Summer Applications of Plant Growth Retardants Affect Spring Forcing of Hydrangeas

Douglas A. Bailey¹ and
Bernadette Clark²

Additional index words. *Hydrangea macrophylla*, daminozide, paclobutrazol, uniconazole

Summary. Summer spray applications of 5000 ppm daminozide (1× or 2×), 62 ppm paclobutrazol (1× or 2×), or 5 ppm uniconazole (1× or 2×) were applied to seven cultivars (Böttstein, Enzian-dom, Kasteln, Mathilde Gütges, Merritt's Supreme, Red Star, and Schenkenburg) of florists' hydrangea [*Hydrangea macrophylla* subsp. *macrophylla* var. *macrophylla* (Thunb.) Ser.] to evaluate cultivar response to plant growth retardants (PGRs). Both daminozide treatments and the 2× uniconazole treatment effectively reduced plant height for all cultivars during the summer growth period; cultivars varied in response to the paclobutrazol treatments and the 1× uniconazole treatment. Daminozide and uniconazole treatments resulted in less elongation than all other treatments during forcing for most cultivars tested. Paclobutrazol treatments had no residual effect on shoot elongation during forcing of the cultivars tested. The 2x treatments of all PGRs decreased inflorescence diameter of some of the cultivars tested compared with nonsprayed controls. Results from this study indicate that 1) summer application of PGRs can have a residual effect on plant height and inflorescence diameter of hydrangeas during the spring greenhouse forcing phase; and 2) hydrangea cultivars differ significantly in response to the PGRs tested. Therefore, the need for height control during the **spring forcing period of**

hydrangeas will vary with cultivar, and it will depend on how plants were treated the previous summer growing season. We recommend that producers of dormant hydrangeas provide records of their summer height control program to forcers so that height control programs during spring forcing can be adjusted appropriately.

Height control is one of the major cultural problems during summer production of dormant hydrangeas. Research has been conducted on applications of plant growth retardants (PGRs) during the forcing phase of hydrangeas (Bailey, 1989; Bailey et al., 1986; Grower, 1973; Scott, 1982; Tjia et al., 1976) but only a few studies have investigated height control during summer vegetative growth (Jung, 1964; Ulery, 1978). Little is known about height variation among hydrangea cultivars and we found no information on cultivar sensitivity to PGBs. Another area of concern regarding summer height control is the possibility of residual effects of PGR applications on subsequent greenhouse forcing; effects such as delayed flowering, reduced inflorescence size, and reduced stem elongation are possible, especially for the long-lasting triazole compounds paclobutrazol and uniconazole. Therefore, this study was undertaken to 1) compare daminozide, paclobutrazol, and uniconazole as height-control treatments during summer production of seven hydrangea cultivars; 2) note any differences in response to the PGR treatments among the cultivars; and 3) record any residual effects of the PGR treatments during spring forcing of the plants.

On 21 June 1990, rooted terminal cuttings of 'Böttstein', 'Enzian-dom', 'Kasteln', 'Mathilde Gütges', 'Merritt's Supreme', 'Red Star', and 'Schenkenburg' were pinched back to two nodes per cutting and potted one cutting per 79-inch³ (1.3 liter), 6-inch (15cm) diameter pot in a 3 pine bark : 1 sand : 1 peat moss (by volume) substrate amended with 12 lbs dolomitic limestone/yard³ (7.1 kg·m⁻³), 4 lbs superphosphate (0N-8.7P-0K)/yard³ (2.4 kg·m⁻³), and 3 lbs calcium sulfate/yard³ (1.8 kg·m⁻³). After a 3-week establishment period in the greenhouse plants were placed outdoors in full sun

Department of Horticultural Science, North Carolina State University, Raleigh, NC 27695-7609.

¹Assistant Professor and State Extension Specialist-Floriculture Crops.

