Forcing Herbaceous Perennials to Flower after Storage Outdoors under a Thermoblanket

Jeffery K. Iles[1] and
Nancy H. Agnew[2]

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Summary. Nine herbaceous perennial species were evaluated for use as flowering potted plants for late winter and early spring sales. Plugs of 'King Edward' *Achillea* × *Lewisii* Ingw. (yarrow), *Arabis sturii* Mottet. (rock-cress), 'Alba' *Armeria maritima* (Mill.) Willd. (common thrift), 'New Hybrid' *Bergenia cordifolia* (Haw.) Sternb. (bergenia), *Chrysogonum virgianum* L. (goldenstar), 'War Bonnet' *Dianthus* × *Allwoodii* Hort. Allw. (Allwood pinks), *Phlox* × *chattahoochee* L. (Chattahoochee phlox), 'Sentimental Blue' *Platycodon grandiflorus* (Jacq.) A. DC. (balloonflower), and *Veronica* L. × 'Sunny Border Blue' (veronica) were established in 14-cm (0.8-liter) round plastic containers, grown for one season and covered with a thermoblanket for winter. Five plants of each species were transferred to a 21 ± 3C glasshouse for forcing under natural daylengths at six 10-day intervals beginning 1 Dec. 1993. *Arabis sturii*, *Phlox* × *chattahoochee*, *Platycodon grandiflorus* 'Sentimental Blue', and *Veronica* × 'Sunny Border Blue' flowered out of season without supplemental lighting. 'Alba' *Armeria maritima* and *Chrysogonum virginianum* also flowered; however,

[1]*Assistant professor, Department of Horticulture, Iowa State University, Ames, IA 50011.*

[2]*Associate professor, Department of Horticulture, Iowa State Unversity, Ames, IA 50011.*

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their floral displays were less effective. 'New Hybrid' *Bergenia cordifolia* did not flower and 'King Edward' *Achillea* x *Lewisii* and 'War Bonnet' *Dianthus* x *Allwoodii* only flowered sporadically, therefore, these perennials are not recommended for forcing out of season using our vernalization method.

Retail greenhouse and garden center managers, particularly those located in cold climates, are continually searching for ways to expand the selling season. Toward this end, researchers have evaluated many hardy herbaceous perennials as out-of-season flowering potted plants for late winter and early spring sales (Armitage, 1993).

In the landscape, seasonal changes in temperature and photoperiod provide herbaceous perennials with the necessary cues to break dormancy and to flower. Forcing container-grown perennials to flower out of season requires that growers imitate specific environmental conditions required by each species to complete its natural growth and development (Iversen and Weiler, 1994). Some species, such as *Paeonia officinalis* (Byrne, 1989), 'Gloriosa' *Liatris spicata* (Waithaka and Wanjao, 1983), *Astilbe* × *arendsii* (Beattie and Holcomb, 1983), *Aquilegia* × *hybrida* (Shedron and Weiler, 1982a), *and Aurinia saxatilis (Shedron* and Weiler, 1982 b), must be exposed to a critical range of low temperatures for a specific time to induce growth and flowering. However, other plants, such as 'Moonbeam' *Coreopsis verticillata, Lysimachia clethroides,* 'Fairy's Petticoat' *Phlox paniculata,* and 'Taplow Blue' *Echinopsritro,* require long days (at least 16 h) for rapid and uniform inflorescence development (Iversen and Weiler, 1994).

