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Influence of Photoperiod on *Liatris spicata* Generative Shoot Growth

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Abstract. **One-year-old corms of** *Liatris spicata* **Willd. produced from seed and 2-year-old corms from division of previously forced corms were placed under 8 hours of natural daylight plus 0, 4, 6, or 8 hours of incandescent (5 µmol·s^{-1}·m^{-2}) day continuation to equal 8-, 12-, or 16-hour photoperiods. Plants were grown under these photoperiods during the first 35 days after shoot emergence (initial) and then were grown under a second photoperiod of 8, 12, 14, or 16 hours until harvest (final). The combination of initial and final photoperiod treatments resulted in a total of 16 photoperiod combinations. Two-year-old corms flowered 10 days earlier than l-year-old corms, but l-year-old corms produced twice as many vegetative shoots and 15% more flowering shoots than the 2-year-old corms. Long initial photoperiod (14 or 16 hours) treatments . (LD) reduced-the days to flower by 8 days and increased flower shoot elongation by 20 cm, compared with initial short days (8 or 12 hours, SD). However, initial LD treatments decreased the number of flowering shoots by** 50%, **compared to initial SD treatments. An initial SD followed by a final LD did not decrease the number of flowering shoots, yet promoted greater stem elongation (92 cm) than continuous LD (83 cm).**

The effect of photoperiod on *Liatris* has been studied by various authors. Flowering in *L. spicata* was promoted by long days (LD) (Durieux, 1978), while *L. graminifolia* was described as a short-day (SD) plant (Allard and Garner, 1940). A LD treatment was not obligatory for flower initiation, but stem elongation (Durieux, 1978; Kofranek, 1980; Koziol et al., 1981; Zieslin and Geller, 1983) and stem rigidity (Zieslin and Geller, 1983) were promoted by LD.

Zieslin and Geller (1983) found that an 8-hr photoperiod doubled the number of flower stems harvested compared to the 16-hr treatment. An 8-hr photoperiod for 3 weeks, followed by one of 16 hr until anthesis, did not reduce the number of flowering stems. This result was in contrast to reports with gladiolus, where SD caused a low flowering percentage (Halevy, 1985; Shillo and Halevy, 1976). Long-day treatments provided by incandescent lamps promoted winter flowering of gladiolus in greenhouses (Halevy, 1985) and in fields in Israel (Shillo et al., 1981) and Australia (Mckay et al., 1982). In California, Kofranek (1980) recommended that *Liatris* be grown under LD (2200 to 0200 HR) to promote stem elongation. This recommendation seems to have been intuitive, as no data were presented to support this recommendation. Once the stem was elongated, flowering occurred more rapidly under natural winter SD conditions than under LD (Shillo and Halevy, 1976).

The objective of our research was to study the effect of photoperiod treatment and corm age during two developmental stages on generative shoot development of *Liatris spicata.*

One- and 2-year-old corms (2.5- to 3.5-cm diameter) were used. One-year-old corms, produced in the Netherlands from seedlings, were cold-treated at 2C for 8 weeks, then stored at -2C until used. The 2-year-old corms were obtained by division of corms forced in Maryland the first year, then cold-treated to break dormancy (12 weeks at 2.5 C). These corms were divided into single-bud corm divisions of uniform size. The corms were planted 24 Jan., one per 1.75-liter pot, and grown in a glasshouse at 18C night air temperature. Plants were fertilized weekly with 20N-9P-16.6K at 200 mg/liter.

After emergence, photoperiod treatments of an 8-hr natural day plus a 0-, 4-, 6-, or 8-hr day continuation with incandescent irradiance (5 µmol·s^{-1}·m^{-2}) to equal 8-, 12-, 14-, or 16-hr photoperiods were applied for 35 days. (initial). The plants were then moved to an 8-, 12-, 14-, or 16-hr photoperiod until harvest. This combination resulted in a total of 16 photoperiods. Each photoperiod treatment had 12 plants, each of 1- and 2-year-old corms. The experiment was

