Benzyladenine Improves Summer Quality of Hosta[1]

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Abstract

A study was conducted to determine the effects of benzyladenine (BA) on improving summer quality of hosta in container production and in the landscape. For container production, stock plants of *Hosta* 'Sum and Substance', *H. sieboldiana* 'Elegans', *H.*'Francee', *H. sieboldiana* 'Frances Williams', *H. plantaginea*, and *H.* 'Tokudama' were divided and potted. When they showed signs of summer dormancy or foliar decline, half the plants of each cultivar/species received a single foliar spray application of 3000 ppm BA. In the landscape, half the established field-planted hosta with 2–4 initial offsets ('Francee') or 0–3 initial offsets ('Frances Williams') received a single foliar spray application of 3000 ppm BA when plants began to show signs of summer dormancy. BA stimulated the outgrowth of axillary and rhizomic buds in all cultivars/species in both parts of the study. Offsets formed more leaves on plants treated with BA compared to the untreated hosta. Offset leaf number was dependent on cultivar in both locations, and initial offset number affected leaf number for 'Frances Williams' in the landscape. Generally, BA application improved plant appearance of cultivars/species in both parts of the study. Cultivar/species and BA influenced whole plant growth index in container production, but had no effect in the landscape.

Index words: plantain lily, hosta, cytokinin, growth regulator, summer quality.

Species used in this study: hosta, *Hosta* Tratt. (*Funkia* K. Spreng; *Niobe* Salisb.) 'Sum & Substance', 'Francee', and 'Tokudama'; *H. sieboldiana* (Lodd.) Engl. [*H. glauca* (Siebold ex Miq.) Stearn] 'Elegans', and 'Frances Williams'; *H. plantaginea* (Lam.) Asch. [*H. subulata* (K. Spreng.) Hort.].

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

Significance to the Nursery Industry

The diverse geographic areas of Japan from which hostas originated account for their versatility in the North American landscape. Depending on the cultivar, hostas can be grown as far south as USDA Hardiness Zone 9; however, many cultivars decline both during production and in the landscape during summer months in Zones 7–9. Summer decline in hosta includes foliar necrosis, reduced vigor, and increased susceptibility to diseases and insects, all of which reduce marketability. Our results suggests that summer quality can be enhanced with summer BA application through increased offset production, reduced foliar necrosis, or both. Improved quality late in the growing season has the potential to enhance marketability of hosta as well as improve the appearance of established landscape plantings.

Introduction

Elongation of hosta offsets is regulated by an internal balance of hormones, specifically, auxin and cytokinins (1). Benzyladenine (BA), a synthetic cytokinin, was effective in inducing the outgrowth of inhibited buds (1). Previous studies conducted at Auburn University have demonstrated that BA promotes offset formation in hosta (4). These offsets were harvested and rooted under intermittent mist, and rooting percentage was positively correlated with the number of unfurled leaves on the offsets, referred to as offset stage of development (5). However, response to BA was cultivar dependent (2), and sequential applications of BA were necessary to continue the positive response to BA after offset removal (3). Plants with no offsets at the time of BA application produced more offsets than plants that had multiple offsets (6).

A secondary effect of BA-induced offset formation was that the outgrowth of newly formed offsets would often mask the foliage of the mother plant, improving overall plant appearance (2, 3, 4). We have observed that hostas grown in the southern United States often experience a condition referred to as summer dormancy by midsummer. This condition is characterized by foliar chlorosis and necrosis, and reduced plant vigor, leading to increased susceptibility to diseases and insects and lower plant quality. The spring market may be extended into summer or fall and landscape quality during the summer may be improved if declining foliage is overshadowed by a flush of new growth. Our objective was to to promote foliage development in several hosta cultivars/species with BA both during container production and in the landscape, thus enhancing summer quality and landscape value.

