Precooling, Planting Depth, and Shade Affect Cut Flower Quality and Perennialization of Field-grown Spring Bulbs

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Abstract. *Narcissus* L. 'Music Hall', *N.* 'Tahiti', *Tulipa* L. 'Couleur Cardinal', and *T.* 'White Emperor' bulbs were precooled at 5 °C for 0 or 5 weeks and planted 15, 30, or 45 cm deep (from bulb base) into raised ground beds under 0%, 30%, or 60% shade. Plant growth was monitored for two consecutive years after planting. Precooling reduced the percentage of *T.* 'White Emperor' that flowered but did not affect flowering percentage of the other cultivars. Precooling delayed anthesis in one or both years for all cultivars. The greatest percentage of bulbs flowered when planted 15 cm deep and the 45-cm planting depth reduced flowering percentage. Increasing planting depth delayed anthesis for all cultivars. Increasing shade increased stem lengths in one or both years for all cultivars, but did not influence flowering percentage. Perennialization was low for all cultivars regardless of treatment. Cultivar differences in perennialization occurred; in year 2 up to 30% of *N.* 'Tahiti' bulbs flowered vs. 32% for 'Music Hall' and up to 30% of *T.* 'White Emperor' bulbs flowered vs. only 22% of 'Couleur Cardinal'.

Numerous bulb species can be grown in southern Great Plains states, but are often used as annuals due to inconsistent perennialization. High bulb cost limits profitable cut flower production or annual landscape use. Bulb perennialization and cut flower harvests for two or more years would allow cost effective cut flower production. Factors affecting perennialization include inadequate duration of cold, improper planting depth, and excessive spring heating (Armitage, 1993; A. De Hertogh, personal communication).

Proper temperatures are the most important factor for bulb flowering and production (Buschman and Roozen, 1980; De Hertogh, 1996; Hartsema, 1961; Rees, 1972a). Precooling promotes rapid growth after planting and earlier shoot elongation (Le Nard and De Hertogh, 1993). Precooling also improves root development at temperatures as high as 30 °C compared to the optimum rooting temperature of 13 to 17 °C (Jennings and De Hertogh, 1977; Le Nard and De Hertogh, 1993).

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Daughter bulb formation and growth is essential for perennialization. Extended foliage life contributes to the photosynthate storage of bulbs. Aung et al. (1973) reported that 83% of the starch in the matured *Tulipa* bulblets was derived from photosynthesis. Early senescence of roots due to warm temperatures deprive bulbs of essential nutrients for development (Le Nard and De Hertogh, 1993). Plants that senesce rapidly during early hot dry summers have reduced bulb yields (Rees, 1972b).

Shallow planting causes poor rooting and increased probability of disease due to the higher soil temperatures (Le Nard and De Hertogh, 1993). Thus, deep planting depths may improve perennialization. Soil temperatures remain cool for long periods at deep depths. However, planting bulbs too deep delays emergence and flowering, and decreases bulb yield (Allen, 1938; Le Nard and De Hertogh, 1993; Wallis, 1964).

Finally, reducing light intensity by shading may reduce soil temperatures and protect the foliage from excessive heat. Shading also increases stem length (Armitage, 1991; Armitage et al., 1990; Gude et al., n.d.). Many plant species produce fewer flowers, but longer stems when grown under shade. However, when *Anemone coronaria* L. was grown under 67% shade, flower number per plant did not decrease and stem lengths were longer compared to 55% shade or ambient light levels (Armitage, 1991).

Narcissus and *Tulipa* have similar annual growing requirements and exhibit potential as field cut flowers. *Narcissus* are popular garden plants and *Tulipa* have long been the

most popular of the bulbous species for cut flowers. Limited published information exists on the field production of *Narcissus* and *Tulipa* in Oklahoma or other southern Great Plains states; however, *Narcissus* generally naturalize well in Oklahoma (P. Mitchell, personal communication).

The objective of this study was to determine the effect of precooling, planting depth, and shade on cut flower characteristics and perennialization of *Narcissus* and *Tulipa* as cut flowers or landscape plants in the southern Great Plains region of the United States.

Material and Methods

Narcissus 'Music Hall' and 'Tahiti' and *T.* 'Couleur Cardinal' and 'White Emperor' bulbs were divided into two groups per cultivar. One group received 5 weeks of precooling at 5 ± 1.5 °C and the other group received no precooling. The precooling began at the same time, 19 Dec. 1997, that the nonprecooled bulbs were planted in the ground. Bulbs were stored at 18 ± 1.0 °C prior to planting or precooling.