²Technical Assistant.

and irrigated as needed, using a drip tube system. Plants were fertilized at every irrigation with 226 ppm N supplied from 2 oz ammonium nitrate/100 gal (150 mg·liter⁻¹), 10 oz calcium nitrate/100 gal (75.1 mg·liter⁻¹), and 6.4 oz potassium nitrate/100 gal (479 mg·liter⁻¹). Iron-deficiency chlorosis was detected, and all plants were drenched with 4 oz iron chelate (10% Fe)/100 gal (300 mg·liter⁻¹) on 10 Aug. 1990.

The PGR treatments applied to the plants were 1) a no-spray control; 2) and 3) 5000 ppm daminozide spray 1× or 2×; 4) and 5) 62 ppm paclobutrazol spray 1× or 2×; and 6) and 7) 5 ppm uniconazole spray 1× or 2×. PGR rates were derived from previously reported research (Bailey, 1989; Grower, 1973; Scott, 1982). The first sprays were made 24 July 1990 and the second sprays on 17 Aug. 1990. All spray treatments were made applying one-half gallon of spray per 100 ft² (204 ml·m⁻²) of production area. Treatments were applied using a hand-held pump sprayer without a pressure regulator. Sprays were applied during the early (0800-0930 HR) morning. Treatments were replicated five times using a randomized complete-block design.

Plants were removed from the field 29 Oct. 1990 and transferred to a 75/65F (24/18C) day/night greenhouse. From 3-5 Nov. 1990, the plants were placed in a 75F (24C) room equipped with an ethylene generator to induce defoliation. After ethylene treatment, the plants were transferred back to the greenhouse to allow remaining leaves to abscise before placing plants into a dark, 40F (4C) cooler on 12 Nov. 1990. Height measurements were taken just before placement in the cooler. All heights were measured from the upper rim of the pot to the top of the tallest shoot.

Plants were removed from the cooler 28 Dec. 1990 and placed in a 68/62F (20/17C) day/night greenhouse. Plants were fertilized with 200 ppm N at each watering supplied from Peters General Purpose 20N-8.7P-16.6K (Grace/Sierra, Fogelsville, Pa.) and treated monthly with 3.5 oz iron chelate/100 gal (262 mg·liter⁻¹) to prevent Fe-deficiency chlorosis. The date of anthesis (when pollen was present) for the first flower on each plant was recorded. Plant height, number of flowering shoots (as compared with blind shoots, which had no

inflorescences), and the diameter of the inflorescence in bloom also were recorded for each plant at anthesis. All data were subjected to analysis of variance using Costat (Cohort Software, Berkeley, Calif.); mean separations were achieved using LSD, when appropriate.

Summer height control

The cultivar × PGR treatment interaction was significant ($P = 0.029$) for plant height attained during the summer production period (Table 1). Daminozide 1× and 2× treatments effectively reduced summer elongation for plants of all seven cultivars compared with unsprayed controls. However, paclobutrazol 1× was effective only on plants of 'Kasteln' and 'Mathilde Gütges'. The 2× paclobutrazol treatment was only slightly more effective, suppressing height of 'Enziandom', 'Kasteln', 'Mathilde Gütges', and 'Schenkenburg'. Uniconazole 1× was effective on 'Böttstein', 'Enziandom', 'Kasteln', 'Red Star', and 'Schenkenburg'; 2× uniconazole was effective on plants of all cultivars tested. Daminozide and 2× uniconazole seem to be the most effective treatments in controlling growth of hydrangea plants during summer production.

Effects during forcing

The daminozide and uniconazole treatments had residual effects on some cultivars, resulting in less shoot elongation during forcing (Table 1). The daminozide 1× treatment resulted in less elongation during forcing for 'Böttstein' plants and more elongation for 'Red Star' but did not affect elongation of the other five cultivars as compared with controls. The daminozide 2× treatment suppressed elongation for 'Böttstein' and 'Kasteln' plants and increased elongation for 'Red Star' but did not affect elongation of the other four cultivars. The increase in plant height seen with daminozide on 'Red Star' is difficult to explain. We did not count the number of nodes produced by plants in the different treatments, but if daminozide caused more nodes to be formed before flower bud initiation the previous fall, the extra height may have been due to elongation of those internodes. Uniconazole 1× spray resulted in less elongation during forcing only for 'Böttstein' plants; uniconazole 2× sprays suppressed elongation for 'Böttstein', 'Enziandom', 'Kasteln',

and 'Mathilde Gütges'. The inhibition of elongation during forcing obtained with some of the treatments may be desirable, since height control often is required during forcing. Given that there is the possibility of residual effects, it is essential to know what height control treatments were used the previous summer to anticipate any effect on elongation during forcing. Perhaps fewer height control procedures will be needed during spring forcing if multiple daminozide or uniconazole applications were made the previous summer.

