

# Life After Cold!

In this issue, we look at herbaceous perennials that require vernalization and long-day photoperiods to flower.

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**F**LOWER induction of most cold-hardy herbaceous perennials can be categorized based on their response to vernalization and photoperiod (See Table 1). In previous articles, we discussed general aspects of the vernalization process and the specifics for plants that have an obligate vernalization requirement and are day neutral for flowering. In this article, we discuss responses of perennials that require both vernalization and subsequent long days for flowering.

From an ecological point of view, the dual control of flowering by vernalization and long-day photoperiods ensures that plants will not flower during a warm spell late in the winter, and, in fact, will only flower in the summer after the day length exceeds a critical photoperiod. This strategy seems to be important to plants native to regions where the springs can be mild but are often interspersed by brief cold spells late in the season.

At Michigan State University, we have studied the flower induction requirements of more than 400 herbaceous perennial species and cultivars during the last 15 years. We have learned that many perennials require vernalization but, following cold, most are day neutral with respect to photoperiod. In fact, there are relatively few examples of plants that absolutely require both vernalization and long-day photoperiods. Some of the more popular plants in this group include *Campanula punctata* 'Cherry Bells,' *Coreopsis grandiflora* 'Baby Sun,' *Coreopsis grandiflora* 'Sunray' and *Tanacetum niveum* 'Jackpot.' In each of these selections, flowering is strictly regulated and occurs only after vernalization, and then only with exposure to long days during forcing.

A second category of perennials has an obligate vernalization requirement followed by a facultative response to long-day photoperiods. Examples of plants in this category include *Astilbe chinensis* 'Pumila,' *Campanula garganica*, *Digitalis thapsi* 'Spanish Peaks' and

the season.

In some instances, we have observed that when actively growing, vernalization-requiring perennials are held in the greenhouse for a prolonged period of time, sporadic flowering can occur. For example, in one trial with *Campanula*

Table 1:

## Response To Vernalization And Photoperiod

Flower induction of a wide range of northern temperate herbaceous perennial plants can be categorized based on their response to vernalization and photoperiod. In our experience, short-day plants typically do not respond to vernalization.

Long-day Photoperiod Requirement	Vernalization Requirement		
None	None These plants flower regardless of cooling or photoperiod.	Facultative Cold improves flowering but is not absolutely required; plants are day neutral.	Obligate Cold is absolutely required for flowering; plants are day-neutral after cold.
Facultative	These plants do not require cold but flowering is improved by long-day photoperiods.	Cold and long days both improve flowering percentage, number and/or quality, or potentially reduce time to flower.	Cold is absolutely required; long-days improve plant quality and/or reduce time to flower.
Obligate	These plants do not require cold but have an obligate long-day photoperiod requirement.	Cold is helpful, but long-day photoperiods are absolutely required for flowering.	Cold and long-day photoperiods are absolutely required for flowering.

*Isotoma axillaris* (previously known as *Laurentia axillaris*). For these plants, forcing under long days greatly improves flowering characteristics in one or more ways, including greater flowering percentage, reduced time to flower, increased bud number and improved branching. In fact, in many cases, long days are essentially required to obtain plants with acceptable horticultural quality. In both cases, the relatively complex flower induction requirements of some herbaceous perennials provide extra challenges for growers who wish to produce them in flower at specific times of

*punctata* 'Cherry Bells,' two plants out of 50 in the population flowered within six months when grown under a 16-hour photoperiod without cooling. This implies that botanically, *campanula* 'Cherry Bells' may not have an obligate vernalization requirement. However, growers are interested in rapid, uniform and profuse flowering to obtain a saleable crop. Therefore, we have included *campanula* 'Cherry Bells' in the obligate vernalization category. It is important to note that categorization into vernalization and photoperiod responses is based on horticultural requirements for flowering.

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Herbaceous Perennials Requiring Vernalization And Long-Day Photoperiods

Tanacetum niveum 'Jackpot'

Tanacetum niveum 'Jackpot' has an obligate requirement for cold and long-day photoperiods. In our trials, complete flow-



Figure 1A. *Campanula garganica* did not flower without cold under nine-hour photoperiod or 16-hour photoperiod provided by night interruption or high pressure sodium lamps.

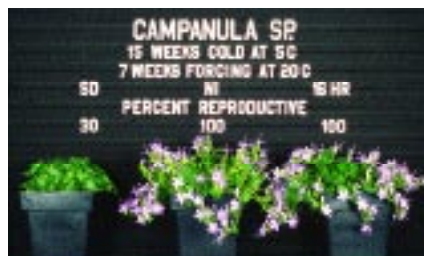


Figure 1B. Though *Campanula garganica* flowered under short days and long days after vernalization at 41°F for 15 weeks, long days improved flowering characteristics.

ering of *tanacetum* 'Jackpot' occurred only after cooling at 41°F for ≥ 12 weeks, and only when followed by forcing under long days. No plants flowered without cold regardless of the photoperiod. In fact, without a vernalization treatment, plants remained on the bench in a heated greenhouse for months and still remained vegetative. Following cold treatment, supplemental lighting increased the number of buds but did not affect time to flower in this cultivar. *Tanacetum* 'Jackpot' is seed-propagated and must be first grown to overcome the juvenile stage before exposure to cold.

*Coreopsis grandiflora* 'Sunray'

*Coreopsis grandiflora* 'Sunray' is another example of a perennial that flowers only after vernalization when grown under long days. When seed propagated, plants

should be bulked until 16 leaves are formed to overcome juvenility. We have found that 'Sunray' plants can be cooled

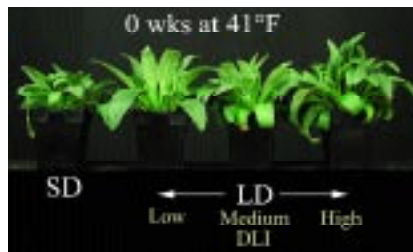


Figure 2A. *Digitalis thapsi* 'Spanish Peaks' did not flower under any photoperiod without vernalization.