Bulbs were planted 15, 30, or 45 cm deep, measured from the soil surface to the bulb base in raised field beds of Norge Loam (fine-silty, mixed, thermic Udic Paleustols) in Stillwater, Okla. [U.S. Dept. of Agriculture (USDA) climatic zone 6b–7a]. The soil was amended based on soil test results (Oklahoma State Univ. Soil, Water and Forage Testing Lab, Stillwater, Okla.) with 4 g·m⁻² NH₄NO₃ for N, 25 g·m⁻² CaCO₃ to adjust soil pH and 74 g·m⁻² bone meal as a P source. Three levels of shade (0%, 30%, or 60%) provided average light intensities of 1480, 831, or 331 μmol·m⁻²·s⁻¹, respectively. The woven polypropylene shade cloth covered the top (1 m above the soil surface) and south side of the raised beds.

Date of anthesis, stem length of flowering plants (cut and measured from the soil surface to the uppermost flower tip of *Narcissus* and from the node of the lowermost leaf, retained intact for photosynthesis, to the uppermost flower tip of *Tulipa*) at harvest, days to foliage senescence, and daily soil temperatures at 15, 30, and 45 cm deep from 19 Dec. 1997 to 20 July 1999 (Fig. 1) were collected. Cut flower quality was determined for each flowering stem on a scale of 1 to 5 with 1 = a thin, crooked stem with small flowers or incomplete flower opening and 5 = a straight, sturdy stem with large flower diameter.

The experiment was a split plot with shade treatment as the main plot and planting depth and cold pretreatment as the subplots. There were four replications with six bulbs/replication for *N.* 'Music Hall', eight bulbs/replication for *N.* 'Tahiti' and 11 bulbs/replication for *T.* 'Couleur Cardinal' and 'White Emperor'. Data were collected for two consecutive growing seasons and analyzed by general linear model procedures with trend analysis for means separation of planting depth and shade (SAS Institute, Cary, N.C.).

Results

Narcissus 'Music Hall'. Precooling did not affect flowering percentage (Table 1). However, precooling delayed anthesis in year 1. Stem length, cut flower quality, and days to foliage senescence were not affected by precooling. Precooling had no effect in year 2 (data not presented). No interactions among precooling, shade, and planting depth occurred in year 1 or 2.

Shading delayed anthesis in year 1 (Table 1). However, stem length and cut flower quality increased when bulbs were grown under shade in both years. Shading did not affect flowering percentage or foliage senescence.

Increasing planting depths linearly decreased flowering percentage and delayed anthesis in both years (Table 1). In year 1, quality and days to foliage senescence were not affected by planting depth. However, in year 2, deep planting depths reduced cut flower quality and promoted early foliage senescence. Planting depth did not affect stem length in either year.

Narcissus 'Tahiti'. Deep planting reduced the percentage of flowering in both years and in year 1 precooling also reduced flowering percentage, except for bulbs planted 45-cm deep where precooling increased the percentage of flowering (Table 2). Deep planting delayed anthesis in both years. Precooling delayed anthesis except for bulbs planted 45 cm deep in year 1 where precooling decreased days to anthesis. In year 1, precooling decreased stem length, especially when bulbs were planted deep, while in year 2 shade increased stem length. In year 1, planting pre-cooled bulbs deep decreased cut flower quality. In year 2, shading increased cut flower quality. In year 1, foliage senescence was not affected by treatments. However, in year 2 pre-cooled bulbs grown under no shade and planted 15 or 30 cm deep senesced the earliest.

Tulipa 'Couleur Cardinal'. In year 1, precooling and deep planting depths reduced flowering percentage except for bulbs planted 45 cm deep where precooling increased flowering percentage (Table 3). In year 2, deep planting depths again reduced the percentage of flowering, thus reduced perennialization. Precooling and deep planting depths delayed anthesis in both years, while in year 1 only, shading also delayed anthesis. In year 1, stems were shortest for pre-cooled bulbs not grown under shade and planted 15 cm deep. In year 2, stems were shortest when not grown under shade and planted 15 cm deep. In year 1, cut flower quality was highest when nonpre-cooled bulbs were planted 30 cm deep. In year 2, shade and deep planting increased quality ratings. In year 1, precooling and shade delayed foliage senescence, but no effect was evident in year 2.

