– Crop By Crop –

FORCING PERENNIALS

Species: *Lavandula angustifolia*
Common Name: Lavender

Figure 1. *Lavandula angustifolia* makes a terrific flowering potted plant.

by ***CATHERINE WHITMAN, ROYAL HEINS, ART CAMERON,*** *and* ***WILL CARLSON***

NATIVE to the Mediterranean region, lavender is grown both for its aromatic oil, which is used in perfumes, and as an ornamental for its purple flowers and attractive grey-green foliage (Figure 1).

In North America, lavender is hardy in USDA zones 5-9, and is popular in rock gardens or flower borders. Both the foliage and flowers are fragrant, with the flowers often being dried and used in potpourri. Since demand for both herbaceous perennials and herbs has been growing recently, lavender can be marketed in either of these popular categories.

Lavender typically blooms in late June, so in spring when the majority of garden plants are sold, it normally isn't in flower. While the foliage is attractive, the presence of flowers makes lavender even more appealing, especially for impulse purchases.

Lavender could be marketed as a potted flowering plant that customers can subsequently plant outdoors and enjoy for many years. The flower buds and flowers remain attractive for several weeks so the plants have good shelf life.

At Michigan State University (MSU), we have been researching the flowering requirements of lavender to develop schedules for year-round forcing.

Many different species and cultivars of lavender exist. English lavender, *Lavandula angustifolia,* is the one most commonly cultivated in North America. Most of our experiments were done with the cultivar 'Munstead.' A few experiments included another seed-propagated *L. angustifolia* cultivar, 'Hidcote,' which has an attractive upright growth habit and dark purple flowers.

Flower Induction Requirements

Many annual bedding plants bloom when they reach a certain size. Adequate plant size is also necessary for flowering in perennials.

The requirement for size in perennials, however, interacts with other factors. Most perennials flower in response to specific environmental conditions like temperature or daylength. But many perennial plants must attain adequate size before they will respond to the environmental cues.

1. PLANT SIZE

For uniform and consistent flowering in 'Munstead' lavender, plants should be grown under natural photoperiods until they have at least 40-50 leaves (20-25 nodes) before the beginning of the cold treatment. With fewer leaves, uniformity, percentage of plants flowering, and flower number decrease.

In experiments on plants with 14-20 leaves (7-10 nodes), only 20% of the plants flowered and they only had one or two flowers per plant. This result compares with 100% flowering and 6-11 flowers per plant on those with 40-50 leaves (Figure 2). In our experience, plants from 128-cell trays had 18-24 leaves, and those from 50-cell trays had 36-50 leaves.

2. COLD TREATMENT

'Munstead' lavender requires exposure to a period of low temperatures for uniform and rapid flowering. Uncooled plants are very slow to flower and the flowering percentage is extremely low (Figure 2).

While 5 weeks of treatment at 40°F (5°C) promotes some flowering, at least 10 weeks of cold is recommended. Increasing the duration of cold treatment from 10 to 15 weeks has little influence on subsequent time to flower but may increase flowering percentage.

Plants can be overwintered as plugs or potted plants in a minimally heated greenhouse, or cooled in a 40°F cooler under lights. Coolers used for MSU research were lit for 9 hours per day with cool-white fluorescent lamps at approximately 50 footcandles.

Figure 2.

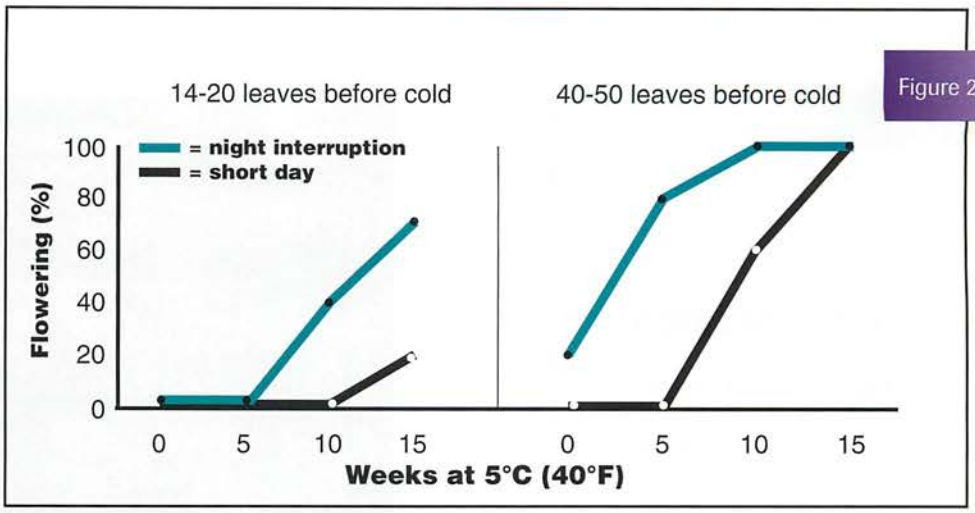

Figure 2. Influence of initial plant size and cold treatments on flowering percentage in lavender. The 14- to 20-leaf plants were from 128-cell trays, and the 40- to 50-leaf plants were from 50-cell trays. Cold treatments were given in a 40°F (5°C) cooler under cool-white fluorescent lamps. Plants were forced under either a 9-hour photoperiod or a 9-hour photoperiod with a 4-hour night interruption.

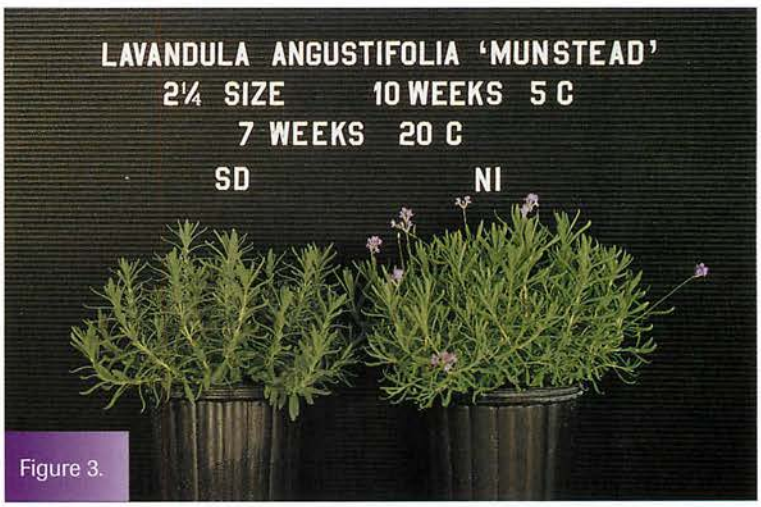

Figure 3. Influence of photoperiod on flowering of 'Munstead' lavender plants cooled for 10 weeks. Flowering percentages were approximately 50 under short days (SD), and 100 under night interruption (NI).

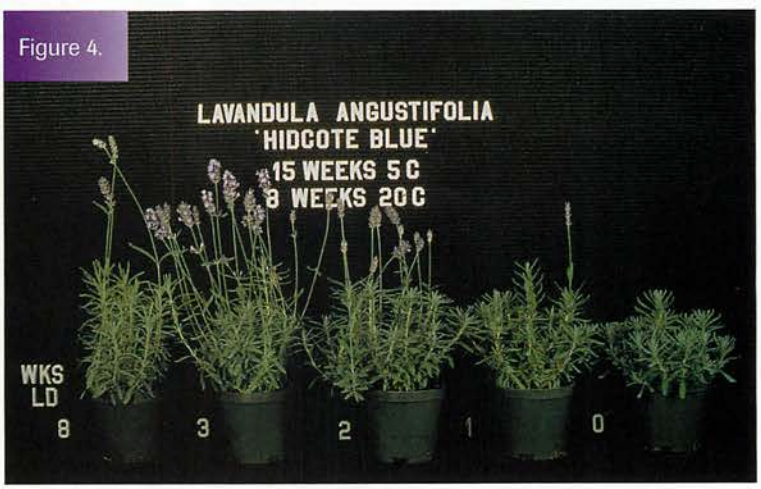

Figure 4. Influence of photoperiod on flowering of 'Hidcote' lavender plants cooled for 15 weeks. LD are required for flowering of this cultivar.

Figure 5. Effectiveness of growth retardants for height control of lavender 'Munstead.' This experiment was designed only to determine effective compounds, not to establish recommended rates.

3. PHOTOPERIOD

Once cold requirements have been met, 'Munstead' lavender plants will bloom under any photoperiod. However, long days (LD) can substitute for suboptimal cold treatment to some extent.

Flowering percentage in plants cooled for 10 weeks was increased when they were subsequently forced under night interruption (NI) long days compared to 9-hour short days (Figure 3).

If plants were cooled for 15 weeks, LD did not improve flowering. Therefore, plants that have been cooled for 15 weeks can be forced under natural daylengths.

If plants are cooled for fewer than 15 weeks, or overwintered in a greenhouse where temperatures periodically become quite warm, they should be forced under LD for most rapid and uniform flowering.

LD can be provided either by extending the daylength to 16 hours, or by night-break lighting for 4 hours from 10 p.m. to 2 a.m.

Incandescent, high-pressure sodium, cool-white fluorescent, and metal halide lamps have proven to be effective at a minimum light intensity of 10 footcandles. When using incandescent lamps, about 1.5 watts of lamp wattage per square foot of growing space is required. Lighting should be provided from the start of forcing until flower buds are visible.

There is an important difference in flowering requirements between 'Munstead' and 'Hidcote.' 'Hidcote' requires LD in order to flower uniformly – even after 15 weeks of cold treatment (Figure 4). Provide LD for at least 3 weeks from the start of forcing, or until flower buds are visible.

4. MEDIA

Lavender is susceptible to root rot, so the use of a sterile, well-drained medium is especially important. Avoid waterlogging. The pH should be maintained around 6.0.

5. LIGHTING AND SPACING

This plant is native to sunny regions, so plant quality will be best under high-light conditions. Provide full natural light intensity during late spring forcing. Supplemental lighting with 500 footcandles of light from high-pressure sodium lamps has greatly improved plant quality during

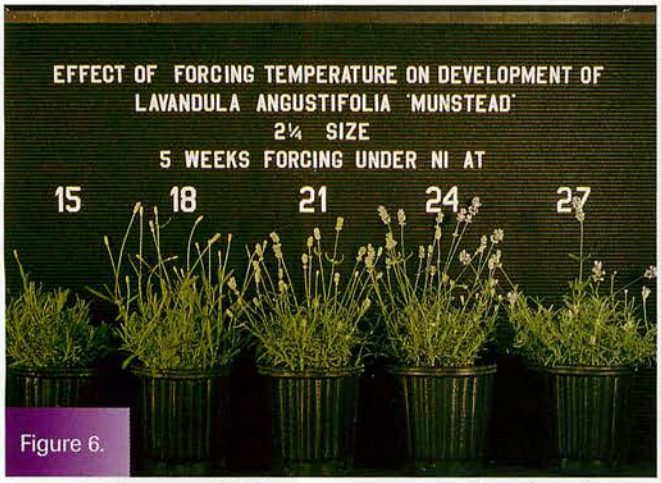

Figure 6. Influence of forcing temperature on flowering of lavender 'Munstead.' Production time from start of forcing to opening of first flower is approximately 10 weeks at 61°F (16°C), 8 weeks at 66°F (19°C), and 7 weeks at 70°F (21°C).

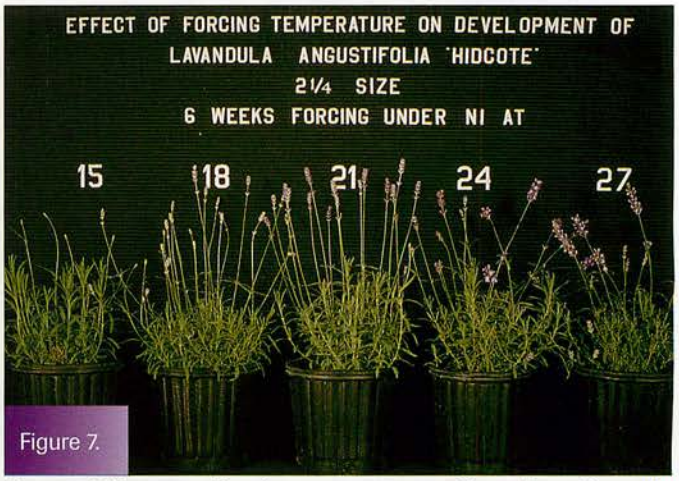

Figure 7. Influence of forcing temperature on flowering of lavender 'Hidcote' plants. Time to flower is similar to that of 'Munstead.'

winter and early spring forcing in Michigan.

Lavender is a relatively upright plant, so pots can be closely spaced.

6. FERTILIZATION

Lavender requires moderate levels of fertility. Constant fertilization at 100-150 ppm N from a balanced fertilizer is adequate.

7. IRRIGATION

Grow plants on the dry side, and allow the media to dry between irrigations. Lavender will tolerate drought more readily than excessive water.

8. PLANT HEIGHT CONTROL

Lavender plants are fairly compact and shrubby, but the stem of the inflorescence may elongate excessively. In growth regulator trials, A-Rest and Sumagic effectively controlled this elongation (Figure 5).

We have had good success using one or more applications of 5-10 ppm of Sumagic on 'Munstead' lavender. Begin applications when shoots begin to elongate – about 1 week before flower buds are visible.

Formula For Success:

1. Start with large plants – at least 40 leaves. The bigger, the better. Plants with 40-50 leaves can be grown in a 4-inch pot. Use larger plants, or more plugs, for larger pots.

2. Provide plenty of cold – a minimum of 10 weeks; 15 weeks is preferred.

3. To ensure successful flowering, provide long days until flower buds are visible. Long days can be provided either by extending the daylength to 16 hours, or by night-break lighting for 4 hours from 10 p.m. to 2 a.m.

4. Grow plants on the dry side.

5. To keep inflorescence more compact, begin applying growth retardants when shoot elongation begins – about 1 week before flower buds are visible.

9. TEMPERATURES AND CROP SCHEDULING

The time to flower depends on plant size and forcing temperature. Plants with 40-50 leaves and cooled for 15 weeks will reach the visible bud stage in about 5 weeks at average daily temperatures of 61°F (16°C), 4 weeks at 66°F (19°C), or 3 weeks at 70°F (21°C).

Once buds are visible, the first flowers generally open after 4-5 weeks. Total crop time is approximately 10 weeks at 61°F, 8 weeks at 66°F, and 7 weeks at 70°F (Table 1).

Lavender plants are compact, upright, and have more flowers when forced at temperatures at or below 65°F (Figures 6 and 7). Plants become floppy and weak and flowering percentage is reduced if forced at day and night temperatures above 73°F.

The lavender inflorescence flowers over a long period allowing a fairly wide window for shipping and marketing.

10. DISEASE AND INSECT PESTS

Rhizoctonia is the biggest disease problem we have encountered. It can cause plant mortality before, during, or after cold treatments. Preventive fungicide drenches for control of rhizoctonia are recommended. We have not observed any insect problems on lavender. **GG**

About the authors: Catherine Whitman is a former graduate student and Drs. Art Cameron, Royal Heins, and Will Carlson are professors in the Department of Horticulture, Michigan State University, East Lansing, MI 48824.

TABLE 1. ***Lavandula angustifolia*** **'Munstead' Production Schedule**

Growing Time	Cultural Practice	Temperature	Photoperiod
4-6 weeks	Chill seeds	36°-40°F (2°-4°C)	Any
2-3 weeks	Sow seeds ↓ Germination OR purchase plugs	65°-75°F (18°-24°C)	Natural daylengths
15-20 weeks	Grow until at least 40-50 leaves have formed	58°-70°F (14°-21°C)	Natural daylengths
10-15 weeks (Can be held longer if needed)	Cold treatment ↓	35°-45°F (1°-7°C)	Natural daylengths or 9 hours of light
	Begin Forcing		
↓ ↓ ↓ ↓ 61°F (16°C) 10 weeks flower	↓ ↓ 66°F (19°C) 8 weeks flower	↓ 70°F (21°C) 7 weeks flower	If cooled for <15 weeks, provide 16 hours of light or a 4-hour night interruption. If cooled for 15 weeks, force under natural daylengths (For 'Hidcote' provide LD regardless of duration of cold.)

– Crop By Crop –

FORCING PERENNIALS

Species: *Leucanthemum* x *superbum* 'Snowcap'
Common name: Shasta daisy

by ***ERIK S. RUNKLE, MEI YUAN, MARY-SLADE MORRISON, ROYAL D. HEINS, ARTHUR CAMERON,*** *and* ***WILL CARLSON***

SHASTA daisy has been a longtime favorite herbaceous perennial in landscapes. Blooming naturally in June and July, a planting in the foreground or midborder makes a nice mass of white with yellow highlights. Plants fare well in full sun and can tolerate some partial shade.

Shasta daisy is fully hardy to USDA zones 4 to 8 and can be grown in most of the U.S. According to University of Georgia's Allan Armitage, it is short-lived in Southern gardens, declining after 2-3 years. But it can persist for many years in Northern gardens.

A member of the sunflower family (Asteraceae), most cultivars have large white ray flowers encircling a raised center of tiny yellow disc flowers. Many selections have only one whirl of ray flowers. Some are semidouble, while others are fully double, and inflorescences are composed primarily of ray flowers.

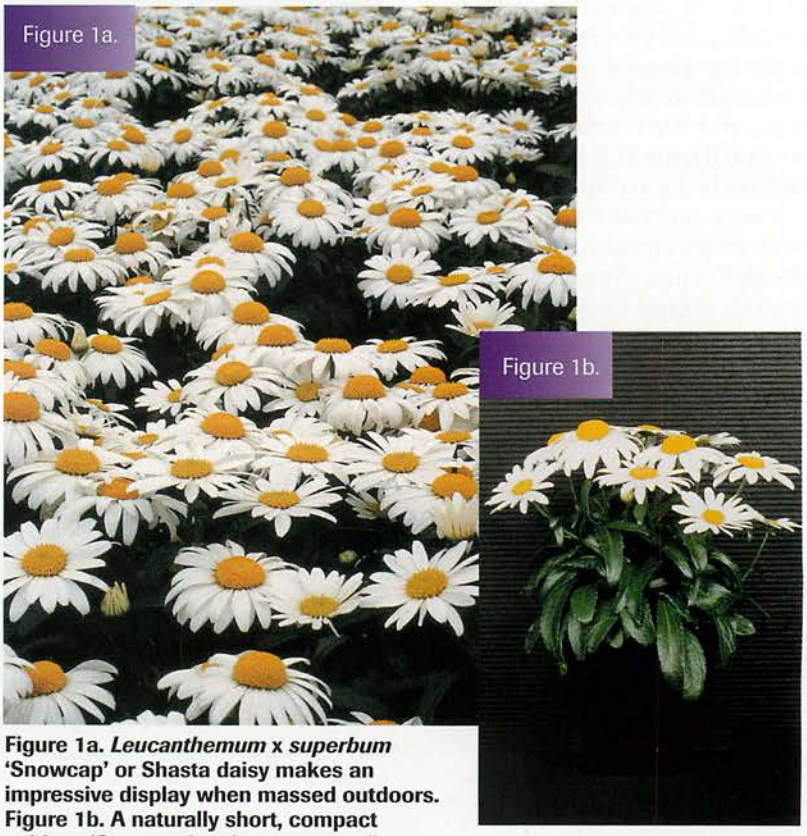

Figure 1a. *Leucanthemum* x *superbum* 'Snowcap' or Shasta daisy makes an impressive display when massed outdoors. Figure 1b. A naturally short, compact cultivar, 'Snowcap' makes an appealing flowering perennial in containers. *Photo 1b courtesy of Catherine Whitman.*

Species And Cultivars

Leucanthemum x *superbum*, sometimes listed as *Chrysanthemum* x *superbum* and *C. maximum*, is a cross between *L. lacustre* and *L. maximum* (*C. lacustre* and *C. maximum*). There are dozens of Shasta daisy cultivars with extremely variable characteristics.

In the garden, the compact cultivars are becoming quite popular since they range from a few inches to a few feet tall. Some of the more popular cultivars include 'Alaska,' 'Esther Read,' 'G. Marconi,' 'Snow Lady,' 'Snowcap,' and 'White Knight.'

One of the more desirable and attractive short cultivars is 'Snowcap' (Figure 1), an introduction by Adrian Bloom of Blooms of Bressingham, UK. Rising above thick, glossy foliage are 3-inch-wide white inflorescences that are rarely taller than 12 inches in the landscape.

Because of its naturally short

stature, 'Snowcap' makes an appealing container plant and is well-suited for flowering perennial production.

Although the environmental control of flowering is somewhat similar among Shasta daisy cultivars, our flowering recommendations apply only to 'Snowcap.' Some forcing comparisons among other cultivars are provided in Table 1.

1. Propagation

'Snowcap' is vegetatively propagated by tip cuttings, tissue culture, and division. Generally, mature plants are shipped in small containers or as bare-root divisions, but plugs are also available. Starting material, especially from tissue culture, is often more expensive than cultivars propagated from seed. But 'Snowcap' proved to be the most reliable, uniform, and trouble-free Shasta daisy we have studied.

2. Plant Size

Plants in $2^1/_4$-inch containers have 12-16 leaves (Figure 2) and are suitable for 5- to 6-inch finishing pots. Gallon cans also can be used for finished plants and are suggested for bare-root plants. If bulking is desired, provide noncooled plants with photoperiods 14 hours or less.

3. Cold Treatment

A cold treatment of at least 6 weeks at 35°-45°F (2°-7°C) increases flowering percentage, hastens time to flower, and increases flower number for 'Snowcap.' Complete flowering of a population is not achieved for noncooled plants under any photoperiod (Figure 3a) and is achieved after only 3 weeks of cold when plants are forced under a 4-hour night interruption (NI) long day (Figure 3b).

Longer durations of cooling don't hasten flowering when plants are forced under long days, but they accelerate flowering under short days. We have cooled plants for 15 weeks with no detrimental effects. Plants can be cold-treated

Figure 2. 'Snowcap' as a $2^1/_4$-inch plant.

in a cooler with 9-hour photoperiods and 25-50 footcandles of light or in a cold greenhouse with natural short photoperiods.

Figure 3a. 'Snowcap' requires a cold treatment for complete flowering. Without cold, only 60%-80% of plants flower under long days (LD, 9-hour photoperiods with a 4-hour night interruption) and no plants flower under 9-hour short days (SD).

Figure 3b. After 3 weeks or more of cooling at 41°F (5°C), all plants flower under LD, and those plants that flower under SD are significantly delayed.