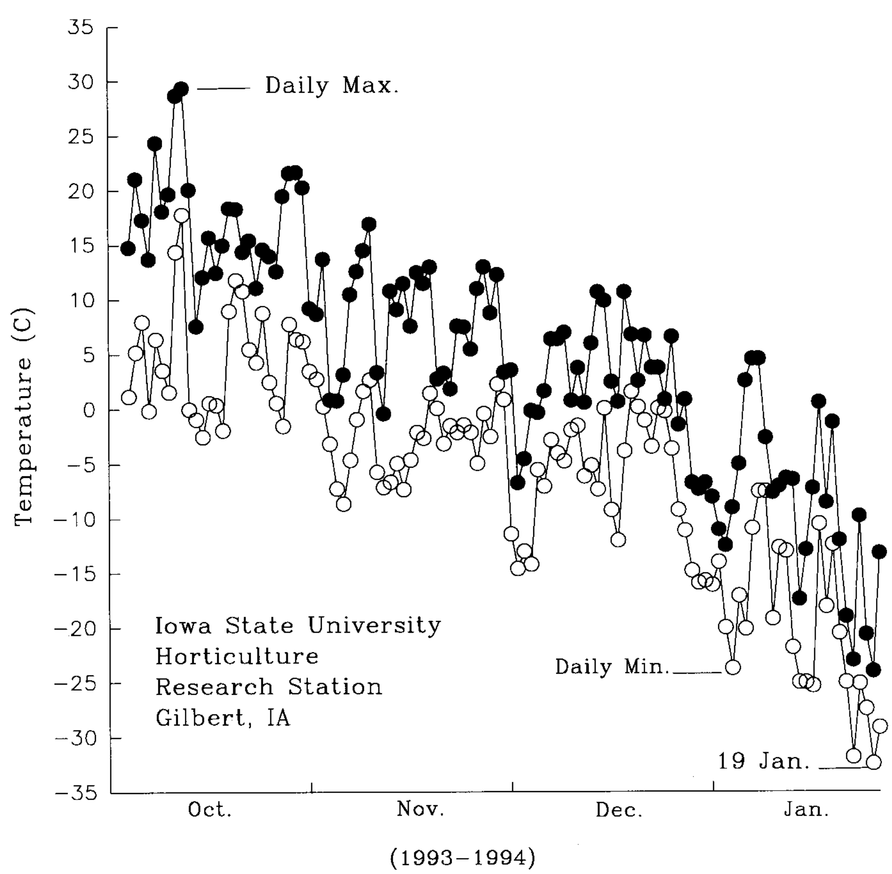
Based on recommendations from existing data, growers and retailers wishing to increase sales by forcing herbaceous perennials to flower out of season must have access to a facility that permits precise control of temperature and photoperiod. Unfortunately, many small-scale perennial growers and retailers do not have the capacity for such stringent environmental control. Therefore, the purpose of this study was to investigate forcing container-grown herbaceous perennials to flower in a glasshouse under natural daylength after winter storage outdoors beneath an insulating thermoblanket.

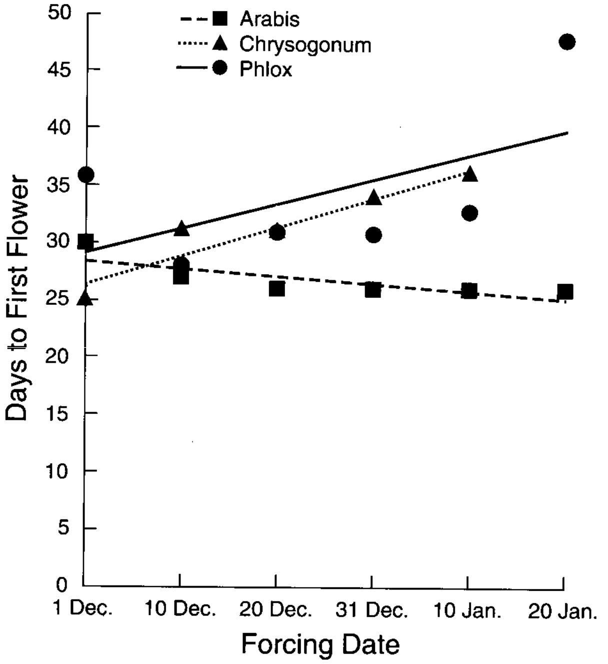
Materials and methods

Plugs (3.2 cm wide x 5.1 cm deep) of 'King Edward' *Achillea* × *Lewisii, Arabis sturii,* 'Alba' *Armeria maritima,* 'New Hybrid' *Bergenia cordifolia, Chrysogonum virginianum,* 'War Bonnet' *Dianthus* × *Allwoodii, Phlox* × *chattahoochee,* 'Sentimental Blue' *Platycodon grandiflorus,* and *Veronica* × 'Sunny Border Blue' were planted on 10 Apr. 1993 in 0.8-liter (14-cm) round plastic containers using a medium of 2 Canadian sphagnum peat: 2 perlite :1 sandy-loam soil (by volume) amended with ground calcitic limestone (pH 6.5). On 20 May, plants were transferred to hoophouses covered with woven black polypropylene shade fabric (20% radiation exclusion). Shade fabric was removed 1 Oct. 1993. Each plant received 5 g of 17N–2.6P–10K Sierra fertilizer plus micronutrients (17-6-12) (The Scotts Co., Marietta, Ga.) and was irrigated as needed.

