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Growth and Flowering Response of 'May Night' Salvia and 'Butterfly Blue' Scabiosa to Growth Retardants[1]

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Abstract

In a 1999 experiment, *Salvia* x *sylvestris* 'May Night' and *Scabiosa columbaria* 'Butterfly Blue' were treated with the following plant growth retardants (PGRs) or PGR mixes: B-Nine (daminozide) at 5000 ppm (applied twice); B-Nine at 5000 ppm + Cycocel (chlormequat chloride) at 1500 ppm; Florel (ethephon) at 500 ppm (applied twice); B-Nine at 5000 ppm + Florel at 500 ppm; Sumagic (uniconazole) at 20 ppm; or B-Nine at 5000 ppm + Sumagic at 10 ppm. B-Nine effectively suppressed growth of salvia but not scabiosa, while Florel was effective on both salvia and scabiosa. However, Florel delayed flowering of both species by about 10 days. Sumagic at 20 ppm suppressed growth of scabiosa but not salvia. The PGR combination treatments, in general, were no more effective, and frequently less effective than the more effective PGR for a given species applied alone. In 2000, Florel was applied once to both salvia and scabiosa at 0, 250, 500, 750, and 1000 ppm. B-Nine (5000 ppm) was also applied to salvia, and Sumagic (20 ppm) was applied to scabiosa. Plant height of salvia was suppressed linearly with increasing Florel concentrations up to 42 days after treatment (DAT). Salvia also responded with a linear increase in inflorescence numbers at 32 and 42 DAT. Florel suppressed the height of scabiosa 'Butterfly Blue' linearly up to 52 DAT without affecting the initial number of inflorescences. When the first set of inflorescences was removed and a second set developed, there was a linear increase in inflorescence numbers with increasing concentrations of Florel.

Index words: growth regulators, herbaceous perennials, nursery production.

Species used in this study: 'May Night' salvia (*Salvia* x *sylvestris* L. 'May Night' ('Mainacht')), and 'Butterfly Blue' scabiosa (*Scabiosa columbaria* L. 'Butterfly Blue').

Chemicals used in this study: B-Nine (daminozide), butanedioic acid mono-(2,2-dimethylhydrazide); Cycocel (chlormequat chloride), (2-chlorethyl) trimethylammonium chloride; Florel (ethephon), (2-chloroethyl) phosphonic acid; Sumagic (uniconazole), E-1-[4-chlorophenyl]-4,4-dimethyl-2-[1,2,4-triazol-1-yl]pent-1-ene-3-ol.

Significance to the Nursery Industry

Consumer demand is high for the popular perennials 'May Night' salvia and 'Butterfly Blue' scabiosa. Intensive production methods and the onset of warmer spring temperatures can cause rapid and excessive elongation of flower spikes. We found that foliar application of the plant growth retardant (PGR) Florel was effective for both species in maintaining compact size and quality. Inflorescence height was reduced linearly as Florel concentration increased from 250 to 1000 ppm. While Florel somewhat delayed flowering of both species, an added benefit of its application to the salvia was a corresponding increase in the numbers of inflorescences produced. B-Nine applied at 5000 ppm suppressed the height of salvia and increased inflorescence numbers equal to the 250 ppm application of Florel, but it had no effect on scabiosa. In contrast, 20 ppm Sumagic moderately suppressed the height of scabiosa, but had no effect on salvia.