4. Photoperiod

Photoperiod's effects on flowering Shasta daisy were first investigated in the 1930s. 'Snowcap' is an obligate long-day plant when plants are not cooled. Plants remain vegetative under photoperiods of 14 hours (Figure 4a).

To flower noncooled 'Snowcap,' use photoperiods of 16 hours or a 4-hour night interruption (NI) during the middle of the night – for example, 10 p.m. to 2 a.m. Because some plants do not flower without cooling, we recommend cold treating plants.

Following 6 weeks of cold treatment, all plants will flower, but plants flower most rapidly under long photoperiods (Figure 4b). In addition, plants under photoperiods of at least 16 hours or NI have three to five times as many flowers as those under shorter photoperiods.

We recommend forcing plants under at least 16 hours of light or with a 4-hour NI. Plants can be grown under continual light, 24 hours a day, for slightly earlier flowering – by about 5 days. Plant height above the pot increases nearly two-fold – from 5 to 9 inches (12-22 centimeters) – as the photoperiod increases from 10 to 24 hours.

Long days can be delivered as day-extension or as NI lighting under natural short-day photoperiods. For the most efficient lighting, extend the day length to 16 hours when photoperiods are longer than 12 hours. When day lengths are less than 12 hours, provide NI lighting for 4 hours. For all lighting strategies, provide a minimum of 10 footcandles at plant height from incandescent, cool-white fluorescent, metal halide, or high-pressure sodium lamps.

5. Media And Fertilization

'Snowcap' prefers a moist, well-drained medium with a slightly acidic to neutral pH: 5.8-6.8. A constant liquid fer-

tilization regimen of 100 to 150 ppm N, 10 to 20 ppm P, and 100 to 150 ppm K (for example, 20-10-20) is sufficient for growth and flowering. Plants were about $^1/_3$ smaller at low fertility (below 50 ppm N) concentrations (Figure 5).

6. Irrigation

Plants have thick, fleshy leaves and require relatively frequent irrigation, especially under high light levels. Fortunately, plants recover well from drought stress, but if the stress is prolonged, leaf margins will become necrotic. Plants forced at less than 60% container capacity were about half the size of plants that were never allowed to dry out. Plants flowered about $1^1/_2$ inches taller when frequently irrigated compared to plants forced at less than 60% container capacity.

Table 1. **Forcing comparisons for three cultivars of Shasta daisy**

	'Snowcap'	*'Snow Lady'*	*'White Knight'*
Propagation	tissue culture or division	seed	seed
Cold treatment	horticulturally required	not required, but flowering is more uniform with cooling	horticulturally required
Forcing with long days	beneficial (required without cold)	beneficial	beneficial
Time to flower at 68°F (20°C)	7 weeks	9-10 weeks	7-8 weeks
Sensitivity to pesticides	none observed	very sensitive	moderately sensitive
Final plant height under LD	7 inches (18 cm)	6 inches (15 cm)	6 inches (15 cm)

7. Lighting And Spacing

As with all Shasta daisies, 'Snowcap' prefers moderate to high light levels. Supplemental lighting is recommended during the winter, when light levels are naturally low. Under such conditions, provide 400-500 footcandles with high-pressure sodium or metal halide lamps for up to 16 hours daily. Plants can be spaced closely because they are naturally compact.

8. Plant Height Control

'Snowcap' is a naturally short, compact cultivar. Height control is not necessary. In containers, plants under photoperiods of 16 hours or NI rarely exceed 9 inches.

9. Temperatures And Crop Scheduling

Time to flower for cooled plants depends on the forcing temperature. At 61°F (16°C), plants take 9 weeks from the start of forcing to flowering. Forcing time is $7^1/_2$ weeks at 66°F (19°C), 7 weeks at 68°F (20°C), and 6 weeks at 73°F (23°C) (Table 2). Temperatures above 73°F accelerate flowering by no more than a few days and can cause a reduction in flower number and size.

For the highest flower count and largest flower size, force at cool temperatures (60°F). As the forcing temperature increases, flower count and flower size decrease. In addition, plant height increases from 4 inches to 8 inches as forcing temperature decreases from 73°F to 61°F. Cooled plants develop 19-20 or 21-22 nodes below the first inflorescence when forced under long or short days.

10. Disease And Insect Pests

Generally, 'Snowcap' has few diseases, but Pythium can be troublesome, especially when plants are overwatered early in forcing. A preventative fungicidal drench after transplanting is suggested. Occasionally, whiteflies, aphids, or thrips can be problematic.

Some other cultivars of Shasta daisy, such as 'Snow Lady' and 'White Knight,' are extremely sensitive to many insecticides, causing moderate to severe phytotoxicity. Symptoms include leaf and

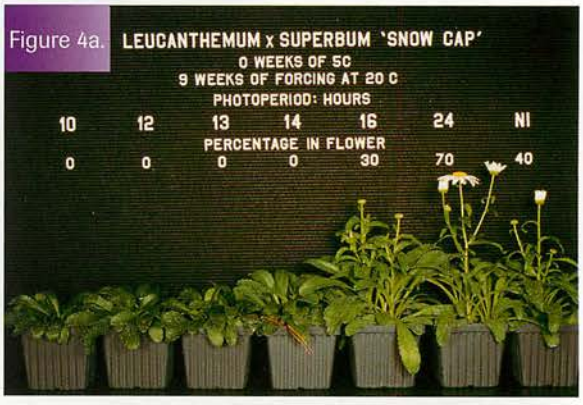

Figure 4a. Noncooled 'Snowcap' requires long days for flowering, but flowering percentage is never 100%.

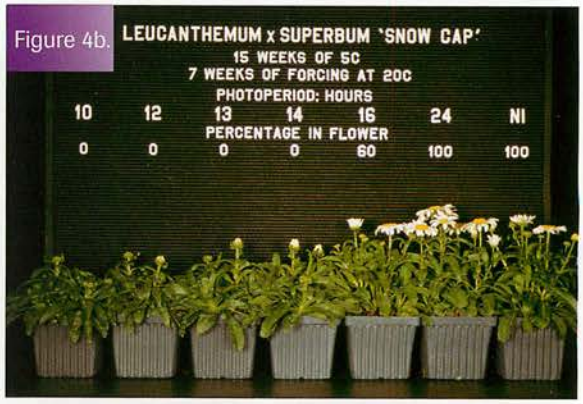

Figure 4b. 'Snowcap' cold-treated for 15 weeks at 5°C (41°F) flowers under all photoperiods of at least 16 hours or with NI. Flowering percentage represents the proportion of plants in flower at the time the photograph was taken.

Table 2. **Leucanthemum x superbum 'Snowcap' Production Schedule**

Growing time	Cultural practice	Temperature	Photoperiod
	Receive plants		
≥ 6 weeks	Cold treatment	35°-45°F (2°-7°C)	Natural daylength or 9 hours of light in cooler
Begin forcing			**≥16 hours or 4-hour night interruption**
↓ ↓ ↓ ↓ ↓ 61°F (16°C) Flower in 9 weeks	↓ ↓ 68°F (20°C) Flower in 7 weeks	↓ 73°F (23°C) Flower in 6 weeks	**Number of days from visible bud to flower** 61°F (16°C) - 34 days 68°F (20°C) - 25 days 73°F (23°C) - 22 days

flower burn, chlorosis, and widespread plant death in some instances. We have not noted any sensitivity in 'Snowcap.'

11. Postharvest Concerns

At moderate temperatures (68°F), the postharvest life of 'Snowcap' is roughly 2 weeks. Flower longevity increases with cool temperatures and decreases with warm temperatures. Ship plants just as the first flower opens, and subsequent flowers will open if adequate light is provided. Plants will continue to require frequent watering.

One negative aspect of 'Snowcap' is its odor, which some people find objectionable, especially when many plants are in a confined area. But all the other merits of this cultivar make it one of the most desirable, easy, and uniform Shasta daisy selections for flowering perennial production. **GG**

About the authors: Erik S. Runkle and Mary-Slade Morrison are graduate research assistants; Mei Yuan is a former research assistant; and Drs. Royal D. Heins, Arthur Cameron, and Will Carlson are professors, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Formula For Success: 'Snowcap'

1. Cool plants (plugs or small containers) for 6 weeks at 35°-45°F (2°-7°C).

2. Force plants at 61°-68°F (16°-20°C) and avoid temperatures above 73°F (23°C).

3. During forcing, provide long days by either extending the day length to 16 hours or providing a 4-hour night interruption.

4. For cultivars other than 'Snowcap,' beware of pesticide phytotoxicity.

5. Ship at first flower.

Figure 5.

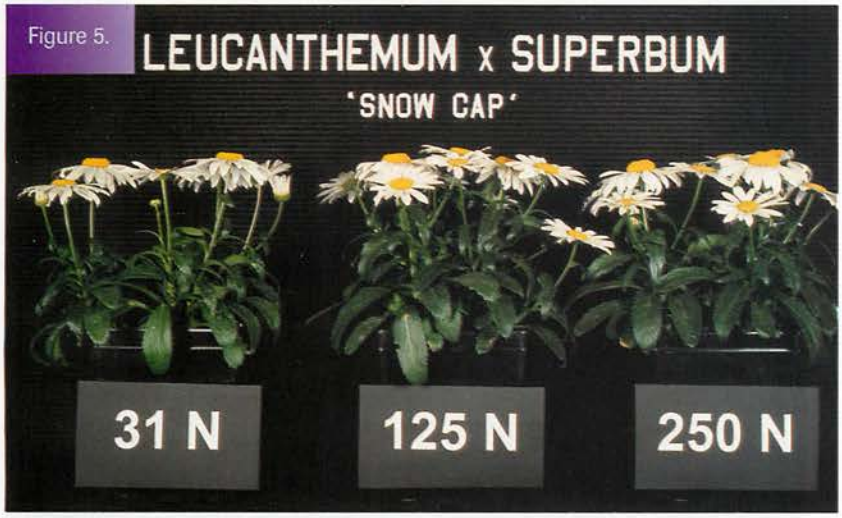

Figure 5. Flower number and plant size are greatest when 'Snowcap' is provided with a constant liquid fertilizer regimen of at least 100 to 150 ppm N, 10 to 20 ppm P, and 100 to 150 ppm K.

– Crop By Crop –

FORCING PERENNIALS

Species: *Lobelia* x *speciosa* 'Compliment Scarlet'
Common name: Lobelia

by ***ALISON FRANE, ERIK RUNKLE, ROYAL D. HEINS, WILL CARLSON,*** *and* ***ARTHUR CAMERON***

NAMED for the Flemish herbalist, Matthias de l'Obel, lobelias are sometimes placed in the Campanulaceae, or Bellflower family, and sometimes given their own family, the Lobeliaceae. The latter classification may seem more sensible to many, as their flowers are not at all bell-shaped.

These eye-catching perennials have long been popular in the garden for their color, (Figure 1) despite some cultural difficulties. They prefer a moist spot, but will not tolerate standing water. With adequate moisture and good drainage they enjoy full sun, but if planted in a drier spot, they need the protection of shade during the hottest part of the day. They are fully hardy, but short-lived, particularly in colder climates, where they must often be replaced after a few years.

Lobelia x*speciosa* has an interesting origin. As the "x" indicates, it is actually a hybrid between two lobelias, both native to North America. *Lobelia cardinalis*, a red-flowered species, and *L. syphilitica*, a blue-flowered species, interbreed to produce a variety of intermediate colored flowers in offspring.

The cultivar 'Compliment Scarlet' most resembles *L. cardinalis*, having particularly striking bright red flowers, produced on tall spikes (Figure 2). Other hybrid cultivars of these parents include: 'Dark Crusader,' 'Cherry Ripe,' 'Queen Victoria,' and 'Illumination.'

Our research has been conducted on *Lobelia* x*speciosa* 'Compliment Scarlet' and information provided here is only for this cultivar. While we expect other cultivars to respond

Figure 1.

Figure 1. Perennial lobelia hybrid in the garden.

similarly, we have found that cultivars often vary.

'Compliment Scarlet' requires long days to flower without cold, and benefits from long days after cold. While a cold treatment is not required if long photoperiods are given, a short cold treatment will improve vigor and uniformity.

1. Propagation

'Compliment Scarlet' is a seed-propagated cultivar that typically has 75%-80% germination. Because seed is very small, it is generally multi-sown, and left uncovered. Warm conditions 70°-75°F (21°-24°C) are best during the 10-14 days seedlings take to emerge. An additional 10 weeks are required to produce a 128-cell plug.

Formula For Success: 'Compliment Scarlet'

1. Provide at least 3 weeks of cooling at 35°-45°F (2°-7°C) for improved vigor and uniformity.

2. Grow under photoperiods of at least 14 hours, or night interruption.

3. Provide 400-500 footcandles supplemental lighting during low light periods.

4. Apply growth regulators as necessary to control height.

2. Plant Size

Plants with as few as 6-7 leaves, in 128-cell plugs responded to floral inductive treatments. Plants may be potted up in the fall to develop a larger plant before going into the cooler, if desired.

3. Cold Treatment

'Compliment Scarlet' flowered without a cold treatment when given long photoperiods. While cold did not affect flowering percentage or time-to-flower, 6 weeks at 41°F (5°C) improved vigor and uniformity in flowering time. More than 6 weeks of cooling provided no further increases in uniformity. When plants were forced under short days (photoperiods less than 14 hours) a cold treatment of at least 12 weeks was required to achieve flowering.

4. Photoperiod

Without cold, plants require at least 14-hour photoperiods for a significant percentage of plants to flower. Following cold, most plants will flower under any photoperiod, but flowering is delayed 10 to 14 days when daylength is less than 14-hours compared to longer days (Figures 3a, 3b). As with many perennials, a 4-hour night interruption from 10:00 to 2:00 will provide long days. Day extension or night interruption treatments should provide a minimum of 10 footcandles at plant level.

5. Media, Fertilization, And Irrigation

We have had good results in our ex-

Figure 2.

Figure 2. The rare color possessed by 'Compliment Scarlet' is guaranteed to stand out in the garden as well as at retail.

Figure 3a.

Figure 3a. Without a cold treatment, plants flowered poorly or not at all under photoperiods less than 14 hours.

periments using a high-porosity media with moderate nutrition. We use a fertilizer solution containing 100-150 ppm N, 10-20 ppm P, and 100-150 ppm K at every irrigation and keep the pH between 5.8-6.4.

6. Lighting And Spacing

Plants are more sturdy and attractive when grown under high-light conditions. Supplemental lighting from high-pressure sodium lamps at 400-500 footcandles may be beneficial when forcing under dark or cloudy conditions, which may occur during the winter. 'Compliment Scarlet' has a vertical growth habit, and may therefore, be spaced fairly closely (Figure 4).

7. Plant Height Control

'Compliment Scarlet' like many perennial lobelias, is a naturally tall plant. In the greenhouse, plants may reach more than 24 inches (60 centimeters), which is likely to be too tall for production in 5-inch pots. With this in mind, we screened growth regulators for effectiveness on this cultivar.

All growth retardants were effective in controlling stem elongation. At the rates used, Bonzi and Cycocel were moderately effective, A-Rest and B-9 were very effective, and Sumagic was the most effective growth retardant on this species. None of the growth regulator treatments caused a significant delay in flowering. The dosages and application frequencies used in our screen were rather high, and are not meant to be taken as recommendations, but rather as indicators of a growth retardant's effectiveness on this plant (Figure 5).

Figure 4.

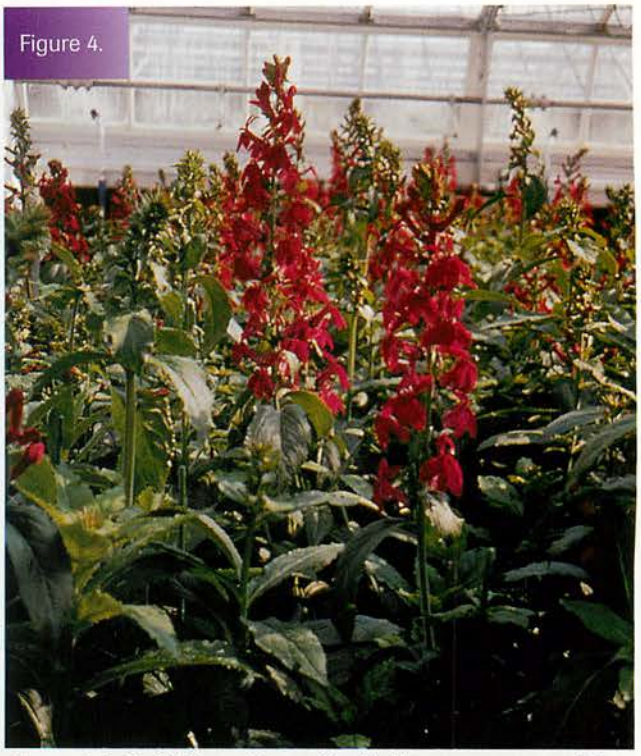

Figure 4. *Lobelia* 'Compliment Scarlet' has a narrow, upright habit, and can be spaced fairly closely. The bench-run plants shown here are in separate pots.

8. Temperatures And Crop Scheduling

Flower number was somewhat reduced as temperatures increased, although there were otherwise very few quality differences between treatments. Flower length and plant height varied little with temperature, from 59°F (15°C) to 80°F (27°C).

The number of days to flower, on the other hand, was strongly influenced by temperature. Plants bloomed in 39 days at 80°F (27°C), as compared to 85 days at 59°F (15°C).

9. Disease And Insect Pests

Pythium has been a problem, particularly when plants were in rosettes (for example, under short days or early in production). Water sparingly during the first few weeks of forcing until plants have become well-established in the pot. Regular application of fungicidal drenches will also help to control Pythium. Although we have had no significant problems with insect pests in our experiments, scouting and other preventative maintenance practices should always be followed.

Figure 3b.

Figure 3b. Even after 15 weeks of cold treatment at 35°-45°F (2°-7°C), flowering is more uniform and vigorous under photoperiods greater than 14 hours.

Table 1. **Lobelia xspeciosa 'Compliment Scarlet' Production Schedule**

Growing time	Cultural practice	Temperature	Photoperiod
14 days	Sow seeds	70°-75°F (21°-24°C)	Natural daylength or darkness
10 weeks	Grow on in plugs	~68°F (20°C)	Natural daylength
	-OR- ***Purchase plugs***		
3 weeks	Cold treatment	35°-45°F (2°-7°C)	Natural daylength or 9 hours of light in the cooler
	Begin forcing		
↓ ↓ ↓ ↓ ↓ ↓ 64°F (18°C) Flower in 77 days (11 weeks)	↓ ↓ 70°F (21°C) Flower in 54 days (8 weeks)	↓ 75°F (24°C) Flower in 51 days (7 weeks)	***Number of days from visible bud to flower*** 64°F (18°C) - 52 days 70°F (21°C) - 32 days 75°F (24°C) - 21 days

10. Postharvest Concerns

'Compliment Scarlet' should be sold at first flower, as spent blooms remain on the plant and are unsightly. Staking may be necessary to stabilize these tall plants during shipping if plants are grown under low-light conditions or growth regulators are not used. While they cannot be expected to "fill out" a pot because of their upright habit, if sold in flower their bright red blooms are guaranteed to attract attention. **GG**

Figure 5. **Growth Regulator Comparison On *Lobelia xspeciosa* 'Compliment Scarlet'**

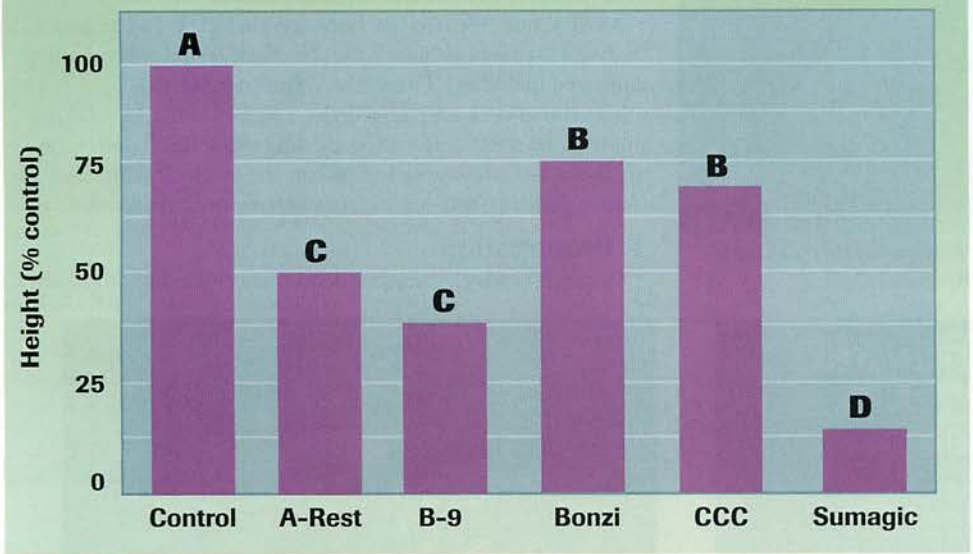

Figure 5. Final plant height relative to the control is shown. Bars with the same letter were not statistically different from each other. Growth regulators were applied three times, 10 days apart, at the following rates: 100 ppm A-Rest; 5000 ppm B-9; 30 ppm Bonzi; 1500 ppm CCC (Cycocel); 15 ppm Sumagic. The dosages and application frequencies used in our screens were rather high, and are not meant to be taken as recommendations, but rather as indicators of a growth retardant's effectiveness on this plant.

About the authors: Alison Frane and Erik Runkle are graduate research assistants, and Drs. Royal D. Heins, Will Carlson, and Arthur Cameron are professors, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

– Crop By Crop –

FORCING PERENNIALS

Figure 1. *Oenothera fruticosa* 'Youngii-lapsley' makes a beautiful potted flowering plant.

Species:
Oenothera fruticosa 'Youngii-lapsley'

Common Name:
Sundrops

THE genus *Oenothera* contains 124 herbaceous annual, biennial, and perennial species native to North and South America. In the early 1800s, many species of oenothera were collected and brought to England, where they became popular garden plants.

Commonly known as Sundrops, *O. fruticosa* (Figure 1) is a striking, day-flowering herbaceous perennial native to eastern North America. In the garden, these low-maintenance plants thrive in full sun, grow to a height of 1-2 feet (30-60 centimeters), and produce $1^1/_2$-inch flowers in June. They can tolerate partial shade, but in full shade, they tend to grow taller and produce fewer flowers.

Oenothera fruticosa is hardy to USDA zone 4. It has an obligate cold requirement and does not perform well in zone 9 or other areas where the chilling requirement is not met.