On 20 Nov. 1993, plants were randomized, placed pot to pot, and covered with a bonded 4-mil white polyethylene–microfoam 0.6-cm thermoblanket (Ametek, Wurtland, Ky.), which was pulled tightly over the plants and secured with landscape timbers. Every 10 days beginning 1 Dec. 1993 and ending 20 Jan. 1994, five plants of each species were chosen randomly from beneath the overwintering cover and transferred to a 21 ± 3C glass-glazed greenhouse for forcing under natural daylength (lat. 42°3'N). Plants in each treatment (forcing date) were randomized in separate blocks on benches and fertilized weekly with 200 ppm N from a 21N–2.2P–16.6K Excel al-purpose water-soluble fertilizer (21-5–20) (The Scotts Co.). Days to first flower, days of flowering (from first open flower to wilting of last flower), flower number (number of racemes for *Veronica* and individual flower heads for *Armeria),* and plant height at first open flower were recorded for each species. Spent flowers were removed from plants as data were recorded. Data were subjected to analy-

Fig. 1. *Maximum and minimum daily ambient air temperatures from 30 Sept. 1993 to 20 Jan. 1994 recorded at the Iowa State Univ. Horticulture Research Station, Gilbert.*





2. *Relationship between days to first flower and forcing date. For each data point, n = 5. Regression equations and r values are as follows:*

*Arabis: y = 28.3 + 0.06x r = 0.78**

*Chrysogonum: y = 26.4 + 0.24x r = 0.94**

*Phlox: y = 28.9+ 0.22x r = 0.59**

P 0.05.

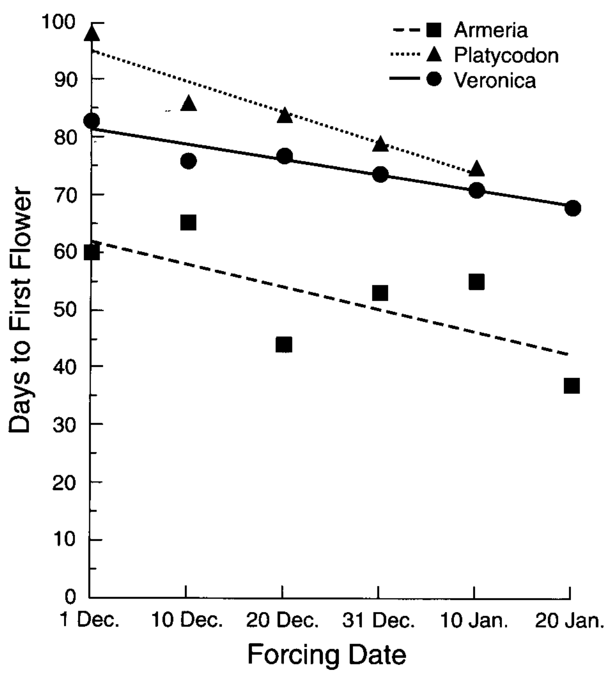
Fig. 3. *Relationship between days to first flower and forcing date. For each data point, n= 5. Regression equations and r values are as follows:*

