Rooting and Lateral Shoot Elongation of *Verbena* Following Benzylaminopurine Application

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Abstract. Rooting and growth of *Verbena* cuttings (*Verbena* × *hybrids* Voss) were measured to determine response to foliar-applied benzylaminopurine (BA). There was no rooting response to BA application when visible nodal roots were present at the base of the cutting. There was no response to 30, 100, or 300 mg BA/liter applied to the foliage 48 or 96 hours after excision from the stock plant. Rooting-zone dry mass, total cutting dry mass, and number of roots were increased by 30 mg BA/liter applied immediately after excision when there were no visible nodal roots at the base of the cuttings. Foliar application of BA at 10 or 30 mg·liter⁻¹ increased lateral bud elongation of subsequently rooted shoots by 20% and 49%, respectively. Application of BA during cutting propagation to enhance subsequent lateral bud elongation does not appear to inhibit rooting in *Verbena* stem cuttings. Chemical name used: 6-benzylaminopurine (BA).

Exogenous application of cytokinins immediately after cutting preparation generally inhibits adventitious root formation (ARF), while application after formation of root primordia has little effect (Hartmann et al., 1990). Cytokinins also can enhance lateral budbreak of shoots of various species (Foley and Keever, 1989; Henny, 1985; Mulgrew and Williams, 1985; Ohkawa, 1979). If foliar application to cuttings having preformed root initials or visible nodal roots does not inhibit rooting, lateral bud elongation of the subsequently rooted shoot may be enhanced. Thus, the objective of these studies was to determine if foliar-applied BA would inhibit ARF or growth of *Verbena* with or without visible nodal roots at the base of stem cuttings, and to determine if BA applied before rooting would enhance lateral bud elongation subsequent to ARF.

Type of cutting. Six-cm-long stem cuttings of *Verbena* × *hybrids* 'Texturf Red' were inserted (basal 1 cm) into 6.2-cm-diameter pots (150 ml medium volume) filled with a moist 2 perlite : 1 peat moss medium (v/v). Cuttings were removed from stock plants by clipping just above or below a node, producing cuttings having nodal or internodal bases. A single preformed adventitious root (< 0.5 cm long) was visible at the base of nodal cuttings.

After cuttings were stuck, foliage was sprayed to runoff with either twice-distilled water, or BA at 30, 100, or 300 mg·liter⁻¹. No spray or drip was allowed into the rooting medium. Twenty-five cuttings were ran-

domly assigned to each of the eight treatments (four rates on either nodal or internodal cuttings) in a completely randomized design.

Cuttings were rooted in a growth chamber at 80% ± 10% RH; a constant 24C, 210 μmol·s⁻¹·m⁻² photosynthetic photon flux (PPF) for 18 h of every 24-h cycle; and ambient CO₂ of 380 μl·liter⁻¹.

Initial rooting-zone (basal 1 cm of stem with or without roots) dry mass, total cutting dry mass, number of roots, and leaf dry mass were determined upon removal of nodal and internodal cuttings from the stock plant. Subsequent harvests were made 5 and 12 days after sticking. Relative growth rate (RGR, mg·day⁻¹) was calculated.

Timing application of BA. Internodal cuttings 6 cm long were stuck and rooted using conditions described above. Cuttings were

sprayed with BA as noted at 0, 48, or 96 h after sticking. Design and measured responses were the same as described above.

Lateral bud elongation. Unbranched 10-cm-long stem tip cuttings of *Verbena* × *hybrida* 'Blaze' were inserted (basal 2 cm) into pots as described above. Only three nodes and the stem tip were above the soil line. After cuttings were stuck, foliage of 30 cuttings (three cuttings per pot) was sprayed to runoff with either twice-distilled water or with BA at 10 or 30 mg·liter⁻¹. No spray or drip was allowed into the rooting medium. Plants were placed under intermittent mist (5 sec of every 5 min) 4 h after sprays were applied. A completely randomized design was used, with individual pots functioning as experimental units.

Cuttings were rooted in a fiberglass propagation house at 85% ± 15% RH; 29 ± 5C day or night; 330 μmol·s⁻¹·m⁻² average PPF with a 16-h photoperiod; ambient CO₂ of 360 μl·liter⁻¹. After 12 days, cuttings were moved to a growing bench under 60% shade (860 μmol·s⁻¹·m⁻² average midday PPF), 65% ± 15% RH, 27 ± 8C day or night, and were irrigated daily.

