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Phytotoxicity of Herbicides to Spring Flowering Bulbs¹

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Abstract

Biennial application for two years of nine commonly used turf and ornamental herbicides were evaluated for phytotoxicity to fourteen species of spring flowering bulbs. OH 2 significantly damaged foliage of *Anemone* 'Rosea', *Crocus* 'Cream Beauty', *Endymion* 'Blue', *Hyacinthus* 'Ostara', *Iris reticulata* 'Harmony', *Muscari armeniacum*, *Narcissus* 'Geranium', *Ornithogalum umbellatum*, *Scilla* 'Spring Beauty', *Triteleia* 'Queen Fabiola', and the *Tulipa* 'Golden Apeldoorn', 'Purissima', and 'Paul Richter'. Ronstar damaged the foliage of *Crocus* 'Cream Beauty', *Crocus* 'Remembrance', *Endymion* 'Blue', *Hyacinthus* 'Ostara', *Iris* 'Harmony', *Muscari armeniacum*, *Narcissus* 'Geranium', *Ornithogalum umbellatum*, *Scilla* 'Spring Beauty', *Triteleia* 'Queen Fabiola', and the *Tulipa* 'Golden Apeldoorn', 'Purissima', and 'Paul Richter'. *Muscari* foliage was damaged by Balan, Dacthal, Devrinol, Fusilade and Poast. *Hyacinthus* 'Ostara' foliage was damaged by Balan. *Anemone* 'Rosea' foliage was injured by Betasan and Pennant. *Tulipa* 'Paul Richter' foliage was deformed by Devrinol and Fusilade damaged *Endymion*.

No flower injury was noted from use of Balan, Betasan, Dacthal, Devrinol, Pennant, Fusilade or Poast for two seasons on the 14 bulb species. OH 2 and Ronstar damaged flowers of *Crocus* 'Remembrance', *Hyacinthus* 'Ostara', *Iris germanica* and *I. reticulata* 'Harmony', *Narcissus* 'Unsurpassable', *Ornithogalum umbellatum*, *Scilla* 'Spring Beauty', *Triteleia* 'Queen Fabiola', and *Tulipa* 'Purissima' and 'Paul Richter'. OH 2 damaged the flowers of *Crocus* 'Cream Beauty', *Hyacinthus* 'Ostara', *Iris germanica*, *Iris reticulata* 'Harmony', *Muscari armeniacum*, *Narcissus* 'Unsurpassable', *Ornithogalum umbellatum*, *Scilla* 'Spring Beauty', *Triteleia* 'Queen Fabiola', and *Tulipa* 'Golden Apeldoorn', 'Purissima', and 'Paul Richter'.

Bulb numbers harvested after two years were unaffected by Balan, Betasan, Devrinol, Pennant or Fusilade. Poast and Dacthal reduced bulb numbers of *Muscari armeniacum*. OH 2 reduced bulb numbers of *Crocus* 'Cream Beauty', *Crocus* 'Remembrance', *Hyacinthus* 'Ostara', *Iris reticulata* 'Harmony', *Muscari armeniacum*, *Triteleia* 'Queen Fabiola', and 'Paul Richter' and 'Purissima' tulips. Ronstar reduced the number of bulbs harvested of *Crocus* 'Cream Beauty' and *Crocus* 'Remembrance', *Hyacinthus* 'Ostara', *Iris reticulata* 'Harmony', and *Triteleia* 'Queen Fabiola'.

Index words: herbicide, weed control, perennial bulbs, flowering bulbs

Bulbs used in this study: *Allium sphaerocephalon* L.; *Anemone blanda* Schott & Kotschy 'Rosea'; *Crocus chrysanthus* Herb. 'Cream Beauty'; *Crocus vernus* Hill 'Remembrance'; *Endymion hispanicus* (Mill.) Chouard 'Blue'; *Hyacinthus albulus* Bak. *orientalis* 'Ostara'; *Iris reticulata* Bieb. 'Harmony'; *Iris germanica* Bieb.; *Muscari armeniacum* Leichtl. ex Bak.; *Narcissus* spp. 'Carlton', 'Geranium', and 'Unsurpassable'; *Ornithogalum umbellatum* L.; *Scilla siberica* Andr. 'Spring Beauty'; *Triteleia laxa* Benth. 'Queen Fabiola'; *Tulipa* spp. 'Golden Apeldoorn', 'Paul Richter', and 'Purissima'.

