Planting Date and In-ground Time Affect Cut Flowers of *Liatris*, *Polianthes*, and *Iris*

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Abstract. Bulbous roots of Kansas gayfeather or liatris (*Liatris spicata* Wind.), tuberose (*Polianthes tuberosa* L.), and Dutch iris (*Iris × hollandica*) were planted between Nov. 1986 and Mar. 1987. Late planting extended harvest times and resulted in highest yields and longest stem lengths for *Liatris spicata* and *Polianthes tuberosa*, but, results were cultivar-dependent with *Iris × hollandica* hybrids. Yield was highest for all cultivars of Dutch iris except 'White Bell' when bulbs were planted in December. Late planting extended harvest time but reduced yield for all cultivars except 'White Wedgwood'. No differences due to planting time occurred after the first season for liatris and tuberose, but both species had higher yields the years after initial planting and may be left undisturbed for at least 3 years. Iris flowers were destroyed by late frosts in two successive years and longevity could not be determined. The yield and stem length were optimum for *Liatris* 10 to 15 days from beginning of harvest, 4 to 5 weeks for single-flowered tuberose, and 5 to 6 weeks from start of harvest for double tuberose. Stem length of tuberose increased over the seasons, regardless of cultivar.

Dutch iris, Kansas gayfeather (syn. *L. callilepis*), and tuberose are well-established cut-flower crops in many countries. These crops are forced under greenhouse conditions to meet peak consumer demands and also grown in the field under minimal protection. One of the limitations to field production is the lack of control of flowering time. Many field-grown species flower only for 1 to 3 weeks, resulting in oversupply while in flower and an undersupply after flowering has terminated. Studies with Dutch iris have demonstrated the necessity of relatively high temperatures after lifting followed by relatively low temperatures for successful flower forcing (Rees, 1985). Ethephon has been used to reduce the percentage of nonflowering bulbs (Durieux and Kamerbeek, 1973) and some growers use smoke from burning damp straw (Stuart et al., 1966). Tuberose production was studied by Brundell and Steenstra (1985) and reviewed by Wilkins (1985). Tuberose is widely grown in California and the southeastern United States where it flowers in late summer and fall. Low temperatures are necessary for flowering in *Liatris* (Waithaka and Wanjao, 1982; Zeislin and Geller, 1983a). Four to 6 weeks of 2C result in flowering, although the vernalization requirement can be partially substituted with gibberellic acid

(Zeislin and Geller, 1983a; Zeislin, 1985). Longer stems are formed with long days (LD) and more flowers per corm result from short days (SD) (Grouper and Shoub, 1970; Zeislin and Geller, 1983 b). Armitage (1987) recorded yields of 12 stems/m² for *Liatris pycnostachya* under field conditions, and De

Hertogh (1989) has presented regional information on outdoor production of numerous bulb species. Some information concerning yields, stem lengths, or longevity of field-grown crops is available in the United States (Laushman, 1989; Perry, 1989), but significant gaps exist in the literature on specialty cut flowers.

The objective of this work was to determine (i) if duration of flowering of bulbous species could be extended by delayed planting, (ii) if flowering time were extended the 1st year, whether a similar response would be repeated the 2nd year if plants remained in the ground, (iii) if bulbous species could be treated as perennial, biennial, or annual crops, and (iv) what yield, flower, and stem quality could be expected from field-grown bulbous species in climatic zone 7b (U.S. Dept. Agr., 1990) of North America.

Raised beds were constructed in 1985 and composted equine manure was incorporated into natural Cecil clay loam soils at a depth of ≈ 60 to 75 cm. The beds were exposed to full sun and irrigated overhead when the soil was dry to the touch. In general, rainfall was supplemented to provide ≈ 25 mm of water per week. Planting depth was approximately three times the diameter of the bulbous root, and spacing depended on the size of the species. Planting techniques are similar to those described by Armitage and Laushman (1990). *Iris × hollandica*, *Polianthes tuberosa*, and *Liatris spicata* [syn. *L. callilepis* (Dress, 1959)] were planted when indicated in Table 1 and in three replicates per planting date in

Fig. 1. Distribution of yield and stem length in 1987 for *Liatris spicata*.

Table 1. Species and planting dates used in the study.

Botanical name (diameter, cm)	Cultivar	Common name	Month planted ^a				
			November	December	January	February	March
<i>Iris × hollandica</i> (9-10)	Blue Ideal	Dutch iris	✓	✓			✓
	Blue Ribbon		✓	✓	✓		
	White Bell		✓	✓	✓		✓
	White Cloud		✓	✓			
	White Wedgwood		✓	✓	✓	✓	✓
<i>Liatris spicata</i> (8-10)		Kansas gayfeather	✓	✓	✓	✓	✓
<i>Polianthes tuberosa</i> (12-14)	Single	Tuberose				✓	✓
	The Pearl					✓	✓

^aActual planting dates: 15 Nov., 18 Dec. 1984, 3 Jan., 19 Feb., 31 Mar. 1985.

