INTERACTIONS OF PHOTOPERIOD AND TEMPERATURE ON FLOWERING OF L I A T R I S

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Abstract

After the cold treatment, a 20°C treatment for 1 to 3 weeks prior to planting increased the variability of emergence and the days to anthesis. Low winter forcing temperatures 35 days after emergence, increased the days to flower by 50% compared to liatris forced in the summer. The days to flower from emergence was inversely related to the forcing temperature. The 18° treatment promoted uniform flower stem development and increased the number of plants which flowered compared to the 13° forcing temperature.

Long day treatment during the first 35 days after emergence hastened flowering at 15° while at the 13° and 18° forcing temperatures the temperature response was negated by the photoperiod response. A sixteen hour photoperiod promoted rapid floral stem elongation.

1. Introduction

Liatris spicata Willd. corms flower in early summer following long-day conditions (Bailey, 1950). Liatris has become an important cut flower crop in several countries, including Kenya (Waithaka and Wanjao, 1982) and Israel (Zieslin and Geller, 1983) with increasing interest being shown in the United States (Kofranek, 1980).

The effect of corm temperature treatments on the growth and flowering of liatris has been reported by several authors (Waithaka and Wanjao, 1982; Zieslin and Geller, 1983a). A 3-5°C cold-treatment for 8 weeks was required in the tropics to maximize cut-flower production (Waithaka and Wanjao, 1982), while two cold-requiring mechanisms were mention by Mediterrenean workers (Zieslin and Geller, 1983a). However, temperature studies during the growing period were not reported as plants were grown in the field under natural days.

Flowering in Liatris spicata may be regulated by vernalization rather than by photoperiodism (Zieslin and Geller, 1983b; Zieslin, 1985). Plants grown under continuous short day (SD) showed increased flower stem formation, with SD grown plants producing twice as many flower stems as plants grown under continuous long day (LD) conditions. Two weeks of LD conditions after corm sprouting reduced the number of flowering stems but after 3 weeks in SD, LD treatment no longer reduced the number of flowering stems (Zieslin and Geller, 1983b).

The objective of this study was to determine the effects of temperature and photoperiod after the cold treatment on the flowering response of liatris.

2. Material and methods

One year old frozen corms of uniform size, produced from seedlings in the Netherlands, were used in all the experiments. Plants were fertilized through the irrigation system at a rate of 200 mg/l of 20-20-20 as needed. The following data were recorded; days to anthesis, number of flowering stems and flowering stem length. In experiment 1 the days to emergence was recorded. Where appropriate, analysis of variance was used to determine treatment effects with mean separation by the least significant difference (LSD).

2.1 Experiment 1

Groups of 25 corms were mixed with moist peat moss (65% moisture) and placed in plastic bags. The bags were placed at 2.5° or 20°C for 1, 2 or 3 weeks. After the treatment the corms were planted in a ground bed under natural day conditions in a glasshouse at a minimum 13°C. A randomize complete block design was used. Plants were planted on April 9, 16 or 23, 1985.

2.2 Experiment 2

Individual corms were planted in 12 cm pots and grown in growth chambers under 8 hr and 18°C until emergence. The plants were then grown under 13°, 15° or 18°C and 8 or 12 hr photoperiod for 35 days after emergence. From day 36 to anthesis plants were grown in a glasshouse under natural days at a minumum 13°C. The experiment began May 30 (Summer) or November 27 (Winter). Each treatment had 30 plants, with a randomize complete block design.

2.3 Experiment 3

Individual corms were planted in 15 cm pots and placed under different photoperiod treatments. The treatments consisted of a photoperiod of 8, 12 or 16 hr for the first 35 days after emergence, at which time the plants were transferred to a second photoperiod treatment of 8, 12 or 16 hr until anthesis. The photoperiod treatment consisted of an 8 hr natural day plus day continuation of incandescent light (5.4 μmol $\cdot$ s^{-1} W^{-1}) to equal 12 or 16 hr. Plants were grown in a glasshouse at a minimum 13°C. A split-plot experimental design, replicted twice in two different glasshouses was used, with each treatment consisted of 15 plants. The experiment began on January 24, 1986.

3. Results and Discussion

3.1 Experiment 1

After the cold treatment, a 20°C treatment for 1 week reduced the days to emergence compared with the other treatments (Figure 1). Plants emerged uniformly, but as the number of weeks at 20° increased, the plants showed delayed and ununiform sprouting compared to the 2.5° treatment. High temperatures after the cold treatment resulted in erratic sprouting, with variable flowering response. Therefore, high temperature exposure to corms after the cold treatment and prior to planting can adversely affect crop production.