Herbicides used in this study: Balan (benefin) *N*-butyl-*N*-ethyl-2,6-dinitro-4-(trifluoromethyl)benzenamine; Betasan (bensulide) *O,O*-bis(1-methylethyl)[2-[(phenylsulfonyl)amino]ethyl] phosphorodithioate; Dacthal (DCPA) dimethyl 2,3,5,6-tetrachloro-1, 4-benzenedicarboxylate; Devrinol (napropamide) *N,N*-diethyl-2-(1-naphthalenyloxy)propanamide; Pennant (metolachlor) 2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1-methylethyl)acetamide; Fusilade (fluazifop) (1)-2-[4[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy]propanoic acid; OH 2 (oxyfluorfen) 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)benzene + (pendimethalin) *N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine; Poast (sethoxydim) 2-[1-(ethoxymino)butyl]-5-[2-(ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one; and Ronstar (oxadiazon) 3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3H)-one.

Introduction

In the last 5 years, utilization of spring flowering bulbs in the United States and Canada has increased significantly (1). It is estimated that 75% of these bulbs are used in landscapes and gardens. Concurrently, there has been a dramatic increase in commercial landscape services provided and herbicides used by this industry. There is a need to determine if herbicides used for turf and landscape shrub

plantings have any phytotoxic effects on flowering bulbs. A two-year study was initiated to simulate herbicide application rates and timing for landscape maintenance in the Southeastern United States. Skroch and Yonce (6) have summarized the limited information concerning herbicide labels for bulbs in the landscape.

Several investigators have examined herbicide tolerance of *Narcissus* spp. (2, 3, 5, 7, 8). They concluded that Devrinol (napropamide), Surflan (oryzalin), and Treflan (trifluralin) could be applied after planting and prior to emergence with little or no injury when used at suggested labeled rates. Marginal injury was reported with Goal and Ronstar.

Damage to newly planted tulips was minimal with Devrinol, Surflan and Treflan (2, 3, 5, 7, 8), but Goal and Ronstar severely damaged tulips when used at a normal use rate. *Crocus* were reported (2, 3, 8) to tolerate Devrinol, Treflan, and Surflan but Ronstar and Goal caused damage.

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Bing (2, 3) reported that Devrinol and Surflan caused no injury on hyacinths, while Lasso (alachlor) caused some injury, and Ronstar and Goal produced high levels of injury. Dutch *Iris* have been reported (5) to be tolerant to CIPC (chlorophospham), Karmex (diuron), Devrinol and Surflan.

Fourteen species of spring-flowering bulbs were utilized in this study. They are representative of the major species used in the landscape (1). The objective of this study was to determine the phytotoxicity of commonly used herbicides in turf and ornamentals to spring flowering bulbs.

Materials and Methods

The experiment was conducted at North Carolina State University Research Unit 4, Raleigh, NC. Prior to planting, the cecil clay soil (clayey Kaolinitic Thermic Typic Hapludult) was amended by incorporation with 7.5 cm (3 in) of pine bark. The bed was fumigated with methyl bromide 73 g/m² (1.5 lb/100 sq. ft.), and pH and fertility were adjusted to recommended levels for bulbs in the landscape (4). Raised beds were constructed and individual plots 120 × 150 cm (4 × 5 ft) were laid out in a randomized complete block design with 4 blocks. On November 23, 1983 the following species and/or cultivars of bulbs were planted: *Allium*; *Anemone* 'Rosea'; *Crocus* 'Cream Beauty'; *Crocus* 'Remembrance'; *Endymion* 'Blue'; *Hyacinthus* 'Ostara'; *Iris* 'Harmony'; *Iris*; *Muscari*; *Narcissus* spp. 'Carlton', 'Geranium', and 'Unsurpassable'; *Ornithogalum umbellatum*; *Scilla* 'Spring Beauty'; *Triteleia* 'Queen Fabiola'; and *Tulipa* spp. 'Golden Apeldoorn', 'Paul Richter', and 'Purissima'. The larger bulbs (*Hyacinth*, *Iris*, *Narcissus* and *Tulipa*) were planted 5 per 0.09 square meters (1 sq ft) and 15 cm (6 in) deep, and the other bulbs 9 per 0.09 square meter (1 sq ft) plot and 7.5 cm (3 in) deep.