Growth retardant treatments also affected inflorescence size for some cultivars (Table 1). Daminozide 1× increased the inflorescence diameter for 'Schenkenburg' plants, but it did not affect inflorescence size for the other cultivars. Daminozide 2× decreased the diameter of 'Böttstein' inflorescences, but it had no effect on other cultivars. Paclobutrazol 2× decreased the diameter of 'Red Star' inflorescences, but this was the only residual effect of either paclobutrazol treatment on any cultivar tested. Uniconazole 1× reduced inflorescence diameter for 'Böttstein' plants, and uniconazole 2× reduced the inflorescence diameter for 'Böttstein', 'Mathilde Gütges', and 'Red Star'. This decrease in inflorescence diameter may be undesirable, but some reduction in flower size might be the compromise for shorter plants at flowering. Unfortunately, the best summer height control treatments (daminozide 1× and 2× and uniconazole 2×) were also the treatments that tended to reduce inflorescence diameter the most, especially uniconazole 2×. If the market demands larger inflorescences, then perhaps a larger-flowering cultivar, such as 'Red Star', should be grown. Although 'Red Star' inflorescence size was reduced by PGR treatments (up to 20% by the uniconazole 2× treatment), the inflorescences were still larger than all other control plants with the exception of 'Böttstein'.

PGR treatments did not affect the number of flowering shoots developing on plants, and cultivars were similar in their number of flowering shoots; the overall experimental average was 3.6 ± 0.7 flowering shoots per plant. PGR treatment did not affect days to anthesis (from start of forcing), but cultivars did differ in forcing time (Table 2). 'Böttstein' and 'Enziandom'

Table 1. Effects of summer applications of plant growth retardants (PGR) on subsequent growth and flowering of seven cultivars of hydrangea.