Most of our research has been conducted on *O. fruticosa* 'Youngii-lapsley,' although we also have tested several other cultivars, including 'Fireworks,' 'Summer Solstice' ('Sonnenwende'), and 'Highlight' ('Hoheslicht'). In catalogs, many *O. fruticosa* cultivars, including those listed above, often are listed as *O. tetragona* but, according to M. Griffiths' *Index of Garden Plants* (1994), are in fact cultivars of *O. fruticosa*.

1. Propagation

'Youngii-lapsley' and other oeno-thera clones are propagated

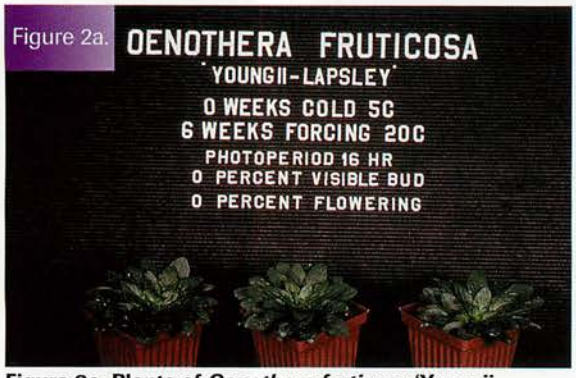

Figure 2a. Plants of *Oenothera fruticosa* 'Youngii-lapsley' will not flower without a cold treatment.

Figure 2b. 'Youngii-lapsley' requires a minimum of 3 weeks of cold treatment to flower.

Formula For Success: 'Youngii-lapsley'

1. Cool plants for at least 3 weeks at 35°-45°F (2°-7°C). Increase cold duration for slightly faster flowering and a higher flower count. We recommend 12-15 weeks.

2. Force 'Youngii-lapsley' at 63°-68°F (17°-20°C) for increased flower number and size and overall higher plant quality.

3. Provide a photoperiod ≤14 hours if plants are growing under low light or incandescent lamps are used for day extension. Flower timing will be slightly slower under shorter photoperiods but plants will be leafier and more floriferous. If intense light or high-pressure sodium lamps are available, a 16-hour photoperiod is acceptable.

4. Provide lots of supplemental lighting during winter.

5. Don't space too closely or plants will elongate excessively and produce few flowers.

commercially by shoot-tip cuttings or division. Approximately 4 weeks after plants flower, offsets produced from basal and root buds can be removed and rooted. In our experience, these offsets root quickly (1-2 weeks) and are immediately ready for cold treatment.

Nonclonal *O. fruticosa* can be propagated by seed, which is easy to germinate and does not require any special treatment to achieve rates of 70% or higher. Seed should not be covered during germination and does best when given bottom heat at 70°-80°F (21°-27°C).

2. Plant Size

In 72-cell trays, plants with an average of 18-19 leaves are suitable for finishing in a 5- or 6-inch pot. On a few occasions, we received small bare-root divisions that required bulking before they could be used to produce finished plants with high flower counts. Very small rosettes can perceive cold treatment and subsequently flower, but the plants will produce only a few flowers. Plants can be bulked in the fall under any daylength, since they will not flower until after a cold treatment.

3. Cold Treatment

A cold treatment of at least 3 weeks at 35°-45°F (2°-7°C) is required for complete flowering of 'Youngii-lapsley' (Figures 2a and 2b). With few exceptions, plants will not flower if they are grown at a consistent 68°F (20°C) without cold treatment. Increasing cold duration from 3 to 15 weeks hastens flowering by about 10 days and increases the number of flowering lateral shoots and the number of flowers.

Plant shape changes with increased cold duration. Plant height at first flower increases 3-5 inches as cold treatment duration increases. Height was maximized (16-21 inches) after 6 or 9 weeks of cold treatment at 41°F (5°C). The number of lateral shoots induced to flower increases with cold duration, giving the plants a fuller, stouter appearance. Plant height decreased slightly – 2-4 inches – as cold duration increased from 6 or 9 to 15 weeks. We recommend 12-15 weeks at 35°-45°F (2°-7°C) for maximum flower counts and more flowering laterals.

4. Photoperiod And Lighting

'Youngii-lapsley' is a facultative long-day plant, which means it will flower under any photoperiod, but it flowers fastest under longer ones. Flowering of 'Youngii-lapsley' occurred 2 weeks faster when plants were grown under a 24-hour photoperiod compared to a 10-hour photoperiod (Figures 3a and 3b).

Although plants flowered faster when grown under longer photoperiods, the number of flowering and vegetative lateral shoots decreased, drastically changing the plants' appearance. Photoperiods 16 hours or greater extended with incandescent lamps made plants spindly and inhibited flower production. Plants grown under photoperiods less than or equal to 16 hours were leafier and more floriferous.

Another disadvantage of longer photoperiods is increased height. Night-interruption lighting from 10 p.m. to 2 a.m. using incandescent lamps was effective for flowering 'Youngii-lapsley,' but plants grown under night-interruption were similar in appearance to those grown under a 16-hour photoperiod. Tall plants had few vegetative or flowering lateral shoots.

'Youngii-lapsley' responds strongly to the amount of light it receives. When 16-hour photoperiods are provided by using high-intensity lights,

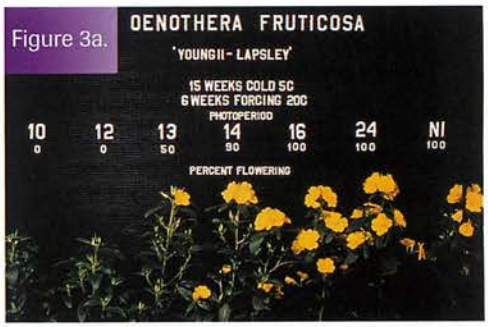

Figure 3a. Cold-treated 'Youngii- lapsley' plants flower under any photoperiod, but flower faster under longer ones. Flowering percentage refers to the proportion of plants with open flowers at the time the photograph was taken.

Figure 3b. 'Youngii-lapsley' plants grown under 10-hour photoperiods flower approximately 2 weeks later than plants grown under 24-hour photoperiods. In this photograph, plants grown under 16-hour, 24-hour, and night-interruption (NI) lighting already have finished flowering.

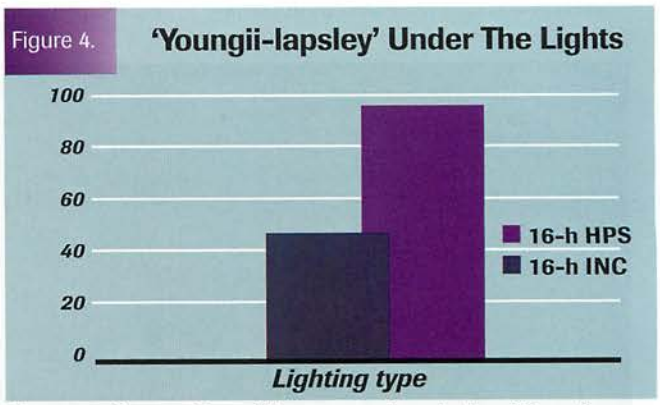

Figure 4. The number of flowers produced when 'Youngii-lapsley' plants are cooled for 15 weeks and grown under a 16-hour photoperiod delivered either by incandescent (INC) or high-pressure sodium (HPS) lamps

such as high-pressure sodium, plants produce many flowers and appear similar to those grown under a 10-hour photoperiod delivered by incandescent lamps. In one experiment, when plants were grown with about twice the amount of light than the control received (supplemented by high-pressure sodium), they produced about two times the number of flowers per plant (Figure 4).

The time to flower for plants grown under high-pressure sodium lamps was 6 weeks, which is approximately the same amount of time plants flowered under a 16-hour photoperiod delivered by incandescent lamps. Because 'Youngii-lapsley' is so responsive to light, we suggest using supplemental lighting from high-pressure sodium lamps at 400-500 footcandles in high latitudes where there is limited natural light during winter. We recommend photoperiods greater than or equal to 14 hours if plants are grown in lower light or if incandescent lamps are used for day-extension lighting. If high light or high-pressure sodium lamps are available, photoperiods of 16 hours are acceptable. 'Youngii-lapsley' may be a perennial best suited for forcing in light-intensive locations or during summer.

5. Media, Fertilization, And Irrigation

In our experiments, we have had good results with pH levels between 5.8 and 6.2. At every irrigation, we typically apply a fertilizer solution containing 100-150 ppm N, 10-20 ppm P, and 100-150 ppm K, which has been sufficient for 'Youngii-lapsley's' growth and development. The plants are quite drought tolerant and will withstand multiple occurrences of wilting without detriment.

6. Spacing

Because of their strong response to light, 'Youngii-lapsley' should not be spaced close together since plants placed on the interior receive less light and produce fewer flowers. A spacing of two 5-inch square pots per square foot produced high quality plants.

7. Plant Height Control

'Youngii-lapsley's' natural height, 13-21 inches (33-54 centimeters), is on the tall side for production in a 5-inch container. In a screen of five commercially available plant growth regulators, only Sumagic at 15 ppm reduced final plant height (Figure 5). Plants sprayed with Sumagic were 30% shorter than the control plants, but their flowers were significantly smaller. In addition, the length of the lateral stems was reduced so that plant shape changed from its natural conical form to cylindrical.

8. Temperatures And Crop Scheduling

Flowering time is greatly decreased as forcing temperature increases. Plants grown at 73°F (23°C) flowered in 4 weeks, while those grown at 64°F (18°C) flowered in 6 weeks (Table 1). When plants were grown at 59°F (15°C), time to flower was increased to $8^1/_2$ weeks. The number of flowers, plant height, and flower size increased with decreasing temperatures (Figures 6a and 6b).

Figure 5. The effect of various plant growth regulators (PGR) on 'Youngii-lapsley'. Although it appears that both B-nine and Sumagic effectively reduced height, only Sumagic's effect was statistically significant.

Plants grown at temperatures higher than 73°F (23°C) were spindly and less attractive. We suggest forcing temperatures between 64° and 68°F (18° and 20°C) to maximize the number and size of flowers while maintaining height control and limiting the finishing time.

9. Disease And Insect Pests

Uncooled plants grow as rosettes and are susceptible to Botrytis. When bulking uncooled plants, let the medium dry before rewatering and apply regular fungicidal drenches to control Botrytis. After a cold treatment, stems rapidly elongate and the rosette habit is lost. The lower leaves senesce and should be removed to prevent Botrytis. No other diseases were observed on 'Youngii-lapsley.'

The large, yellow flowers of 'Youngii-lapsley' were attractive to thrips. In some cases, crinkled petals may be an indication of thrip infestation early in floral development.

10. Postharvest Concerns

Figure 6a. Flowering of 'Youngii-lapsley' takes approximately $3^1/_2$ weeks for plants grown at 84°F (29°C) and $8^1/_2$ weeks at 57°F (14°C). Plant height and flower number increase at cooler temperatures.

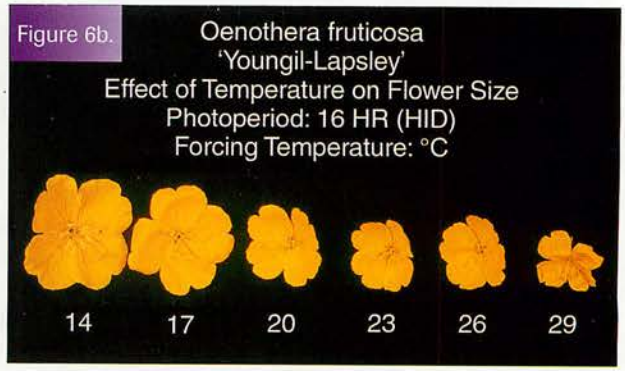

Figure 6b. Flower size of 'Youngii-lapsley' increases dramatically as temperature decreases. HID refers to photoperiod being delivered with high-intensity discharge, or high pressure sodium, lamps.

Table 1. *Oenothera fruticosa 'Youngii-lapsley' Production Schedule*

Growing time	Cultural practice	Temperature	Photoperiod
1-2 weeks	Root stem cuttings or basal offsets	70°F (21°C)	Natural daylength
6 weeks	For rooted stem cuttings, grow on in plugs (rooted offsets are ready for cold treatment)	63°-68°F (17°-20°C)	Natural daylength
≥ 3 weeks	Cold treatment	35-45°F (2°-7°C)	Natural daylength or 9 hours of light in cooler
↓ ↓ ↓ ↓ 64°F (18°C) Flower in 6 weeks	***Begin forcing*** ↓ ↓ 68°F (20°C) Flower in 5 weeks	↓ 73°F (23°C) Flower in 4 weeks (Note: This temperature is not recommended because fewer are produced.)	**These times to flower were observed when plants were grown at 16 hours using high-pressure sodium lamps for supplemental lighting.** **Growing plants at photoperiods <16 hours will increase days to flower 2-10 days** ***Number of days from visible bud to flower*** 64°F (18°C) - 19 days 68°F (20°C) - 16 days 73°F (23°C) - 13 days

Once the first flower opens, 'Youngii-lapsley' continues to bloom in the garden or greenhouse for approximately 4 weeks. In a preliminary postharvest screen, 'Youngii-lapsley' performed very well indoors. At room temperature and under fluorescent lighting, plants maintained a minimum of 20 open flowers a day for 10 days and at least 14 open flowers for 10 additional days. Plants should be shipped either just before or right after the first flower opens since individual flowers last only 3-4 days on the plant, and the abscised flowers make an unsightly mess.

11. *Oenothera fruticosa* Cultivars

The *O. fruticosa* cultivars that we tested flowered in 6 or 7 weeks (Table 2). Plant height and number of flowers per plant varied greatly among cultivars. Like 'Youngii-lapsley,' other cultivars were quite responsive to light – some more than others – and supplemental lighting during winter production (in low-light areas) is recommended for all cultivars.

'Youngii-lapsley' was the tallest cultivar, with an average height of 18 inches, but it also produced numerous large flowers. 'Fireworks' and *O. fruticosa* ssp. *glauca* are both naturally short (9 and 12 inches, respectively), but in one of our studies, ssp. *glauca* flowered 1 week earlier and produced many more flowers.

In a preliminary study, rooted shoot-tip cuttings of 'Fireworks' (cooled for 8 weeks and grown under a 16-hour photoperiod provided by high-pressure sodium lamps) produced plants that flowered in 6 weeks and had as many flowers as ssp. *glauca*. 'Summer Solstice' was relatively tall (16 inches), spindly, and produced few flowers even under intense light. 'Highlight' was impressive for its vast number of small flowers (about 500 per plant) produced under intense light, but it wasn't drought tolerant. **GG**

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Table 2. Flowering characteristics of several cultivars of *O. fruticosa* and *O. fruticosa* ssp. *glauca*

	'Youngii-lapsley'	'Fireworks'	'Summer Solstice'	'Highlight'	ssp. *glauca*
Time to flower at 68°F (20°C)	6 weeks	7 weeks	7 weeks	6 weeks	6 weeks
Plant height at first flower under 16 hours	18 inches (45cm)	9 inches (24cm)	16 inches (40cm)	14 inches (36cm)	12 inches (31cm)
Number of flowers per plant under intense light	100	20	60	500	150

Figure 1.

Figure 1. Foliage and flower spikes of purple fountain grass a striking in almost any gardening setting.

Cultivating Purple Fountain Grass

This perennial, which thrives in warm temperatures, dazzles in the garden.

by ***SHI-YING WANG, WILL CARLSON, HONGWEN GAO, ARTHUR CAMERON,*** *and* ***ROYAL D. HEINS***

THE genus *Pennisetum*, or fountain grass, includes more than 120 species of annual and perennial grasses. Pennisetum comes from the Latin *penna* (feather) and *seta* (bristle). Purple fountain grass, also known as purple-leafed or red fountain grass, is a horticultural selection from *Pennisetum setaceum*. It's a warm-season perennial grass and dies at 20°F (-7C°), making it an annual north of Zone 9.

The three purple fountain grass cultivars that are commercially available are 'Rubrum,' 'Cupreum,' and 'Atrosanguineum.' We have studied 'Rubrum' and 'Atrosan-guineum' and found most responses are similar for the two cultivars.

The bronze-purple leaves and reddish pink flower spikes are striking in almost any garden setting (Figure 1), and the plant makes a stunning centerpiece in a container (Figure 2). In the garden, its glossy foliage grows in upright, arching clumps 3-4 feet tall and just as wide. Leaves are $^1/_4$ -$^1/_2$ inch wide and 8-12 inches long. Its small flowers are grouped as arching spikes about 8-12 inches long and $^3/_4$ - 1 inch wide. The spikes change colors during development (Figure 4), adding to their attractiveness and value.

Propagation

Purple fountain grass doesn't produce viable seeds and must be propagated from cuttings or by division. Cutting propagation is generally not recommended for a number of reasons, including slow root and shoot development and complex propagation methods.

Commercial propagators can make divisions from garden plants as early as fall. Divisions can then be placed into a 50-cell tray and grown in a warm greenhouse. When plugs have 5-6 leaves, they can be shipped or transplanted into larger containers for forcing. After 8-9 weeks, plants grown in 6-inch pots at 70°F (21°C) will produce more than 30 tillers (Figure 4), each capable of starting a new plant if it's divided carefully and has at least one healthy root. Divisions made from actively growing plants will die if cut back too soon after transplanting.

Photoperiod, Cold Treatment, And Light

Purple fountain grass is a quantitative long-day plant (Figure 5) and doesn't require a cold treatment for flowering. When forced at 68°F (20°C), plants under a 14-hour or longer photoperiod flowered 4 weeks earlier than those with a photoperiod less than 13 hours.

Purple fountain grass prefers full sun. Plants grown under greenhouse conditions typically develop green to light purple leaves that turn bronze-purple after moving outdoors. Supplemental lighting from high-pressure sodium lamps at 400-500 footcandles for 8-14 hours each day can considerably improve plant quality in the greenhouse, especially during the winter months.

Media, Fertilization, And Irrigation

In the garden, purple fountain grass prefers a well-drained, moist, fertile loam, but grows well in average soil. It tolerates heavy, rocky, or sandy soil if water is available regularly. Avoid fertilizing if it is planted in well-prepared soil. Overfertilizing, especially with too much nitrogen, results in soft growth and causes floppy plants.

In the greenhouse, plants grow well with 100-150 ppm N, 10-20 ppm P_2O_5, and 100-150 ppm K_2O at each irrigation. Plants grown in a soil mixture of 5 parts loam, 2 parts peat, and 3 parts sand tolerated drought more than those

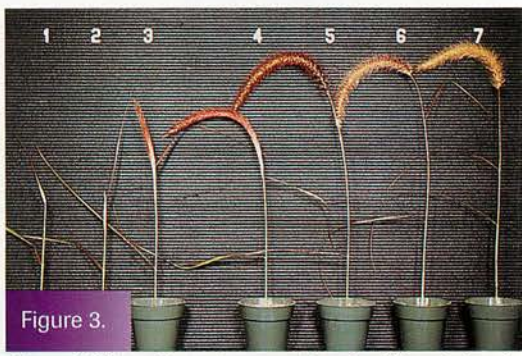

Figure 3.

Figure 3. The spikes change colors in different development stages. It takes about 2 weeks from the spike tip appearance (No. 2) to its full emergence (No. 3).

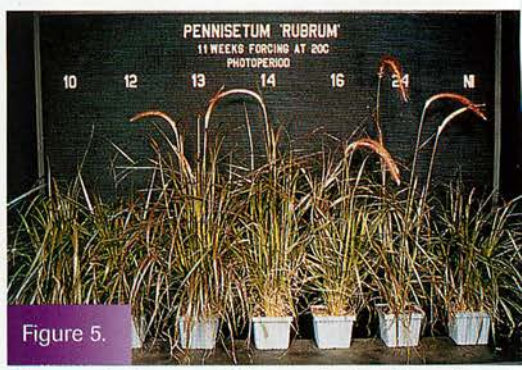

Figure 5.

Figure 5. Influence of photoperiod on flowering of purple fountain grass. NI means night interruption.

Figure 2. Purple fountain grass makes a stunning centerpiece in a container. *Photo courtesy of White Flower Farm.*

Figure 4. Plants grow fast in warm temperatures. Starting from a single tiller, a plant grown 8-9 weeks in a 6-inch pot at 70°F (21°C) with supplemental lights produces more than 30 tillers.

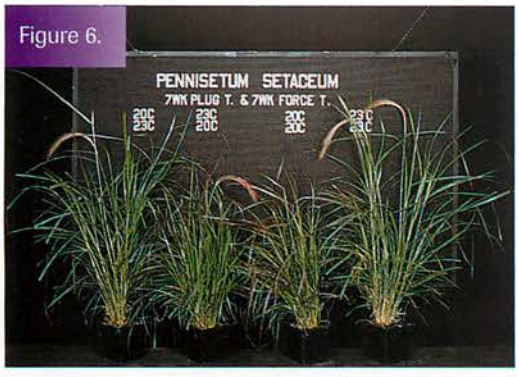

Figure 6. Using higher temperatures for plug production and lower temperatures for forcing will produce a compact finished plant with more tillers.

grown with a commercial soilless medium composed of horticultural sphagnum peat and perlite. But as long as the plant is well-watered, it grows well in peat-lite mixes.

Container Size

Purple fountain grass grows and forms tillers continuously when growing conditions are favorable. Plant size, especially shoot and spike number, can be limited by the container size (Table 1). To limit root competition with other species in a combination container, plant purple fountain grass in a smaller pot before making the combination planting.

Plant Height Control

Purple fountain grass is a naturally tall plant and is beautiful when used in the landscape. But in pots, short plants have the advantage. Cutting back after stem elongation decreases plant height, but this isn't an economical method for growers.

Treating with plant growth retardants such as Bonzi or A-Rest sprays of 50 ppm, Cycocel sprays of 6000 ppm, or Sumagic sprays of 40 ppm just before stem elongation reduces plant height effectively. Keep in mind these treatments may delay flowering.

Temperatures And Crop Scheduling

Although purple fountain grass grows fastest at temperatures between 80°-90°F (26°-32°C), plants can be successfully forced at lower temperatures. It takes about 10-12 weeks at 68°F (20°C) and a 14-hour photoperiod from the onset of forcing to the first appearance of an inflorescence (spike tip stage), and an additional 2 weeks from inflorescence appearance to its full emergence.

Using higher temperatures for plug production and lower temperatures for forcing will produce a compact finished plant with more tillers (Figure 6). Growing plugs at 74°F (23°C) with a 14-hour photoperiod for 5-6 weeks followed by forcing at 68°F (20°C) with natural photoperiod for 8-9 weeks will produce high-quality flowering plants.