Preemergence herbicide treatments included Balan 2.5 G, 3.4 kg/ha (3 lb ai/A); Betasan 7 G, 13.4 kg/ha (12 lb ai/A); Dacthal 5 G, 16.8 kg/ha (15 lb ai/A); Pennant 5 G, 3.4 kg/ha (3 lb ai/A); Devrinol 5 G, 4.5 kg/ha (4 lb ai/A); Ronstar 2 G, 4.5 kg/ha (4 lb ai/A); OH 2, 3 G, 3.4 kg/ha (3 lb ai/A) were applied on November 29, 1983, April 27 and October 12, 1984, and April 10, 1985. Postemergence treatments of Poast 1.53 E 0.20 kg/ha (0.18 lb ai/A) plus crop oil 1% v/v, and Fusilade 4E 0.20 kg/ha (0.18 lb ai/A) plus AG 98 0.25% v/v were applied on April 27, June 22, September 6, 1984 and April 12, 1985. These dates coincide with anticipated herbicide usage in landscape maintenance programs over a two year period. All weeds were removed by hand from all plots at weekly intervals.

Assessment of phytotoxicity to the bulbs was made in 2 consecutive flowering seasons. Only data from the second growing season are presented. Foliage vigor was rated on a scale of 0 to 100 with 0 = dead and 100 = no reduction or visible damage as compared to check plants. Flower quality was also rated on a scale of 0 to 100 with 0 = dead and 100 = no different from check. Flowers per bulb, plant height, length of the flowering period and survival were recorded for each species. The following system was employed for each bulb type. Height was recorded in cm and dates as Julian. Days in flower were obtained by subtracting Julian date in flower from Julian date out of flower. Flowers of each bulb type were recorded as described below:

Allium 'Onion'—This species was considered in flower when the floral head showed 50% color and plant height

was measured from top of the floral bud to the soil surface at that stage of development. Out-of-flower was recorded when all florets had flowered and the umbel had turned completely white.

Anemone 'Rosea'—No plant height, flowering data, or bulb numbers were recorded because of inconsistent stand.

Crocus 'Cream Beauty' and 'Remembrance'—No height data were recorded. In flower was recorded at 50% color, and out-of-flower when all flowers had lost their aesthetic appearance.

Hyacinthus 'Ostara'—Height was measured from top of floral spike to soil surface when the spike reached full flower. The bulb was considered in flower at this time. Bulb was considered out-of-flower when discoloration appeared on first inflorescence that flowered.

Iris reticulata 'Harmony'—Height was measured from top of flower to the soil surface when petals began to fall. Plant was recorded as out-of-flower when the flowers lost their aesthetic appearance.

Iris germanica—Height was measured from top of floral bud to soil surface when the bottom petals began to fall. Out-of-flower was recorded when flowers lost their aesthetic appearance.

Muscari armeniacum—Height was measured from top of the inflorescence to the soil surface when the spike was completely expanded. Each plant was considered out-of-flower when florets were dried on every floral stalk on the plant.

Narcissus 'Carlton', 'Geranium', and 'Unsurpassable'—The plant was considered in flower when the flower reached the goose neck stage. Height was measured at this time from the goose neck to soil surface. Out-of-flower was recorded when the flower lost its aesthetic appearance.

Ornithogalum umbellatum—Height was measured from top of the flower spike to the soil surface when first florets opened. Out-of-flower was recorded when all flowers had lost their aesthetic appearance.

Scilla 'Spring Beauty' and *Endymion* 'Blue'—Height was measured from top of inflorescence to the soil surface when it reached full bloom. Out-of-flower was recorded when flowers lost their aesthetic appearance.

Triteleia 'Queen Fabiola'—Height was measured from the node below the umbel to the soil surface when the first floret opened. Out-of-flower was recorded when flowers lost their aesthetic appearance.

Tulipa 'Golden Apeldoorn', 'Paul Richter', and 'Purissima'—Height was measured from the top of the floral bud to the soil surface when the bud showed 50% color. Out-of-flower was recorded when the first petal faded or dropped.

Number of flower stalks and length of flowering are presented in text only where significantly ($P = 0.05$) affected by treatment. Plant heights were highly correlated with foliage injury ($P = 0.01$), thus the foliage ratings are presented.

At the end of the second flowering season, all bulbs were harvested, graded and counted. All sizes, except the *Iris germanica*, were circumference measurements. Only bulbs considered to be of adequate size to produce a flower when replanted were recorded. The criteria used were those of M. Benschoop (Personal communication).