Cultivar and PGR treatment	Plant ht on 12 Nov. 1990		Increase in plant ht during forcing ^a		Inflorescence diam at anthesis	
	inches	(cm)	inches	(cm)	inches	(cm)
Böttstein						
Control	8.0	(20.2)	9.1	(23.0)	8.6	(21.9)
5000 ppm daminozide 1×	6.1 ^y	(15.5)	6.7 ^y	(16.9)	8.3	(21.1)
5000 ppm daminozide 2×	5.5 ^y	(14.0)	6.5 ^y	(16.5)	7.2 ^y	(18.3)
62 ppm paclobutrazol 1×	8.3	(21.2)	7.4	(18.7)	7.5	(19.0)
62 ppm paclobutrazol 2×	6.9	(17.6)	7.1	(18.1)	8.0	(20.3)
5 ppm uniconazole 1×	6.2 ^y	(15.8)	5.9 ^y	(15.0)	6.7 ^y	(17.1)
5 ppm uniconazole 2×	5.0 ^y	(12.6)	4.2 ^y	(10.6)	6.0 ^y	(15.3)
Enziandom						
Control	12.4	(31.4)	11.4	(28.9)	7.2	(18.3)
5000 ppm daminozide 1×	10.1 ^y	(25.6)	11.9	(30.3)	8.1	(20.6)
5000 ppm daminozide 2×	9.2 ^y	(23.3)	10.1	(25.7)	8.4	(21.3)
62 ppm paclobutrazol 1×	12.0	(30.4)	9.5	(24.2)	8.1	(20.5)
62 ppm paclobutrazol 2×	11.0 ^y	(27.9)	10.3	(26.2)	6.9	(17.6)
5 ppm uniconazole 1×	10.6 ^y	(26.8)	10.3	(26.1)	7.6	(19.2)
5 ppm uniconazole 2×	9.7 ^y	(24.6)	6.7 ^y	(17.0)	6.9	(17.6)
Kasteln						
Control	10.0	(25.3)	7.8	(19.8)	7.0	(17.9)
5000 ppm daminozide 1×	6.6 ^y	(16.7)	6.8	(17.2)	8.0	(20.3)
5000 ppm daminozide 2×	6.2 ^y	(15.7)	4.5 ^y	(11.5)	8.1	(20.6)
62 ppm paclobutrazol 1×	8.3 ^y	(21.1)	7.4	(18.7)	7.1	(18.1)
62 ppm paclobutrazol 2×	7.5 ^y	(19.0)	7.6	(19.3)	7.5	(19.0)
5 ppm uniconazole 1×	8.0 ^y	(20.3)	6.3	(16.1)	7.1	(18.0)
5 ppm uniconazole 2×	6.8 ^y	(17.2)	4.1 ^y	(10.5)	6.1	(15.4)
Mathilde Gütges						
Control	12.7	(32.3)	6.7	(17.0)	7.0	(17.7)
5000 ppm daminozide 1×	10.8 ^y	(27.4)	6.4	(16.2)	6.4	(16.3)
5000 ppm daminozide 2×	8.8 ^y	(22.4)	8.3	(21.1)	7.4	(18.9)
62 ppm paclobutrazol 1×	10.3 ^y	(26.2)	5.8	(14.7)	7.5	(19.0)
62 ppm paclobutrazol 2×	9.8 ^y	(24.8)	6.9	(17.5)	7.5	(19.1)
5 ppm uniconazole 1×	11.8	(30.0)	5.9	(15.0)	7.0	(17.9)
5 ppm uniconazole 2×	7.6 ^y	(19.3)	2.6 ^y	(6.5)	5.1 ^y	(13.0)
Merritt's Supreme						
Control	10.9	(27.6)	8.2	(20.8)	7.2	(18.3)
5000 ppm daminozide 1×	8.7 ^y	(22.0)	8.0	(20.4)	7.4	(18.9)
5000 ppm daminozide 2×	7.8 ^y	(19.8)	9.8	(25.0)	7.3	(18.5)
62 ppm paclobutrazol 1×	11.4	(28.9)	7.7	(19.5)	6.5	(16.4)
62 ppm paclobutrazol 2×	10.2	(26.0)	8.1	(20.6)	7.0	(17.8)
5 ppm uniconazole 1×	10.0	(25.5)	8.5	(21.6)	7.1	(18.1)
5 ppm uniconazole 2×	8.9 ^y	(22.5)	7.8	(19.7)	6.7	(16.9)
Red Star						
Control	10.0	(25.3)	7.7	(19.5)	10.2	(26.0)
5000 ppm daminozide 1×	8.0 ^y	(20.4)	10.9 ^y	(27.7)	9.8	(24.8)
5000 ppm daminozide 2×	8.1 ^y	(20.5)	10.3 ^y	(26.2)	10.6	(26.8)
62 ppm paclobutrazol 1×	10.0	(25.3)	7.8	(19.9)	9.9	(25.1)
62 ppm paclobutrazol 2×	9.3	(23.5)	7.8	(19.9)	8.7 ^y	(22.0)
5 ppm uniconazole 1×	8.2 ^y	(20.9)	9.0	(22.9)	9.9	(25.2)
5 ppm uniconazole 2×	7.3 ^y	(18.6)	8.2	(20.9)	8.2 ^y	(20.8)
Schenkenburg						
Control	11.3	(28.6)	8.6	(21.9)	6.9	(17.5)
5000 ppm daminozide 1×	8.9 ^y	(22.5)	7.7	(19.6)	8.2 ^y	(20.8)
5000 ppm daminozide 2×	7.9 ^y	(20.0)	7.9	(20.0)	7.1	(18.1)
62 ppm paclobutrazol 1×	10.4	(26.4)	7.6	(19.3)	7.7	(19.5)
62 ppm paclobutrazol 2×	9.2 ^y	(23.3)	8.4	(21.3)	7.9	(20.1)
5 ppm uniconazole 1×	9.3 ^y	(23.6)	9.5	(24.1)	7.3	(18.5)
5 ppm uniconazole 2×	8.4 ^y	(21.4)	7.4	(18.8)	7.7	(19.5)
LSD, $\alpha = 0.05$	1.3	(3.4)	2.2	(5.5)	1.2	(3.1)
P						
Cultivar	0.0000		0.0000		0.0000	
PGR	0.0000		0.0000		0.0000	
Cultivar × PGR	0.0291		0.0010		0.0103	