Diseases And Insects

We have not observed any serious pests or problems with purple fountain grass. One symptom to look for is severe water stress, which causes lower leaf necrosis.

Postharvest Concerns

With warm conditions, new spikes continue to emerge from young shoots. But the spikelets (individual grass flowers) in old spikes will eventually detach and fall away. The plant's aesthetic appearance benefits from prompt removal of old spikes, which also can be harvested for dried flower arrangements.

Invasiveness Concerns

In northern zones 3-6, purple fountain grass is an annual and is killed if temperatures drop below 20°F. It won't survive winter unless kept in containers and taken inside during cold months. In zone 7 and above, purple fountain grass is not a running grass and won't spread by means of above-ground or underground stems.

Its inability to produce viable seeds also prevents purple fountain grass from becoming invasive. But keep in mind, it is a warm-season perennial grass and should be used with caution in these zones. **GG**

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Table 1. **Sizing Up Purple Fountain Grass**

Pot size	Plant height	Shoot No.	Spike No.	Spike length	Root dry weight	Shoot dry weight
4½ inch	37.0 inches	35	7	8.7 inches	13 grams	29 grams
6 inch	35.8 inches	53	8	9.4 inches	15 grams	34 grams
1 gallon	40.6 inches	92	19	9.8 inches	35 grams	79 grams

Table 1. Plant size of purple fountain grass is affected by its container size. Data shown here were collected after growing 16 weeks in a glass greenhouse at 70°F (21°C) and a 14-hour photoperiod with supplemental lighting from high-pressure sodium lamps at 400-500 footcandles.

– Crop By Crop –

FORCING PERENNIALS

Species: *Penstemon digitalis* 'Husker Red'
Common Name: Bearded Tongue

Figure 1. The red stems and red-tinged leaves contrast nicely with the bright white flowers of *Penstemon digitalis* 'Husker Red.'

THE Penstemon genus has more than 250 diverse species that include small woody shrubs as well as herbaceous perennials. Most are native to the western United States and Mexico and are excellent choices for gardeners in dry regions because the plants prefer alkaline soil, low humidity, and full sun.

For more than a century, gardeners in England have cultivated Penstemon hybrids (mostly derived from Mexican species) and have developed several that are more amenable to a wetter climate: *P. hartwegii, P. gentianoides, P. campanulatus,* and *P. isophyllus*. A Penstemon species native to the eastern half of North America, from Maine to Texas, that enjoys wetter climates is *P. digitalis*.

In 1976, a *P. digitalis* that was growing in a garden in Hardy, NE, had typical white flowers and red leaves and stems. From this plant, Dale Lindgren of the University of Nebraska-Lincoln collected seeds and selected deeper pigmentation. After two years of selection, a single seedling was chosen, propagated, and evaluated at several locations. This selection was named 'Husker Red' after the university's nickname and the color of the foliage. Its small white flowers with purple lines inside the throat of the corolla contrasts with its burgundy red leaves and stems to make an attractive show in the garden or in a pot (Figure 1).

1. Propagation

'Husker Red' does not come true from seed. Vegetative propagation is by stem cuttings, division, or tissue culture.

2. Plant Size

Juvenility was not a problem for *P. digitalis* 'Husker Red' flowering. All plants that we received in 72-cell plug trays, with an average of 14 leaves, flowered following a sufficient cold treatment. Plants attain a height of 20 to 24 inches (50 to 60 centimeters) and are suited for six-inch pots. Larger starting material, such as field-grown bare-root plants with several eyes per plant, are best suited for one-gallon pots.

3. Cold Treatment

Without a cold treatment, flowering depended on light intensity. In our experiments, we grew *P. digitalis* 'Husker Red' plants under two different light treatments. In one experiment, we provided plants a 16-hour photoperiod using natural light supplemented with day extension from high-pressure sodium (HPS) lamps. In another experiment we tested seven different photoperiods, ranging from 10 to 24 hours, as well as a four-hour night interruption from 10 p.m. to 2 a.m.

In this second experiment, photoperiods were provided with natural light supplemented with HPS lamps and day extension from incandescent (INC) lamps. When the plants were grown without a cold treatment under day extension from INC lamps, there was very minimal flowering (0% to 30%). However, when plants without a cold treatment were grown under day extension from HPS lamps, flowering percentages were higher (50% to 70%, Figure 2).

Cold treatment has a dramatic influence on flower timing. The plants that flowered without a cold treatment did so in about 100 days. Plants with a cold treatment as short as three weeks at 41°F (5°C) flowered in approximately 85 days (Figure 3a). As cold duration increases, flowering time decreases. After 15 weeks at 41°F (5°C), plants flower in about 50 days (Figure 3b).

Cold treatment also can influence plant height. The first time this experiment was conducted, plant height increased from 24 inches (60 centimeters) for plants that had been cold-treated for nine weeks to 31 inches (80 centimeters) for plants that had been cold-treated for 15 weeks. When this experiment was repeated the following year, plant height remained between 20 and 24 inches (50 and 60 centimeters) regardless of cold-treatment duration.

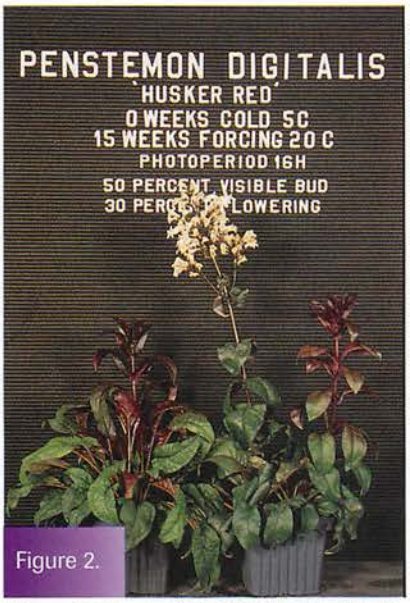

Figure 2. When *P. digitalis* 'Husker Red' plants were grown without cold treatment under a 16-hour photoperiod provided by high-pressure sodium lamps, 50% flowered.

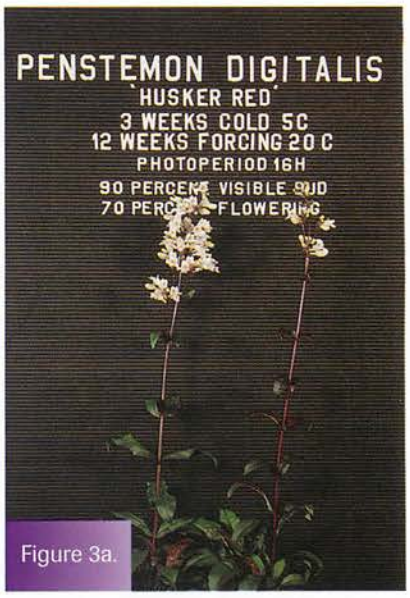

Figure 3a. Flowering time decreases as cold-treatment duration increases. These plants received three weeks of cold treatment at 41°F (5°C) and flowered in 11 weeks.

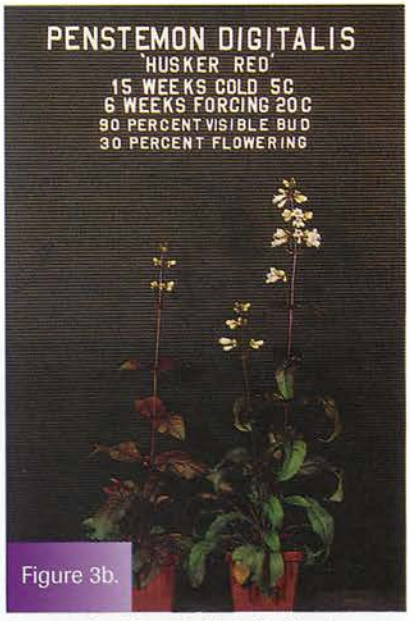

Figure 3b. After *P. digitalis* 'Husker Red' received a 15-week cold treatment, it flowered in six weeks.

4. Photoperiod

After a 15-week cold treatment, *P. digitalis* 'Husker Red' behaves as a day-neutral plant, flowering in about 50 days, regardless of the photoperiod (Figure 4).

5. Lighting And Spacing

As mentioned above, light intensity plays an important role in flowering for plants that have not received a cold treatment. Increased light intensity also can influence flower number. In the first year, *P. digitalis* 'Husker Red' that was grown under day extension lighting from HPS lamps had 2 $^1/_2$ times more flowers than plants grown under day extension from INC lamps. But in the second year, the type of lamp used for day extension did not influence flower number for *P. digitalis* 'Husker Red.'

We found that providing a 16-hour photoperiod by using day extension from HPS lamps increased flower number for several other Penstemon species as well. Flower number of *P. barbatus* 'Elfin Pink' and *P. campanula-*

Table 1. ***Penstemon digitalis* 'Husker Red' Production Schedule**

Growing time	*Cultural practice*	*Temperature*	*Photoperiod*
Two weeks	Root cuttings	65°-70°F (18°-21°C)	Natural daylength
Three to four weeks	Grow in plugs	65°-70°F (18°-21°C)	Natural daylength
- OR - *Purchase plugs*			
Nine to 15 weeks	Cold treatment	35°-45°F (2°-7°C)	Natural daylength or nine hours of light in cooler
	Begin forcing		**These times to flower were recorded for plants grown after 15 weeks of cold under 16 hours of light with day extension from HPS lamps.**
↓ 63°F (17°C) Flower in eight weeks	↓ 72°F (22°C) Flower in six weeks	↓ 86°F (30°C) Flower in four weeks	**From visible bud to flower** 63°F (17°C) - 21 days 72°F (22°C) - 15 days 86°F (30°C) - 10 days

tus 'Garnet Red' was greatly increased when plants were grown under day extension with HPS lamps rather than a four-hour night interruption using INC lamps or a nine-hour short day.

During forcing, plants can be spaced closely together initially, but will require more spacing as they grow. A five- to six-inch spacing between pots should be sufficient for reducing spread of any disease and for light penetration into the canopy to prevent unwanted stretching.

Figure 4.

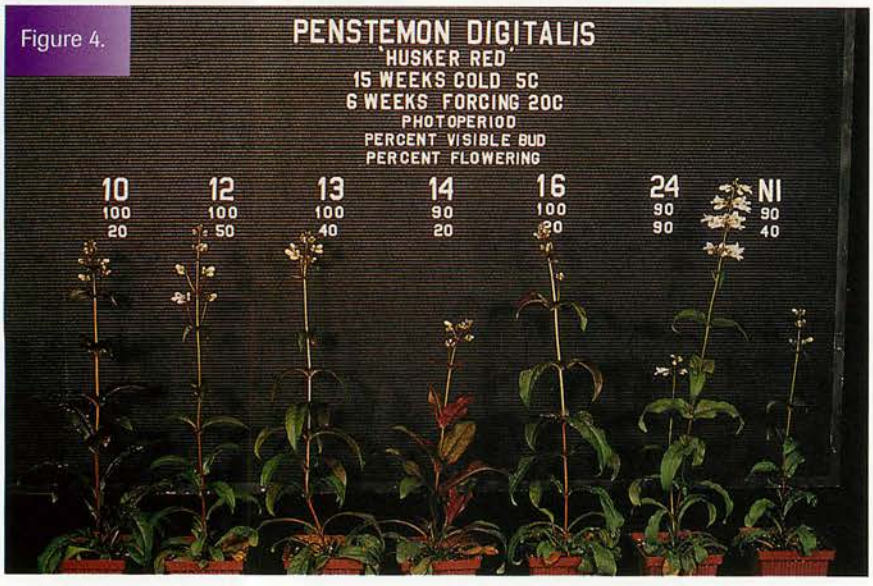

Figure 4. *P. digitalis* 'Husker Red' is a day-neutral plant. After a 15-week cold treatment, plants under 10- to 24-hour photoperiods and a four-hour night interruption all flower at the same time.

6. Media, Fertilization, And Irrigation

Although in the garden *P. digitalis* 'Husker Red' tolerates wet climates and humidity, like their other Penstemon relatives, they prefer a well-drained soil. Plants in our experiments performed considerably better when grown in a porous soilless medium of sphagnum peat moss, perlite, vermiculite, and bark compared to a medium with more peat moss, some perlite, and no vermiculite or bark.

We fertilized at every irrigation using a fertilizer of 125 ppm N, 12 ppm P, and 125 ppm K, which was sufficient for plant growth and development. We maintained pH levels between 5.8 and 6.2.

7. Plant Height Control

The natural height of *P. digitalis* 'Husker Red' is rather tall (up to 24 inches or 60 centimeters), so plants would benefit from height control. We tested five different commercial-

ly- available plant growth regulators (PGRs): A-Rest at 100 ppm, Bonzi at 30 ppm, B-Nine at 3,000 ppm, Cycocel at 1,500 ppm, and Sumagic at 15 ppm.

Plants were first cooled for 15 weeks, allowed to establish for two weeks, and then sprayed every 10 days for a total of three applications before the first flower opened. All PGRs except Cycocel controlled height, but some were more effective than others (Figure 5).

For example, plants sprayed with B-Nine attained a height of 15 inches (38 centimeters), while those sprayed with A-Rest or Bonzi were both approximately 10 inches (26 centimeters) tall. In comparison, the unsprayed control plants had an average height of 18.5 inches (47 centimeters). Sumagic also controlled height but slowed development significantly. Plants sprayed with Sumagic flowered about two weeks later than unsprayed plants or plants sprayed with any of the other PGRs.

The rates and application frequencies that we used in this screen are not recommendations. They were used only to determine these PGRs' effectiveness on *P. digitalis* 'Husker Red.'

Figure 5.

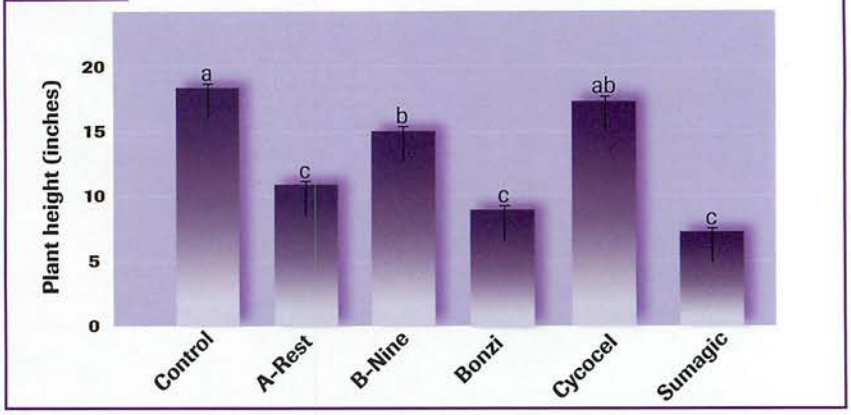

Figure 5. Plants sprayed with various PGRs show that height is relative to control. Bars with the same letter were not statistically different from each other. Plants were cooled for 15 weeks, allowed to establish for two weeks, and sprayed every 10 days for a total of three applications. The rates and application frequencies used are not recommendations, but indicate a plant growth regulator's effectiveness.

8. Temperatures And Crop Scheduling

Temperature is one of the primary factors controlling plant development. At warmer temperatures, plant development occurs much more quickly than at cooler temperatures. Plants of *P. digitalis* 'Husker Red' flower in four weeks when grown at 86°F (30°C), in six weeks when grown at 72°F (22°C), and in eight weeks when grown at 63°F (17°C) (Table 1).

Forcing temperature influences plant quality as well as flower timing. For many species, plants grown at warm temperatures are shorter with sparse, small flowers, while those grown at cool temperatures are tall with many large flowers.

The same is true for *P. digitalis* 'Husker Red,' although the effect of temperature on flower number is not as dramatic as it is for many other species (Figures 6a and 6b).

Plants grown at 86°F (30°C) were about 14 inches (35 centimeters) tall and had about 84 flowers per plant. At 63°F

Figure 6a.

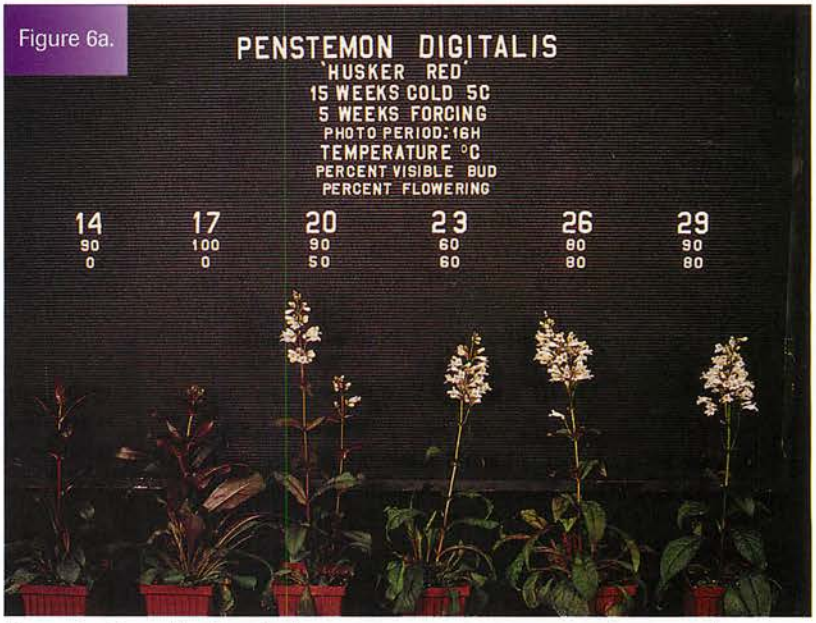

Figure 6a. Flowering time is shorter at warmer temperatures than at cooler temperatures. After five weeks, plants grown at temperatures warmer than 72°F (22°C) are already in flower. Plants grown at temperatures cooler than 66°F (19°C) are still only in visible bud.

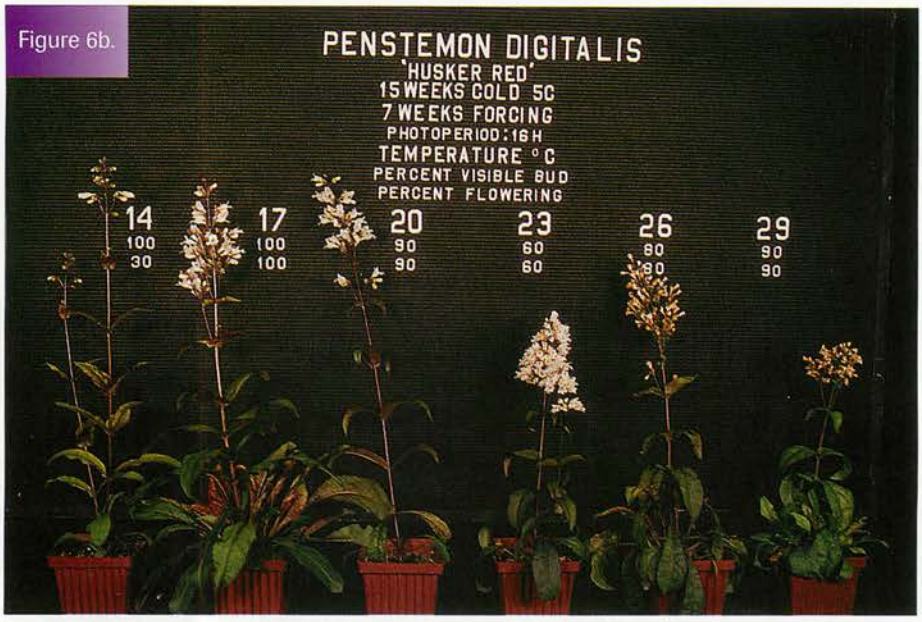

Figure 6b. After seven weeks of forcing, plants grown at 63°F (17°C) are in flower. Plants grown at temperatures above 75°F (24°C) remain more compact than plants grown at cooler temperatures.

(17°C) plants had an average height of 20 inches (50 centimeters) and produced almost two times the number of flowers that plants produced at 86°F (30°C). In comparison, when *Oenothera fruticosa* 'Youngii-lapsley' was grown at 65°F (18°C), plants had five times as many flowers as those grown at 86°F (30°C).

Growing *P. digitalis* 'Husker Red' at warm temperatures (≥ 75°F [24°C]) offers another way to control plant height. Unlike many species, *P. digitalis* 'Husker Red' grown at warmer temperatures were more attractive than plants grown at cooler temperatures, despite the lower flower number since they did remain more compact. We recommend forcing temperatures between 75°F (24°C) and 86°F (30°C) for minimizing flower timing and controlling plant height.

9. Disease And Insect Pests

In several cases, phytophthora was found on *P. digitalis* 'Husker Red' as well as *P. campanulatus*, causing stem blackening and eventual plant death. Phytophthora did not infect *P. barbatus* 'Elfin Pink' or *P. campanulatus* 'Garnet Red.'

No insects were particular pests of *P. digitalis* 'Husker Red' or any other Penstemon species.

10. Postharvest Concerns

Plants should be shipped before the first flower opens. *Penstemon digitalis* 'Husker Red' remains in flower for about three to four weeks. Many of the spent flowers remain on the flower stalk, turn brown as they dry, are very unattractive, and should be removed promptly to maintain a neat appearance for sale. Once flowering has finished, plants will not flower again until the following year. **GG**

Formula For Success: *Penstemon digitalis* 'Husker Red'

1. Provide a cold treatment of nine to 15 weeks at 41°F (5°C) for rapid flowering.

2. Provide supplemental lighting of 400-500 footcandles if growing under low light.

3. Force at temperatures between 75°F and 86°F (24°C and 30°C) for minimal time to flower and height control.

4. Ship before the first flower opens.

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– Crop By Crop –

FORCING PERENNIALS

SPECIES:
Physostegia virginiana
COMMON NAME:
Obedient Plant

by ***CHERYL K. HAMAKER, ROYAL HEINS, ARTHUR CAMERON,*** *and* ***WILL CARLSON***

THE genus *Physostegia* belongs to the Lamiaceae, or mint family, which is characterized by square stems. Physostegia flower spikes are typically 1-11/2 feet tall and each side of the four-sided stems is lined with 1-inch bi-lobed flowers.

Physostegia virginiana, commonly known as obedient plant, is aptly named for the tendency of its individual flowers to remain in any position to which they are shifted. When planted in full sun or partial shade, this vigorous perennial quickly spreads to form broad sweeps of spiky white, pink, or lavender flowers. Obedient plant typically flowers in late summer or fall and may bloom for a month or more if continually deadheaded in the garden.

