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Benzyladenine-induced Offset Formation in Hosta Dependent on Cultivar

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Abstract. **A foliar spray of 0, 1250, 2500, or 3750 mg benzyladenine (BA)/L was applied to 10 *Hosta* Tratt. (*Funkia* K. Spreng; *Niobe* Salisb.) cultivars. Response to BA treatment was cultivar dependent, with BA promoting offset formation in half of the cultivars. Compared to the control, increase in offsets produced by cultivars treated with 3750 mg BA/L ranged from 116% in 'Francee' to 3500% in 'Francis Williams' at 30 days after treatment (DAT) and from 150% in 'Royal Standard' to 2250% in 'Francis Williams' at 60 DAT. Offset stage of development, as indicated by the number of unfurled leaves, was also cultivar- and BA-dependent. All cultivars treated with 3750 mg BA/L had an average of three or more unfurled leaves at 60 DAT, while among control plants, 40% of cultivars averaged fewer than three unfurled leaves. No phytotoxic symptoms were noted in any cultivar, and plant size was either increased or not affected by BA treatment. Chemical name used: *N*-(phenylmethyl)-1*H*-purin-6-amine (benzyladenine; BA).**

Hosta, herbaceous perennials in the lily family, are the most popular perennials for use in the shaded landscape (Rhodus, 1995). Hostas are conventionally propagated by crown division or tissue culture. However, division yields relatively few plants per clump and is typically accomplished only annually (Walters, 1981). Tissue-cultured explants are costly and frequently may not be true to type (Meyer, 1980). Moreover, propagation of plants by tissue culture requires specialized techniques and facilities unavailable to most growers. Increasing the numbers of plants available and the introduction of new cultivars may be impeded by these factors.

Vegetative buds and roots of hosta grow from rhizomes, and the rhizomic apex appears to suppress outgrowth of axillary and rhizomic buds by apical dominance (Schmid, 1991). A primary factor in the mechanism of apical dominance is a hormonal interaction between auxins and cytokinins (Cline, 1988). Cytokinins, including benzyladenine (BA), can release lateral buds from inhibition when applied exogenously (Mok and Mok, 1994). Previous studies have demonstrated the effectiveness of BA in promoting the outgrowth of rhizomic and axillary buds in hosta (Keever, 1994). Furthermore, offsets formed from BA-induced buds can be removed from the mother plant soon after elongation and rooted under intermittent mist, with a higher percentage of rooting from offsets at a more advanced stage of development (Keever et al., 1995). Earlier studies were conducted using *Hosta sieboldiana* (Lodd.) Engl. only, yet considerable differences in response to BA application may be expected among the diverse hosta cultivars available, due to the large number of recombinations from which cultivars of this genus are derived (Schmid, 1991). The objective of this study was to determine differences among hosta cultivars in response to BA application.

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Materials and Methods

On 20 Feb. 1995, dormant, bare-root divisions of 10 hosta cultivars were potted in 2.7-L containers in a 6 pine bark : 1 sand medium (v/v). The medium was amended with 3 kg dolomitic lime, 0.9 kg Micromax (The Scotts Co., Marysville, Ohio), and 7.4 kg 24N–1.8P–10K (Polyon 12-month formulation; Pursell Industries, Sylacauga, Ala.) per m^3.

Cultivars included *Hosta fortunei* (Bak.) L.H. Bailey 'Aureo-marginata' (AM), *H.* 'Big Daddy' (BD), *H.* 'Francee' (FR), *H.* 'Francis Williams' (FW), *H.* 'Gold Standard' (GS), *H.* 'Krossa Regal' (KR), *H. montana* (Maekawa) 'Aureo-marginata' (MA), *H.* 'Royal Standard' (RS), *H. undulata* (Otto & A. Dietr.) L.H. Bailey 'Albo-marginata' (UA), and *H.* 'Wide Brim' (WB). Plants were grown under 47% shade and irrigated by overhead rotary nozzles twice daily for 30 min per application, for a total volume of ≈30 mm·day^{-1}.

On 7 July 1995, single-eye (no offsets) plants were selected for uniformity, and 10 single-plant replications of each cultivar were randomly assigned to each of four BA rates (0, 1250, 2500, or 3750 mg·L^{-1}). Buffer-X (Kalo Agr. Chemicals, Overland Park, Kan.) at 2 mL·L^{-1} was added to all BA solutions as a surfactant before foliar application at 0.2 L·m^{-2} or ≈5.4 mL/plant. Application was made with a CO_2 sprayer fitted with a cone nozzle at 275 kPa. Temperature and relative humidity at the time of application were 27 °C and 85%, respectively.