Statistical analysis. All variables were tested for differences using analysis of variance, with means separated by Waller-Duncan Bayesian Method.

Results and Discussion

Allium—Evaluations of foliage damage, flower rating, and number of bulbs produced after two seasons were not different between the untreated check and the nine chemical treatments.

Anemone 'Rosea'—Flowering was very sparse, thus, no data were recorded on plant height or flowering. Foliage was injured by Betasan, Pennant, and OH 2 (Table 1). Only OH 2 affected bulb numbers (data not shown).

Crocus 'Cream Beauty'—Foliage damage was recorded from use of Ronstar, and OH 2 (Table 1). OH 2 also reduced flower quality (Table 2) and bulb yields (Table 3).

Crocus 'Remembrance'—Ronstar caused foliage and flower damage, and OH 2 damaged the flowers and reduced bulb yield.

Endymion 'Blue'—OH 2 and Ronstar reduced plant survival (data not shown) and foliage ratings (Table 1). Bulb production was reduced by OH 2 compared to all other herbicide treatments except Ronstar but was not significantly less than the check (Table 3).

Hyacinthus 'Ostara'—Severe foliage and flower injury was observed from OH 2 and Ronstar (Table 1 and 2). Bulb yields were not significantly different from the check (Table 3).

Table 1. Effects of herbicides on foliage vigor rating of spring-flowering bulbs.²

Herbicide Treatment	<i>Allium</i>	<i>Anemone</i> 'Rosea'	<i>Crocus</i> 'Cream Beauty'	<i>Crocus</i> 'Remembrance'	<i>Endymion</i> 'Blue'	<i>Hyacinthus</i> 'Ostara'	<i>Iris germanica</i>	<i>Iris reticulata</i> 'Harmony'	<i>Muscari</i>	<i>Narcissus</i>	<i>Scilla</i> 'Spring Beauty'	<i>Triteleia</i> 'Queen Fabiola'	<i>Tulipa</i>
Check	100	100	100	100	100	100	100	100	100	100	100	100	100
Balan	100	80	99	97	89	59	95	93	48	99	75	100	97
Betasan	100	65	98	96	94	91	75	84	100	100	94	85	100
Dacthal	99	91	100	98	92	94	80	82	0	100	79	92	99
Devrinol	100	85	99	98	95	84	80	80	50	100	98	88	78
Pennant	100	63	99	96	98	77	85	100	100	100	97	100	100
Fusilade	98	98	100	96	84	83	65	96	12	99	92	100	96
OH 2	95	4	62	81	7	1	81	32	0	82	82	0	16
Poast	100	96	96	95	100	84	86	99	12	100	79	100	100
Ronstar	96	73	85	68	20	35	86	27	17	91	92	0	47
MSD 0.05 ³	NS	30	5	22	12	25	NS	17	40	7	NS	20	11

²Foliage vigor rated as 0 = dead plant, 100 = no damage.

³Minimum significant difference determined by Waller-Duncan test K ratio = 100.

Table 2. Effects of herbicides on flower rating of spring-flowering bulbs.²

Herbicide Treatment	<i>Allium</i>	<i>Anemone</i> 'Rosea'	<i>Crocus</i> 'Cream Beauty'	<i>Crocus</i> 'Remembrance'	<i>Endymion</i> 'Blue'	<i>Hyacinthus</i> 'Ostara'	<i>Iris germanica</i>	<i>Iris reticulata</i> 'Harmony'	<i>Muscari</i>	<i>Narcissus</i>	<i>Scilla</i> 'Spring Beauty'	<i>Triteleia</i> 'Queen Fabiola'	<i>Tulipa</i>
Check	100	—	100	100	—	100	100	100	100	100	100	100	100
Balan	100	—	96	90	—	97	92	100	55	100	97	100	95
Betasan	100	—	100	88	—	100	86	100	72	100	100	77	97
Dacthal	100	—	100	100	—	100	88	100	29	100	98	98	100
Devrinol	100	—	99	100	—	98	100	100	53	100	99	82	100
Pennant	96	—	100	100	—	90	97	100	82	100	100	88	96
Fusilade	98	—	100	94	—	96	90	99	56	100	99	100	93
OH 2	95	—	77	74	—	11	32	22	8	100	65	0	37
Poast	100	—	96	86	—	96	88	100	51	100	99	100	98
Ronstar	96	—	95	63	—	34	42	25	27	95	89	0	71
MSD 0.05 ³	NS	—	11	28	—	19	27	8	78	NS	10	21	7

²Flower quality was rated as 0 = dead or absent, 100 = equal to check.