The crown of the obedient plant expands through creeping stems. P. virginiana is indigenous to eastern North America and is hardy in USDA zones 3 through 9. Because of its low maintenance and value as both a cut flower and a naturalizer, *P. virginiana* has become a popular choice for the garden.

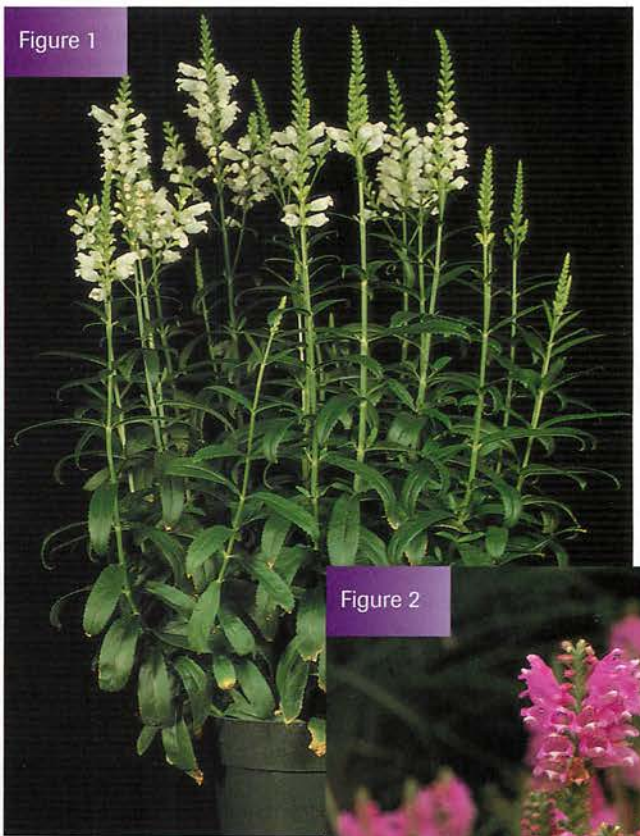


Figure 1. *Physostegia* 'Alba' can yield an impressive flowering plant, shown here in a 6-inch standard pot.

Figure 2. The bright pink flowers of *Physostegia* 'Pink Bouquet' are quite showy in the landscape.

Photo courtesy of Ann Hanchek.

Cultivars

P. virginiana carries its purple-red, rose-pink, or lilac flowers on wand-like stems of 4-5 feet. Many cultivars of various heights and flower color, including white, are available. Physostegia 'Alba' is a seed-propagated cultivar with pure white blooms on 3- to 4-foot-tall stems (Figure 1). Another white cultivar, 'Summer Snow,' has a relatively low stature of only 3 feet and an earlier bloom time in the landscape than other *P. virginiana* cultivars. 'Pink Bouquet' sports bright-pink flowers on 3- to 4-foot-tall stems (Figure 2). 'Vivid' is a 2-foot-tall selection with vibrant rose-pink

flowers. 'Variegata' is unusual in that it has cream-edged leaves to offset its pale pink blossoms.

Flower Induction Requirements

All suggested production information is based on observed responses of various cultivars of *P. virginiana*. Flowering requirements among other cultivars may vary.

1. PLANT SIZE

P. virginiana plants are available as plugs or field-grown divisions. It is important that starting material, whether plugs or divisions, be sufficiently large to fill the container when plants are in bloom. Shorter cultivars of P. virginiana are more suitable for smaller containers.

2. COLD TREATMENT

A cold treatment is required to uniformly flower *P. virginiana* (Figure 3). Sporadic and nonuniform flowering will occur without a cold treatment. However, to achieve 100% flowering, a cold period of at least 5 weeks at 41°F (5°C) is necessary. We recommend a 10-week cold treatment to accelerate flowering and increase final inflorescence number.

3. PHOTOPERIOD

P. virginiana is a facultative long-day (LD) plant (Figure 4). Plants eventually flower under short days, but flowering is delayed up to 4 weeks. Flowering occurs fastest when plants are exposed to LD in excess of 16 hours or a 4-hour night interruption from 10 p.m. to 2 a.m. (Figure 4). As the daylength increases, time to flower decreases and the final number of inflorescences increases.

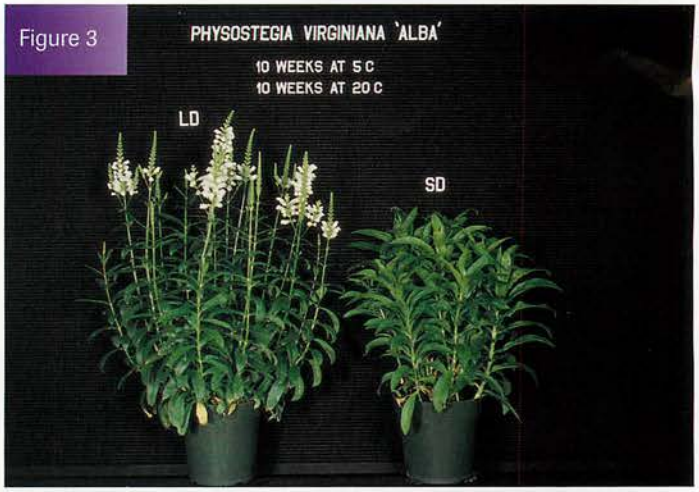
Both high-pressure sodium and incandescent lamps successfully promote flowering for *P. virginiana*. The minimum light intensity for all lamp types should be 10 footcandles.

4. PROPAGATION

In the garden, propagation of *P. virginiana* usually is accomplished by division in spring or late fall. It is necessary to divide clumps frequently to rejuvenate old plants and control their invasive nature. In the commercial industry, many cultivars of *P. virginiana* have been selected for flower color or other characteristics and are vegetatively propagated by stem cuttings. Physostegia 'Summer Snow' has been chosen for its white blooms, shorter height, and less-invasive nature. Propagation from seed may not ensure these characteristics. Two nice seed-propagated cultivars are 'Alba' and 'Crown of Snow.'

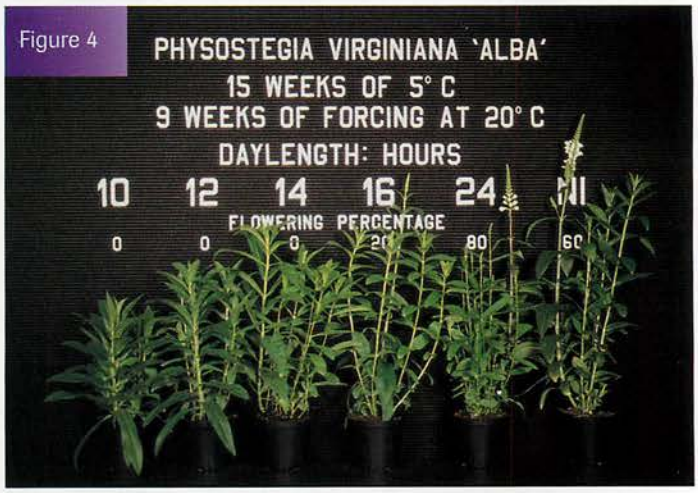
Because *P. virginiana* is an LD plant, stock plants must be held under short days to ensure vegetative development. Cuttings produced under short photoperiods will root more vigorously than those produced under LD.

Figure 3



Horticulturally, *P. virginiana* has an obligate requirement for both cold and long days (LD) for flowering. Both plants received cold; however, the plant on the left was forced under a 4-hour night interruption, while the plant on the right was forced under a 9-hour short day.

Figure 4



***Physostegia* 'Alba' requires a photoperiod longer than 16 hours for fastest flowering. However a 4-hour night interruption is as effective as a 16-hour photoperiod for flower initiation and development. Following a cold treatment, plants will flower under a 14-hour photoperiod, but flowering will be delayed.**

Photo courtesy of Erik Runkle.

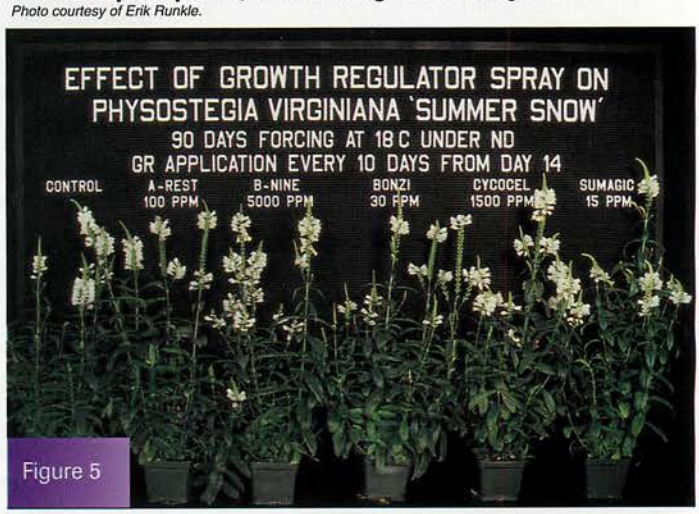


Figure 5

Unfortunately *Physostegia* 'Summer Snow' did not respond to growth retardants even when applied at high rates at 10-day intervals during forcing.

5. MEDIA AND FERTILIZATION

P. virginiana does not have a specific medium requirement. Plants will perform well in the greenhouse in any well-drained, evenly moist medium with a pH range of 5.5-6.0. It does not require a high fertilizer concentration either in the greenhouse or garden. Plants become excessively tall with weak stems when high nitrogen fertilization is provided; therefore, a constant fertilization at 100 ppm N from a balanced fertilizer is suggested.

6. IRRIGATION

While *P. virginiana* will tolerate considerable moisture, best growth occurs when plants are kept evenly moist. Leaf necrosis will occur if plants are allowed to become overly dry.

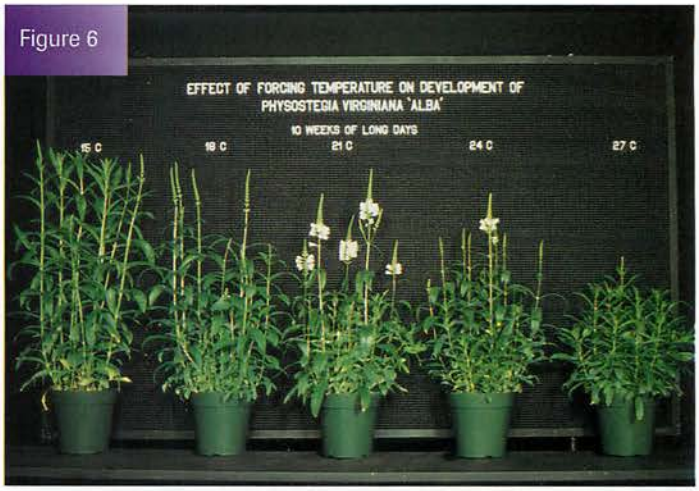
7. LIGHTING AND SPACING

P. virginiana thrives in high light conditions as long as moisture requirements are met. Overall plant quality is best when appropriate lighting and spacing are used. Supplemental lighting from high intensity discharge lights at 400-500 footcandles is beneficial in greenhouse conditions, especially during dark winter months. To encourage proper growth habit and stem strength, pots should be spaced in the greenhouse so that light can penetrate into the lower part of the plant.

8. PLANT HEIGHT CONTROL

Often the final plant height of *P. virginiana* becomes quite exorbitant for container production. Unfortunately, no growth retardant tested effectively controlled final plant height of *P. virginiana* (Figure 5). However, the often leggy habit of this species may be curbed by growing in full sun or selecting more compact cultivars.

Figure 6



Influence of forcing temperature on flowering of *Physostegia* 'Alba.' Plants performed best when grown under cooler temperatures.

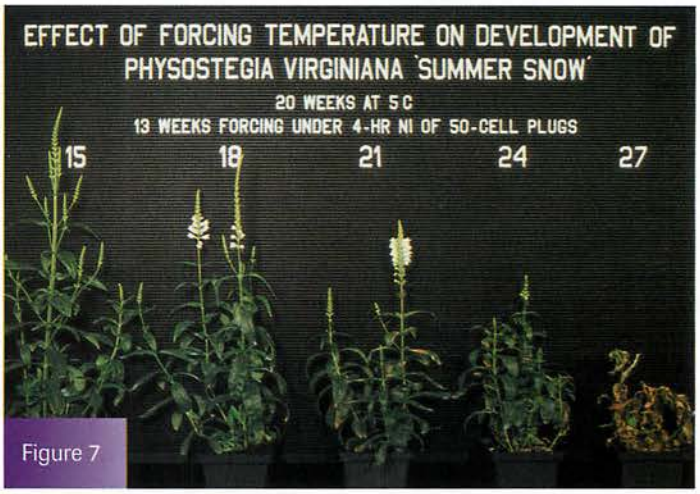


Figure 7

Production time of *Physostegia* 'Summer Snow' from the start of forcing to opening of the first flower is approximately 13-14 weeks at 59°F (15°C), 12-13 weeks at 64°F (18°C), and 11-12 weeks at 71°F (21°C). Unfortunately, some cultivars of Physostegia may be sensitive to higher temperatures. Plants grown at 75°-80°F (24°-27°C) never reached flowering. Plant death may have been caused by INSV infection that was expressed at elevated temperatures.

9. TEMPERATURES AND CROP SCHEDULING

It is important when forcing *P. virginiana* to consider the size of the starting material when selecting final pot size. Cooled plugs and bare-root plants can be purchased and directly forced into bloom. For small containers, 4- or 5-inch pots, one plug is sufficient for final size. In order to fill a 6-inch or 1-gallon container, larger plants are required.

Two strategies for "filling" larger containers are using field-grown divisions or planting an uncooled plug in late September or early October to allow bulking during the late fall. If small plugs are used as starting material, it may be necessary to plant several plugs per 6-inch or 1-gallon container to produce a quality final product. Only shorter cultivars of this species are suitable for both small and large containers.

To fill large containers, it may be necessary to increase the vegetative size of smaller starting material. Final plant size can be influenced by either pinching plants before forcing or growing them in photoperiods short enough to prevent induction but long enough for vegetative development to occur, known as bulking. Pinching encourages lateral branching, and plants have more but smaller, flowering spikes.

The decision to pinch or bulk the plugs is determined by the time of forcing. We recommend that plants be either pinched in spring or bulked in fall. After pinching, plants are placed under inductive photoperiods as soon as new growth is detected. Pinching does not necessarily increase the number of new stalks originating from below the soil but will cause the lower laterals to develop, which adds bulk to the final product.

Bulking requires a longer period for subsequent development than pinching the plugs. The length of the bulking interval is determined by the size of the starting material and the desired final pot size. Bulking plugs for 3 weeks in natural daylengths during late October at 68°F (20°C) or overwintering in a cool greenhouse increased

Table 1

Physostegia virginiana 'Alba' Production Schedule

Growing Time	Cultural Practice	Temperature	Photoperiod
3-4 weeks	Take cuttings ↓ Root	Media temperature 72°-76°F (22°-24°C)	<14 hours of light
4-5 weeks (50-cell plug) Longer for larger plugs	Bulk or pinch to increase vegetative growth of plants	Air temperature 68°-72°F (20°-22°C) 58°-62°F (14°-17°C) for 1-2 weeks before cold	13-14 hours of light initially 10-12 hours of light for final weeks before cold
– OR – Purchase plugs or bare root plants			
10-15 weeks (Can be held longer if needed)	Cold treatment ↓	35°-45°F (1°-7°C)	< 12 hours of light
	Begin Forcing		**≥16 hours of light** or a 4-hour night interruption
↓ ↓ 59°F (18°C) 10-11 weeks flower	↓ 64°F (18°C) 10 weeks flower	↓ 70°F (21°C) 9-10 weeks flower	**Visible Bud to Flower** 59°F (15°C) – 44 days 64°F (18°C) – 42 days 70°F (21°C) – 39 days

the final bud number 30% and 50%, respectively, compared to a 3-week pretreatment of 9 hours of natural daylight plus a 4-hour night interruption.

If forcing schedules do not permit time for bulking, adequate-size plant material for the final pot size should be purchased.

Time to flower depends on the forcing temperature from the start of LD (Figure 6). *P. virginiana* performs best when forced between 59°F and 70°F (15°-21°C). For 'Alba,' allow about 10-11 weeks at daily averages of 59°F (15°C), 10 weeks at 64°F (18°C), or 9-10 weeks at 70°F (21°C) (Table 1). High temperatures (81°F) stressed the plants, stunting growth, delaying flowering for 2 weeks, and decreasing flower bud number.

Cultivars 'Summer Snow' and 'Vivid' require 2 and 4 weeks longer to flower, respectively, than 'Alba.' We have had mixed results growing different cultivars of *P. virginiana*. Some cultivars may not tolerate high temperatures during forcing (Figure 7). However, this intolerance may be related to symptom expression of impatiens necrotic spot virus (INSV) (see Section 10).

Formula For Success: 'Alba'

1. Grow plants in 6-inch or larger pots.
2. Large plants make a more impressive display. Use multiple or field-grown divisions that are disease free.
3. Provide plants with a 10-week cold treatment at 41°F (5°C) before LD treatment.
4. Provide LD either by extending the daylength to 16 hours or by a 4-hour night interruption.
5. Force at temperatures between 59°F and 71°F (15°-21°C).

10. DISEASE AND INSECT PESTS

P. virginiana is susceptible to spider mites, aphids, and western flower thrips. It also contracts INSV, which causes a unique crinkling in the foliage. However, the symptoms of INSV may not become noticeable until plants are grown at higher temperatures or are drought-stressed (Figure 7). This problem can be avoided by purchasing virus-indexed plant material.

11. POSTHARVEST CONCERNS

P. virginiana should be shipped just before the first flower opens, which is important for two reasons: 1) as flowers open, they senesce and drop from the stem, leaving behind a rather unattractive flowering stalk, and 2) plants tend to become more floppy the longer they are held after flowering has begun.

P. virginiana can be cut back after the initial flush of flowers for a repeated full bloom. Plants will continue to flower if provided bright light, continual long days, and sufficient water and can be enjoyed in the garden for many years. **GG**

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– Crop By Crop –

FORCING PERENNIALS

SPECIES:
Platycodon grandiflorus
'Sentimental Blue'

COMMON NAME:
Balloon Flower

by ***CATHERINE WHITMAN, ROYAL D. HEINS, ARTHUR CAMERON,*** *and* ***WILL CARLSON***

PLATYCODON GRANDIFLORUS, or Balloon flower, is native to eastern Asia. The common name refers to the unique flower buds of this plant, which are inflated and very puffy before opening. The large, showy, five-petaled flowers can be shades of blue, pink, or white and are mostly single, although a few double cultivars are available. This plant is reliably hardy in USDA zones three to eight, and is among the 50 top-selling genera of herbaceous perennials in the U.S. Balloon flower normally blooms in July and August in Michigan.

Cultivars

Some cultivars of balloon flower reach 2-3 feet in height and are used as cut flowers. These include the Fuji series, 'Album,' and 'Double Blue.' 'Mariesii' is somewhat shorter, about 1-2 feet tall. A popular dwarf variety, 'Sentimental Blue,' is 8-12 inches in height and is well suited for production in a 4-inch pot (Figure 1). Recommendations in this article refer only to 'Sentimental Blue.'

Flower Induction Requirements

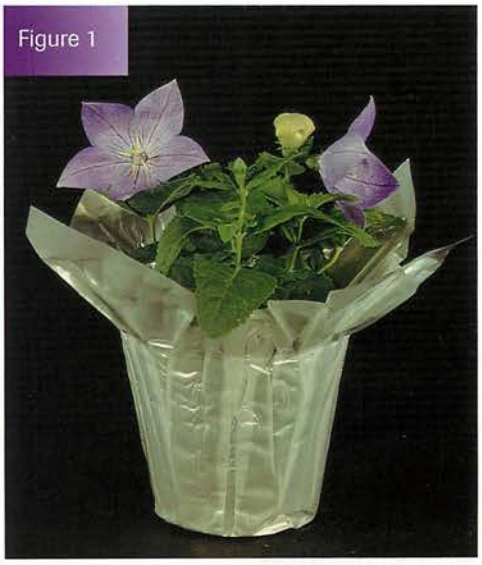
Flowering of 'Sentimental Blue' seedlings is very easy with few specific requirements.

1. PLANT SIZE

'Sentimental Blue' flowers readily, and we have observed flowering on small seedlings with as few as 13 leaves. This compact cultivar is best suited for 6-inch or smaller pots. Plants from 128-cell plug trays are appropriate for 4-inch pots. Use several plugs to fill out larger containers.

2. COLD TREATMENT

Cold temperatures are not required for flowering. Exposure to low temperature causes the foliage to die back. Regrowth from the crown of cooled plants typically consists of several sturdy shoots, and more flowers are produced on each plant (Figure 2). We have experienced significant mortality when holding plugs in a cooler at 40°F (5°C). Avoid excessively wet or dry conditions during cold treatment.



P. grandiflorus **'Sentimental Blue' is perfect in a 4-inch pot.**

P. grandiflorus **'Sentimental Blue' foliage dies back upon exposure to cold temperatures. Regrowth from the crown is generally sturdy and consists of several shoots.**

3. PHOTOPERIOD

'Sentimental Blue' can be forced under any daylength, but flowering will be a little faster under long days. On average, plants forced under a 9-hour photoperiod flowered 7-10 days later than those forced under a 9-hour photoperiod with 4-hour night interruption.

Table 1 ***Platycodon grandiflorus* 'Sentimental Blue' Production Schedule**

Growing Time	Cultural Practice	Temperature	Photoperiod
10-15 days	Sow seeds ↓ Germinate OR purchase plugs	60°-72°F (18°-22°C)	Natural photoperiods
≈10 weeks	Grow on until 6-8 true leaves have formed. ↓ Transplant and pinch, leaving 4 leaves. OR store at 35°-45°F (1°-7°C)	60°-72°F (18°-22°C)	Natural photoperiods
Begin Forcing			4-hour night interruption for fastest flowering. (Natural photoperiods are acceptable; may delay flowering by 7-10 days) **Visible Bud to Flower** 64°F (18°C) - 28 days 70°F (21°C) - 25 days 75°F (24°C) - 24 days
↓ ↓ ↓ 64°F (18°C) 12-13 weeks flower	↓ ↓ 70°F (21°C) 10-11 weeks flower	↓ 75°F (24°C) 9-10 weeks flower	

4. PROPAGATION

'Sentimental Blue' is easily propagated by seed. Germinate at 60°-72°F (18°-22°C), and cover the seeds lightly. Seedlings emerge in 10-15 days. Alternatively, plugs can readily be purchased. Plants can also be propagated by division, but this method is difficult because the fleshy elongated root is easily damaged. If the plants are overwintered, be aware that balloon flower plants are quite late to emerge in the spring, later than many other perennials. Be patient.