Materials and Methods

Container production. Stock plants of *H.* 'Sum & Substance', *H. sieboldiana* 'Elegans', *H. plantaginea*, *H.* 'Francee', *H. sieboldiana* 'Frances Williams', and *H.* 'Tokudama' were divided into single-eye plants and potted on June 30, 1998, into 3.8 liter (#1) containers using a pine bark:sand (6:1 by vol) medium amended per m^3 (yd^3) with 10.8 kg (18 lb) 22N–1.8P–11.6K (Polyon 22–4–14, 12-month formulation, Pursell Industries, Sylacauga, AL), 3 kg (5 lb) dolomitic limestone, and 0.9 kg (1.5 lb) Micromax (The Scotts Co., Marysville, OH). Plants were grown under 47% shade and irrigated for 30 minutes twice per day (1.3 cm (0.5 in) per application) by overhead rotary nozzles. On August 20, 1998, when plants were showing symptoms of summer decline (foliar chlorosis/necrosis and reduced vigor), 10 plants of each cultivar were sprayed with 3000 ppm BA (Pro-Shear, Abbott Laboratories, Chicago, IL; Pro-Shear is no longer available, however BA is marketed as BAP-10 by Plant-Wise Biostimulant Co., Louisville, KY) at 0.2 liter/m^2

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Table 1. **Hosta cultivar/species × BA effects on offset number, quality rating (QR), and offset stage of development (SOD) 30 days after treatment during container production of hosta.**

Cultivar/species	BA[z]	Offset number	SOD[y]	QR[x]
‘Sum & Substance’	+	3.9a[w]*[v]	3.2b*	3.0bc*
‘Elegans’	+	2.8ab*	3.6b	3.5ab*
plantaginea	+	0.6c	5.9a*	4.4a
‘Frances Williams’	+	0.6c	3.6b	2.9bc
‘Francee’	+	1.8bc*	3.9b	2.0c
‘Tokudama’	+	2.2abc*	3.5b	3.0bc
‘Sum & Substance’	–	0.4a	2.4a	1.6b
‘Elegans’	–	0.2a	2.7a	1.9b
plantaginea	–	0.2a	3.5a	3.7a
‘Frances Williams’	–	0.1a	4.0a	3.1a
‘Francee’	–	0.0a	3.0a	2.9a
‘Tokudama’	–	0.2a	2.3a	2.9a

[z]Plants either received a foliar application of 3,000 ppm BA (+) or did not (–).

[y]SOD was as follows: 1 = elongated bud with first leaf furled; SOD 2–6 = 1–5 unfurled leaves, respectively.

[x]Quality rating: 1 = ≥75% foliar necrosis; 2 = ≥50% but <75% necrosis; 3 = ≥25% but <50% necrosis; 4 = ≥10% but <25% necrosis; 5 = <10% necrosis.

[w]BA × cultivar interactions significant at P = 0.05; mean separation among cultivars within + or –BA using Duncan’s multiple range test; P = 0.05.

[v]Means for +BA treatments followed by an asterisk are significantly different from corresponding cultivar means for –BA treatments; P = 0.05.

(0.5 gal/100 ft^2) using a CO_2 sprayer with a flat fan nozzle (LPT-JET 8001, R&D sprayers, Opelousas, LA) at 137 kPa (20 psi). Buffer-X (Kalo Agr. Chemicals, Overland, KS) at 0.2% was added to each BA solution as a surfactant before spraying. Temperature and relative humidity at the time of BA application were 30C (86F) and 63%, respectively and there was no wind. Plants were not irrigated until the following day. Offset number and a quality rating (QR) were recorded 30 and 60 days after treatment (DAT). The following scale was used to assess QR: 1 = ≥75% foliar necrosis; 2 = ≥50% but <75% necrosis; 3 = ≥25% but <50% necrosis; 4 = ≥10% but <25% necrosis; 5 = <10% necrosis.