Tulipa 'White Emperor'. In both years, precooling and 45-cm planting depths reduced the percentage of flowering (Table 4). Increasing planting depth and precooling increased days to anthesis in both years. In year 2, shade delayed anthesis, but only for

Fig. 1. (A) Soil temperatures 15 cm below surface with 0%, 30%, or 60% shade; and (B) soil temperatures at 15, 30, and 45 cm below soil surface with no shade from Dec. 1997 to June 1998. Temperatures were significantly different among depths at $P < 0.05$.

Table 1. Effect of precooling^a, shade, and planting depth on cut flower characteristics and perennialization of *Narcissus 'Music Hall'*. There were 24 bulbs per treatment.

Treatment	Bulbs flowering (%)	Days to anthesis ^y	Stem length (cm) ^x	Quality rating ^w	Days to foliage senescence ^y
<i>Year 1—Precooling</i>					
Precooled	83	54	29.2	2.9	126
Nonprecooled	67	51	29.5	3.0	126
Significance	NS	**	NS	NS	NS
<i>Year 1—Shade</i>					
0%	79	52	28.4	2.8	125
30%	82	52	29.8	3.0	125
60%	64	54	29.9	3.1	128
Significance	NS	L*	L**	L*	NS
<i>Year 1—Planting depth (cm)</i>					
15	98	49	29.7	3.0	126
30	84	54	29.8	3.0	125
45	43	58	27.4	2.7	125
Significance	L***	L***	NS	NS	NS
<i>Year 2—Shade</i>					
0%	14	21	30.2	3.3	144
30%	21	22	30.6	3.3	144
60%	19	20	32.3	3.7	143
Significance	NS	NS	L***	L**	NS
<i>Year 2—Planting depth (cm)</i>					
15	32	19	31.2	3.5	144
30	19	23	31.0	3.4	144
45	3	26	30.6	2.9	143
Significance	L**	L***	NS	L* Q*	L*

^aBulbs received 0 or 5 weeks of 5 °C precooling.

^yDays from 20 Feb. 1998 in year 1 and 20 Feb. 1999 in year 2.

^xStem length was measured from the soil line to uppermost tip of the flower.

^wRating on a scale of 1–5, where 1 = short thin, crooked stems with small flowers or incomplete flower opening and 5 = long, straight, sturdy stems with a large flower diameter.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$; linear (L), quadratic (Q).

Table 2. Effect of precooling, shade, and planting depth on cut flower characteristics and perennialization of *Narcissus* 'Tahiti'. There were 32 bulbs per treatment.

Precooling ^z	Shade (%)	Planting depth (cm)	Bulbs flowering (%)	Days to anthesis ^y	Stem length (cm) ^x	Quality rating ^w	Days to foliage senescence ^y
<i>Year 1</i>							
No	0	15	97	50	38.1	4.0	128
		30	94	53	33.3	3.4	128
		45	13	68	33.5	3.4	127
	30	15	100	52	39.3	4.2	128
		30	91	56	32.4	3.1	128
		45	6	65	35.5	3.8	127
	60	15	88	52	37.2	3.8	130
		30	84	55	33.6	3.1	128
		45	9	73	43.3	4.5	127
Yes	0	15	84	53	32.3	3.4	127
		30	84	55	27.1	2.6	128
		45	44	60	26.1	2.4	126
	30	15	97	53	32.3	3.3	125
		30	88	57	31.2	3.2	126
		45	28	62	27.7	2.6	128
	60	15	94	54	31.3	3.1	128
		30	78	58	30.6	3.1	128
		45	31	67	27.6	2.9	128
Precooling (P)			NS	***	***	***	NS
Shade (S)			NS	L**	NS	NS	NS
Depth (D)			L***	L*** Q***	L***	L***	NS
Significant ($P \leq 0.05$) interactions			P × DL	P × DQ	P × DQ	SL × DL P × DQ	None
<i>Year 2</i>							
No	0	15	22	38	34.5	3.7	118
		30	21	41	35.5	3.6	124
		45	0	---	---	---	---
	30	15	20	39	40.2	4.0	113
		30	22	41	38.2	3.8	124
		45	1	43	41.0	4.0	109
	60	15	24	38	40.8	4.1	125
		30	22	42	40.8	4.0	126
		45	0	---	---	---	---
Yes	0	15	22	43	34.4	3.8	113
		30	16	43	35.6	3.8	119
		45	6	44	30.0	3.1	124
	30	15	30	42	38.2	4.0	112
		30	20	43	38.2	3.8	122
		45	10	45	33.9	3.5	128
	60	15	24	42	39.1	4.0	120
		30	20	42	37.7	3.7	123
		45	4	45	37.5	4.0	128
Precooling (P)			NS	***	NS	NS	NS
Shade (S)			NS	NS	L*** Q*	L*	NS
Depth (D)			L***	L***	NS	L*	L*
Significant ($P \leq 0.05$) interactions			None	P × DL	None	None	P × DQ P × SL × DL

^zBulbs received 0 or 5 weeks of 5 °C precooling.