3.2 Experiment 2

The days to anthesis decrease significantly as the forcing temperature increase from 13° to 18°C. A similar response between the two seasons was observed with the days to anthesis increased significantly in Winter compared to Summer (Table 1). The different flowering response could be related to the seasonal photoperiod or temperature after the 35 days of treatment. The number of flowers produced in the 18° treatment was significantly higher with a more uniform population reaching anthesis compared to the 13° treatment (Figure 2).

The LD treatment during the 35 days after emergence hastened flowering at 15° while at the 13° and 18° forcing temperatures the temperature response was negated by the photoperiod response (Table 2). Therefore at low forcing temperatures a LD is required to hasten flowering while at 18°C supplemental photoperiods are not required for rapid flowering.

3.3 Experiment 3

A 16 hour photoperiod from emergence to anthesis promoted the most rapid flowering (Table 3). The first 35 days was the critical period, compared for promoting rapid flowering as LD treatment from day 36 to anthesis was not as effective as during the first 35 days post emergence. This result suggests that the increase in days to anthesis observed between Winter and Summer (Table 1), was not due to the natural photoperiod from day 36 to anthesis, but the delay in flowering was due to the forcing temperature.

Total shoot length was dependent on the photoperiod treatment from day 36 to anthesis, as the plants at the 8 or 12 hr starting photoperiod and a final 16 hr photoperiod were the tallest (Table 4).

Our results support that flowering may be regulated by vernalization (Waithaka and Wanjao 1982, Zieslin and Geller 1983) but photoperiod is also directly involved with photoperiod interacting with temperature to affect flowering (Table 2). At low forcing temperatures (13°C) a LD is required to hasten flowering while at high forcing temperatures, photoperiod has little effect. A LD photoperiod during the first 35 days after emergence will promote rapid flowering compared with the SD treatment (Table 3). It appears that 14 hrs was the critical photoperiod as there was no difference between 14 and 16 hr treatment (data not presented). A LD treatment after the first 35

days of growth is required to maximize stem elongation, since a SD/LD treatment results in significantly greater stem elongation compared to a continuous LD treatment. Therefore, photoperiod control of stem elongation occurs at later stages of development and not at early stages, while days to flower is affected during early stages.

References

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Table 1. Effect of 12 hr photoperiod (8 hr light period plus 4 hr incandescent from 22:00 to 02:00) and 13° or 18°C for the first 35 days after emergence during two different seasons (Summer and Winter) on the days to anthesis of Liatris spicata Willd. Plants were grown from day 36 to anthesis under natural days in a glasshouse at a minimum 15°C.

	Temperature	
	13°	18°
Summer		
	60.2 a[z]	53.4 b
Winter		
	94.3	80.4

z. Means within rows with different letters are significantly different at the 5% level using LSD.