*Armeria: y = 62.2 + 0.40x r = 0.71**

*Platycodon: y = 95.3+ 0.54x r= 0.95**

*Veronica: y = 81 + 0.26x r= 0.94**

**P 0.05.*



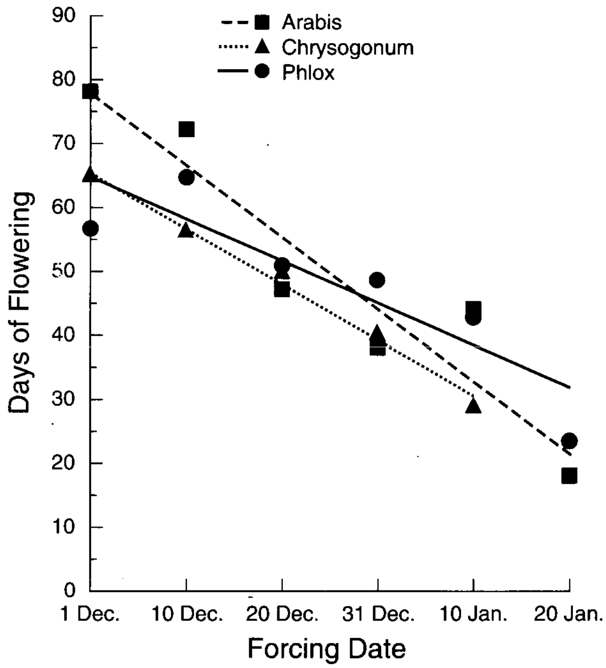


Fig. 4. *Relationship between days of flowering and forcing date. For each data point, n = 5. Regression equations and r values are as follows:*

*Arabis: y = 77.9+ 1.13x r = 0.94**

*Chrysogonum: y = 65.9+ 0.90x r = 0. 99**

Phlox: y = 65+ 0.70x r = 0.89’

**P < 0.05.*

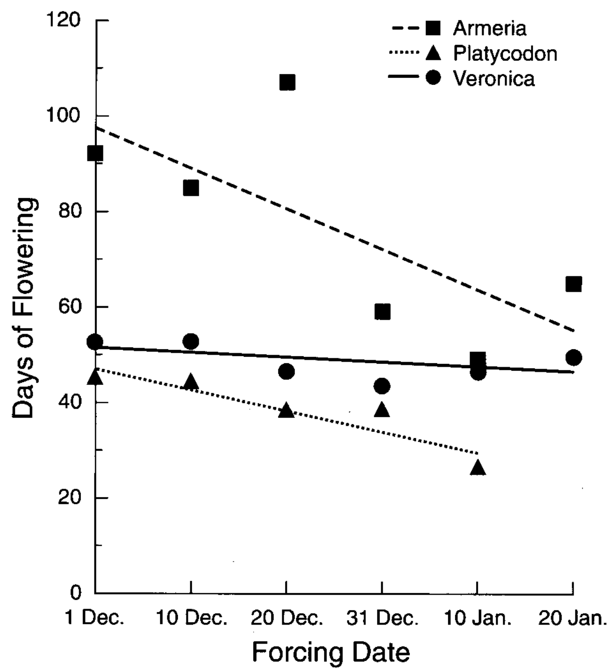
Fig. 5. *Relationship between days of flowering and forcing date. For each data point, n. 5. Regression equations and r values are as follows:*

*Armeria: y = 97.5 + 0.84x r = 0.70**

*Platycodon: y = 47 + 0.44x r . 0.93**

Veronica: y = 51.6+ 0.10X r =0. 51^{NS}

*^{NS},*Nonsiflnificant or significant at P 0.05, respectively.*



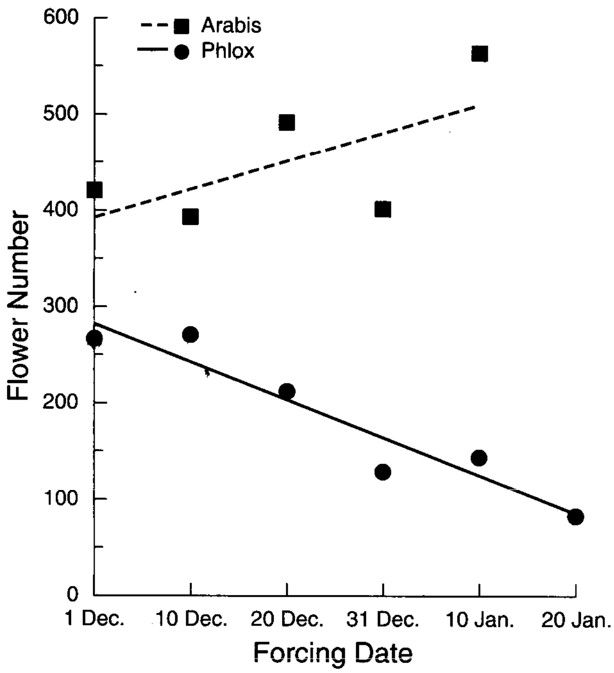


Fig. 6. *Relationship between floweR number and forcing date. For each data point, n. 5. Regression equations and r values are as follows:*

*Arabis: y = 394 + 2.99x r= 0.65**

*Phlox: y= 284+ 4.0xr = 0. 96**

**P 0.05.*

sis of variance procedures and regression analysis.