^yDays from 20 Feb. 1998 in year 1 and 20 Feb. 1999 in year 2.

^xStem length was measured from the soil line to uppermost tip of the flower.

^wRating on a scale of 1–5, where 1 = short thin, crooked stems with small flowers or incomplete flower opening and 5 = long, straight, sturdy stems with a large flower diameter.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001; linear (L), quadratic (Q).

precooled bulbs. In year 1, stem lengths decreased with increasing planting depth, except for nonprecooled bulbs grown without shade. In year 2, shading increased stem lengths. Quality ratings were lowest when bulbs were planted 45 cm deep, especially with nonprecooled bulbs. In year 2, shade increased quality except for precooled bulbs planted 15 cm deep. In year 1, foliage senescence was delayed when precooled bulbs were planted 30 or 45 cm deep and grown under shade. In year 2, precooled bulbs planted 45 cm deep had the greatest number of days to foliage senescence.

Discussion

Precooling and deep planting reduced flowering percentage in year 1 for all cultivars and species except *N. 'Music Hall'* where only deep planting reduced flowering percentage. Increased planting depth decreased flowering percentage which was noted also by Fodor (1974), Van der Knaap (1969), Van Ouwkerk (1969) and Wallis (1964). In contrast, *N. 'Tahiti'* and *T. 'Couleur Cardinal'* flowering percentage increased at 45-cm planting depths with precooling. Bulbs planted at 45 cm produced few or no flowers. Thus, the increase in flower-

ing percentage from precooling for *N. 'Tahiti'* and *T. 'Couleur Cardinal'* was not commercially useful. Bulbs planted at 15 cm generally produced more flowers than at 30 cm.

Precooling and deep planting depths also delayed anthesis. Le Nard and De Hertogh (1993) noted that days to anthesis were generally reduced when bulbs were precooled. However, in our study anthesis was delayed by precooling in one or both years for all cultivars (Tables 1, 2, 3, and 4). Nonprecooled bulbs were planted five weeks prior to precooled bulbs. Earlier planting probably allowed the nonprecooled bulbs to produce roots while precooled bulbs were still in a cooler. These results were similar to those of Van Staden (1978) who reported *Narcissus* root well without precooling and Le Nard and Cohat (1968) who noted *Tulipa* grow well at optimum planting temperatures without precooling.

Bulbs planted 30 or 45 cm deep required more days to reach anthesis compared to the 15 cm planting depth for all cultivars (Tables 1, 2, 3, and 4). This was also noted by Allen (1938), Le Nard and De Hertogh (1993), and Wallis (1964). Anthesis was also delayed in year 1 for *N. 'Music Hall'*, *N. 'Tahiti'*, and *T. 'Couleur Cardinal'* by shading which possibly slowed plant growth (Fig. 1).

For all cultivars except *T. 'White Emperor'*, precooling did not affect perennialization. The daughter bulb was not present during precooling, so no affect would be expected. Precooling was significant for *T. 'White Emperor'* in year 2, but likely as a residual effect from year 1.

Long stems were generally produced from nonprecooled bulbs grown under shade. However, Le Nard and De Hertogh (1993) noted that precooling generally produced longer stems. In our study, the nonprecooled bulbs may have received sufficient cooling from ground temperatures (Fig. 1). Shading reduced light intensity and increased stem length which has also been reported on *Anemone coronaria* L., *Centaurea americana* Nutt., *Echinops ritro* L., *Eryngium planum* L., *Oxypetalum caeruleum* (D. Don) Decne., *Tulipa* L. and *Zantedeschia* Spreng. (Armitage, 1991; Armitage et al., 1990; Gude et al., n.d.) Cut flower quality was increased by shading which reduced light intensities and may have reduced heat stress.