Cuttings were observed daily for rooting responses to BA. Plants were evaluated for percentage of elongated lateral buds per stem and for stem length (soil line to apex) 24 days after cuttings were stuck.

Foliar-applied BA did not influence any measured characteristics of nodal cuttings at either 5 or 12 days after sticking (data not shown). Internodal cuttings sprayed immediately after sticking responded similarly in studies of cutting type and timing of application, and were combined for analysis. Internodal cuttings sprayed with 30 mg BA/liter immediately after sticking of the cuttings had 47% more rooting-zone dry mass, 20% more total dry mass, and 83% more roots than the control after 12 days (Table 1). Leaf dry mass and RGR were not influenced by BA. Averaged across treatments, RGR was 7.2 ± 0.8 and 8.6 ± 0.6 mg·day⁻¹

Table 1. Dry mass partitioning and rooting of internodal cuttings of *Verbena* × *hybrida* 'Texturf Red' as influenced by concentration of benzylaminopurine (BA) and timing of application after sticking. Data taken 12 days after treatment. Means ± standard errors.

BA (mg·liter ⁻¹)	Rooting-zone dry mass (mg)	Total dry mass (g)	Roots (no.)
<i>BA applied immediately</i>			
0	302 ± 42	1.48 ± 0.16	24.6 ± 5.9
30	444 ± 38	1.79 ± 0.13	45.1 ± 2.3
100	322 ± 38	1.56 ± 0.13	22.3 ± 2.9
300	235 ± 59	1.51 ± 0.16	18.6 ± 5.1
<i>BA applied after 12 h</i>			
0	301 ± 40	1.44 ± 0.14	19.8 ± 1.1
30	452 ± 41	1.86 ± 0.16	32.3 ± 3.4
100	340 ± 37	1.63 ± 0.10	21.3 ± 3.0
300	236 ± 59	1.53 ± 0.16	16.7 ± 2.9
Significance			
BA applied immediately			
Quadratic	*	*	*
BA applied after 12 h			
Quadratic	*	*	*

*Significant at *P* = 0.05, ANOVA *F* test, *n* = 14 or *n* = 7 for BA applied immediately or 12 h after sticking. No significant responses were found (*P* > *F* above 0.05) upon removal from the stock plant or 5 days after sticking.

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Table 2. Percent elongated lateral buds and stem length of *Verbena* × *hybrida* ‘Blaze’ cuttings in response to benzylaminopurine (BA) concentration. Data from 24 days after cuttings were treated. Means ± standard errors.

BA (mg·liter ⁻¹)	Elongated buds (%)	Stem length (cm)
0	15.8 ± 3.8	17.8 ± 0.5
10	35.8 ± 4.3	15.5 ± 0.4
30	65.0 ± 2.4	14.0 ± 0.3
Significance		
Linear	**	**
Quadratic	*	*

***Significant at $P = 0.05$ or 0.01 , respectively, ANOVA F test, $n = 10$. Percentage elongated buds was analyzing using inverse-sine transformed data; reported means are of nontransformed data.

for nodal and internodal cuttings, respectively.

There was no effect of BA on internodal cuttings 5 or 12 days after sticking when application was delayed 48 h or longer (data not shown). Internodal cuttings sprayed with 30 mg BA/liter 12 h after sticking had 50% more rooting-zone dry mass, 28% more total mass, and 63% more roots than the control after 12 days (Table 1).

Application of 30 mg BA/liter produced more roots when applied immediately than when applied 12 h after sticking, but no other measured characteristics differed between the 0 h and 12 h application times (Table 1).

Visual observations indicated no influence of BA on ARF of 10-cm-long cuttings. The percentage of elongated lateral buds was 20% or 49% higher, and stem length was 13% or 21% shorter than for the controls for 10 or 30 mg BA/liter, respectively (Table 2).

Development of more roots at low concentrations of BA applied immediately after excision of internodal cuttings from the stock plant is consistent with reports that cytokinins may promote ARF when applied at low concentrations and have little influence during the later stages of ARF (Hartmann et al., 1990; Van Staden and Harty, 1988). Application of BA at 30 or 100 mg·liter⁻¹ did not inhibit ARF of *Verbena*. Increased lateral bud elongation and shorter stem length of BA-treated cuttings may enhance the morphological quality of the subsequently rooted shoots.

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