Growth index [GI = (height + width at widest point + width 90° to first width) / 3] and offset stage of development (SOD), or number of unfurled leaves, were recorded 60 DAT. SOD was recorded as follows: 1 = elongated bud with first leaf furled, SOD 2–5 = 1–4 unfurled leaves, respectively. Treatments in this 6 × 2 (cultivar × ±BA) factorial experiment were completely randomized with ten single plant replications. Analysis of variance (ANOVA) was used to test for significance of main effects and interactions. Mean separations among cultivar groups and BA treatments were made using Duncan’s multiple range test.

Landscape application. Two 1 m × 20 m (1.1 yd × 3.3 yd) ground beds were amended with a 7.6 cm (3 in) layer of amendment grade pine bark and 1.1 kg (1.8 lb) 15N–0P–12.5K (Polyon 15–0–15) on June 1, 1998. ‘Francee’ and ‘Frances Williams’ plants grown in 3.8 liter (#1) containers with 0–2 initial offsets were planted on June 30, 1998. Plants were grown under 47% shade and irrigated for 30 minutes twice daily (1.3 cm (0.5 in) per irrigation). They were allowed to establish and grow until symptoms of summer decline appeared. At that time, some plants had produced additional offsets; therefore, offsets were counted on each plant. ‘Francee’ plants were placed in groups with either 2 (4 plants), 3 (14 plants), or 4 (14 plants) initial offsets. ‘Frances Williams’ plants had either 0 (20 plants), 2 (20 plants), or 3 (16 plants) initial offsets. On August 21, 1998, half of the plants in each offset group from each cultivar were sprayed with 3000 ppm BA at 0.2 liter/m^2 (0.5 gal/100 ft^2) and Buffer-X at 0.2%. Temperature and relative humidity at the time of BA application were 29.4C (85F) and 60%, respectively, and there was no wind. Plants were not irrigated until the following day. Offset number and QR were recorded 30 and 60 DAT. GI and SOD were recorded 60 DAT. Treatments in this 2 × 3 (±BA × initial offsets) factorial experiment were completely randomized among cultivars. Because initial offset treatments differed, cultivars were analyzed separately by analysis of variance (ANOVA) to test for significance of main effects and interactions. Comparisons among initial offset groups and between BA treatment and controls were made using single degree of freedom orthogonal contrasts.

Table 2. **BA comparison across cultivars for offset number, quality rating (QR), and growth index (GI) 60 days after treatment, during container production of hosta.**

BA[z]	Offset number	QR[y]	GI[x]
+	1.7a[w]	3.5a	31.9a
–	0.3b	2.7b	28.5b

[z]Plants either received a foliar application of 3,000 ppm BA (+) or did not (–).

[y]QR was assessed using the following scale: 1 = ≥75% foliar necrosis; 2 = ≥50% but <75% necrosis; 3 = ≥25% but <50% necrosis; 4 = ≥10% but <25% necrosis; 5 = <10% necrosis.

[x]GI = (height + width at widest point + width 90° to first width) / 3, in cm.

[w]Mean separation within columns by Duncan’s multiple range test; P = 0.05.

Results and Discussion

Container production. There was a significant interaction between cultivar and BA for offset number 30 DAT. More offsets were produced by plants treated with BA than by controls in ‘Sum & Substance’, ‘Elegans’, ‘Francee’, and ‘Tokudama’ (Table 1). Among +BA plants, ‘Sum & Substance’ and ‘Elegans’ produced more offsets than ‘Frances Williams’ or *H. plantaginea*; these results support previous work showing a cultivar-dependent response in hosta to BA (2). Offset number was not influenced by cultivar for control

Table 3. **Hosta cultivar/species comparisons across BA treatments for offset number and growth index (GI) 60 days after treatment, during container production of hosta.**

Cultivar/species	Offset number	GI[z]
‘Sum & Substance’	1.8a[y]	34.8b
‘Elegans’	1.3b	29.9bc
plantaginea	0.3c	40.6a
‘Frances Williams’	0.4c	28.8bc
‘Francee’	1.1b	27.0cd
‘Tokudama’	1.2b	20.9d

[z]GI = (height + width at widest point + width 90° to first width) / 3, in cm.

