two weeks after treatment, although following dormancy no negative effects were evident (8).

[1]Received for publication February 2, 2004; in revised form March 31, 2004.
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In previous studies with hosta, BA was applied to established plants, presumably to ensure adequate root development for water and nutrient uptake to support new shoot counts. However, in some crops like hosta, root mass following division is often adequate to not require placement in propagation. Schultz et al. (16) examined the response of *H.* 'Frances Williams' and *H.* 'Francee' to foliar sprays of BA applied at division and one through six weeks after potting (WAP) in one-week increments. At 6 WAP, both cultivars had more new offsets than controls when treated at 1, 2, or 3 WAP, and at 30 DAT plants treated at 3, 4, 5, and 6 WAP produced more offsets than the controls. Drench applications of BA at division or establishment, if as effective or more effective than foliar sprays to established plants, would provide growers with additional options for BA use. Therefore, the objective of this study was to determine the effectiveness of BA crown drenches applied at different concentrations to two hosta cultivars at division and establishment.

Materials and Methods

Mature stock plants of two hosta cultivars, *H.* 'Frances Williams' and *H.* 'Francee', were separated on September 9, 1999, into uniform single-bud divisions with adequate roots to not require placement in propagation (a minimum of 10 roots per division) and placed into 12 groups of 10 plants each. Five groups of 10 plants per cultivar then received a 50 ml (1.7 oz) drench of 100, 500, 1000, 2000 or 3000 ppm (mg/liter) BA (BAP-10, Plant-Wise Biostimulant Co., Louisville, KY) by pouring solutions over the crown. The relatively small volume used was adequate to throughly wet crown and roots. All plants then were potted into 3.8 liter (#1) containers using a 6:1 bark:sand medium amended per cu m (cu yd) with 4.7 kg (8.0 lb) 18N–2.6P–10K (Osmocote 18–6–12, The Scotts Co., Marysville, OH), 3.0 kg (5.0 lb) dolomitic limestone, and 0.9 kg (1.5 lb) Micromax (The Scotts Co.). Plants were placed outdoors under 47% shadecloth and irrigated by overhead sprinklers twice daily during the growing season for a total of 3.8 cm (1.5 in) per day. On September 23, 1999, plants were considered established due to the presence of extensive root development at the substrate-container interface. At this time, BA crown drenches were applied to established plants at the same concentrations and volumes as applied at division. Treatments also included a 3000 ppm (mg/liter) foliar spray of BA at 0.2 liter/sq m (2 qt/100 sq ft) and an untreated control. Buffer X (Kalo Agr. Chemicals, Overland, KS), a nonionic surfactant, was added to all BA solutions at 0.2% (v/v). The foliar spray treatment was applied with a compressed air sprayer equipped with a flat spray nozzle (TeeJet 8004VS, Bellspray, Inc., Opelousas, LA) at 138 kPa (20 psi). Treatments in the 2 × 5 factorial experiment + standard + control were completely randomized within cultivar and replicated with 10 single plants. Offsets were counted in plants treated at division when BA was applied to established plants on September 23, 1999, and on all plants 30 and 60 days later and on May 11, 2000, following a period of dormancy. Analysis of variance (ANOVA) was used to test the significance of main effects and interactions within cultivar using the SAS General Linear Model procedure (13). BA concentration response and differences between time of application were determined by orthogonal contrasts. The foliar spray treatment was compared to each other treatment using Dunnett's T-Test ($P = 0.05$).

Results and Discussion

Hosta 'Francee'. At division, *H.* 'Francee' had mature foliage and there was no new growth present. No abnormal response was evident at rates below 2000 ppm (mg/liter) BA, however, in plants treated at division or establishment with either 2000 or 3000 ppm (mg/liter) BA, new growth was abnormally twisted, and leaf margins were bleached and necrotic. On September 23, 1999, two weeks after drench treatments were applied at division, offsets of *H.* 'Francee' were counted (Table 1). New offset counts increased quadratically with increased concentration in plants treated at division, from 50% with 100 ppm (mg/liter) BA, to the greatest increase of 550% with 3000 ppm (mg/liter). Keever (1994) reported a similar rapid increase in offset production in response to both a foliar spray and crown drench BA application in *H. sieboldiana*. Similarly, *H.* 'Francee' and *H.* 'Frances Williams' receiving a foliar spray of BA at potting increased new offset formation by 6 weeks after potting as compared to controls (16).