5. MEDIA AND FERTILIZATION

Balloon flower has a fleshy tap root and is susceptible to root rot, so the use of a sterile, well-drained medium is especially important. Avoid waterlogging. The pH should be maintained at about 5.0-6.0. Constant fertilization at 100-150 ppm N, 10-20 ppm P, and 100-150 ppm K20 is adequate (for example, 20-10-20).

6. LIGHTING AND SPACING

Provide full natural light intensity during late spring forcing. Supplemental lighting with 500 footcandles of light from high-pressure sodium lamps has greatly improved plant quality during winter and early spring forcing in Michigan.

Figure 3

The *P. grandiflorus* 'Sentimental Blue' plant on the left was pinched after transplant, while the one on the right was not pinched. Flowering is delayed on the pinched plant, but more flowers will be produced and the shoots are more upright.

7. IRRIGATION

Grow plants on the dry side, allowing the media to dry between irrigations.

8. PLANT HEIGHT CONTROL

'Sentimental Blue' is naturally quite compact, and chem-

ical growth retardants are not needed. However, plants which have not been mechanically pinched or exposed to low temperatures may become floppy and weak. Plants that have not been cooled should be pinched at transplant to encourage lateral branching (Figure 3).

9. TEMPERATURES AND CROP SCHEDULING

'Sentimental Blue' is a relatively slow-growing crop. Fortunately this plant thrives under warm temperatures, which will hasten development. Time to opening of the first flower after transplant and pinching averages 12-13 weeks at 64°F (18°C), 10-11 weeks at 70°F (21°C) and 9-10 weeks at 75°F (24°C) (Figure 4). Pinching the plants will delay flowering by approximately 3-4 weeks but will increase lateral branching and flower number.

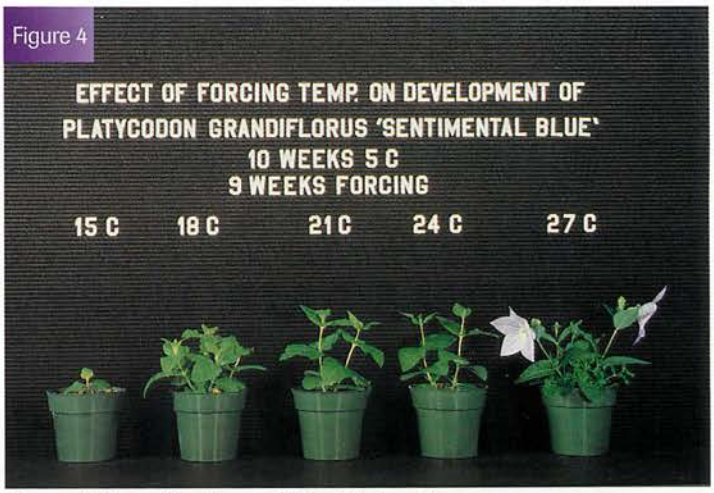
10. DISEASE AND INSECT PESTS

Whiteflies and aphids can be a problem on 'Sentimental Blue.'

11. POSTHARVEST CONCERNS

Removing spent flowers will promote lateral branching and more flowers. **GG**

Figure 4



***P. grandiflorus* 'Sentimental Blue' thrives in warm temperatures. These plants were forced under a 4-hour night interruption.**

FORMULA FOR SUCCESS: 'SENTIMENTAL BLUE'

1. Grow plants on the dry side. The fleshy tap root is susceptible to root rot.
2. Warm temperatures are preferred. Grow at 65°F or warmer.
3. Pinch the seedlings if they will not be exposed to cold temperatures prior to forcing.
4. Cold storage or overwintering of plugs can be tricky – be sure they don't become excessively wet or dry.
5. Overwintered plants are slow to emerge in the spring. Be patient.

– Crop By Crop –

FORCING PERENNIALS

SPECIES: *Rudbeckia fulgida* 'Goldsturm'
COMMON NAME: Black-eyed Susan

Figure 1a.

***Rudbeckia fulgida* 'Goldsturm' forced in a greenhouse and ready for sale as attractive flowering potted perennials (left). Rudbeckia looks fabulous in the landscape, especially next to ornamental grasses (below).**
Photo courtesy of Marlene Cameron.

Figure 1b

by ***MEI YUAN, ERIK S. RUNKLE, ROYAL D. HEINS, ARTHUR CAMERON,*** *and* ***WILL CARLSON***

RUDBECKIA FULGIDA is a member of Asteraceae or the sunflower family. It is native from Connecticut to West Virginia and west to Michigan and Missouri, flowers through late summer into early fall, and produces abundant daisylike flowers. The yellow flower heads have conical black centers that remain an interesting display even after the petals have fallen. The flowers are long lasting and ideal for cuttings.

The plant is fully hardy from zones 4 to 9 and often reaches a height of 2-3 feet in gardens but is shorter when planted in containers. It grows as a rosette plant in almost any type of soil and bolts before flowering. Plants tolerate partial shade but flower best in full sun.

The flowering of Rudbeckia is strictly controlled by photoperiod, which can be manipulated to flower a crop at any time of the year. Plants may be sold in flower, enjoyed indoors for weeks, then planted outdoors for continued enjoyment (Figures 1a and 1b).

Cultivars

The most popular cultivar is 'Goldsturm,' which has beautiful golden flowers about 2-3 inches across. 'Deami' has lighter-yellow flowers. There are many other species of Rudbeckia, several of which are annuals, such as *R. hirta*.

Flower Induction Requirements

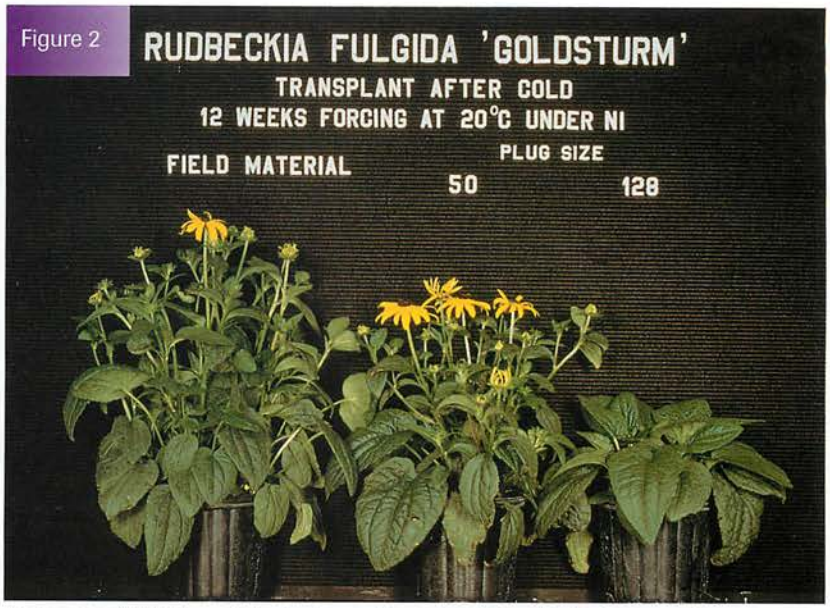
The following production information is based on *R. fulgida* 'Goldsturm.' 'Goldsturm' must be mature and exposed to long days in order to flower. A cold treatment is not required, but it does hasten flowering.

1. PLANT SIZE

Juvenile plants will not flower in response to inductive photoperiods (Figure 2). Our research has shown that 'Goldsturm' reaches maturity when plants develop about 10 nodes (leaves). Plants that have fewer leaves take much longer to flower and do so sporadically.

Grow plants under photoperiods no longer than 12 hours to an average of 10 or more leaves. Field-grown plants are generally mature and do not require further growth before exposure to cold temperatures or long days. After cold treatment and exposure to long days, mature plants develop an additional 12-15 leaves under the first flower.

Figure 2



Only some 'Goldsturm' plants flower in a population if plants are not mature. After 22 weeks of long days, only 60% of plants from 128-cell plugs that averaged five nodes flowered, 75% of plants from 50-cell plugs that averaged nine nodes flowered, and 100% of plants from bare-root material flowered.

Figure 3a

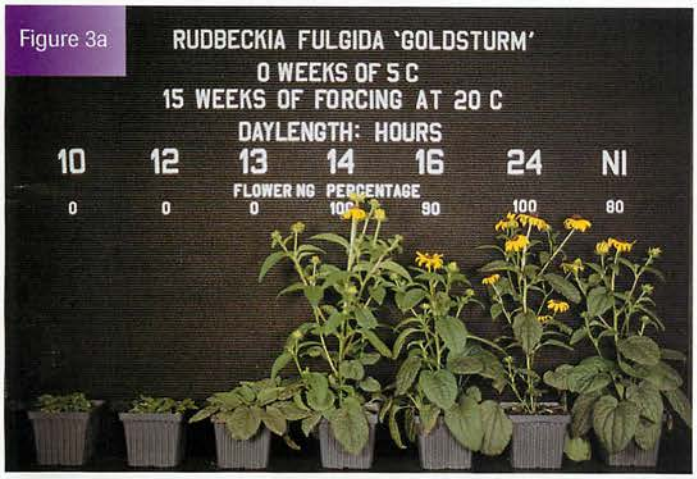
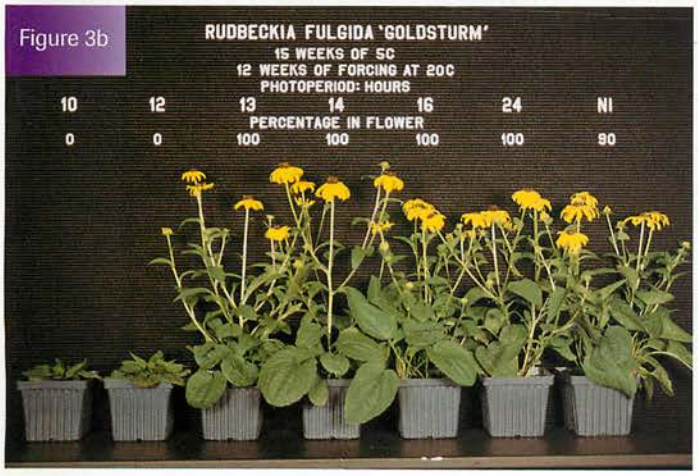


Figure 3b



Rudbeckia that are not provided with a cold treatment (left) only flower when photoperiods are 14 hours or longer or with a 4-hour night interruption (NI) from 10 p.m. to 2 a.m. After a cold treatment of 10-15 weeks at 41°F (5°C) (right), Rudbeckia flowers only when photoperiods are 13 hours or longer with a 4-hour night interruption (NI) from 10 p.m. to 2 a.m.

2. COLD TREATMENT

'Goldsturm' does not require a cold treatment for flowering. However, 10 weeks or more in a cold (41°F or 5°C) greenhouse or cooler is recommended because it reduces time to flower by approximately 3 weeks; extending the cold treatment for more than 10 weeks does not further accelerate flowering. Cold treatment does not seem to influence other flowering characteristics. Plants may be held in coolers for longer periods if needed.

3. PHOTOPERIOD

The effects of photoperiod on flowering of Rudbeckia has been investigated since the discovery of photoperiodism by Garner and Allard in the early 1920s. Over the years, many Rudbeckia species have been studied, and all have been found to be long-day plants.

Rudbeckia fulgida 'Goldsturm' is an obligate long-day plant. Without a cold treatment, plants remain as

rosettes when photoperiods are shorter than 13 hours. Flowering occurs only when plants are exposed to long days of 14 hours or more or are provided with 4-hour night interruption (e.g., 10 p.m.-2 a.m.). After a cold treatment, plants flower under photoperiods of at least 13 hours (Figures 3a and 3b). Some plants flower under 12-hour photoperiods, but flowering is greatly delayed, and the flowering percentage is poor. Daylengths longer than 14 hours do not further accelerate flowering.

'Goldsturm' will flower with 1 or 2 hours of night-interruption lighting or 20% cyclic lighting (6 minutes on, 24 minutes off for 4 hours), but flowering is delayed by 3 weeks or more compared to that following a continuous 4-hour night interruption (Figure 4). Lighting for more than 4 hours during the middle of the night is recommended for the most rapid and uniform flowering.

Incandescent, high-pressure sodium, cool-white fluorescent, and metal halide lamps all effectively extend the daylength or night-interruption lighting (Figure 5). However, incandescent lamps may cause more stem elongation than light from other sources. The minimal light intensity for fastest flowering should be 10 footcandles in all corners of the greenhouse.

4. PROPAGATION

'Goldsturm' can be propagated by seed or division, the latter being the most common method used by gardeners. In the landscape, division is recommended every few years for rejuvenation and plant-size control and is best when performed in the spring or after flowering in the late fall.

Seed propagation is prevalent for commercial production because it is less expensive. For optimum seed germination, cold-treat seeds for 8-12 weeks at 41°F (5°C). Seeds will germinate in either light or dark. Keep the medium at 68°-72°F (20°-22°C) and maintain high humidity (90%-95%). Seedlings emerge in 1-2 weeks.

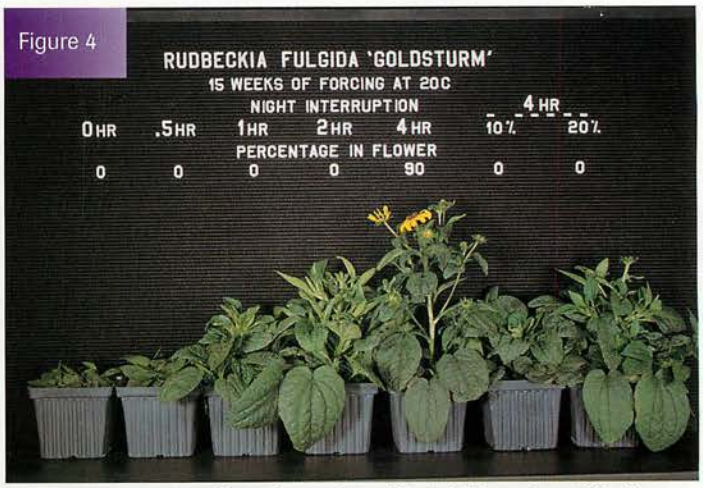
5. MEDIA AND FERTILIZATION

'Goldsturm' can grow in almost any kind of soil but prefers a moist medium. The pH should be maintained around 5.8-6.4. The cultivar prefers moderate fertility; constant fertilization of 100-200 ppm N, 10-20 ppm P, and 100-150 K20 is recommended (for example, 20-10-20).

6. LIGHTING AND SPACING

'Goldsturm' thrives in bright light. Supplemental lighting from high-pressure sodium lamps at 400-500 footcandles improves plant quality during the winter and slightly accelerates development. Plants may be spaced pot to pot before and during cold treatment. However,

Figure 4



Fastest and most uniform flowering of *R. fulgida* under night-interruption lighting occurs when plants are exposed to at least 4 hours of light during the middle of the night. Plants flower with as little as 1 hour of light during the middle of the night or with cyclic lighting of 6 minutes on, 24 minutes off for 4 hours (20% cyclic), but flowering is delayed by at least 3 weeks.

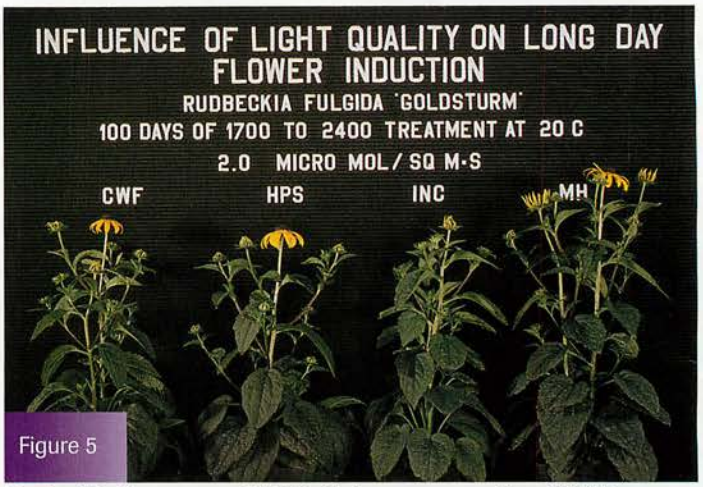


Figure 5

Cool-white fluorescent (CWF), high-pressure sodium (HPS), incandescent (INC), and metal halide (MH) lamps effectively induce flowering of *R. fulgida* 'Goldsturm.' Note: 2 $\mu mol \cdot m^{-2} \cdot s^{-1}$ is approximately 10 footcandles.

Figure 6

128-cell and 50-cell plugs and field-grown 'Goldsturm.'

space plants soon after forcing under long days or plants will develop too tall.

7. IRRIGATION

'Goldsturm' grows well in moist medium and therefore requires frequent irrigation when plants are large. Plants readily wilt as the medium dries under intense light and warm temperatures, which may result in leaf damage (such as leaf-tip burn). However, plants usually will recover quickly after watering if the water stress was not severe.

8. PLANT HEIGHT CONTROL

'Goldsturm' tends to be too tall when grown in 4- or 6-inch pots. Our research has shown that 'Goldsturm' responds to limited-induction photoperiod, although the exact number of long days required for flower induction is unknown. After flower induction, transferring plants to short days will not delay flowering but will reduce flower number. Our research indicates that A-Rest, B-Nine, Bonzi, and Cycocel only slightly reduce plant height, with little or no delay in flowering.

9. TEMPERATURES AND CROP SCHEDULING

Rudbeckia can be purchased in a variety of plug sizes or as field-grown plants (Figure 6). Mature, cooled plugs or bare-root plants can be purchased, planted, and directly forced into bloom. Bare-root plants are ideal for 1-gallon or larger containers. When 128-cell plugs are used for large containers, two or three plugs may be required to fill a pot properly. Final plant size will depend on the size of the plant at the start of long days.

For the most rapid development, juvenile plants should be grown at warm temperatures (70°-75°F or 21°-24°C) until they develop approximately 10 nodes. From forcing to flower, plants grown above 72°F (22°C) have fewer and smaller flowers. Thus, a temperature setting of 65°-68°F (18°-20°C) is recommended for the highest quality and most floriferous plants. Plants may be grown at cooler temperatures, but flowering will be delayed.

Time to flower depends on the forcing temperature. Allow about 16-17 weeks from the start of long days with a daily average of 59°F (15°C), 14-15

Table 1. ***Rudbeckia fulgida* 'Goldsturm' Production Schedule**

Growing Time	Cultural Practice	Temperature	Photoperiod
1-2 weeks	Sow seeds ↓ Germination OR purchase plugs	68°-72°F (20°-22°C)	natural day lengths
10-12 weeks	Grow until at least 10 leaves have formed	72°-76°F (22°-24°C)	≤ 12 hours of light
10 weeks (can be held longer if needed)	Cold treatment ↓	35°-45°F (1°-7°C)	≤ 12 hours of light
Begin Forcing			≥14 hours of light or a 4-hour night interruption
↓ ↓ 59°F (15°C) 16-17 weeks flower	↓ 64°F (18°C) 14-15 weeks flower	↓ 70°F (21°C) 11-12 weeks flower	**Visible Bud to Flower** 60°F (15°C) – 49 days 65°F (18°C) – 44 days 70°F (21°C) – 38 days

weeks at 64°F (18°C), or 11-12 weeks at 70°F (21°C) (Table 1). Plants not provided with a cold treatment flower approximately 2-4 weeks later. Rudbeckia takes longer to force into flower than most other herbaceous perennials we have investigated, but they are in demand once in flower.

10. DISEASES AND INSECTS

'Goldsturm' has few pests. Occasionally plants may develop cupped or deformed leaves or inflorescences that are branched at the base. The cause(s) remains unknown, but fortunately the problem does not reduce ornamental value unless it is severe.

11. POSTHARVEST CONCERNS

'Goldsturm' has long-lasting flowers, so for the best display, plants should be shipped after the first flower has opened. Plants tend to improve in quality as subsequent flowers open for up to several weeks. Individual flowers will last 3 weeks or more if enough light and especially water are provided. **GG**

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FORMULA FOR SUCCESS: 'GOLDSTURM'

1. Grow plants under photoperiods (≤ 12 hours) until plants average at least 10 leaves (nodes).

2. Provide mature plants with at least 10 weeks of cold at 41°F (5°C) before long-day treatment.

3. Grow plants under long days (≥14 hours) after cold treatment. Long days can be easily provided by using 4-hour night-interruption lighting from 10 p.m. to 2 a.m.

4. Force at 60°-70°F (15°-21°C) for the highest quality plants.

– Crop By Crop –

FORCING PERENNIALS

Species: *Saxifraga* x *arendsii* 'Triumph'
Common Name: Saxifrage


Figure 1.

Figure 1. Small, delicate flowers and attractive foliage make *Saxifraga* x *arendsii* 'Triumph' an attractive potted flowering plant.

by ***EMILY CLOUGH, ARTHUR CAMERON, ROYAL HEINS,*** *and* ***WILL CARLSON***

SAXIFRAGA is an extremely large genus containing more than 300 species and 200 natural hybrids. *Saxifraga* spp. grow naturally in many parts of the world, including Europe, Asia, and North and South America.

They are primarily alpine plants, and many species grow as small rosettes, forming dense mats. In their natural environment, they are sometimes found growing in the cracks of rocks. They are ideal for rock gardens and prefer raised, well-drained conditions.

Saxifraga x *arendsii* 'Triumph' was developed by the Arends nursery in Ronsdorf, Germany. Its parents are *S. exarata* and *S. rosacea*. The variety makes an attractive flowering potted plant, with its deeply dissected, succulent foliage and numerous, small, light pink to red flowers (Figure 1). *Saxifraga* spp. are already grown as potted flowering plants in Europe.

In the garden, plants typically bloom in April and May, and grow to a height of approximately 6 inches (15 centimeters). They are hardy to USDA zone 5 and do not perform well in warmer climates. High humidity and heat cause the centers to brown and will even cause plant death if the plants remain in these conditions. Because *Saxifraga* spp. prefer cool temperatures, this is an ideal crop for winter production.

1. Propagation

Saxifraga x *arendsii* 'Triumph' is propagated by division or stem cuttings. The hybrid does not come true when grown from seed. Divisions can be made in early summer after flowering, but before the full heat.

Straight species of Saxifraga can be propagated by seed. Fresh seed (less than 1 year old) germinates

quite easily and does not require a cold treatment. However, if seed has been stored, a cold treatment is recommended. Seedlings emerge in 8-10 days, but they grow very slowly. Mist and overhead watering should be avoided to control algae growth and washing away of the seedlings.