[y]Means separation within columns by Duncan’s multiple range test; P = 0.05.

Table 4. **Hosta 'Francee' and 'Frances Williams' BA comparisons across initial offset number for change in offset number 30 and 60 days after treatment (DAT) and 'Francee' quality rating (QR) 60 DAT in a landscape evaluation.**

	Francee'			'Frances Williams'	
	Change in offset number[z]		QR[y]	Change in offset number	
BA[x]	30 DAT	60 DAT	60 DAT	30 DAT	60 DAT
+	4.6a[w]	4.5a	4.6a	0.6a	0.5a
–	0.8b	0.7b	3.8b	0.3b	0.3b

[z]Change between 0 and 30 DAT, and between 0 and 60 DAT.

[y]Quality rating: 1 = ≥75% foliar necrosis; 2 = ≥50% but <75% necrosis; 3 = ≥25% but <50% necrosis; 4 = ≥10% but <25% necrosis; 5 = <10% necrosis.

[x]Plants either received a foliar application of 3,000 ppm BA (+) or did not (–).

[w]Means for variables within a BA group separated by single degree of freedom contrast; P = 0.05.

plants, probably due to the low numbers of offsets formed by all cultivars. The interaction between cultivar and BA was not significant for offset number 60 DAT. Across cultivars, plants treated with BA produced 467% more offsets than controls (Table 2). Across BA treatments, 'Sum & Substance', 'Elegans', 'Francee', and 'Tokudama' produced more offsets than 'Frances Williams' and *H. plantaginea* (Table 3).

The interaction between BA and cultivar/species was significant for SOD 30 DAT. 'Sum & Substance' and *H. plantaginea* +BA plants had higher (33% and 69%, respectively) SOD values than corresponding controls (Table 1). In the presence of BA, *H. plantaginea* had a higher SOD than the cultivars. These results support previous research that reported the influence of BA on SOD was cultivar-dependent (2). A higher SOD has been associated with a higher rooting percentage in offsets (5). Cultivar had no effect on SOD for –BA plants, again probably due to the low numbers of offsets produced by all cultivars.

For QR, the interaction between cultivar and BA was significant 30 DAT but not 60 DAT. 'Sum & Substance' and 'Elegans' +BA plants had an 88% and 82%, respectively, higher QR than corresponding controls 30 DAT (Table 1). In the presence of BA, *H. plantaginea* had a higher QR than all cultivars, except 'Elegans'. In the absence of BA, *H. plantaginea*, 'Frances Williams', 'Francee', and 'Tokudama' had a higher QR than 'Elegans' and 'Sum & Substance'. *H. plantaginea* is a species that is more heat tolerant than the cultivars tested, as evidenced by its high QR for both +/–BA treatments. It grows readily in USDA Hardiness Zone 9, whereas the cultivars tested are only hardy through Zone 8 (7). Only BA was significant for QR 60 DAT; +BA plants had a 28% higher QR than –BA plants (Table 2). The higher QR appeared to relate to a flush of new growth in +BA plants.

The effects of both cultivar/species and BA were significant for GI, but the interaction was not. Among cultivars/species, *H. plantaginea* had a higher GI than the cultivars (Table 3). Across cultivar, +BA plants had a 12% higher GI than controls (Table 2). A previous study reported GI of BA-treated plants was higher or similar to that of controls; the higher GI was attributed to the expansion of BA-induced offsets, new foliage production, or both (2).

Landscape application. Only BA was significant for change in offset number in both cultivars 30 and 60 DAT. Across initial offset groups, +BA 'Francee' plants produced 475% more offsets than controls 30 DAT (4.6 vs. 0.8) and 543% more offsets than controls 60 DAT (4.5 vs. 0.7, Table 4). 'Frances Williams' +BA plants produced 100% more offsets than controls 30 DAT (0.6 vs. 0.3), and 67% more offsets than controls 60 DAT (0.5 vs. 0.3). This is the first report of BA stimulation of offset formation in an established landscape planting. Unlike a previous study that reported offset formation decreased as initial offset number increased (6), BA application was effective on established plants that had a wide range of initial offsets. Previous research with multiple-offset plants used *H. sieboldiana*, a species that may respond differently to BA than 'Francee' and 'Frances Williams'.