Bulbs planted 15 or 30 cm deep generally had longer stems than bulbs planted 45 cm deep (Table 3). These results are similar to those obtained for *Narcissus* by Wallis (1964). Occasionally, bulbs planted 45 cm deep had longer stems compared to bulbs planted 15 or 30 cm deep; however, in those instances flowering percentages were low (1% to 9%) which may have produced misleading results. Planting depth had no effect on *N. 'Music Hall'* stem length.

Foliage senescence was delayed for precooled *Tulipa* bulbs. Precooling may have improved root development and prolonged foliage life (Jennings and De Hertogh, 1977; Le Nard and De Hertogh, 1993).

Deep planting delayed foliage senescence for *N. 'Music Hall'* (year 2), *N. 'Tahiti'* (year 2), and *T. 'White Emperor'* (both years) by

Table 3. Effect of precooling, shade, and planting depth on cut flower characteristics and perennialization of *Tulipa* 'Couleur Cardinal'. There were 44 bulbs per treatment.

Precooling ^z	Shade (%)	Planting depth (cm)	Bulbs flowering (%)	Days to anthesis ^y	Stem length (cm) ^x	Quality rating ^w	Days to foliage senescence ^y
Year 1							
No	0	15	82	44	13.8	1.6	95
		30	70	49	15.0	1.9	91
		45	0	---	---	---	---
	30	15	84	46	15.4	1.6	98
		30	86	49	17.1	2.3	100
		45	0	---	---	---	---
	60	15	89	45	16.4	1.9	98
		30	73	51	18.2	2.4	101
		45	9	59	12.3	1.5	99
	Yes	15	70	55	10.3	0.9	97
		30	56	56	15.0	1.6	99
		45	23	59	11.7	1.6	99
Yes	30	15	86	58	12.6	1.2	103
		30	77	60	12.0	1.2	106
		45	30	66	11.9	1.3	102
	60	15	84	58	13.0	1.4	104
		30	50	63	11.1	1.0	105
		45	25	65	12.5	1.4	102
Precooling (P)			NS	***	***	***	***
Shade (S)			NS	L*	NS	NS	L*
Depth (D)			L***	L*** Q**	Q**	Q**	NS
Significant ($P \leq 0.05$) interactions			P × DL	SL × DL P × DL	P × SL P × SL × DL	P × SL × DL	None
Year 2							
No	0	15	22	44	16.4	1.3	94
		30	7	46	19.8	2.1	94
		45	0	---	---	---	---
	30	15	20	46	19.0	1.8	99
		30	6	49	22.6	2.6	104
		45	0	---	---	---	---
	60	15	22	46	19.1	1.8	99
		30	3	49	24.0	2.8	96
		45	0	---	---	---	---
Yes	0	15	5	47	17.8	1.5	99
		30	6	48	20.4	2.3	100
		45	3	48	21.8	2.4	102
	30	15	5	47	22.8	2.7	97
		30	8	48	24.3	3.1	99
		45	0	---	---	---	---
	60	15	6	48	21.9	2.6	97
		30	3	48	20.3	2.7	102
		45	2	50	26.0	3.3	83
Precooling (P)			NS	*	**	NS	NS
Shade (S)			NS	L***	L*** Q*	L**	NS
Depth (D)			L***	L***	L**	L**	NS
Significant ($P \leq 0.05$) interactions			None	P × DL	None	None	None

^zBulbs received 0 or 5 weeks of 5 °C precooling.^yDays from 20 Feb. 1998 in year 1 and 20 Feb. 1999 in year 2.^xStem length was measured from node of wrapper leaf to uppermost tip of the flower.^wRating on a scale of 1–5, where 1 = short thin, crooked stems with small flowers or incomplete flower opening and 5 = long, straight, sturdy stems with a large flower diameter.NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001; linear (L), quadratic (Q).

delaying the increase of soil temperatures and may have improved rooting which extended foliage life (Fig. 1) (Le Nard and De Hertogh, 1993).

Shading extended foliage life for *T.* 'White Emperor' and *T.* 'Couleur Cardinal' bulbs planted 15 cm deep in year 1. The lower light level may have reduced foliage temperatures allowing it to live longer.

In conclusion, the 45-cm planting depth reduced flowering. Increasing planting depth delayed anthesis; while shading increased stem length and delayed anthesis. For cut flower production, the 15-cm planting depth was suf-

ficient, 30% to 60% shade lengthened stems and precooling was unnecessary. To prolong the cut flower harvest period of a specific cultivar, bulbs can be planted both 15 and 30 cm deep. However, deep planting (45 cm) may reduce flowering percentage.