Plants treated at establishment rapidly increased new offsets such that the interaction between time of application and

Table 1. Effects of BA drenches applied at division and establishment and foliar spray applied at establishment on offset formation in 'Francee' hosta at establishment, 30 and 60 days after treatment of established plants (DAT) and in spring of the following year when grown in 3.8 liter (#1) containers.

		Offset counts			
Method of application	**Concn. (ppm)**	**Establishment**	**30 DAT**	**60 DAT**	**Spring**
Drench	0	0.8[z]	1.3[y]	1.7	4.2
	100	1.2	2.0	1.8	4.1
	500	3.3	3.9	4.2	5.6
	1000	3.8	3.8	3.6	6.0
	2000	5.1	5.3	5.2	7.6
	3000	5.2	5.5	5.4	6.1
Significance[x]		Q***	Q*	Q*	L**
Foliar	3000	—	6.0	5.6	7.6

[z]Means for drench treatments applied at division; established plants not treated at this time.

[y]Means for drench averaged over division and establishment due to nonsignificant interactions at 30 and 60 DAT and spring of the following year.

[x]Linear (L) or quadratic (Q) response at $P = 0.05$ (*), 0.01 (**) or 0.001 (***) based on orthogonal polynomial analysis.

Table 2. **Effects of time of application on offset counts in 'Francee' hosta grown in 3.8 liter (#1) containers at 30 and 60 days after established plants were treated (DAT) with different concentrations of BA and in spring of the following year.**

	Offset counts		
Time of application	**30 DAT**	**60 DAT**	**Spring**
Division[z]	3.9a[y]	3.9a	5.2b
Establishment	4.2a	4.1a	6.7a

[z]Division and establishment means are the averages of all BA concentrations, except the control.

[y]Mean separation within columns by single degree of freedom orthogonal contrasts ($P = 0.05$).

concentration for offset counts was nonsignificant by 30 DAT and at all subsequent data collection dates, hence, main effects only are reported (Table 1). As drench concentrations increased, offset counts increased quadratically up to 218% and 284% at 30 and 60 DAT, respectively, in plants treated at division or establishment. In spring 2000, following a period of dormancy, new offset counts increased linearly up to 45% as drench concentrations of BA increased. The reduction in the percent increase in offset counts over time in response to BA drench application was due to an initial rapid increase in offset counts following application with few offsets forming during the remainder of the study. This rapid increase in new offset formation followed by minimal further increases has been reported (8, 10, 16) in hosta treated with a foliar BA spray, with further increases in new offset formation requiring additional applications of BA (5). In contrast, offset production in controls gradually increased during the season of division and dramatically increased 147% in spring, following a period of dormancy.

Plants treated at division and establishment had similar numbers of new offsets at 30 and 60 DAT (Table 2). However, in spring of the following year, plants treated at division had 22% fewer offsets than plants treated at establishment.

Plants treated at establishment with a 3000 ppm (mg/liter) foliar spray of BA had similar numbers of offsets at 30 (6.0 offsets) and 60 DAT (5.6 offsets) as those treated at division or establishment with all drench concentrations, except for fewer offsets in controls [1.3 (30 DAT) and 1.7 (60 DAT) offsets], plants drenched with 100 ppm (mg/liter) BA at division [2.0 (30 DAT) and 2.1 (60 DAT) offsets], and 100 ppm (mg/liter) [2.0 (30 DAT) and 1.5 (60 DAT) offsets] and 1000 ppm (mg/liter) [3.2 (30 DAT) and 3.0 (60 DAT) offsets] at establishment (Table 1, means across application time only). Following a period of dormancy, offset counts of plants treated with a foliar spray of BA were similar to those of plants in all other treatments (data not shown).