The interaction between BA and initial offset number was significant for SOD in 'Francee', but not in 'Frances Williams' 30 DAT. Initial offset number did not affect SOD in +BA 'Francee' plants, although there was a trend toward higher SOD as initial offset number increased (Table 5). 'Francee' +BA plants with 2 initial offsets had a 65% higher SOD than –BA plants, and +BA plants with 3 initial offsets had a 50% higher SOD than –BA plants. BA did not affect SOD for plants with 4 initial offsets. SOD was not affected by BA or initial offset number in 'Frances Williams', possibly because of the low number of offsets produced in all treatments. SOD is a critical factor in the accelerated propagation of hosta because of the positive correlation between SOD and rooting percentage (5).

Only BA was significant for QR in 'Francee' 60 DAT; 'Francee' +BA plants had a 21% higher QR than controls (Table 4). There were no significant effects on QR in 'Frances Williams' 30 or 60 DAT, possibly due to the low numbers of offsets produced in all treatments (data not shown). There were no significant treatment effects on GI for either cultivar (data not shown), which agrees with previous work that investigated the effect of BA and initial offset number on offset formation (5).

BA was effective in inducing the outgrowth of axillary and rhizomic buds, however, in agreement with earlier research (2), the response of hosta to BA for offset number was cultivar/species dependent both during container production and in the landscape. In container production, there

Table 5. **Hosta 'Francee' initial offset × BA interaction for offset stage of development (SOD)[z] 30 days after treatment in a landscape evaluation.**

	Initial offset number			
BA[y]	2	3	4	Significance[x]
+	3.3a[w]	3.6a	4.2a	NS
–	2.0b	2.4b	4.2a	L***

[z]SOD was as follows: 1 = elongated bud with first leaf furled, SOD 2–5 = 1–4 unfurled leaves, respectively.

[y]Plants either received a foliar application of 3,000 ppm BA (+) or did not (–).

[x]Nonsignificant (NS) or significant linear (L) regression response at the P ≤ 0.001 (***) level.

[w]Means for variables within an initial offset group separated by single degree of freedom contrast; P ≤ 0.05.

was an interaction between BA and cultivar 30 DAT, but only for cultivar 60 DAT. These results support earlier research that reported a diminished response to BA over time compared to controls (6), and sequential applications were necessary to continue the positive response (4). In the landscape, offset number was affected by BA 30 and 60 DAT. The interaction between initial offset number and BA for change in offset number was not significant for 'Frances Williams' possibly due to cultivar differences (2); 'Frances Williams' is slower to respond to BA than 'Francee' and low numbers of offsets were produced by both + and –BA treatments.

The influence of BA on QR was also dependent on cultivar 30 DAT during container production; QR for 2 of the 6 cultivars treated with BA was higher than that of controls 30 DAT, but by 60 DAT QR was higher in all cultivars. In the landscape, QR was higher for +BA 'Francee' plants 60 DAT, but there was no QR effect on 'Frances Williams'; again, probably due to the growth habit of 'Frances Williams'. The influence of BA on SOD for the container production experiment was cultivar-dependent 30 DAT. Although *H. plantaginea* formed fewer offsets than all cultivars, with the exception of 'Frances Williams', this species had the highest SOD among +BA plants. Earlier work reported that a higher SOD resulted in a higher rooting percentage, which is critical for accelerated propagation of hosta (5). SOD increased linearly as offset number increased for –BA plants. In the landscape, SOD for 'Francee' increased linearly as initial offset number increased for –BA plants. In this study, summer application of BA promoted offset development and increased SOD, thus improving plant quality by masking declining foliage both during container production and in the landscape.

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