Precooling, deep planting, and shade were not sufficient to encourage perennialization. The highest percentage of plants flowering in year 2 occurred with bulbs planted 15 cm deep. Precooling influenced percentage of plants flowering for *T.* 'White Emperor' but did not influence any other cultivars and does not appear to be commercially useful to promote

perennialization of spring flowering bulbs in the southern Great Plains region of the United States. Overall perennialization was low, regardless of treatment, as 32% or less of bulbs survived to the second year. Species and cultivar selection may be most important in perennialization as the highest percentage of bulbs flowering in the second year was 30% for *N.* 'Tahiti' vs. 32% for *N.* 'Music Hall' and 30% for *T.* 'White Emperor' vs. 22% for *T.* 'Couleur Cardinal'. Interestingly of the four species studied, *Narcissus* were considered the best for perennialization in the southern Great Plains, yet *Tulipa* performed as well as *Narcissus* (Armitage, 1993; P. Mitchell, personal communication). Apparently *Narcissus* cultivars other than the ones used in this study perform well in the southern Great Plains.

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Table 4. Effect of precooling, shade, and planting depth on cut flower characteristics and perennialization of *Tulipa* 'White Emperor'. There were 44 bulbs per treatment.

		Planting depth (cm)	Bulbs flowering (%)	Days to anthesis ^y	Stem length (cm) ^x	Quality rating ^w	Days to foliage senescence ^y	
Precooling ^z	Shade (%)							
Year 1								
No	0	15	82	43	20.8	2.7	93	
		30	84	48	21.2	2.5	96	
		45	0	---	---	---	---	
	30	15	80	43	23.4	2.7	96	
		30	82	46	22.2	2.6	96	
		45	9	55	16.5	1.6	94	
	60	15	82	43	23.2	2.8	98	
		30	77	47	22.4	2.8	100	
		45	2	56	10.0	1.0	94	
	Yes	0	15	61	45	22.9	2.8	92
			30	52	49	21.3	2.4	90
			45	16	52	16.7	1.9	90
30		15	59	47	20.5	2.4	100	
		30	57	49	21.3	2.5	100	
		45	18	54	16.3	1.9	100	
60		15	64	51	19.4	2.1	96	
		30	48	49	23.4	2.8	102	
		45	34	53	19.1	2.2	104	
Precooling (P)		*	***	NS	NS	NS		
Shade (S)		NS	NS	NS	NS	L**		
Depth (D)		L***	L*** Q*	L* Q**	L* Q**	NS		
Significant (<i>P</i> ≤ 0.05) interactions		P*DL	P × SL P × DL P × DL	P × SL P × DL P × SL × DL	P × DL P × SL × DL	SL × DL P × SQ		
Year 2								
No	0	15	22	33	22.4	2.4	80	
		30	12	34	20.3	1.9	81	
		45	0	---	---	---	---	
	30	15	28	34	24.6	2.4	85	
		30	21	37	24.1	2.5	83	
		45	2	38	27.0	3.5	83	
	60	15	30	34	25.4	2.6	82	
		30	20	37	25.2	3.0	83	
		45	0	---	---	---	---	
	Yes	0	15	15	36	23.4	2.8	82
			30	11	36	23.3	2.6	84
			45	0	---	---	---	---
30		15	14	37	23.1	2.7	83	
		30	17	38	23.3	2.6	84	
		45	0	---	---	---	---	
60		15	17	36	24.7	2.7	84	
		30	11	38	27.8	3.3	88	
		45	3	39	24.0	3.0	90	
Precooling (P)		**	**	NS	NS	*		
Shade (S)		NS	L** Q**	L***	L*	NS		
Depth (D)		L***	L***	NS	NS	L**		
Significant (<i>P</i> ≤ 0.05) interactions		None	SL × DL P × DL	None	SL × DL	None		

^zBulbs received 0 or 5 weeks of 5 °C precooling.

^yDays from 20 Feb. 1998 in year 1 and 20 Feb. 1999 in year 2.

^xStem length was measured from the node of the wrapper leaf to uppermost tip of the flower.

^wRating on a scale of 1–5, where 1 = short thin, crooked stems with small flowers or incomplete flower opening and 5 = long, straight, sturdy stems with a large flower diameter.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001; linear (L), quadratic (Q).

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