At 30 and 60 days after treatment (DAT), visible offset counts and a growth index [(height + width at widest point + width 90° to first width) ÷ 3] were determined for each plant. At 60 DAT, stage of development (SOD) was determined for each offset, with SOD 1 = elongated bud with first leaf furled; 2 = one unfurled leaf; 3 = two unfurled leaves, etc. Data were tested by analysis of variance, using the SAS General Linear Model procedure, to test main effects and interactions. Comparison of controls to BA treatment and rate response to BA was determined by single degree of freedom orthogonal contrasts. Mean separation among cultivars was accomplished by Duncan's multiple range test (SAS Institute, 1988).

Results and Discussion

Offset counts. Offset formation in hosta in response to BA application was cultivar-dependent. At 30 DAT, more offsets were produced by treated plants than by controls for BD, FR, FW, KR, and RS (Table 1). Compared to controls, increases in offset counts at optimal BA rate ranged from 116% (FR) to 3500% (FW). Offset counts increased linearly with increasing BA rate in FR, FW, and RS, but in KR, optimal response to BA was achieved at the intermediate rate, 2500 mg BA/L. For BD, offset counts were higher among treated plants compared to controls, and the highest number of offsets was formed in plants receiving 3750 mg BA/L. Offset counts for treated plants were similar to controls in AM, GS, MA, UA, and WB at 30 DAT.

Offset counts generally increased between 30 and 60 DAT, but at 60 DAT, the response of most cultivars (AM, BD, FW, GS, KR, RS, UA, and WB) to BA was similar to that observed at 30 DAT. Offset counts for treated plants were higher than those of controls at 60 DAT in BD, FW, KR, MA, and RS. Compared to controls, increases in offset counts at optimal BA rate ranged from 150% (RS) to 2250% (FW). As observed at 30 DAT, offset counts increased linearly with increasing BA rate in FW and RS, and at 60 DAT, response in MA was also linear. With KR, optimal response to BA was again achieved with the intermediate rate, 2500 mg BA/L. In BD, offset counts were again higher in treated plants, as compared to controls, and the highest number of offsets was formed in plants receiving 3750 mg BA/L. In FR, a cultivar that readily forms offsets, sufficient offsets had formed in control plants at 60 DAT such that offset counts were similar to those of treated plants. In contrast to the

response at 30 DAT, offset counts among BA-treated plants of MA were higher than those of controls at 60 DAT.

At 30 DAT, control plants of AM, FR, GS, RS, UA, and WB had formed more offsets than other cultivars, indicating that these cultivars readily form offsets in the absence of BA. Among treated plants, BD, GS, KR, and RS formed more offsets at 30 and 60 DAT than other cultivars in the study. Cultivars BD, FW, and KR, which did not readily form offsets in the absence of BA, produced more offsets than other cultivars when treated with BA.

Stage of development. Influence of BA on offset SOD at 60 DAT also was cultivar-dependent. Offset SOD was more advanced for treated plants of BD and KR; yet, offset SOD lagged in treated plants of GS, RS, and WB as compared to controls (Table 2). With RS, the formation of more offsets in treated plants appeared to result in a slowing of development. There were no differences in offset SOD between BA-treated plants and controls in the remaining five cultivars.

Growth index. The growth index, measured at 30 and 60 DAT, generally increased or was not affected by BA rate (Table 3). At 30 DAT, the growth index was higher for treated plants than controls of BD, FR, and KR. The growth index of UA treated with BA was lower than that of control plants at 30 DAT, but similar to that of the controls at 60 DAT. The growth index in treated plants was similar to that of controls in the other cultivars at 30 DAT. At 60 DAT, the growth index was higher in treated plants than in controls for BD, KR, and MA, but similar to controls for all other cultivars. No phytotoxic symptoms were noted in any cultivar, and plant appearance was not adversely affected by BA. In many cases, plant appearance was enhanced by BA application. For example, the growth index increased for treated plants of KR at all BA rates between 30 and 60 DAT, while that for controls declined due to foliar necrosis in the mother plants. Expansion of BA-induced offsets appeared to enhance growth and appearance of KR, accounting for the increase in the growth index.