Hosta 'Frances Williams'. At division, *H*. 'Frances Williams' had no new growth and exhibited marginal necrosis of the existing foliage. *H*. 'Frances Williams' is commonly noted for exhibiting foliar necrosis before eventually completely deteriorating when exposed to average summer environmental conditions in the southern United States. (14). While marginal foliar necrosis was present in all treatments of *H*. 'Frances Williams', it appeared more severe in plants receiving drenches of 2000 or 3000 ppm (mg/liter) BA at either time of application. Keever (8) reported similar foliar necro-

Table 3. **Effects of BA foliar application or drench at division and establishment on offset formation in 'Frances Williams' hosta grown in 3.8 liter (#1) containers at establishment, 30 and 60 days after established plants were treated (DAT), and in spring of the following year.**

Application			Offset counts			
Method	**Time**	**Concn. (ppm)[z]**	**Establishment**	**30 DAT**	**60 DAT**	**Spring**
Drench						
	Division	0	0.0	0.0*	0.0*[y]	0.4
		100	1.4	1.6	1.6	1.9
		500	1.6	1.5	1.1	2.0
		1000	2.7	2.4	2.1	0.8
		2000	3.9	2.9	2.1	2.4
		3000	3.8	1.9	2.0	1.7
	Significance[x]		Q***	Q**	L*	NS
	Establishment	0	—[w]	0.0*	0.0*	0.4
		100	—	0.1	0.2*+[v]	0.3
		500	—	3.0	2.6+	2.0
		1000	—	2.9	2.4	1.8
		2000	—	4.4	3.9+	2.4
		3000	—	4.9+	3.6	3.6*
	Significance		—	L***	Q***	L***
Foliar		3000	—	3.2	2.4	1.4

[z]Time of application × rate significant at 30 and 60 DAT and in spring of the following year.

[y]Treatment means followed by and asterisk (*) were significantly different from foliar spray treatment based on Dunnett's T-Test, $P = 0.05$.

[x]Non-significant (NS), linear (L), or quadratic (Q) response for concentration at $P = 0.05$ (*), 0.01 (**) or 0.001 (***).

[w]No treatment applied at time of data collection.

[v]Division treatment means followed by a plus (+) were significantly different from corresponding establishment means within concentration, based on orthogonal contrasts, $P = 0.05$.

sis in *H. sieboldiana* drenched with higher concentrations of BA.

Offsets in plants drenched at division and counted two weeks later increased quadratically as BA concentration increased (Table 3). Similar to results seen in *H.* 'Francee', control plants formed no new offsets, while offset counts increased from 1.4 with 1000 ppm (mg/liter) BA to 3.9 and 3.8 new offsets in plants treated with 2000 and 3000 ppm (mg/liter) BA, respectively.

There was a significant time of application × drench concentration interaction at 30 DAT and later data collection dates for *H.* 'Frances Williams' (Table 3). At 30 DAT, offset counts in plants drenched at division increased as BA concentrations increased from 100 ppm (mg/liter) to 2000 ppm (mg/liter), before decreasing at 3000 ppm (mg/liter). At 60 DAT, offset counts of plants treated at division increased linearly as BA concentration increased. Control plants had formed no offsets at either sampling. Offset counts in plants drenched at establishment increased linearly at 30 DAT and quadratically at 60 DAT, with increasing concentrations of BA. Following a period of dormancy offset counts were 800% greater in plants drenched with 3000 ppm (mg/liter) than in controls. In summary, drenches of 2000 and 3000 ppm (mg/liter) BA maximized offset formation in two hosta cultivars, regardless of application immediately following division or when surface root growth was evident (establishment), but resulted in injury to existing foliage and foliage of offsets formed in the season of application. No injury was evident to foliage following a period of dormancy.

With few exceptions, offset counts were similar in *H.* 'Frances Williams' treated at division and establishment (Table 3). For example, at 30 DAT and in spring following dormancy, the only difference in offset counts occurred in plants treated with 3000 ppm (mg/liter), with fewer offsets forming on plants drenched at division compared to those drenched at establishment. Although differences in offset counts between plants drenched with 3 BA concentrations at division and establishment occurred at 60 DAT, results were inconsistent. Plants drenched at division had more offsets when treated with 100 ppm (mg/liter) BA but fewer offsets when treated with 500 or 2000 ppm (mg/liter) BA compared to those treated at establishment.