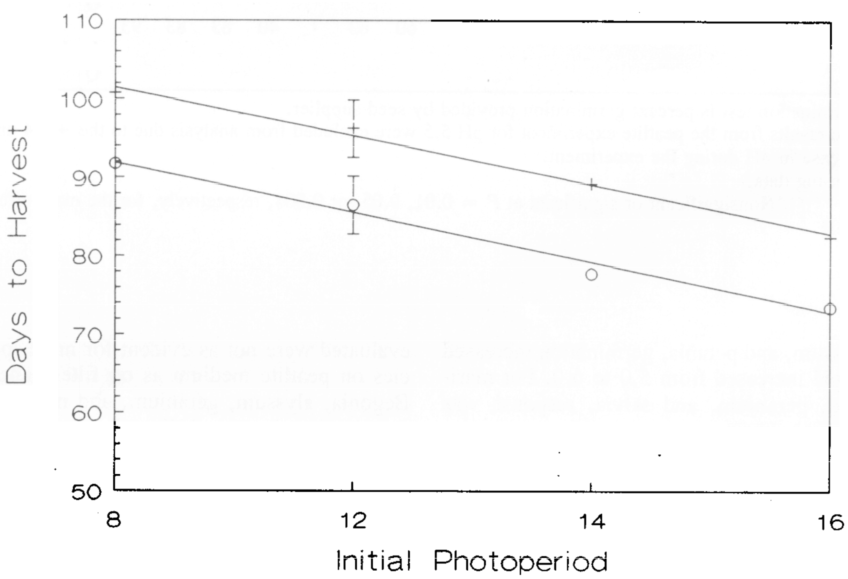

Fig. 1. Effect of photoperiod on the days to harvest of *Liatris spicata* Willd. The initial photoperiod continued until 35 days after emergence. Seedling corms are designated as 1-year corms (+), while corms that were divided into single-eye divisions are designated as 2-year corms (O). Equations are: 1-year corms, Days = 107.6 − 6.18x, r^2 = 0.99; 2-year corms, Days = 98.25 − 6.35x, r^2 = 0.98.

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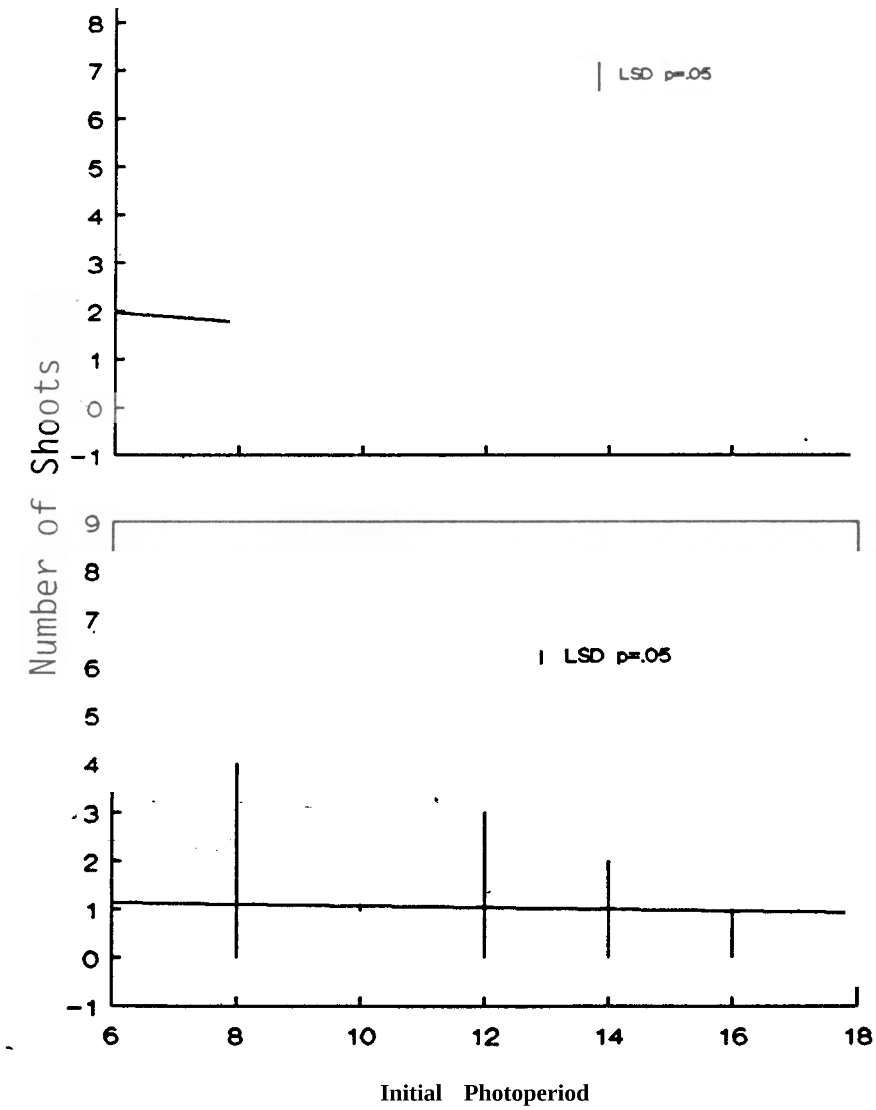