³Minimum significant difference determined by Waller-Duncan test K ratio = 100.

Table 3. Effect of herbicides on bulb numbers produced, two years after planting.

	<i>Allium</i>	<i>Crocus</i> 'Cream Beauty'	<i>Crocus</i> 'Remembrance'	<i>Endymion</i> 'Blue'	<i>Hyacinthus</i> 'Ostara'	<i>Iris germanica</i>	<i>Iris reticulata</i> 'Harmony'	<i>Muscari</i>	<i>Narcissus</i>				
									'Geranium'	'Unsurpassable'	<i>Ornithogalum</i>	<i>Scilla</i> 'Spring Beauty'	<i>Triteleia</i> 'Queen Fabiola'
Herbicide Treatment	Total bulbs	Total bulbs	Total bulbs	Total bulbs	Total bulbs > 8 cm ^z	Total bulbs	Total bulbs	Total bulbs	Total bulbs over 18 cm ^z	Total bulbs	Total bulbs	Total bulbs	Total bulbs
Check	65.0	26.0	37.3	9.0	3.8	17.8	21.7	67.3	21.0	22.0	7.5	11.7	22.7
Balan	48.0	23.5	44.7	13.0	2.8	21.7	21.0	29.7	17.9	15.0	13.0	13.0	21.0
Betasan	34.7	23.0	40.5	13.5	4.5	16.4	22.5	57.2	18.1	17.7	8.8	13.5	23.0
Dacthal	40.0	22.7	42.5	12.5	5.5	18.1	20.2	4.0	19.2	16.2	10.2	13.5	20.3
Devrinol	35.4	17.5	39.0	11.7	7.8	18.0	23.2	32.2	18.4	21.2	9.5	18.7	23.3
Pennant	55.9	20.5	36.2	11.2	5.0	24.0	21.7	29.0	17.4	20.5	16.5	14.7	21.8
Fusilade	59.2	26.2	42.2	11.5	6.0	11.9	26.5	21.7	19.4	19.0	6.2	12.5	26.5
OH 2	47.9	3.5	22.2	0.2	0.0	14.9	7.2	11.5	16.4	18.2	8.5	9.2	7.3
Poast	52.4	16.3	42.0	15.0	6.5	20.5	24.0	2.2	20.9	11.7	13.5	10.2	24.0
Ronstar	57.9	25.0	38.3	3.2	0.8	17.4	3.0	16.2	18.9	19.2	12.2	9.5	3.0
MSD 0.05 ^y	NS	10.0	13.2	9.7	6.8	NS	8.3	53.0	NS	8.7	13.0	NS	8.3

^zCircumference bulb size.^yMinimum significant difference determined by Waller-Duncan test K ratio = 100.

Table 4. Effect of herbicides on yield of 3 cultivars of tulips two years after planting.

Herbicide Treatment	'Paul Richter'			'Golden Apeldoorn'			'Purissima'		
	Total bulbs per size ^z			Total bulbs per size ^z			Total bulbs per size ^z		
	<8	8–11	>11	<8	8–11	>11	<8	8–11	>11
Check	7.7	10.7	1.0	10.3	12.7	5.3	4.0	8.3	2.0
Balan	13.0	14.0	3.5	11.2	12.0	5.5	2.7	6.3	3.5
Betasan	7.0	12.5	1.3	10.0	13.3	4.0	1.7	6.8	2.5
Dacthal	9.0	8.3	2.0	11.2	11.0	2.8	3.0	6.5	3.5
Devrinol	5.2	9.3	2.3	10.7	15.0	4.5	2.0	6.8	2.8
Pennant	8.0	6.3	1.8	12.5	15.2	4.0	2.7	8.3	2.8
Fusilade	8.5	8.5	2.8	10.5	16.8	4.8	6.7	6.5	3.8
OH 2	6.2	1.5	—	9.5	9.0	1.0	3.2	7.5	1.5
Poast	10.0	9.8	2.8	6.5	15.3	4.8	3.5	8.0	2.5
Ronstar	8.5	5.3	1.5	11.5	13.8	2.3	2.5	8.0	1.5
MSD 0.05 ^y	4.7	5.5	NS	NS	NS	NS	3.7	NS	NS

^zCircumference bulb size in centimeters.^yMinimum significant difference determined by Waller-Duncan test K ratio = 100.