2. Plant Size

Juvenility was not a problem for 'Triumph,' and all the plants we received in 128-cell plugs flowered after the appropriate cold treatment. However, a single rooted cutting from a 128-cell plug will only produce one flower stalk with a total of two to five flowers (Figure 2a).

For a plant with more flowers, bulking is required before cold treatment. After plants were bulked for 15 weeks at 68°F (20°C) and cooled for 12 weeks at 41°F (5°C), plants produced an average of 30 flower stalks and approximately 133 flowers (Figure 2b). A 128-cell plug will fill a 5-inch square pot in 6-9 weeks at 68°F (20°C). To decrease the amount of time needed for bulking, use several plugs per pot.

3. Cold Treatment

'Triumph' has an obligate requirement for cold treatment. Without a cold treatment, plants do not flower (Figure 3a).

In the experiment's first year, 60% of plants flowered after they had received a 6-week cold treatment at 41°F (5°C). In the experiment's second year, no plants flowered until they had received at least 9 weeks of cold treatment, when 80% of the plants flowered (Figure 3b). All plants flowered after 9 weeks of cold treatment in the first year and 12 weeks of cold treatment in the second year (Figure 3c).

As cold duration at 41°F (5°C) was increased from 6 to 15 weeks (year 1) or 9 to 15 weeks (year 2), time to flower decreased about 10 days. Cold treatment had no effect on either flower number or plant height when plants were grown from 128-cell plugs. However, after plants had been bulked for 15 weeks at 68°F (20°C), flower number increased substantially as cold duration increased from 6 to 12 weeks (Figure 2b).

During cold treatment, plugs or pots of *S.* x *arendsii* 'Triumph' can be cared for easily. They need only minimal lighting, such as a 9-hour day with fluorescent lamps, which provides approximately 50 footcandles. Water occasionally – about once every $1^1/_2$ -2 weeks. Too much water damages these plants. They do not require much water during forcing and even less during cooling.

4. Photoperiod

S. x *arendsii* 'Triumph' behaves as a facultative, long-day plant. After cold treatment, it flowered under any photoperiod of 10-24 hours as well as a 4-hour night interruption from 10 p.m. to 2 a.m. But it flowered about 3 weeks faster under 24 hours than it did grown under 10-hour photoperiods (Figure 4).

Figure 2a. When *Saxifraga* x *arendsii* 'Triumph' is forced from a single 128-cell plug, plants only produce one flowering stalk with two to five flowers per plant.

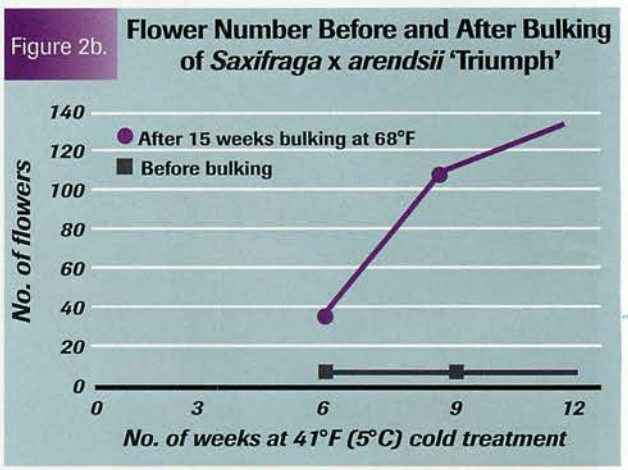


Figure 2b. Bulking dramatically increases the number of flowers per plant. After 15 weeks of bulking at 68°F (20°C), plants got cold treatments of 41°F (5°C) for 6, 9, or 12 weeks. Flower number of bulked plants increased with longer cold durations.

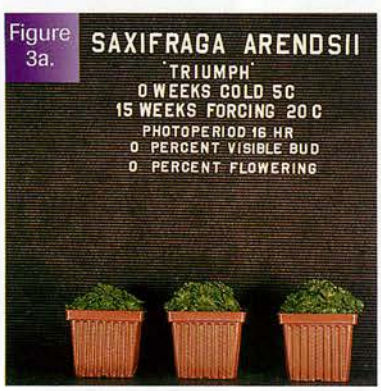


Figure 3a. Plants of *Saxifraga* x *arendsii* 'Triumph' do not flower without a cold treatment.

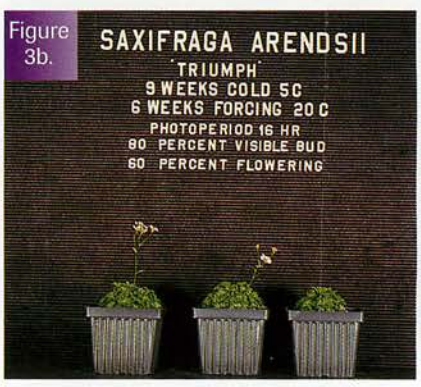


Figure 3b. In the experiment's second year, plants of *Saxifraga* x *arendsii* 'Triumph' required 9 weeks of cold treatment at 41°F (5°C) before 80% flowering occurred. In the first year, 60% of the plants flowered after 6 weeks of cold treatment. Flowering percentage refers to the proportion of plants with open flowers at the time the photograph was taken.

Under continuous light, plants forced directly from a 128-cell plug without bulking produced only a few flowers per plant (an average of 2), and the flower stalks tended to topple. Plants grown under 10-hour photoperiods were about 2 inches shorter than those grown under photoperiods of 12 hours or more, and they averaged five flowers per 128 cell-plug.

The most compact, floriferous plants were grown under 10-hour photoperiods. But plants grown under longer photoperiods – up to 16 hours – were still attractive and made acceptable potted flowering plants.

5. Lighting And Spacing

We used two different lamp types to provide day-extension lighting. In one experiment, we used natural days supplemented with day extension from high-pressure sodium (HPS) lamps to provide 16-hour photoperiods. In the other experiment, we tested photoperiods ranging from 10 to 24 hours and a 4-hour night interruption using natural days supplemented with HPS lamps and day extension from incandescent (INC) lamps. Day-extension lighting using HPS lamps provided approximately 30% more light than INC lamps.

There was no obvious effect of the different lamp types on flowering *S.* x *arendsii* 'Triumph.' Because the variety doesn't respond strongly to light quantity or quality, it can be grown in low light conditions. It is an ideal crop for winter.

Since *Saxifraga* spp. are such small plants, they can be spaced close together. Spacing them with 1-2 inches between pots is sufficient since the foliage does not grow much beyond the pots, and the flower stalks are held upright over the foliage.

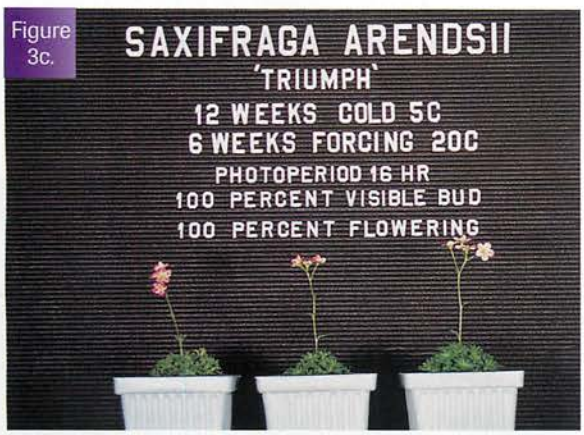


Figure 3c. After 12 weeks of cold treatment, all plants of *Saxifraga* x *arendsii* 'Triumph' flowered. In the first year, only 9 weeks of cold treatment were required for 100% flowering.

Figure 4. *Saxifraga* x *arendsii* 'Triumph' behaves as a facultative long-day plant. Plants grown under 24 hours flowered about 3 weeks before this photograph was taken, and here they are almost finished flowering. Plants under 10 hours have just opened their flowers.

6. Media, Fertilization, And Irrigation

In the garden, *S.* x *arendsii* 'Triumph' and other Saxifraga species prefer well-drained soils. In the *Ball Perennial Manual* on propagation and production, Jim Nau says soils with a gravel or sandy base are best for extending plant life.

The plants in our experiments were grown in a high-porosity soilless medium containing sphagnum peat moss, perlite, vermiculite, and composted bark that, if allowed to dry out between watering, was an acceptable media for growing *S.* x *arendsii* 'Triumph.' We fertilized at every irrigation using 125 ppm N, 12 ppm P, and 125 ppm K, which was sufficient for growth and development. We maintained pH levels of 5.8-6.2.

7. Plant Height Control

Because of 'Triumph's' natural short stature, it does not require any height control.

8. Temperatures And Crop Scheduling

Forcing temperature influences flower timing as well as plant quality. *S.* x *arendsii* plants flowered fastest – in 3 weeks – when they were grown at 75°F (24°C). At temperatures above 75°F (24°C), flowering percentage decreased and bud abortion occurred. Time to flower was increased to 4 weeks when plants were grown at 84°F (29°C). In addition, plants grown at this warm temperature had burned leaves and barely grew at all.

At cooler temperatures, plants took longer to flower, but were much more attractive, producing a few more flowers per stalk. Flowers had darker pigmentation than those grown at warmer temperatures (Figure 5). Plants grown at temperatures warmer than 75°F (24°C) had very small flowers with almost no pigmentation.

Time to flower was 6 weeks for plants grown at 59°F (15°C), 4 weeks for plants grown at 64°F (18°C), and 3.5

Table 1. *Saxifraga x arendsii* 'Triumph' Production Schedule

Growing time	Cultural practice	Temperature	Photoperiod
2 weeks	Root cuttings	55°-60°F (13°-16°C)	Natural daylength
6-8 weeks	Grow in plugs	55°-60°F (13°-16°C)	Natural daylength
	- OR - *Purchase plugs*		
6-9 weeks	Bulk (if starting from small plug size, such as a 128-cell)	65°-68°F (18°-20°C)	Natural daylength
9-12 weeks	Cold treatment	35°-45°F (2°-7°C)	Natural daylength or 9 hours of light in cooler
↓ ↓ ↓ ↓ 59°F (15°C) Flower in 6 weeks	***Begin forcing*** ↓ ↓ 64°F (18°C) Flower in 4 weeks	↓ 68°F (20°C) Flower in 3.5 weeks	**These times to flower were recorded for plants grown under 16 hours of light with day extension from HPS lamps** ***Number of days from visible bud to flower*** 59°F (15°C) - 19 days 64°F (18°C) - 16 days 68°F (20°C) - 15 days

weeks for plants grown at 68°F (20°C). Use temperatures of 59°F (15°C)-68°F (20°C) for the highest quality plants.

A problem growing this crop is trying to prevent flowering while forcing during late winter or early spring, when day temperatures in the greenhouse rise dramatically. Flowering occurs quite quickly after cold treatment, and *Saxifraga* spp. can grow quite well at cool temperatures. Development is estimated to occur at temperatures as low as 1.5°C. One strategy that can be used to address this problem is bulking the plants longer at warm temperatures (60°F [16°C]) before providing cold treatment.

Once a sufficient cold treatment has been given (9-12 weeks when temperatures are between 35°-45°F [2°-7°C]), move plants to a house with warmer temperatures. This strategy will reduce the amount of time in fluctuating cold and warm temperatures, which makes scheduled flowering difficult.

9. Disease And Insect Pests

S. x *arendsii* 'Triumph' is susceptible to Rhizoctonia, which causes root and crown rot. If watering is carefully monitored and plants are allowed to dry between watering, incidences of Rhizoctonia should be less frequent. No insect pests were observed on *S.* x *arendsii* 'Triumph.'

Figure 5. Growth and flowering are reduced when plants of *Saxifraga* x *arendsii* 'Triumph' are grown at temperatures warmer than 75°F (24°C). Growing plants at temperatures between 59°F (15°C) and 68°F (20°C) will result in attractive plants with dark flower color.

10. Postharvest Concerns

S. x *arendsii* 'Triumph' holds its flowers for approximately 3 weeks. Flowers have a faint, sweet scent that adds to the plant's beauty.

If sold as a flowering potted plant, include watering instructions because many consumers are apt to overwater and kill the plants. Plants should be shipped just before the flowers open so retailers can take full advantage of their blooms during sale. **GG**

About the authors: Emily Clough is a graduate research assistant and Arthur Cameron, Royal Heins, and Will Carlson are professors, Department of Horticulture, Michigan State University, East Lansing, MI 48824. Sources include the *Index of Garden Plants* and *Ball Perennial Manual*.

– Crop By Crop –

FORCING PERENNIALS

Species: *Sedum spectabile* x *telephium* 'Autumn Joy'
Common name: Sedum 'Autumn Joy'

by ***LOUIS E. SMITH, PAUL KOREMAN, ALISON FRANE, ROYAL D. HEINS, ARTHUR CAMERON,*** *and* ***WILL CARLSON***

THE succulent dark green leaves and delicate pink flowers of sedum 'Autumn Joy' have made this tough, drought-resistant, and easy-to-grow plant a favorite with gardeners throughout the world. It fits nicely into rock gardens, as an edging, or as a border plant (Figure 1) and has great potential for both spring and fall sales (Figure 2).

This perennial will grow in climates ranging from USDA zones 3 to 10 and is winter hardy to -40°F (-40°C). Sedum 'Autumn Joy' will grow 12-36 inches tall in full sun or partial shade.

Sedum 'Autumn Joy' is part of the Crassulaceae or Stonecrop family. Originally the result of a cross between *S. spectabile* and *S. telephium*, 'Autumn Joy' is commonly listed as a cultivar of *S. spectabile*. It naturally blooms from late summer until early fall, giving the garden a wonderful last splash of color at season's end.

In early to midsummer, the flower buds have a delightful broccoli-like appearance, with clusters approximately 3-4 inches across. By mid-August, the flower buds swell and develop a light pink color that deepens as the flowers open.

As the flower clusters mature, they become a brick red color and eventually dry to a nice dark wheat in the beginning of winter. The dried flower heads are present throughout the winter season, which make for great winter interest.

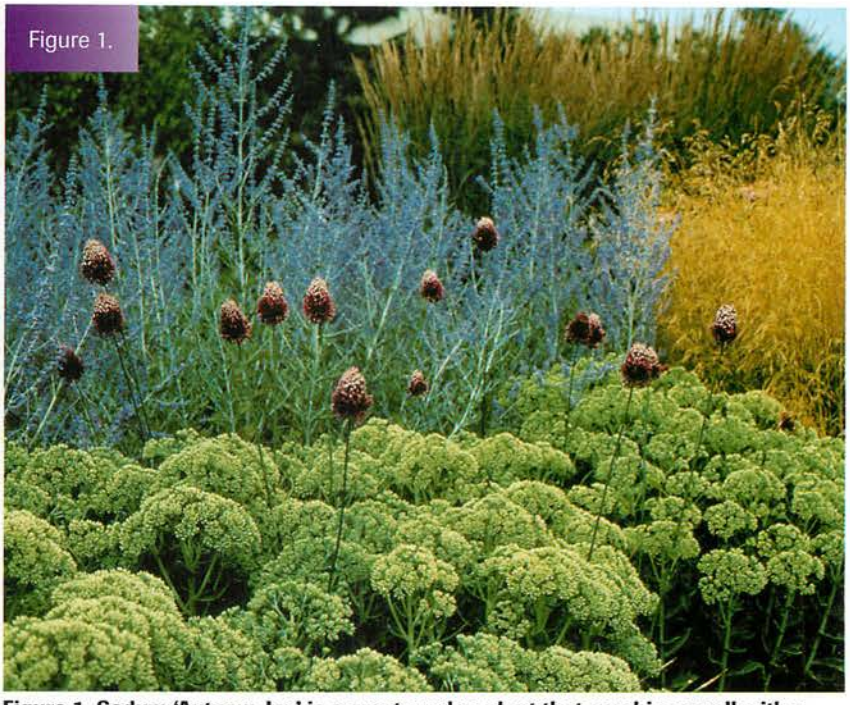


Figure 1. Sedum 'Autumn Joy' is a great garden plant that combines well with a range of textures and colors. Photo courtesy of Laura Coit.

A true perennial, sedum 'Autumn Joy' persists for decades – even in abandoned gardens. Plants form thick root masses from which the new shoots grow. This root mass spreads, slowly increasing the width of the plant every year.

The plants do not need any division to maintain their appearance. But for propagation purposes, the plants can be divided in either the fall or spring.

Sedum is a large group of plants, many of which have ornamental value. Some of the more closely related plants include: sedum 'Brilliant,' with light pink flowers, *Sedum maximum* 'Atropurpureum,' with dark purple foliage, and the more compact sedum 'Vera Jameson.'

Our research has principally focused on sedum 'Autumn Joy,' so the following tips may not work for other sedum.

1. Propagation

Sedum 'Autumn Joy' is a sterile plant, so it must be asexually propagated. In the garden, this can be accomplished by dividing the root mass in the fall or spring. Commercially, sedum 'Autumn Joy' is propagated via tip or leaf/stem cuttings during the growing season.

Terminal cuttings taken in May or later already contain flower buds, and these flowers continue to develop during the rooting process. Leaves and subterminal cuttings also root easily but do not immediately develop flowers. Therefore, when mixed cuttings are used, plugs can be quite variable.

It is fairly easy to produce high-quality plugs of sedum 'Autumn Joy.' Tip-cuttings should be stuck in plug trays with a well-drained plug medium and rooted under light mist for 2 weeks at 78°F (25°C).

The plugs can be hardened off for 1-2 weeks before transplanting or cold storage. Vegetative cuttings root more quickly than reproductive cuttings, produce a higher number of longer, healthy roots, and yield an even, consistent crop.

Keeping the stock plants under a 14-hour photoperiod is one way to increase the number of vegetative cuttings because more vegetative growth develops before the plants become reproductive. Under longer photoperiods, the plants will be induced to flower in about 3 weeks (Figure 3).

But even under 14 hours, sedum 'Autumn Joy' will initiate flower buds after 100 days at 68°F (20°C) if plants are left to grow without taking cuttings.

Buds arising at the base of the stems after flowering make excellent propagules. These plantlets can be removed in mid to late fall and stored for months at 28°F (-2°C) in plastic bags to prevent desiccation.

Figure 2.

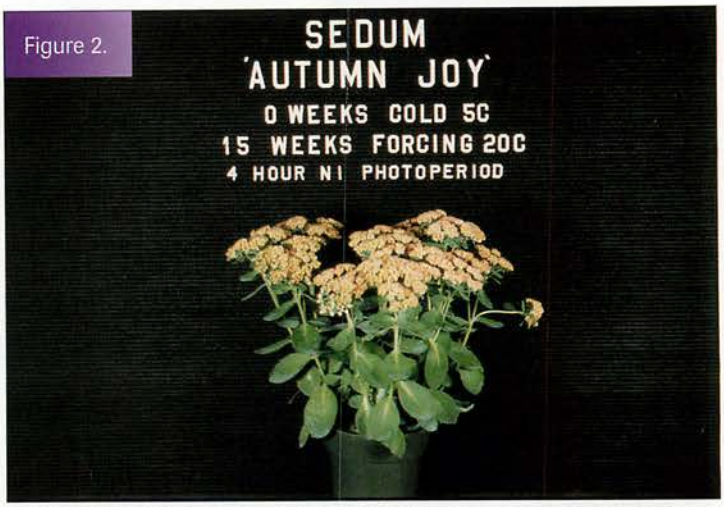


Figure 2. Sedum 'Autumn Joy' makes a wonderful potted plant, shown here in a 5-inch square pot.

Figure 3.

Figure 3. Sedum 'Autumn Joy' requires a photoperiod of 16 hours or longer for fastest flowering, but a 4-hour night interruption is as effective as a 16-hour photoperiod for flower initiation and development. Plants grown under 14-hour photoperiods have an extended vegetative phase before flowering.

2. Plant Size

Juvenility has not been a problem for us in flowering sedum 'Autumn Joy.' All rooted cuttings have flowered under long-day conditions, regardless of starting size.

Sedum 'Autumn Joy' is well-suited for a 5-inch pot with one plug per pot. It also can be an attractive plant in a 1-gallon pot using three plugs per pot or a bare-root plant.

3. Photoperiod

For rapid and uniform flowering, sedum 'Autumn Joy' is an obligate long-day (LD) plant and flowers similarly with or without a cold treatment. Plants forced under photoperiods of 10, 12 or 13 hours had very little growth and remained in a rosette form (Figure 3). All plants grown under photoperiods of 14, 16, or 24 hours or a 4-hour night interruption (NI) from 10 p.m. to 2 a.m. flowered.

The most rapid flowering (30-35 days for flower bud initiation) occurs when the plants are placed under a 16-hour or longer photoperiod or a 4-hour night interruption (Figure 3). As the daylength increases, the time to flower decreases, and the final number of inflorescences slightly increases.

Either high-pressure sodium (as a 16-hour day-extension) or incandescent lamps (as either a 16-hour day-extension or a 4-hour NI) successfully promoted flowering for sedum 'Autumn Joy.' We recommend 16-hour day-extension lighting or a 4-hour NI for consistent and uniform flowering.

Time to flower and height can be reduced by moving the plants after flower initiation from LD to short days (SD). We forced plants under a 4-hour night interruption LD for 1-8 weeks and then switched the plants to a 9-hour SD until they flowered.

The fastest combination – 4 weeks of LD followed by about 5 weeks of SD – reduced the time to flower by more than 2 weeks and plant height by nearly half (Figure 4). Providing 5 weeks of LD before transfering to SD reduced time to flower by 8-10 days and plant height by 2-3 inches.

4. Lighting And Spacing

Sedum 'Autumn Joy' thrives when it is grown under high-light conditions in the garden. The quality of greenhouse-grown plants is dramatically improved during the winter months when they are grown with 16 hours of supplemental lighting with HID lamps at 400-500 footcandles (Figure 5).

But supplemental lighting may be cost prohibitive. Sedum 'Autumn Joy' is a good candidate for summer production, since plants will benefit from the naturally high light levels.

The spacing of sedum 'Autumn Joy' should be wide enough to allow for light to penetrate into the lower part of the plant. This should reduce stretching and minimize disease. Spacing 5-inch pots on 7-inch centers and 6-inch pots on 8-inch centers works well.