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Fig. 2. Distribution of yield and stem length during 1987 for *Polianthes tuberosa* 'Mexican Single' (top) and 'The Pearl' (bottom).

Table 2. Effect of planting dates on 1st year harvest of *Liatris spicata* and *Polianthes tuberosa*.

Plant and month of planting	Yield (stems/plant)	First harvest (date)	Harvest duration (days)	Stem length (cm)	Stem diameter (mm)	Flower length (% of stem)
<i>Liatris</i>						
November	2.2 bc [*]	1 July	14 ^{NS}	62.5 b	7.1 ab	36.0 b
December	1.2 c	1 July	15	56.9 bc	6.9 b	36.0 b
January	2.0 bc	8 July	14	50.0 c	6.9 b	26.5 c
February	3.4 b	12 July	12	66.3 b	7.9 a	30.0 bc
March	4.5 a	21 July	15	72.2 a	8.0 a	42.0 a
<i>Polianthes</i>						
<i>Mexican Single</i>						
February	0.8	2 July	87	109.2	8.3	
March	1.1	22 July	67 [*]	92.3 [*]	7.4 [*]	
Significance						
<i>The Pearl</i>						
February	0.9	16 July	73	82.9	8.9	
March	1.1	1 Aug.	58 [*]	87.6	9.3	
Significance	NS			NS	NS	

^{*}Tukey's HSD test within columns, $P = 0.05$.

^{NS} Nonsignificant or significant at $P = 0.05$, respectively.

a completely randomized design. Dutch iris were stored at 9C, tuberose at 20C, and liatris at 2C in a commercial facility until the appropriate shipping date. No sprouting was apparent at any planting date. Planting was completed within 4 days of the bulbs' receipt at the Univ. of Georgia (34°N latitude, climatic zone 7b). Flowers were initially harvested during the 1986 growing season. Bulbs remained in the ground and flowers were again harvested in 1987 and 1988. Upon harvest, the time to flower, stem length, and stem diameter were recorded. Analyses of vari-

ante and Tukey's ω test (HSD) were conducted where appropriate.

Although significant differences in flower yield, initial harvest date, duration of harvest, and flower quality occurred the first season (1986) due to planting times, no differences occurred in subsequent years (data not shown). Therefore, data presented for 1987 and 1988 were pooled for all planting dates.

Liatris. Flower yield of liatris increased significantly after the February planting but the first harvest date was delayed 4 to 9 days

for each successive planting date beginning with those planted in December (Table 2). Harvest duration was not affected due to planting dates. Longest stems, largest stem diameter, and greatest percentage flower length resulted from March-planted corms. Stem diameter tended to increase as planting was delayed to February or March. First harvest date for March planting was extended by 20 days compared with those planted in November. Harvests had essentially been terminated on all other plantings by the time harvesting began on March-planted corms. The increase in yield for the later plantings likely resulted from additional time in cold storage. Geller (1981) and Zeislin and Geller (1983b) showed that as duration of cold storage increased, so did percentage of flowering plants. Apparently, additional flower primordia were activated due to longer storage times. The additional stem length may have been due to the additional time in cold storage, similar to tulips (Rees, 1969), or to warmer weather during stem elongation.

Yield and stem length were significantly greater in 1987 and 1988 than in 1986 (Table 3). This change was a function of maturity and additional meristems being formed on the corms over time. These data indicate that 3 to 4 years of production life are reasonable for liatris corms. During the 1987 harvest, peak harvest time and longest stem occurred between 10 and 20 days from the beginning of the harvest period (Fig. 1).

Polianthes. No significant differences in flower yield or number of flowers per inflorescence occurred due to planting time for 'The Pearl', but all characteristics were significantly affected for 'Mexican Single' (Table 2). The reduction in flowering of February-planted rhizomes of 'Mexican Single' may have been due to low soil and air temperatures in February. Post (1955) suggested that optimum growth of tuberose occurred at 21C or above and Kosugi and Kimura (1961) concluded that high temperatures were necessary for flower initiation, organogenesis, and flower maturation. The last frost-free date for north Georgia is mid-April. These data demonstrate the reduction of yield when rhizomes are planted in February. The first harvest from March-planted rhizomes was 16 to 20 days later (depending on cultivar) than from those planted in February (Table 2). 'Mexican Single' had longer stems and larger stem diameter from the February than the March planting (Table 2), suggesting that 'Mexican Single' is more responsive to early planting time than 'The Pearl'. While early planting reduced yield, an increase in stem length, stem diameter, and longer harvest duration from early planted bulbs may offset the decrease. Yield of 'Mexican Single' was unchanged between 1986 and 1988 but stem length declined significantly after 1986. Yield of 'The Pearl', however, was higher in 1987 than in 1986 or 1988, but the stems were shorter and length about equal in both later years (Table 3). Number of flowers per inflorescence and stem diameter were similar in all years (data not shown). Based on this study, *Polianthes* could