These results indicate a cultivar-dependent response to BA for the hosta cultivars evaluated. Offset counts were higher in treated plants of BD, FW, KR, and RS at both 30 and 60 DAT. The same was true for FR at 30 DAT and for MA at 60 DAT. Stimulation of offset formation by BA application concurs with previous research (Keever, 1994). Offset counts in treated plants were similar to those of the controls in AM, GS, UA, and WB. Compared to controls, offset SOD for treated plants increased in BD and KR; decreased in GS, RS, and WB; and was similar in the remaining five cultivars. Ninety percent of all BA × cultivar combinations showed an average SOD ≥4 at 60 DAT, and with all cultivars, some level of BA treatment resulted in an average SOD >4. However, among offsets that formed in the control treatment, 40% of the cultivars averaged <4. Results from previous studies indicated a higher rooting percentage for SOD 4 than for less advanced stages (Keever et al.,

Table 1. Offset counts of hosta cultivars at 30 and 60 days after treatment (DAT) with four BA rates.[z]

BA rate	Offset counts									
	Cultivar[y]									
(mg·L^{-1})	AM	BD	FR	FW	GS	KR	MA	RS	UA	WB
					30 DAT					
0	2.1 c[x]	0.4 d	1.9 c	0.1 d	3.9 a	0.5 d	0.2 d	2.9 a–c	2.5 bc	3.4 ab
1250	3.1 bc	4.7 ab	2.5 cd	1.0 de	5.9 a	5.2 a	0.1 e	6.3 a	2.2 cd	2.7 cd
2500	3.2 bc	4.1 b	2.9 bc	1.6 c	3.4 bc	6.9 a	1.5 c	8.6 a	2.2 bc	2.7 bc
3750	2.6 de	4.8 c	4.1 cd	3.6 cd	4.6 c	5.4 b	0.7 e	10.4 a	3.3 cd	2.5 de
0 vs. BA	NS	***	*	**	NS	***	NS	***	NS	NS
BA rate	NS	Q**	L**	L***	NS	Q***	NS	L***	NS	NS
					60 DAT					
0	3.4 a	0.5 b	3.7 a	0.2 b	4.4 a	0.8 b	0.5 b	4.4 a	4.0 a	3.7 a
1250	3.7 bc	5.4 ab	2.9 cd	0.9 de	5.6 ab	5.7 ab	0.5 e	6.7 a	5.0 ab	2.9 cd
2500	4.6 b	4.3 b	4.6 b	1.9 d	4.6 b	7.7 a	2.4 cd	9.0 a	5.5 b	3.9 bc
3750	3.0 cd	5.6 b	4.5 bc	4.7 bc	4.2 bc	5.7 b	2.1 d	11.0 a	5.1 bc	3.1 cd
0 vs. BA	NS	***	NS	**	NS	***	*	***	NS	NS
BA rate	NS	Q*	NS	L***	NS	Q***	L***	L***	NS	NS

[z]Cultivar × BA interaction significant ($P \leq 0.01$) at 30 and 60 DAT.
[y]AM = *Hosta fortunei* 'Aureo-marginata', BD = *H.* 'Big Daddy', FR = *H.* 'Francee', FW = *H.* 'Francis Williams', GS = *H.* 'Gold Standard', KR = *H.* 'Krossa Regal', MA = *H. montana* 'Aureo-marginata', RS = *H.* 'Royal Standard', UA = *H. undulata* 'Albo-marginata', WB = *H.* 'Wide Brim'.
[x]Mean separation within rows by Duncan's multiple range test, $P \leq 0.05$.
[NS,*,**,***]Nonsignificant, linear (L), or quadratic (Q) response at the $P \leq 0.05$ (*), 0.01 (**), or 0.001 (***) level; control included in regression analysis.

Table 2. Offset stage of development (SOD) at 60 days after treatment (DAT) of hosta cultivars with four BA rates.[z]

BA rate	Offset stage of development									
	Cultivar[y]									
(mg·L^{-1})	AM	BD	FR	FW	GS	KR	MA	RS	UA	WB
0	5.8 bc[x]	1.8 d	5.8 bc	1.4 d	9.0 a	3.1 cd	1.8 d	9.7 a	8.1 ab	9.2 a
1250	5.4 bc	4.4 cd	4.3 cd	2.3 de	8.2 a	6.1 a–c	1.5 e	7.9 ab	6.0 a–c	6.3 a–c
2500	5.3 a–c	4.0 cd	4.7 a–d	2.7 d	5.7 a–c	6.0 a–c	4.4 b–d	6.4 ab	6.8 a	5.0 a–c
3750	4.6 d	5.0 cd	7.2 a–c	4.9 d	7.1 a–c	7.4 ab	5.3 b–d	8.3 a	8.9 a	7.3 ab
0 vs. BA	NS	***	NS	NS	*	***	NS	***	NS	*
BA rate	NS	L***	Q*	L*	L**	L***	L**	Q***	NS	Q**