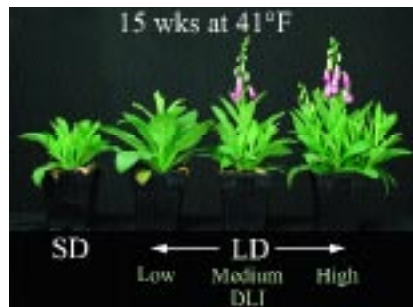


Figure 2B: Following vernalization, more plants of *Digitalis thapsi* 'Spanish Peaks' flowered under LD (80-90%) than SD (30%) and increasing light levels further increased flowering percent.

in plug trays prior to forcing under long days. In separate studies, we learned that the critical photoperiod of *coreopsis* 'Sunray' was 12 hours and, therefore, plants must be forced under photoperiods of 12 hours or longer for flowering.

Interestingly, *coreopsis* 'Sunray' also flowered after exposure to short days followed by long days. Thus, in this cultivar, short days can substitute for vernalization and holding plants under nine-hour short days for six weeks is as effective as vernalization. This response type (short-long-day) is fairly unique in our experience.

Herbaceous Perennials That Absolutely Require Vernalization And Have A Facultative Response To Long-Day Photoperiods

*Campanula garganica*

*Campanula garganica* did not flower without cooling in our studies and flowered under both long days and short days after 15 weeks at 41°F (Figures 1A and 1B). However, more plants forced under long days flowered and long days reduced the time to flower by 25 days and increased the number of buds at first open flower. Thus, the response to long days is not completely obligate, but highly desirable for production of quality

plants. Therefore, for commercial production, *Campanula garganica* should be vernalized and then forced under long days.

*Digitalis thapsi* 'Spanish Peaks'

*Digitalis thapsi* 'Spanish Peaks' required cold to flower in our trials. No plants flowered without cold, even though they developed considerable size (Figure 2A). After 15 weeks at 41°F, about 50 percent of the plants flowered under short days while almost all of the plants flowered under long days (Figure 2B). Time to flower was not affected by the forcing photoperiod in this cultivar. The quality of 'Spanish Peaks' was greatly improved under long-day photoperiods by increasing light levels from 7 to 17 mol·m<sup>-2</sup>·d<sup>-1</sup> (Figure 2B). We recommend vernalization treatment followed by forcing under bright, long days.

*Isotoma axillaris*

*Isotoma* (previously known as *Laurentia*) *axillaris* has a reputation of being a late bloomer when started from seed. In some garden books, it states that plants will not bloom until August or even September. However, we have learned that vernalization greatly accelerates flowering of *isotoma* (Figure 3A). In our studies, all plants cooled for 10 weeks flowered when grown under long days. Flowering percentage of plants forced under short days increased from 30 percent to 80 percent as the duration of cooling increased from 10 and 15 weeks (Figure 3B). Thus, exposure to longer durations of cold reduced the requirement of long days in *Isotoma axillaris*. Forcing under long days also reduced the time to flower by three to four weeks. For quick and uniform flowering, *Isotoma axillaris* should be vernalized at 41°F for six weeks and forced under long-day photoperiods. We have found that vernalization temperatures below 40°F are injurious to *isotoma* plugs and that temperatures as high as 55°F can be effective.

Producing Plants With Dual Flower Induction Requirements

Perennials discussed in this article have both vernalization and long-day requirements for flowering. Some plants in this category should first be grown to an adequate size ("bulked") prior to cooling. The effect of photoperiod during bulking is species specific. For example, we successfully bulked *Campanula punctata* 'Cherry Bells' under short days prior to cooling. However, *Astilbe chinensis* 'Pumila' plants bulked under a nine-hour photoperiod became dormant, with ces-

sation of growth and loss of leaves. This dormancy ended only after cooling.

We have vernalized many perennials under a nine-hour photoperiod at 41°F. We have often seen that many perennials that go dormant under short days also show browning or loss of leaves in the cooler. However, as in the case of *Astilbe chinensis* 'Pumila', the roots and crown survive during the cooling and flourish later during the force. We have also compared the effect of cooling *Coreopsis grandiflora* 'Sunray' under short days and long days at 41°F. In this cultivar, the photoperiod during cooling did not affect the subsequent flowering response.

The best compromise temperature for vernalizing plugs and young herbaceous perennial plants is 41°F. Lower temperatures can injure some plants on occasion and higher temperatures may not always be as effective. Still, temperatures up to 55°F can be effective for vernalizing select perennials, including *Isotoma axillaris*. GG

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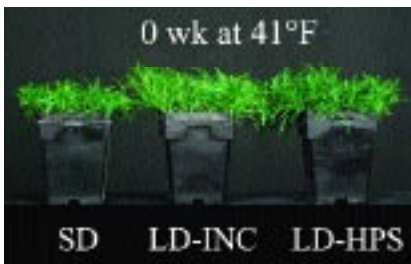


Figure 3A: *Isotoma axillaris* did not flower under any photoperiod without vernalization.

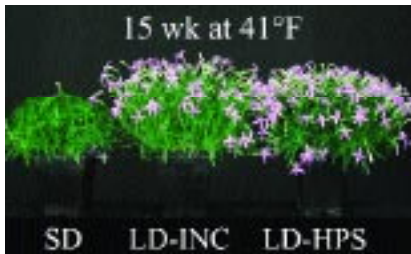


Figure 3B: Following vernalization, *isotoma* flowered poorly under short days, but readily under long-day photoperiods. Increasing light levels further improved flowering performance.



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