Introduction

Salvia x *sylvestris* 'May Night' ('Mainacht'), 1997 Perennial Plant of the Year (1), is an herbaceous perennial with numerous spikes of deep indigo flowers reaching 46 to 61 cm (18 to 24 in) tall (11). In cool weather the flower spikes maintain an upright habit; however, in USDA hardiness zone 7 and above, the flower spikes elongate rapidly and may tend to flop or lay over (1), leaving the plant open in the center. This can be a problem for nursery container production in the warm southern states since compact flowering plants which remain in proportion to their containers are desired. *Scabiosa columbaria* 'Butterfly Blue', 2000 Perennial Plant of the Year (12), has lavender-blue flowers on stalks to 70 cm (28 in) (7). As flower stalks elongate rapidly during nursery container production, they may develop a loose, floppy appearance. Plant growth retardants (PGRs) such as B-Nine (daminozide), Sumagic (uniconazole), Florel (ethephon) or other ethephon products, and B-Nine + Cycocel (chlormequat chloride) tank mixes have been used on certain other herbaceous perennials to control growth and produce more compact plants (2, 4, 5, 9). Sumagic and Cycocel are labeled for controlling growth in greenhouses. B-Nine and Florel are labeled for use both in greenhouses and outdoors. In addition to suppression of shoot elongation, Florel has been used to stimulate branching of crops such as geranium (6) and chrysanthemum (8) and it has increased the number of flowering stems of liatris (3). The objectives of this study were to evaluate several PGRs or PGR combinations for control of flowering stem elongation of salvia 'May Night' and scabiosa 'Butterfly Blue' and, to determine if Florel could increase the number of flowering stems of these species.

Materials and Methods

This study was conducted in spring 1999 and 2000 with plants started in March of each year as 5.7 cm (2.3 in) plugs potted into 3.8 liter (#1) containers in a pine bark:sand medium (9:1, by vol). The medium was amended with 2.4 kg/m^3 (4 lb/yd^3) 18N–2.6P–10K (Osmocote 18–6–12, The Scotts Co., Marysville, OH), 2.4 kg/m^3 (4 lb/yd^3) dolomitic limestone, and 0.7 kg/m^3 (1.5 lb/yd^3) C-Trel micronutrients (Coor Farm Supply Services, Inc., Smithfield, NC). PGR treatments

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were applied as foliar sprays at 2.5 kg/cm^2 (35 psi), with a volume of 210 ml/m^2 (1 gal/200 ft^2) using a CO_2-pressurized sprayer with a ConeJet TXVS-8 hollow cone nozzle. PGR treatments were applied to salvia on April 8, 1999, and to scabiosa on May 10, 1999, to include the following: B-Nine (5000 ppm), B-Nine + Cycocel (5000/1500 ppm), Florel (500 ppm), B-Nine + Florel (5000/500 ppm), Sumagic (20 ppm), B-Nine + Sumagic (5000/10 ppm), and a water control. The temperature at the time of treatment on April 8 was 23.9C (75F), with a relative humidity of 54%. On May 10, at the time of the scabiosa treatments, the temperature was 28.3C (83F), with a relative humidity of 40%. B-Nine, and Florel alone were re-applied 8 days after the initial treatments to both species. The temperature was 16C (61F) for the second B-Nine and Florel applications to salvia, and relative humidity was 57%. For the second applications to scabiosa, temperature was 17C (62F), with a relative humidity of 76%. A randomized complete block design was used with seven single plant replications. Each species was blocked according to initial size which ranged in diameter from 13 to 18 cm (5 to 7 in) for salvia, and from 15 to 20 cm (6 to 8 in) for scabiosa. In 1999, the plants were measured 21 and 36 days after treatment (DAT). Measurements included plant heights (flowering) and widths [(widest width + width perpendicular to widest width) / 2]. Data were analyzed with analysis of variance (ANOVA) with mean separations by LSD at P = 0.05.

In 2000, treatments for both salvia and scabiosa were applied on April 7. The treatments for salvia included: Florel at 250, 500, 750, or 1000 ppm, B-Nine at 5000 ppm, and a water control. Treatments for scabiosa were the same as for salvia except that Sumagic at 20 ppm was substituted for B-Nine. All treatments in the 2000 experiment were applied once. The temperature at time of treatment was 20C (68F) with a relative humidity of 30%. A randomized complete block design was used, four replications of two plants each. Each species was blocked by initial size which ranged in diameter from 10 to 17 cm (4 to 7 in) for salvia, and from 12 to 18 cm (5 to 7 in) for scabiosa. In 2000, plants were evaluated at 32, 42, and 52 DAT. Data collected included plant widths (as described above), height of foliage, height and number of inflorescences. On June 6 (58 DAT), the first sets of inflorescences were cut off of both the salvia and the scabiosa just above the top of the foliage. On June 26 (78 DAT), the number of new inflorescences that developed was determined, along with inflorescence and foliage heights and widths. A visual quality rating was also obtained based primarily on fullness of the inflorescence canopy (1 = less than ¼ of canopy covered with flowers, 2 = ¼ to ½ cover, 3 = ½ to ¾ cover, 4 = ¾ to almost complete cover, 5 = complete dense cover of flowers). Data were analyzed using general linear models and orthogonal contrasts for trend analysis of Florel rate responses, with control included.