Table 3. Comparison of yield and stem length of *Liatris spicata* and *Polianthes tuberosa* between 1986, 1987, and 1988.^a

Plant and year	Yield (stems/plant)	Stem length (cm)
<i>Liatris</i>		
1986	2.7 C	61.6 c
1987	8.0 b	74.9 b
1988	15.0 a	98.0 a
<i>Polianthes</i>		
Mexican Single		
1986	0.9 a	100.0 a
1987	0.9 a	78.5 b
1988	1.1 a	79.9 b
The Pearl		
1986	1.0 a	84.0 a
1987	2.7 b	68.4 b
1988	1.2 a	71.3 b

^aTukey's HSD test ($P = 0.05$), within species or cultivar.

be considered perennial for cut-flower production. Harvest peaked in weeks 4 and 5 for 'Mexican Single' and in weeks 5 and 6 for 'The Pearl', indicating that planting of both cultivars extends peak harvest time of tuberose. Stem lengths for 'Mexican Single' (Fig. 2, top) increased with time, but stem length of 'The Pearl' started to decline by week 8 (Fig. 2, bottom).

Dutch iris. Yield (flowers per bulb) tended to be higher for November and December plantings than for later plantings (Table 4), and initial harvest dates were later in later plantings. In general, harvest duration was similar for all plantings for all cultivars except 'Blue Ribbon', where it was longest for December plantings. Initial harvest was delayed for 18 days ('Blue Ribbon'), 13 days ('White Bell'), and 9 days ('White Wedg-

wood') between December and January plantings. Delaying planting until March resulted in 27, 59, and 28 days' delay in harvest compared with December plantings for 'Blue Ideal', 'White Bell', and 'White Wedgwood', respectively (Table 4). Stems became shorter with late plantings for most cultivars. A substantial reduction in stem length occurred for all cultivars except 'White Cloud' between the first and last planting date (Table 4). 'Blue Ideal' (18%), 'Blue Ribbon' (43%), and 'White Wedgwood' (26%) were most affected by planting dates.

Our data suggest harvest dates can be extended by sequential plantings, but loss of yield and flower quality as measured by stem length and diameter may also result. De Hertogh (1989) suggested 15C as the maximum soil temperature for planting. He concluded that, in general, planting between August and December, depending on climatic zone, was optimum for Dutch iris. Cultivars vary in their response to sequential planting and 'Blue Ribbon', 'Blue Ideal', and 'White Bell' were suitable for planting after December in zone 7b, but 'White Wedgwood' showed little decline in quality even with plantings as late as March. Due to a late frost in Spring 1987, all flowers were destroyed, resulting in unavailability of data for 1986. Bulbs declined during Summer 1986 and no data were collected in subsequent years. Environmental fluctuations dictate that Dutch iris be used as an annual in climatic zone 7b.

In summary, extending planting dates can extend harvest time but may result in decline of yield and stem quality, depending on species and cultivar. No effects of extended planting dates were observed after the first flowering season. Cut flowers of liatris and tuberose can be produced as perennials (pro-

duction does not significantly decline for at least 3 years), but Dutch iris should be treated as an annual in this climatic zone.