^aPlants were placed in a dark, 40F cooler on 12 Nov. 1990 and transferred to a 68/62F day/night greenhouse for forcing on 28 Dec. 1990.

^yPlant response to treatments was significantly different from unsprayed controls of the same cultivar.

Table 2. Days from start of forcing (28 Dec. 1990) until anthesis (pollen first present) for seven cultivars of hydrangea.

Cultivar	Days to anthesis
Böttstein	100 D ^a
Enziandom	99 D
Kasteln	101 CD
Mathilde Gütges	108 A
Merritt's Supreme	105 A
Red Star	105 AB
Schenkenburg	104 BC

^aMean separation by Student-Newman-Kuels, $\alpha = 0.01$

dom' reached anthesis most rapidly, while plants of 'Mathilde Gütges' and 'Merritt's Supreme' were the slowest to flower. Table 2 represents days to anthesis and not days to salable color. In general, plants were salable, based on sepal color, ≈ 10 days before anthesis, so subtracting 10 days from data in Table 2 gives forcing times (from start to sale) for these cultivars when a 62F (17C) minimum night temperature is maintained under our growing conditions.

Our experiences suggest that cultivars of hydrangea respond differently to a given PGR treatment, so growers may have to treat every cultivar differently to achieve the same height and flower size upon forcing. Forcing time also varies significantly among cultivars.

Based on rates tested, multiple applications of daminozide and uniconazole appear to be the best height control method during the summer growing season. The need for height control during forcing may partially depend on how plants were treated the previous summer. If such information can be made available to forcers, height control programs during forcing may be able to be adjusted appropriately.

Perhaps the most interesting data of this study are the large differences among cultivars in final plant height

and inflorescence diameter. Forcers may want to evaluate alternative cultivars. A good example is 'Red Star', which has a very large inflorescence but does not have a tall growth habit, as do 'Enziandom' and 'Rose Supreme'. There are >100 hydrangea cultivars available, but information on crop timing, growth habit, and general culture is lacking for the majority of them. Further evaluation of less popular cultivars is needed.

Literature Cited

- Bailey, D.A. 1989. Uniconazole effects on forcing of florists' hydrangeas. *HortScience* 24:518.
- Bailey, D.A., T.C. Weiler, and T.I. Kirk. 1986. Chemical stimulation of floral initiation in florists' hydrangea. *HortScience* 21:256-257.
- Grower. 1973. Good results achieved with growth regulators on hydrangeas. *Grower* (London) 80:647.
- Jung, R. 1964. The status of hydrangea growing today. *Florists' Rev.* 135(3486):13-14, 35-37, 40.
- Scott, B. 1982. Hydrangeas respond to new growth regulator. *N.C. Flower Growers' Bul.* 26(4):10-12.
- Tjia, B., L. Stoltz, M.S. Sandhu and J. Buxton. 1976. Surface active agent to increase effectiveness of surface penetration of ancymidol on hydrangea and Easter lily. *HortScience* 11:371-372.
- Ulery, C.J. 1978. Quality hydrangea production. *Ohio Florists' Assn. Bul.* 582:3-4, 9.

Acknowledgments

We thank Oregon Propagating Co., Brookings, Ore., for donating the hydrangeas and Franklin Brothers Greenhouse and Nursery for allowing the summer production portion of this project to be conducted at their facility in Henderson, N.C.