Except for fewer offsets in control plants at 30 and 60 DAT and in plants drenched with 100 ppm (mg/liter) BA at establishment and more offsets present in spring, following a period of dormancy, in plants drenched with 3000 ppm (mg/liter) BA at establishment, plants drenched at division or establishment formed similar numbers of offsets as plants receiving a foliar spray of 3000 ppm (mg/liter) BA at establishment, regardless of drench rate (Table 3). These results are similar to those of *H.* 'Francee' in this study and in *H. sieboldiana* in a similar study (8). Generally, *H.* 'Francee' showed increases in new offset formation over time, regardless of treatment, in contrast to *H.* 'Frances Williams' in which offsets increased within 30 DAT, but declined thereafter when treated with BA by either method or time of application. Previous studies have reported this random bud abortion as another expression of phytotoxicity (8). This poor performance of *H.* 'Frances Williams' has been reported in response to typical summer conditions in the southern United States and was presumably unrelated to treatment applications (14).

Stimulation of offset formation in response to BA drenches at division and establishment and a foliar spray at establishment was rapid, occurring in 30 days or less, but the effect was less pronounced following a period of dormancy due to the natural offset formation in untreated plants. Our research showed crown drenches of 2000 or 3000 ppm (mg/liter) BA, a rate similar to that which maximized offset formation in numerous hosta cultivars (4, 5, 8, 10, 15, 16), applied at either division or establishment were as effective as a foliar spray of 3000 ppm (mg/liter) BA and significantly more effective than an untreated control at 30 and 60 days after application in *H.* 'Francee' and *H.* 'Frances Williams'. However, drenches at these rates resulted in foliar injury that persisted throughout the season of application. These findings, while providing growers with additional options in using BA to promote offset development in hosta, may be less cost effective than foliar sprays applied to established plants.

Literature Cited

1. Altman, A. and R. Moses. 1977. Comparative basipetal transport of 6-benzylaminopurine-C14, gibberellin A3 3H, 1AA-Z C14 and sucrose C14 in the roots of intact *Citrus aurantium* seedlings. Physiol. Plant. 39:233–235.

2. Boe, A.A. 1990. Effects of application of BA to seedlings of *Pinus sylvestris* and *Pinus nigra*. J. Environ. Hort. 8:212–214.

3. Cline, M.G. 1988. Apical dominance. Bot. Review 57:318–358.

4. Garner, J.M., G.J. Keever, D.J. Eakes, and J.R. Kessler. 1997. BA-induced offset formation in hosta dependent on cultivar. HortScience 32:91–93.

5. Garner, J.M., G.J. Keever, D.J. Eakes, and J.R. Kessler. 1998. Sequential BA applications enhance offset formation in hosta. HortScience 33:707–709.

6. Henny, R.J. 1985. N-6 benzyladenine induces lateral branching of *Peperomia obtusifolia*. HortScience 20:115–116.

7. Henny, R.J. and W.C. Fooshee. 1985. Induction of basal shoots in *Spathiphyllum* 'Tasson' following treatment with BA. HortScience 20:1715–1717.

8. Keever, G.J. 1994. BA induced offset formation in hosta. J. Environ. Hort. 12:36–39.

9. Keever, G.J., D.J. Eakes, and C.H. Gilliam. 1995. Offset stage of development affects hosta propagation by stem cuttings. J. Environ. Hort. 13:4–5.

10. Keever, G.J. and T.J. Brass. 1998. Offset increase in hosta following benzyladenine application. J. Environ. Hort. 16:1–3.

11. Keever, G.J. and W.J. Foster. 1990. Chemically induced branching of woody landscape plants. J. Environ. Hort. 8:78–82.

12. Ryan, G.F. 1985. Branching of *Photinia ×fraseri* in response to growth regulators and fertilizer. J. Environ. Hort. 3:15–18.

13. SAS Institute. 1988. SAS/SAT user's guide. Release 8.02. SAS Institute. Cary, NC.

14. Schmid, G.W. 1991. The Genus Hosta. Timber Press, Portland, OR.

15. Schultz, H.C., G.J. Keever, J.R. Kessler, R.R. Dute, and J.W. Olive. 2000. Root mass and BA affect offset formation in hosta. J. Environ. Hort. 18:45–48.

16. Schultz, H.C., G.J. Keever, J.R. Kessler, and R.R. Dute. 2000. BA application timing affects offset formation in hosta. J. Environ. Hort. 18:63–65.

17. Svenson, S. 1991. Rooting and lateral shoot elongation of verbena following benzylaminopurine application. HortScience 26:391–392.

18. Wilson, M.R. and T.A. Nell. 1983. Foliar application of benzyladenine increases branching of 'Welkeri' dieffenbachia. HortScience 18:447–448.