Literature Cited

- Armitage, A.M. 1987. The influence of spacing on field-grown perennial crops. HortScience 22:904-907.
- Armitage, A.M. and J.M. Laushman. 1990. Planting date, in-ground time affect cut flowers of *Acidanthera*, *Anemone*, *A. ilium*, *Brodiaea*, *Crocasmia*. HortScience 25(10):1236-1238.
- Brundell, D.J. and D.R. Steenstra. 1985. The effects of protected cultivation, pre-sprouting and lateral tuber removal on tuberose production. Acts Hort. 177:364-367.
- De Hertogh, A.A. 1989. Holland bulb forcer's guide. 4th ed. Intl. Flower Bulb Centre, Hillegom, The Netherlands.
- Dress, W.J. 1959. Notes on the cultivated Compositae. III. *Liatris*, Bailey-7:23-32.
- Durieux, A.J.B. and G.A. Kamerbeek. 1973. The prevention of "three-leaved" plants in the forcing of *Iris* $\times$ *hollandica* by early heat treatment of stored bulbs or by ethephon field spraying. Scientia Hort. 2:101-104.
- Geller, Z. -1981. Horticultural and physiological aspects in growing of *Liatris spicata*. MSc. Agr. Thesis, Hebrew Univ. Rehovot, Israel.
- Grouper, G., and J. Shoub. 1970. *Liatris*: The effect of the corm origin, storage temperature, and growing conditions on flowering (in Hebrew). Annu. Rev. Dept. Ornamental Hort. Hebrew University, Rehovot, Israel. p. 88-91.
- Kosugi, K. and Y. Kimura. 1961. On the flower bud differentiation and flower bud development in *Polianthes tuberosa* L. Tech. Bul. Faculty Agr. Kagawa Univ., Japan. p. 230-234.
- Laushman, J.M. 1989. Annual cut flowers. Proc. 2nd Natl. Conf. on Specialty Cut Flowers, Athens, Ga. p. 120-122.
- Perry L.P. 1989. Perennial cut flowers. Proc. 2nd Natl. Conf. on Specialty Cut Flowers, Athens, Ga. p. 155-161.
- Post, K. 1955. Florist crop production and marketing. Orange Judd, New York.
- Rees, A.R. 1969. Effects of duration of cold treatment on the subsequent flowering of tulips. J. Hort. Sci. 44:27-36.
- Rees, A.R. 1985. *Iris*, p. 282-287. In: A.H. Halevy (ed.). Handbook of flowering. vol I. CRC Press, Boca Raton, Fla.
- Stuart, N. W., S. Asen, and C.J. Gould. 1966. Accelerated flowering of bulbous iris after exposure to ethylene. HortScience 1:19-20.
- U.S. Dept. of Agriculture. 1990. Plant hardiness zone map. USDA Misc. Publ. 814.
- Waithaka, K. and L.W. Wanjab. 1982. The effect of duration of cold treatment on growth and flowering of *Liatris*. Scientia Hort. 18:153-158.
- Wilkins, H. 1985. *Polianthes tuberosa*, p. 127-129. In: A.H. Halevy (ed.). Handbook of flowering vol. IV, CRC Press, Boca Raton, Fla.
- Zeislin, N. 1985. *Liatris*, p. 287-291. In: A.H. Halevy (ed.). Handbook of flowering vol. 111. CRC Press, Boca Raton, Fla.
- Zeislin, N. and Z. Geller. 1983a. Studies with *Liatris spicata* Wind. I. Effect of temperature on sprouting, flowering and gibberellin content. Ann. Bot. 52:849-853.
- Zeislin, N. and Z. Geller. 1983b. Studies with *Liatris spicata* Wind. II. Effect of photoperiod on stem extension, flowering and gibberellin content. Ann. Bot 52:855-859.

Table 4. Effect of planting dates on Dutch iris.^a

Cultivar and month of planting	Yield (flowers/bulb)	First harvest (date)	Harvest duration (days)	Stem length (cm)	Stem diameter (mm)
Blue Ideal					
November	0.79 ab	10 Apr.	15 a	35.2 a	8.8 a
December	0.87 a	13 Apr.	15 a	34.4 a	8.7 a
March	0.75 b	20 May	18 a	28.7 b	7.6 b
Blue Ribbon					
November	0.85 ab	21 Apr.	13 b	39.8 a	9.8 a
December	0.91 a	14 Apr.	17 a	34.0 a	10.1 a
January	0.12 c	2 May	12 b	27.8 b	9.3 a
White Bell					
November	0.90 a	14 Apr.	15 a	51.8 a	9.9 a
December	0.91 a	14 Apr.	15 a	49.8 ab	10.0 a
January	0.96 a	27 Apr.	15 a	46.8 b	9.9 a
March	0.58 b	12 June	14 a	44.1 b	9.5 a
White Cloud					
November	0.93 a	21 Apr.	15 a	39.0 a	9.7 a
December	0.86 a	14 Apr.	18 a	35.6 a	9.6 a
White Wedgwood					
November	0.72 b	11 Apr.	15 a	36.3 a	9.1 a
December	0.92 a	12 Apr.	15 a	34.4 a	8.9 a
January	0.92 a	21 Apr.	15 a	35.4 a	8.7 a
February	0.84 ab	28 Apr.	13 a	30.7 ab	7.5 b
March	0.85 ab	20 May	17 a	28.9 b	7.9 ab

^aTukey's HSD test, $P = 0.05$, within columns and cultivars.