Results and discussion

Growers that force herbaceous perennials to initiate and develop flowers for early spring sales must be cognizant of the natural flowering tendencies of their crop and then provide the requisite environmental cues. Low temperature, photoperiod, and light quality play important roles in flower initiation. Results from this study are largely attributed to the effects of low temperature; however, longer photoperiods present at the later forcing dates must be considered when interpreting these data.

By the first forcing treatment (1 Dec.), perennials beneath the thermoblanket had experienced about 4 weeks of temperatures below 5C (Fig. 1). Very low ambient temperatures (below–25C) occurring near the completion of the study were probably responsible for the death of *Chrysogonum* and *Platycodon* and for the poor performance of *Arabis* and *Phlox* in the last forcing date treatment (20 Jan.). Ambient temperatures below –25C can result in potentially injurious root-zone temperatures (below –10C), even under thermoblankets (Iles et al., 1993).

Relationships between days to first flower and forcing date were negative and linear for *Arabis* (Fig, 2), *Armeria*, *Platycodon*, and *Veronica* (Fig, 3). This trend was especially noteworthy for *Platycodon,* as days to first flower decreased. by 23 days between the 1 Dec. and 10 Jan. forcing date. Low temperatures occurring beneath the overwintering cover may have injured *Chrysogonum* and *Phlox* and may have been responsible for the significant increase in days to first flower over the course of the study (Fig. 2).

The relationship between days of flowering and forcing date were negative and linear for all species except *Veronica* (Figs. 4 and 5). Days of flowering for *Arabis*, *Armeria*, and *Phlox* decreased 60, 27, and 33 days, respectively, from the 1 Dec. to the 20 Jan. forcing date. Days of flowering for Chrysogonum and Platycodon decreased 36 and 19 days, respectively, from 1 Dec. to 10 Jan. No significant change in flower number was observed with respect to forcing date for *Armeria* and *Veronica* but a significant decrease was noted for *Chrysogonum* and *Phlox* (Figs. 6 and 7). For *Arabis* and *Platycodon*, fewer days of flowering did not result in lower flower numbers. In fact, flower number increased for *Arabis* and *Platycodon* resulting in a more impressive floral display over a shorter period of time. Because *Arabis* suffered low-temperature injury by the 20 Jan. forcing date, flower number data ii-em that treatment were dropped from the analysis.

Changes in plant height relative to forcing date were significant only for *Platycodon* (data not shown). Increasing exposure to low temperature or longer photoperiods increased stem length for *Platycodon* forced in the later treatments. Increased stem length is not always desirable when forcing herbaceous perennials, but, in this study, longer erect stems improved the visual quality of this species.

Achillea and *Dianthus* survived the outdoor vernalization treatment and regrew vegetatively inside the glasshouse, but flowers developed sporadically. *Bergenia* displayed handsome foliage, but failed to flower regardless of forcing date. Sporadic, sparse, or the complete absence of flowering suggests a requirement by these species of longer photoperiods for flower initiation and development.

Fig. 7. *Relationship between flower number and forcing date. For each data point,* n = 5. *Regression equations and r values are as follows:*