Results and Discussion

Salvia x sylvestris 'May Night'. In 1999 B-Nine (5000 ppm applied twice) and Florel (500 ppm applied twice) were more effective over a longer period of time than the other treatments evaluated (Table 1). B-Nine reduced plant height 38 and 24% at 21 and 36 DAT respectively, while Florel reduced height 46 and 26% at 21 and 36 DAT respectively. At 36 DAT, B-Nine-treated plants were 13% less wide, and the Florel-treated plants were 16% less wide than the control plants. B-Nine + Florel was statistically similar in effectiveness to B-Nine or Florel alone 21 days after treatment (DAT) but provided no significant growth control 36 DAT. B-Nine + Sumagic was statistically similar in effect to B-Nine alone 21 DAT but less effective than B-Nine alone 36 DAT. Sumagic applied alone at 20 ppm, and the B-Nine/Cycocel mix (5000/1500 ppm) provided no significant height control. At 36 DAT, Florel-treated plants appeared to have more inflorescences than those of plants in the other treatments although inflorescences were not counted at this time.

In 2000 there was a linear suppression of plant (inflorescence) height with increasing concentrations of Florel at 32 and 42 DAT and a quadratic response at 52 DAT (Table 2). In order to maintain compact growth and to suppress opening up of the plant centers, we considered plant heights of 1 to 1.5 times container height to be acceptable. Since the height of #1 containers is 17 cm (6 ¾ in), this would suggest that at 32 DAT, plants treated with 750 or 1000 ppm Florel were unacceptably short. However, for plants maintained until 42 DAT, all Florel-treated salvia fell within an acceptable range. Individual nurseries would need to select specific treatments based on their own standards and production schedules.

There was also a linear increase in numbers of inflorescences 32 and 42 DAT, and a quadratic increase at 52 DAT.

Table 1. Height (cm) and width of *Salvia* 'May Night' and *Scabiosa* 'Butterfly Blue' after treatment with growth regulators (1999).

		Salvia				*Scabiosa*			
		21 DAT[z]		36 DAT		21 DAT		36 DAT	
Growth regulator	Conc. (ppm)	height[y] (cm)	width (cm)	height (cm)	width (cm)	height (cm)	width (cm)	height (cm)	width (cm)
	0	26a[x]	23ab	42a	38ab	40a	34a	44a	35
B-Nine	5000	16c	22bc	32c	33c	37ab	32a	42ab	34
B-Nine/Cycocel	5000/1500	23ab	23ab	39ab	38ab	40a	33a	42ab	34
Florel	500	14c	19c	31c	32c	20e	26b	40bc	35
B-Nine/Florel	5000/500	20bc	23ab	39ab	38ab	26d	27b	41ab	33
Sumagic	20	28a	26a	42a	39a	32c	24b	32d	31
B-Nine/Sumagic	5000/10	18bc	22bc	36b	36b	35b	27b	37c	32
									NS

[z]DAT = days after treatment.

[y]Height of inflorescences.

[x]Mean separation within columns by LSD (P = 0.05)

Table 2. Growth and inflorescence numbers of *Salvia* 'May Night' after treatment with Florel or B-Nine (2000).

Growth regulator	Conc. (ppm)	32 DAT[z]			42 DAT			52 DAT		
		inflorescence height (cm)	width (cm)	inflorescence number	inflorescence height (cm)	width (cm)	inflorescence number	inflorescence height (cm)	width (cm)	inflorescence number
Control	0	32	24	19	34	28	22	33	27	33
Florel	250	23	23	28	26	26	35	26	26	51
	500	18	22	30	24	24	37	23	24	51
	750	15	23	29	22	23	40	24	23	44
	1000	13	23	30	23	25	39	25	26	51
Significance[y]		L**	NS	L**	L***	L**	L***	Q***	Q**	Q*
B-Nine	5000	24	23	26	27	27	33	27	25	42
$LSD_{.05}$		3.5	NS	7.1	2.7	2.5	6.5	3.1	2.8	9.5

[z]DAT = days after treatment.