Fig. 2. Effect of corm age (l-year-old, top; 2-year-old, bottom) and initial photoperiod (during the first 35 days after emergence) on the number of generative shoots of *Liatris spicata* Willd. The bars represent the minimum and maximum number of generative shoots harvested under each photoperiod. Equations are: l-year corms number of shoots = 2.55 – 0.096x, r^2 = 0.97; 2-year corms number of shoots = 1.25 – 0.0175x, r^2 = 0.96.

replicated in two separate glasshouses with a split-split-plot design with the whole plot as the initial photoperiod, the subplot the final photoperiod, and the sub-subplot the corm age.

Generative shoots were harvested when the apical 5 cm of flowers had opened. At harvest, the following variables were measured: number of vegetative and generative shoots per pot, generative shoot length, inflorescence length, and the days to harvest calculated from the day of emergence. Analysis of variance was used to determine treatment effects with mean separation by least significant difference, where F values were significant at P = 0.05.

Days to harvest. Two-year-old corms flowered 10 days earlier than those 1 year old (92 vs. 82 days; sig. P = 0.05). A linear relationship exists between days to harvest and photoperiod. As the length of the initial photoperiod increased from 8 to 16 hr, the days to harvest were reduced by up to 18 days (Fig. 1). The final photoperiod did not affect the days to harvest.

Shoot production. One-year-old corms averaged more vegetative shoots than 2-year-old corms (5 vs. 2 shoots; sig. $P = 0.01$). This response may be due to the method of corm division, since the 2-year-old corms were divided into single bud sections.

One-year-old corms produced 15% more generative shoots per corm than 2-year-old corms (Fig. 2). Unlike the number of vegetative shoots, the number of generative flowering shoots decreased to one shoot as the initial photoperiod increased from 8 to 16 hr. The variability in number of generative shoots recorded per corm also decreased as the initial photoperiod increased.

Generative shoot length. Corm age had no effect on shoot length. The 8- or 12-hr photoperiod during both the initial and final reatment periods produced plants that were up to 20 cm shorter than those grown under a 14- or 16-hr photoperiod (Fig. 3). An 8- or 12-hr final photoperiod reduced the promotive effect of an initial long photoperiod. Furthermore, plants that received an 8-hr then a 16-hr photoperiod produced a shoot 11 cm longer than did a continuous 16-hr photoperiod.

Percentage of shoot length bearing flowers. Due to the variation in shoot length and inflorescence length (data not presented), the percentage of shoot length bearing flowers was calculated to normalize the data. The 2-year-old corms produced a slightly longer generative portion of stem length than did 1-year-old corms (32% vs. 29%; P = 0.05). As the initial photoperiod increased, the percentage of the shoot that bore flowers increased from 29% to 32%, but the final photoperiod had no effect (30% to 31%). In terms of inflorescence quality, this difference could be commercially important (Zieslin and Geller, 1983). The increase in percentage of the shoot length bearing flowers may be due to either an increase in internode length or number of flowers initiated.

The decrease in days to harvest observed with the 2-year-old corms could be due to a more-developed growing point at the time of planting or lack of competition from the other lateral buds. The latter observation is supported, by the relationship between the number of generative shoots and the days to harvest (Figs. 1, 2). The days to harvest decreased as the number of shoots decreased.

The effect of the photoperiod treatment on the days to flower occurs primarily during the first 35 days of growth (Fig. 1). Therefore, a grower may manipulate the photoperiod during this period to program the harvest date. This response may also explain the differences between results in Kenya and Europe; in Kenya, plants flower within 90 days year around, while in the Netherlands only 70 days are required during summer plantings (Durieux, 1978; Mevel, 1983). The natural photoperiod is up to 4 hr 30 min longer in the Netherlands (16 hr 44 min) than in Kenya (12 hr 11 min) during the summer season. When summer twilight is taken into consideration, plants in the Netherlands perceive constant twilight, whereas plants in Kenya perceive only 1 hr 15 min of twilight. Data presented in this study (Fig. 1) by Mevel (1983) and by Zieslin and Geller (1983) clearly show that *Liatris spicata* is a facultative long-day plant.