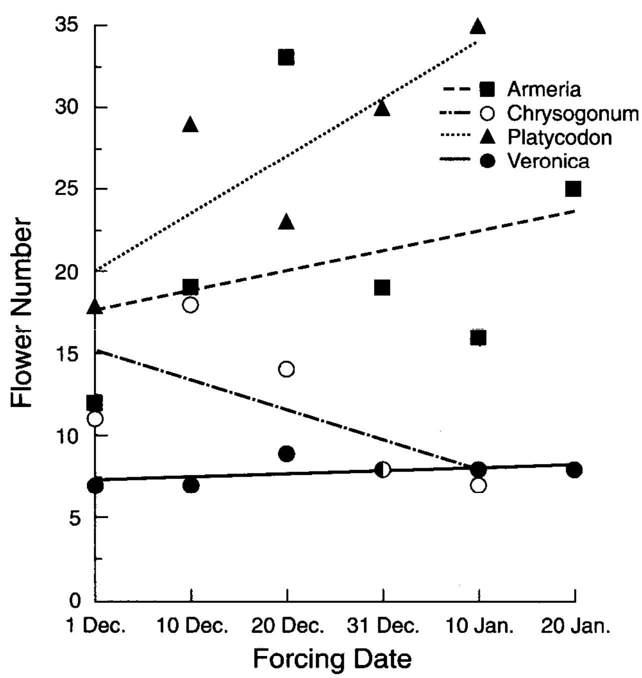
Armeria:y = 17.9 + 0.11x r = 0.29[NS]

*Cbrysogonum: y = 15+ 0.17x r= 0.60**

Platycodon: y = 20.3 + 0.34x r = 0.83*

Veronica: y= 7.43+ 0.02x r = 0.35[NS]

[NS],**Nonsignificant or significant at* P 0.05, *respectively.*



Herbaceous perennials are a diverse and variable group of landscape plants, and providing general guidelines for inducing out-of-season flowering is difficult. Iversen and Weiler (1994) stated that early spring-flowering plants that require cold but lack a daylength requirement should be forced in the glasshouse after receiving 12 weeks of cold. In this study, several perennials were forced to flower out of season under natural daylengths with < 12 weeks of cold.

Perennials recommended for forcing. Compact and uniform habit, attractive foliage, and abundant white flowers qualifies *Arabis sturii* for serious consideration as a flowering potted plant for late winter and early spring sales. Providing at least 7 weeks of cold (temperatures below 5C) improved plant quality by synchronizing fiord development over a condensed period.

Phlox × chattahoochee produced an abundance of fragrant pale purple flowers when forced in the glasshouse. And, like *Armeria* and *Chrysogonum, Phlox × chattahoochee* is capable of flowering after only 4 weeks ‘of cold.

Results from this study indicate that ‘Sentimental Blue’ *Platycodon grandiflorus* can produce its blue, balloon-like flowers under natural daylengths, but requires at least 8 weeks of cold for the development of acceptable plant height and flower number.

For *Veronica* × ‘Sunny Border Blue’, increasing exposure to cold reduced days to first flower but had no significant effect on days of flowering, number of racemes produced, or plant height. By providing about 4 to 6 weeks of cold, growers can force several crops of *Veronica* × ‘Sunny Border Blue’ to flower at intervals throughout the winter without reducing plant quality. The violet-blue racemes are a determinate inflorescence and are most ornamental as flowering proceeds past the midpoint of the raceme. Unfortunately, as the most distal portion of the in florescence is flowering, flowers at the proximal end wither and die, detracting from the plant’s appearance.

Perennials recommended, with reservation, for forcing. ‘Alba’ *Armeria maritima* was success filly induced to flower over a wide range of forcing dates without reducing flower number or plant quality. Unfortunately, ‘Alba’ flowers discolor quickly and detract from the overall appearance of the plant.

Chrysogonum virginianum is best forced in early winter (after 4 to 6 weeks of cold) to capitalize on its ability to flower after a modest cold treatment and to avoid injurious midwinter low temperatures. Results from this study suggest *C. virgnianum* may have limited use as a flowering potted plant because only four to five flowers are open and effective at a time, and many of those are hidden by foliage frequently disfigured by powdery mildew, which is encouraged by the forcing environment.

Perennials not recommended for forcing. ‘New Hybrid’ *Bergenia cordifolia* did not flower and ‘King Edward’ *Achilles × Lewisii* and ‘War Bonnet’ *Dianthus × Allwoodii* flowered only sporadically. Therefore, these perennials are not recommended for forcing out of season using our vernalization method.

Thermoblankets are useful insulating covers for protecting hardy perennial species from low-temperature injury (Iles et al., 1993). Chrysogonum and *Platycodon,* and to a lesser degree *Arabis* and *Phlox,* were injured by low temperatures in late January beneath these covers. These cold-sensitive species destined for forcing using ambient air for vernalization will require added protection from cold in regions where minimum temperatures routinely fall below -25C.

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