[y]Regression response non-significant (NS), linear (L), or quadratic (Q) at the 0.05 (*), 0.01 (**), or 0.001 (***) level. Control included in the analysis.

For the 500 ppm Florel treatment, inflorescence numbers increased by 58, 68, and 55% at 32, 42 and 52 DAT respectively. At 32 DAT, many of the inflorescences had not yet opened, with a linear suppression of floret opening at that time corresponding to increasing Florel concentration (P = 0.0002). For the control plants, 100% of the plants had open florets at 32 DAT while 88, 50, 25, and 0% of the plants had open florets for the 250, 500, 750, and 1000 ppm Florel treatments respectively (data not shown). All plants in the B-Nine treatment also had 100% of the plants with open florets present at 32 DAT. By 42 DAT, all salvia plants had inflorescences with open florets. Thus, although there was an increase in inflorescence numbers with increasing Florel rates, inflorescence development and floret opening was delayed. Florel or other ethephon products have also delayed flowering of chrysanthemum (8, 10), New Guinea impatiens (13), achillea and gaura (4). The B-Nine treatment controlled growth and increased inflorescence numbers at a level approximately equivalent to the 250 ppm Florel treatment. After the first set of inflorescences was cut back at 58 DAT and another set allowed to develop, there were no differences in plant height, GI or number of inflorescences among treatments when evaluated 20 days after the cut back (78 DAT) (data not shown).

Scabiosa columbaria 'Butterfly Blue'. In 1999, at 21 DAT Florel (500 ppm applied twice) provided the most height control with treated plants being 50% shorter than control plants (Table 1). The B-Nine/Florel mix (5000/500 ppm) was next in effectiveness, with plants that were 35% shorter than controls. Sumagic-treated plants at 21 DAT were 20% shorter than controls. By 36 DAT Florel controlled height by only 9% while Sumagic treated plants were 27% shorter than control plants. B-Nine and the B-Nine/Cycocel treatments provided no significant growth control for scabiosa. Moderate growth control was obtained with B-Nine/Florel mix and B-Nine/Sumagic mix treatments but this was probably from the Florel and Sumagic components of these mixtures.

In 2000, increasing Florel concentrations resulted in a linear suppression of inflorescence height 32, 42, and 52 DAT (Table 3). At 32 DAT, the Florel treatments also decreased inflorescence numbers quadratically. However, by 42 and 52 DAT, there were no significant differences in inflorescence numbers, suggesting that the reduced numbers of inflorescences seen at 32 DAT was due to a delay in inflorescence development. Inflorescence height at 32 and 42 DAT on scabiosa treated with 750 and 1000 ppm Florel could be considered excessively retarded. However, by 52 DAT, the inflorescences on these plants had reached acceptable heights while retaining compact growth, making these the more attractive plants. Production scheduling needs to be considered when selecting optimum Florel concentration.

Although at 32 and 42 DAT no differences were measured in the height or width of the foliage (data not shown),

Table 3. Growth and inflorescence numbers of *Scabiosa* 'Butterfly Blue' after treatment with Florel or Sumagic (2000).

Growth regulator	Conc. (ppm)	32 DAT[z]		42 DAT		52 DAT		
		inflorescence height (cm)	inflorescence number	inflorescence height (cm)	inflorescence number	foliage height (cm)	inflorescence height (cm)	inflorescence number
Control	0	21	27	34	44	8	36	67
Florel	250	14	26	26	44	8	36	63
	500	8	16	22	42	10	35	81
	750	9	8	18	32	12	31	59
	1000	8	16	15	34	13	30	72
Significance[y]		L**	Q*	L***	NS	L***	L***	NS
Sumagic	20	16	22	29	46	7	33	69
$LSD_{.05}$		9.5	7.6	5.9	16.1	2.6	4.5	26.1

[z]DAT = days after treatment.