[z]Cultivar × BA interaction significant ($P \leq 0.01$) at 60 DAT; SOD 1 = elongated bud, first leaf furled, 2 = 1 unfurled leaf, 3 = 2 unfurled leaves, etc.
[y]AM = *Hosta fortunei* 'Aureo-marginata', BD = *H.* 'Big Daddy', FR = *H.* 'Francee', FW = *H.* 'Francis Williams', GS = *H.* 'Gold Standard', KR = *H.* 'Krossa Regal', MA = *H. montana* 'Aureo-marginata', RS = *H.* 'Royal Standard', UA = *H. undulata* 'Albo-marginata', WB = *H.* 'Wide Brim'.
[x]Mean separation within rows by Duncan's multiple range test, $P \leq 0.05$.
[NS,*,**,***]Nonsignificant, linear (L), or quadratic (Q) response at $P \leq 0.05$ (*), 0.01 (**), or 0.001 (***); control included in regression analysis.

Table 3. Growth index of hosta cultivars at 30 and 60 days after treatment (DAT) with four BA rates.[z]

BA rate	Growth index									
	Cultivar[y]									
(mg·L^{-1})	AM	BD	FR	FW	GS	KR	MA	RS	UA	WB
					30 DAT					
0	28.1 b[x]	21.5 c	27.4 b	32.8 a	32.6 a	22.1 c	26.9 b	34.9 a	32.0 a	25.1 bc
1250	29.7 b	25.3 d	26.7 b–d	34.3 a	35.5 a	29.1 bc	25.6 cd	34.9 a	28.2 b–d	25.5 cd
2500	30.5 cd	25.0 f	31.3 cd	32.7 bc	37.2 a	33.2 bc	28.8 de	34.7 ab	30.0 c–e	27.1 ef
3750	23.8 e	25.6 de	31.3 b	33.4 ab	32.9 ab	31.8 b	27.9 cd	35.0 a	31.0 bc	27.2 d
0 vs. BA	NS	**	*	NS	NS	***	NS	NS	*	NS
BA rate	Q**	L**	L***	NS	Q*	Q**	NS	NS	Q*	NS
					60 DAT					
0	30.0 bc	22.7 d	30.6 bc	33.0 ab	32.3 ab	21.7 d	27.2 c	35.6 a	33.1 ab	27.0 c
1250	30.4 c	26.8 d	27.0 d	35.2 a	35.0 ab	31.7 bc	27.2 d	35.9 a	32.6 a–c	25.0 d
2500	30.4 d–f	27.1 f	31.7 c–e	35.2 bc	34.3 b–d	36.2 b	31.3 c–e	40.4 a	34.0 b–d	28.2 ef
3750	27.1 f	27.0 f	34.7 bc	36.3 ab	31.8 cd	34.4 bc	30.8 de	38.6 a	34.4 bc	28.2 ef
0 vs. BA	NS	***	NS	NS	NS	***	*	NS	NS	NS
BA rate	NS	Q*	Q*	NS	Q*	Q**	L**	L*	NS	NS

[z]Cultivar × BA interaction significant ($P \leq 0.01$) at 30 and 60 DAT; growth index = (height + width at widest point + width 90° to first width) ÷ 3, in cm.
[y]AM = *Hosta fortunei* 'Aureo-marginata', BD = *H.* 'Big Daddy', FR = *H.* 'Francee', FW = *H.* 'Francis Williams', GS = *H.* 'Gold Standard', KR = *H.* 'Krossa Regal', MA = *H. montana* 'Aureo-marginata', RS = *H.* 'Royal Standard', UA = *H. undulata* 'Albo-marginata', WB = *H.* 'Wide Brim'.
[x]Mean separation within rows by Duncan's multiple range test, $P \leq 0.05$.
[NS,*,**,***]Nonsignificant, linear (L), or quadratic (Q) response at $P \leq 0.05$ (*), 0.01 (**), or 0.001 (***); control included in regression analysis.

1995). The SOD of most cultivars, when treated with BA, was so advanced at 60 DAT that well-developed roots were present on most offsets; these offsets would likely require minimal care for establishment. Generally, the growth index either increased or was not affected by BA rate. Plants displayed no phytotoxic symptoms as a result of BA application, and plant appearance was often enhanced by the outgrowth and development of BA-induced offsets.

BA application to hosta may decrease production time of a wide range of cultivars, including certain cultivars that are otherwise slow to produce offsets, possibly increasing efficiency and decreasing production costs. Among the cultivars evaluated in this study, BA application to BD, FR, FW, KR, MA, and RS resulted in the largest increase in offset production. Understanding the cultivar-dependent response to BA application appears to be a key factor in capitalizing on BA-induced offset formation and development during hosta production.

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