The number of vegetative shoots and the number of flowering shoots produced were related to corm age and photoperiod (Fig. 2). This response could have been predetermined by the division method of the 2-year-old corms that allowed for selection of single buds, which was not the case for the multiple-budded l-year-old corms. Other researchers (Mevel, 1983; Waithaka and Wanjao 1983) have found second-year corms to be very floriferous, which is in partial disagreement with our data (Fig. 2). These authors did not indicate whether their 2-year-

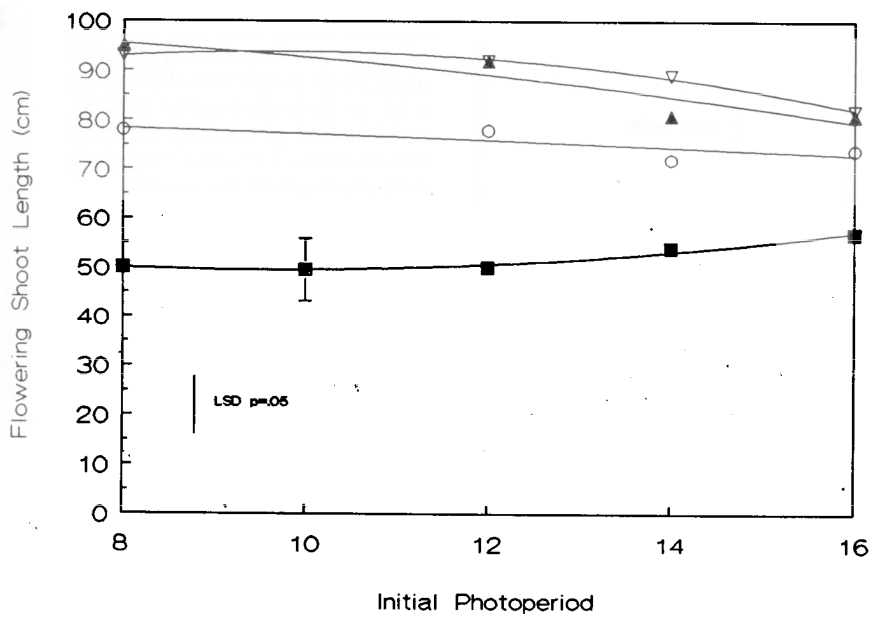

Fig. 3. Effect of initial (first 35 days after emergence) and final photoperiod (35 days after emergence until harvest) on the flowering shoot length of *Liatris spicata* Willd. Final photoperiods: 8 h(■), length = 66.5 – 3.6x + 0.18x^2, r^2 = 0.98; 12 hr (o), length = 80.7 – 0.11x – 0.02x^2, r^2 = 0.75; 14 hr (A), length = 92.7 + 1.5x – 0.14x^2, r^2 = 0.91; 16 hr(▿) length = 65.1 + 5.9x - 0.3x^2, r^2 = 0.99.

old corms were divided before forcing.

The number of shoots produced by the 2-year-old corms grown under continuous 16-hr photoperiod was almost twice the number produced under other treatments; however, the number of flowering shoots was not similarly increased (Fig. 2).

As photoperiod increases, shoot length increases (Durieux, 1978; Halevy, 1985; Shillo and Ha levy, 1976) (Fig. 3). But our results, as well as those of Durieux (1978) and Zieslin and Geller (1983), suggest that a more-speciflc combination of an initial SD (8 or 12 hr) and final LD (14 or 16 hr) after the first 35 days of growth is required to obtain a good quality flowering shoot. Corm age does not influence shoot length (Fig. 3); therefore, growers can force either l-year-old corms or divided 2-year-old corms to produce specific shoot lengths required by the market.

Although this study was primarily concerned with cut-flower production of *Liatris,* a continuous 8-hr photoperiod produced multiple short-flowering shoots (two 50-cm shoots per plant) that would be ideal for pot plant production. Therefore, photoperiod studies should be undertaken to evaluate the effect of photoperiod as it relates to pot plant production of *Liatris.*

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