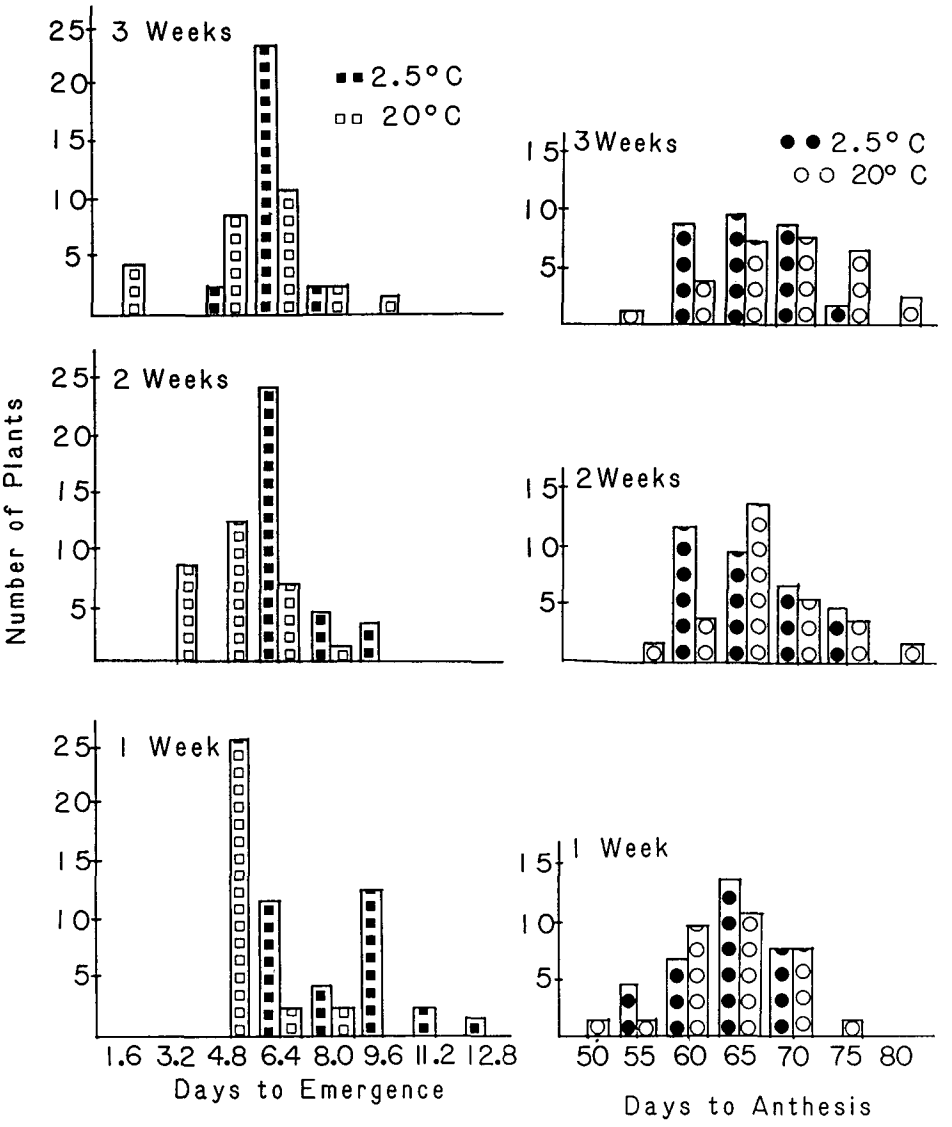

Figure 1. The effect of 1 to 3 weeks of preplanting temperatures on the distribution of Liatris spicata plants for the days to emergence and the days to anthesis. Corms were planted on April 9, 16 or 23, 1985.

Table 2. Effect of 8 or 12 hr photoperiod (8 hr light period or 8 hr light period + 4 hr incandescent from 22:00 to 02:00) and 13°, 15° or 18°C temperatures during the first 35 days after emergence on the days to flower of Liatris spicata Willd. Plants were grown from day 36 to anthesis under natural days in a glasshouse at a minimum 15°C.

Short day (8 hr)			Long day (12 hr)		
13°	15°	18°	13°	15°	18°
65.7a[z]	67.7a	56.6bc	60.2b	55.6c	53.4c

z. Means with different letters are significatly different at the 5% level using LSD.

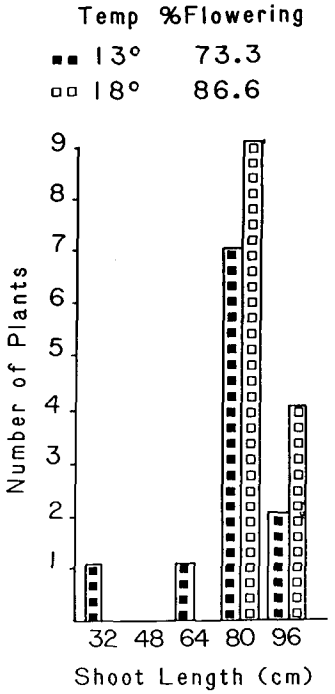

Figure 2. The effect of 13° or 18°C forcing temperatures during the first 35 days after emergence on the percentage of plants which flowered and the distribution of the flowering stem length of Liatris spicata.

Table 3. Effect of photoperiod sequences on the days to flower of Liatris spicata Willd. Plants were grown at 15°C in a glasshouse under 8, 12 or 16 hr photoperiod for the first 35 days after emergence (Start) and then transfered to a second photoperiod of 8, 12 or 16 hr until anthesis (End). The photoperiod treatment consisted of an 8 hr natural day plus day continuation of incandescent light (5.4 μmol · s^{-1} W^{-1}) to equal 12 or 16 hr.

Start	End		
	8 hr	12	16
8 hr	99.86	103.78	96.87
12	101.25	97.04	93.45
16	82.23	84.10	79.04

Start	**[z]
End	ns
Start*End	ns

M S E = 103.43

z. ns = not significant, ** = significant at the 1% level.

Table 4. Effect of photoperiod sequences on the length of the flowering stems of Liatris spicata Willd. Plants were grown at 15°C in a glasshouse under 8, 12 or 16 hr photoperiod for the first 35 days after emergence (Start) and then transfered to a second photoperiod of 8, 12 or 16 hr until anthesis (End). The photoperiod treatment consisted of an 8 hr natural day plus day continuation of incandescent light (5.4 μmol · s^{-1} W^{-1}) to equal 12 or 16 hr.

Start	End		
	8 hr	12	16
8 hr	52.86 d[z]	74.52 c	94.29 a
12	53.20 d	76.69 bc	91.70 a
16	54.58 d	71.68 c	83.23 b

z. Means with different letters are significantly different at the 5% level using LSD.