[y]Regression response non-significant (NS), linear (L), or quadratic (Q) at the 0.05 (*), 0.01 (**), or 0.001 (***) level. Control included in the analysis.

Table 4. ***Scabiosa*** **inflorescence regrowth 20 days after cut back of the initial set of inflorescences (78 days after the growth regulator treatments were applied) (2000).**

Growth regulator	Conc. (ppm)	Growth index[z] (cm)	Inflorescence height (cm)	Inflorescence number	Quality rating[y]
Control	0	15	29	27	3.1
Florel	250	15	28	20	3.4
	500	16	30	33	4.3
	750	17	31	41	4.3
	1000	17	32	53	4.4
Significance[x]		L**	NS	L**	L**
Sumagic	20	14	25	28	3.0
$LSD_{.05}$		1.8	4.8	19.0	0.9

[z]Growth index = (foliage height + width) / 2.

[y]Quality rated on a scale of 1 to 5 with 1 = less than ¼ of canopy covered with flowers, 2 = ¼ to ½ cover, 3 = ½ to ¾ cover, 4 = ¾ to almost complete cover, 5 = complete, dense cover of flowers.

[x]Regression response non-significant (NS) or linear (L) at the 0.05 (*) or 0.01 (**) level. Control included in the analysis.

at 52 DAT there was a linear increase in foliage height with increasing Florel concentration (Table 3). When the old inflorescences were cut off 58 DAT, the inflorescences that redeveloped increased in number linearly with increasing Florel concentration from the earlier treatments (Table 4). There was no difference in inflorescence height at this time but the growth index based on foliage height and widths also increased linearly with increased Florel concentration along with a linear increase in overall plant quality. It appears that there may have been a delayed growth response from the Florel applications where suppressed growth energy that initially would have gone into inflorescence elongation went into increased foliage growth between 42 and 52 DAT. This increase in foliage then supported an increase in the second set of inflorescence numbers. This increase in inflorescence numbers and foliage is reflected in a linear increase in the plant quality rating as the Florel concentration increases (Table 4).

Plants in the 20 ppm Sumagic treatment had inflorescence heights that averaged 24, 15, and 8% shorter than controls at 32, 42, and 52 DAT respectively, although these differences were not statistically significant (LSD, 0.05) (Table 3). Sumagic provided no differences in inflorescence numbers from the controls at any time. Sumagic-treated plants also showed no differences from the controls in GI, inflorescence height or number, or quality rating when evaluated 20 days after cutting back the initial set of inflorescences (Table 4).

In summary, Florel provided control of reproductive shoot elongation for 'May Night' salvia and 'Butterfly Blue' scabiosa and, increased the number of inflorescences of salvia in proportion to the concentration applied. Florel also delayed inflorescence development and flower opening for both species. By 52 DAT scabiosa responded to the initial growth suppression from Florel with an increase in foliage growth proportional to the Florel concentration applied. When the first inflorescences were cut off at this time, the second set of scabiosa inflorescences grew back in numbers that increased linearly with increasing concentrations of the Florel treatments and in proportion to the increased growth of foliage.

B-Nine (5000 ppm) suppressed shoot elongation of salvia 'May Night' and increased inflorescence numbers approximately equivalent to Florel at 250 ppm. Sumagic at 20 ppm provided moderate growth suppression of scabiosa 'Butterfly Blue', but had no effect on inflorescence numbers. A combination treatment of B-Nine/Cycocel (5000/1500 ppm) provided no significant height control for either salvia or scabiosa. On salvia, a B-Nine/Florel (5000/500 ppm) mix was similar in height control effectiveness to B-Nine or Florel alone 21 DAT but had no significant effect by 36 DAT. On scabiosa, the B-Nine/Florel mix was more effective than B-Nine alone and less effective than Florel alone 21 DAT. It had no significant effect by 32 DAT. On salvia, the B-Nine/Sumagic (5000/10 ppm) mix was more effective than Sumagic alone (20 ppm) but about the same as B-Nine alone (5000 ppm applied twice) at 21 DAT and less effective at 36 DAT. On scabiosa, The B-Nine/Sumagic mix was less effective than Sumagic alone both 21 and 32 DAT, but more effective than B-Nine alone at 32 DAT.

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