Iris germanica—OH 2 and Ronstar reduced the flower quality ratings of this species (Table 2).

Iris reticulata 'Harmony'—OH 2 and Ronstar significantly reduced the foliage ratings (Table 1), flower rating (Table 2) and total bulb yield (Table 3). They also reduced the span of flowering of the surviving plants (data not presented). Foliage injury was also observed from Dacthal and Devrinol.

Muscari armeniacum—Only Betasan and Pennant did not affect the foliage rating (Table 1). Flower injury was variable with only OH 2 showing definitive damage. Bulb yields were significantly reduced by Dacthal, OH 2 and Poast (Table 3).

Narcissus 'Carlton', 'Geranium' and 'Unsurpassable'—All of the foliage of 'Carlton' was poor, possibly due to

Fusarium (data not shown). Bulb yields were not recorded for 'Carlton' because of the rot problem. The foliage of 'Geranium' was reduced by OH 2 and Ronstar (Table 1). This herbicide also reduced the number of flowers of 'Unsurpassable' (data not presented). Flower ratings of 'Unsurpassable' were reduced with OH 2 and Ronstar. Bulb numbers of 'Unsurpassable' were reduced by Poast (Table 3).

Ornithogalum umbellatum—OH 2 and Ronstar damaged the foliage and flowers with no effect on bulb production (Tables 1 and 2). In addition, significant flower damage was detected when Betasan was used.

Scilla 'Spring Beauty'—Foliage quality was reduced by OH 2, Ronstar, Betasan and Fusilade (Table 1). Flower ratings were affected by OH 2 and Ronstar (Table 2). Bulb yields were not affected (Table 3).

Triteleia 'Queen Fabiola'—OH 2 and Ronstar nearly eliminated this species (Tables 1–3). In addition, Pennant and Betasan damaged the flowers (Table 2).

Tulipa 'Golden Apeldoorn', 'Purissima', and 'Paul Richter'—OH 2 and Ronstar affected the foliage of all 3 cultivars (Table 1). In addition, some foliage damage was detected with Devrinol. These herbicides also affected the span of flowering of 'Golden Apeldoorn' and 'Paul Richter', but not 'Purissima' (data not presented). Ronstar reduced the flower quality (Table 2) for 'Purissima' and 'P. Richter', whereas OH 2 reduced all flower ratings. Bulbs harvested greater than 11 cm were not affected by the herbicide treatments but the yield of 8 to 11 cm size bulbs of 'Paul Richter' were reduced by OH 2.

Based on bulbs produced, it appears that use of Balan, Betasan, Dacthal, Devrinol or Pennant in the landscape and turf would have little effect on spring flowering bulbs. OH 2 and Ronstar, two materials that can be absorbed through the leaves, caused considerable foliage injury and reduced bulb numbers similar to results reported by others (2, 3, 5, 7, 8).

However, this study demonstrates that each bulb species must be considered separately since exceptions were noted. For example, Dacthal, Devrinol, Fusilade, Betasan and Poast damaged foliage of *Muscari* (Table 1) and reduced bulb yield (Table 3). Another noteworthy exception is the reduced bulb yield of 'Paul Richter' tulips with several herbicides (Table 3) and no differences in bulb production for 'Golden Apeldoorn' or 'Purissima'.

With the exception of *Muscari*, Poast and Fusilade can be sprayed on the foliage with a fair degree of safety. The data indicate that these herbicides can be applied in the landscape without significant damage. Applications when the bulbs are in full bloom should be avoided as damage to flowers has been seen on some occasions (J. Neal, Department of Floriculture and Ornamental Horticulture, Cornell University, personal communications).

Significance to the Nursery Industry

Results indicate that there is wide variation in the phytotoxic responses of various spring flowering bulb species

to specific herbicides. Also, each species and in some cases specific cultivars need to be evaluated. Two herbicides, OH 2 and Ronstar, produced phytotoxic effects on several species. *Muscari armeniacum* was the most sensitive species to a wide range of herbicides. This may be because its foliage emerges in the fall and overwinters while all the other species have foliage that emerges in the spring. Tolerance of most bulbs appears to be adequate to make herbicide usage on bulbs feasible. Labels are being expanded continuously, thus a check of current product labels is in order before anticipated use.

Editorial Note: This paper reports the results of research only, and does not imply registration of a pesticide under FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.

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