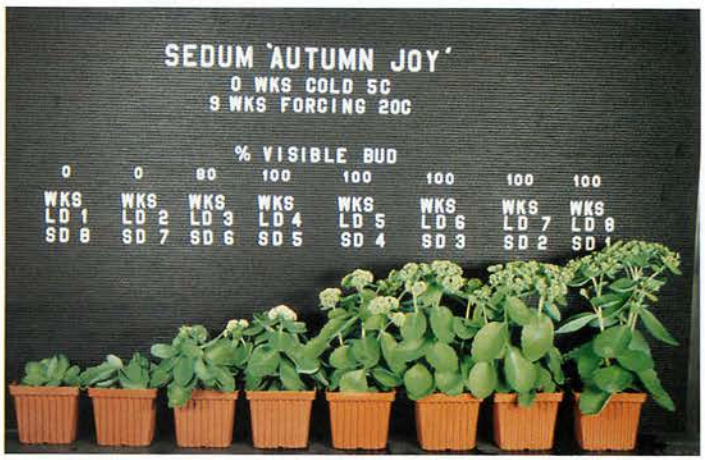


Figure 4. Sedum 'Autumn Joy' plants were forced under long-day durations (LD) varying from 1 week to 8 weeks, then switched to 9-hour short days (SD) until flower. S. 'Autumn Joy' initiated flowering with as few as 3 weeks of LD.

5. Media, Fertilization, And Irrigation

In the garden, sedum 'Autumn Joy' tolerates poor soil and some drought stress. Commercially, it grows best in well-drained, evenly moist soil with a pH range of 5.5-6.0. A constant feed of 100 ppm of a balanced fertilizer such as 20-10-20 is adequate for good growth.

Although sedum 'Autumn Joy' should not be overwatered, we did not observe crown or root rot during our experiments.

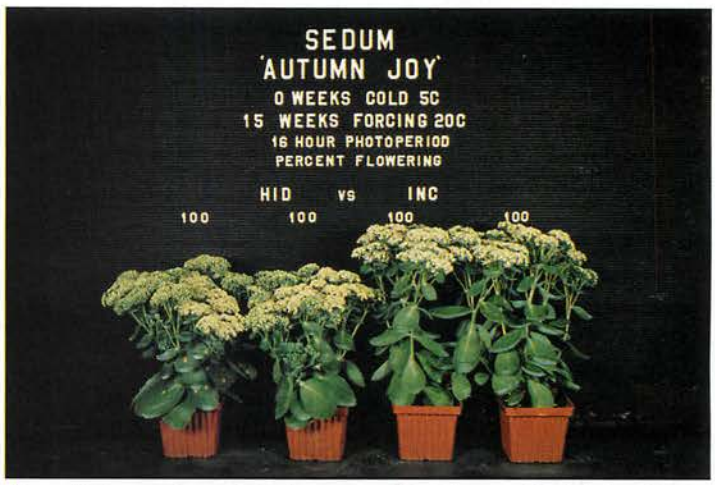


Figure 5. Comparison of plants grown with 9 hours of high-intensity lighting provided by high-pressure sodium (HPS) lamps and those grown with 16 hours of high-intensity lighting. Plants grown under 9 hours of light from HPS lamps and 7 hours of low-intensity lighting from incandescent bulbs were taller and faster to flower. Plants grown under 16 hours with HPS lamps were darker green with smaller leaves and brighter pink flowers.

6. Plant Height Control

In our greenhouse environment, sedum 'Autumn Joy' grew 12-14 inches under LD greater than 16 hours or a NI. Under 14 hours, the plants will grow much taller before flowering (Figure 3).

Height control has not been a major concern in our studies. To encourage branching and keep a crop at an even, attractive height, a hard pinch 4 inches (10 centimeters) above the pot 4 weeks after the start of forcing produced excellent plants that averaged 14 inches (35 centimeters) tall. Flowering was delayed about 4 weeks.

The onset of SD after flower initiation also can reduce final plant height (Figure 4). In fact, 6-inch tall plants can be produced that would be salable in a $2^1/_2$-inch pot by using only 4 weeks of LD followed by 4-5 weeks of SD. These compact plants could be an interesting product for unique markets.

7. Temperatures And Crop Scheduling

Under long-day conditions, average daily temperatures in the 64°-84°F (17°-29°C) range did not greatly influence flower development.

The time to flower was about 12 weeks at 68°-74°F (20°-23°C) and 13 weeks at 64° and 84°F, respectively.

Plant height and general plant quality were largely unaffected by production temperatures. Using specific production temperatures doesn't appear to be as critical for sedum 'Autumn Joy' as it has been for some of the other perennials.

Table 1. **Sedum spectabile x telephium 'Autumn Joy' Production Schedule**

Growing time	Cultural practice	Temperature	Photoperiod
	Stock plant growth	68°-74°F (20°-23°C)	14 hours of light or natural days
2-4 weeks	Take cuttings ↓ root	Media temperature 78°F (25°C)	14 hours of light
	- OR - *Purchase plugs*		
	Begin forcing		***≥ 16 hours of light or a 4-hour night interruption***
↓ ↓ ↓ ↓ ↓ 64°F (17°C) Flower in 13 weeks	↓ ↓ 68°-74°F (20°-23°C) Flower in 12 weeks	↓ ↓ ↓ ↓ ↓ 84°F (29°C) Flower in 13 weeks	***Number of days from visible bud to flower*** 64°F (17°C) - 58 days 68°F (20°C) - 52 days 74°F (23°C) - 49 days 84°F (29°C) - 54 days

8. Disease And Insect Pests

In the garden, there are few diseases or pest problems with sedum 'Autumn Joy.' In the greenhouse, we have occasionally observed powdery mildew in high humidity and cool temperatures.

We also observed one case of Rhizoctonia on the lower stems of the plant. When sedum 'Autumn Joy' stems were harvested from the field, thrips were present. In the greenhouse, we have observed no other pests.

9. Postharvest Concerns

Sedum 'Autumn Joy' can be shipped at any stage of development, but plants are most attractive just as the first flowers are opening. The plants will continue to bloom for at least 2 weeks.

After all the flowers have opened, the plants will still be attractive as the flowers darken during maturation. Sedum 'Autumn Joy' is very drought-tolerant and should withstand a range of retail conditions. They can even survive a Michigan winter outdoors in a 5-inch container – as we learned by accident. This tough plant definitely deserves its place in the garden. **GG**

About the authors: Louis E. Smith, Paul Koreman, and Alison Frane are research associates, and Drs. Royal D. Heins, Arthur Cameron, and Will Carlson are professors of horticulture, Department of Horticulture, Michigan State University, East Lansing, MI 48824.

Formula For Success: Sedum 'Autumn Joy'

1. Grow individual plants in a 5- or 6-inch pot (one plant per pot) or a 1-gallon pot (three plants per pot).

2. Use uniform plugs for a more uniform crop.

3. Provide plants with a long-day treatment by natural or extended photoperiods of 16 hours or by night interruption from 10 p.m. to 2 a.m. with a minimum light intensity of 10 foot-candles.

4. Force in the summer or consider providing supplemental lighting from high pressure sodium lamps during the dark winter months to increase branching and overall plant quality.

5. When possible, shift plants to short days after flower buds are visible to reduce the time to flower and plant height.

– Crop By Crop –

FORCING PERENNIALS

Species:
Stokesia laevis 'Klaus Jelitto'

Common Name:
Stoke's Aster

by **EMILY CLOUGH, ARTHUR CAMERON, ROYAL HEINS,** and **WILL CARLSON**

STOKESIA laevis is an attractive member of Asteraceae, the sunflower family, and is native to the southeastern coastal plains of the U.S., from South Carolina to Louisiana (Figure 1). The flowers are large – up to 4 inches diameter – and are usually pale lavender-blue. White-, yellow-, and purple-flowered cultivars also exist. *Stokesia laevis* is hardy to USDA zone 5. In northern climates, it flowers from July through October. In southern regions, it flowers almost all year long.

Stokesia laevis grows 15-20 inches (38-52 centimeters) tall and works well as a specimen plant. It also can be used as a cut flower. Although *S. laevis* tolerates partial shade, it performs best in warm, sunny, well-drained locations. Extremely moist areas should be avoided.

Most of our research has been on 'Klaus Jelitto.' We also have tested 'Alba' (white flowers); 'Blue Danube' (lavender-blue flowers); 'Mary Gregory' (small, pale yellow flowers); 'Purple Parasols' (bright magenta-purple flowers); and 'Wyoming' (small lavender-blue flowers).

Figure 1. Under short photoperiods of 10-12 hours, *Stokesia laevis* 'Klaus Jelitto' remains short, produces many flowers, and makes an attractive flowering potted plant.

1. Propagation

The *S. laevis* cultivars we tested do not come true from seed. They must be vegetatively propagated via crown divisions or root cuttings. Shoots develop readily from cut, exposed roots. Divisions are often made in spring but also can be done in the fall. Nonclonal *S. laevis* can be grown quite easily from seed. At 70°F (21°C) seeds germinate in 12 days and do not require covering.

2. Plant Size

Grown from seed, *S. laevis* has a juvenile period and will not flower the first year. In our experiments, 'Wyoming' plants started from divisions with as few as three leaves flowered, but the flowering percentage was low – 20%-60%.

Other cultivars started from larger plant material had higher flowering percentages. All 'Klaus Jelitto' plants we received in $2^1/_2$-inch pots with an average of 10 leaves flowered under the appropriate photoperiod and grew to an appropriate size for a 1-gallon pots.

3. Cold Treatment

Cold treatment is not necessary for 'Klaus Jelitto' to flower. Without a cold treatment, flowering depends on photoperiod and light intensity.

Experiments were conducted under two different light

treatments. In the first, we provided a 16-hour day with natural light, along with supplemental light and day extension from high-pressure sodium (HPS) lamps.

In the second experiment, we tested photoperiods of 10, 12, 13, 14, 16, and 24 hours and a 4-hour night interruption with a 9-hour natural day supplemented with HPS lamps and day extension to the desired photoperiod from incandescent (INC) lamps. Using HPS lamps for day extension rather than INC lamps increased the daily light integral by approximately 30%, an increase from 9.8 to 12.6 $mol \cdot m^{-2} \cdot day^{-1}$.

When photoperiods were provided with day extension from INC lamps, noncold-treated plants flowered only under 10, 12, 13, and 14 hours. Flowering percentage was consistently higher under photoperiods of 12 and 13 hours (Figure 2a).

Plants grown under 16 hours provided by day extension from HPS lamps flowered without a cold treatment, but the flowering percentage was low – 50%-60% (Figure 2b).

Flowering percentage increased and time to flower decreased as cold duration increased from 0 to 6 weeks at 35°-45°F (2°-7°C) for plants forced under a 16-hour photoperiod provided by day extension from HPS lamps. Flower timing changed little with cold durations longer than 6 weeks, but variability continued to decrease with longer cold treatments.

After 15 weeks of cold treatment, plants flowered under all photoperiods, but flowering percentage was lower under photoperiods ≥ 14 hours and was extremely low (0%-10%) under 24-hour photoperiods.

Under 12- to 13-hour photoperiods provided by day extension with INC lamps, time to flower decreased by about 2 weeks after plants received a 15-week cold treatment at 41°F (5°C).

For the most consistent, rapid, and uniform flowering, we recommend 10-15 weeks of cold treatment at 41°F (5°C). If starting material is small, such as a 128-cell, longer durations of cold treatment (15-plus weeks at 41°F [5°C]) may be necessary for 100% flowering.

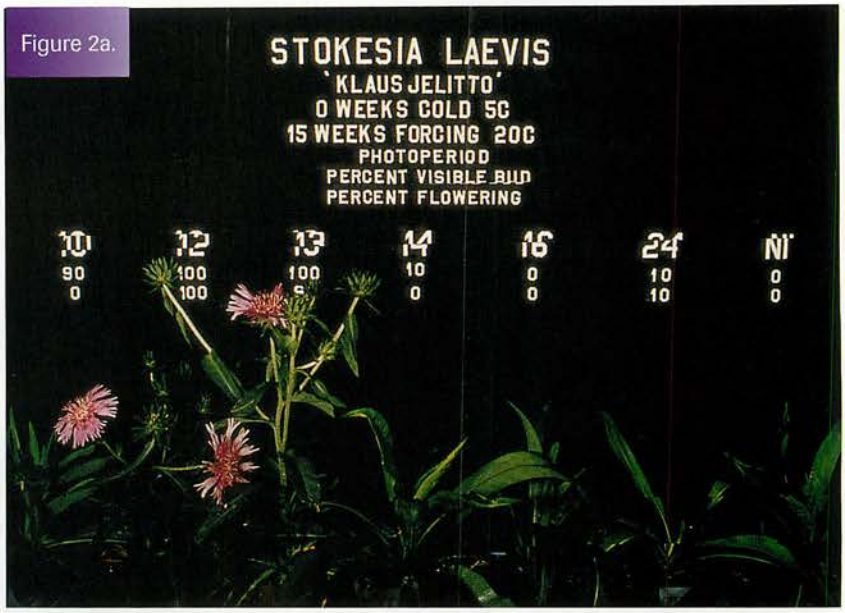


Figure 2a. Without a cold treatment, 'Klaus Jelitto' plants flower under photoperiods of 10-14 hours. A single plant flowered without cold under a 24-hour photoperiod. In the first year, plants flowered without a cold treatment only with photoperiods of 12-14 hours.

4. Photoperiod

'Klaus Jelitto' is best described as a facultative intermediate-day plant. It will flower under all photoperiods, but it flowers most consistently and rapidly at intermediate ones (Figure 3).

The highest flowering percentage and fastest time to flower occurred at photoperiods of 12 and 13 hours, both before and after cold treatment. Flowering under night-interruption lighting from 10 p.m. to 2 a.m. with INC lamps occurred only after a 15-week cold treatment, and the percentage was never higher than 90%.

Photoperiod also influenced flower timing, flower number, and plant height at flower. After 15 weeks at 41°F (5°C), plants grown at 68°F (20°C) under photoperiods ≥ 12 hours flowered in approximately 10 weeks. Plants grown under a 10-hour photoperiod flowered in 18 weeks during the experiment's first year and 11 weeks in its second.

Flower number decreased from 13 to four flowers per plant as photoperiod increased from 10 to 24 hours. Plant height at flowering dramatically increased with a longer photoperiod.

Plants under a 10-hour photoperiod were 7-11 inches (17-27 centimeters) tall and at this height, would make acceptable flowering potted plants. Plants under a 16-hour photoperiod grew to about 18 inches (46 centimeters) tall. Plants under night interruption appeared similar to those under a 16-hour photoperiod.

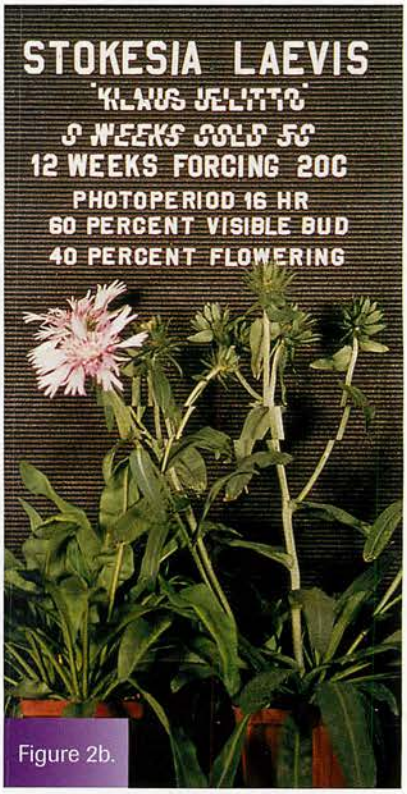


Figure 2b. When 'Klaus Jelitto' is grown without a cold treatment under 16-hour photoperiods provided by day extension with high-pressure sodium lamps, 50%-60% of plants flower.

5. Media, Fertilization, And Irrigation

In our experiments, we maintained pH levels between 5.8 and 6.2. At every irrigation, we applied a fertilizer solution containing 100-150 ppm N, 10-20 ppm P, and 100-150 ppm K, which was sufficient for 'Klaus Jelitto's' growth and development.

All cultivars of *S. laevis* grown in the greenhouse were drought tolerant and could withstand wilting without detriment.

However, in the garden, *S. laevis* does not perform well, and plants are often short-lived if they are grown in moist locations.

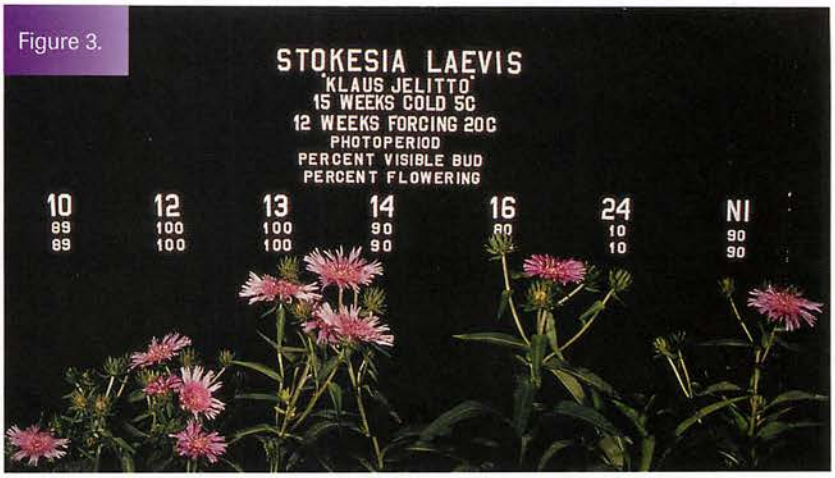


Figure 3. After a 15-week cold treatment at 41°F (5°C), 'Klaus Jelitto' plants flowered under all photoperiods but was limited under 24-hour photoperiods. In the first year, no plants flowered under 24-hour photoperiods. In the second year, one plant flowered.

6. Lighting And Spacing

In the garden, *S. laevis* prefers a bright, sunny location, but it will tolerate partial shade. In our experiments, 'Klaus Jelitto,' 'Blue Danube,' and 'Purple Parasols' responded to increased light levels. These cultivars produced $1^1/_2$-2 times more flowers when they were grown under a 16-hour photoperiod provided by day extension with HPS lamps rather than INC lamps – an increase from approximately 11 to 14 $mol \cdot m^{-2} \cdot day^{-1}$.

Plants can be spaced quite close together initially, but as they grow during forcing, more space is required. At flower, 'Klaus Jelitto' plants are large, and flower stems can become tangled if the plants are not adequately spaced.

7. Plant Height Control

Naturally short cultivars of *S. laevis*, such as 'Mary Gregory' (11 inches) and 'Wyoming' (13 inches) do not require height control. The height of taller cultivars, such as 'Klaus Jelitto,' may be best controlled by photoperiod. Again, photoperiod strongly influences 'Klaus Jelitto's' height at flower. Plant height doubles as photoperiod increases from 10 to 16 hours.

Although only 'Klaus Jelitto' was tested under the various photoperiods (all others were grown under 16 hours only), it is likely that other cultivars will behave similarly.

Forcing temperature also influences plant height. 'Klaus Jelitto' grown at 86°F (30°C) was approximately 8 inches tall, while those grown at 61°F (16°C) were 19 inches (48 centimeters). Temperatures above 70°F (21°C) are not recommended, because flowering percentage and plant quality decrease with higher temperature.

To our knowledge, the effectiveness of plant growth regulators on *S. laevis* has not yet been tested.

8. Temperatures And Crop Scheduling

Forcing temperature influences flower timing and plant quality. Time to flower decreased from 13 to 6

Figure 4a. Plants flower faster but with decreasing percentages as forcing temperature increases. Plant height and flower number also decrease with higher forcing temperature.

Figure 4b. After 13 weeks of forcing, 'Klaus Jelitto' plants grown at the coolest temperature of 61°F [16°C]) flowered. In this photograph, plants grown at warmer temperatures have already finished flowering.

Table 1. ***Stokesia laevis* 'Klaus Jelitto' Production Schedule**

Growing time	Cultural practice	Temperature	Photoperiod
6 weeks	Root divisions/ basal root cuttings	68°F (20°C)	Natural daylength
8-10 weeks	Grow in plugs	65°-68°F (18°-20°C)	Natural daylength
- OR - *Purchase plugs*			
10-15 weeks	Cold treatment	35°-45°F (2°-7°C)	Natural daylength or 9 hours of light in cooler
Begin Forcing			
↓ 64°F (18°C) Flower in 11 weeks		↓ 70°F (21°C) Flower in 9 weeks	

weeks as forcing temperature increased from 61°F to 86°F (16°-30°C) (Figures 4a and 4b). In our experiments, the flowering percentage also decreased with increasing temperatures. All plants flowered when they were grown at 61°F-70°F (16°-21°C). Flowering was 90% at 75°-81°F (24°-27°C) and 50% at 86°F (30°C).

Plant quality features, such as height and flower number, also decreased at warmer temperatures. Plants grown at 61°F (16°C) produced six times as many flowers as those grown at 86°F (30°C). We recommend forcing temperatures at 64°-70°F (18°-21°C) for optimizing flower timing and plant quality (Table 1).

9. Disease And Insect Pests

A notable problem with 'Klaus Jelitto' was interveinal chlorosis followed by necrosis of the leaves that appeared approximately 3 weeks into forcing (Figure 5a). In addition, there was leaf puckering (Figure 5b).

The symptoms were not associated with any mineral nutrient deficiency or toxicity. Although plants in every experiment exhibited symptoms, they were most severe when day extension lighting was provided by HPS lamps.

The least-severe symptoms were on plants grown under shorter photoperiods and day extension from INC lamps. There was no apparent effect of the leaf chlorosis, necrosis, or puckering on the flowers.

Other cultivars of *S. laevis*, including 'Purple Parasols' and 'Alba' also showed these same symptoms, but 'Klaus Jelitto' was affected the most. Only mild interveinal chlorosis was observed on 'Blue Danube,' and

Figure 5a. Leaf chlorosis and necrosis as shown in this photograph were observed on 'Klaus Jelitto' plants in every experiment conducted. Symptoms appeared approximately 3 weeks into forcing. *Photo courtesy of Mary-Slade Morrison.*

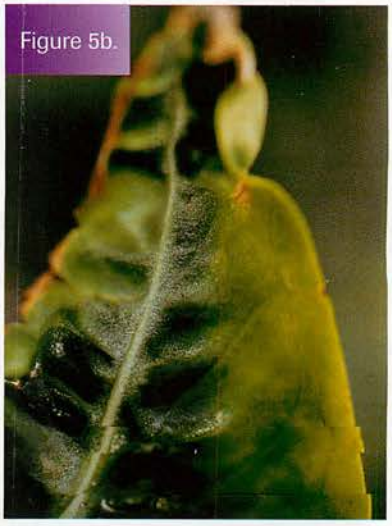


Figure 5b. The leaf chlorosis and necrosis was accompanied by leaf puckering as shown in this photograph. Flowers on affected plants were not influenced by the symptoms and developed normally.

'Mary Gregory' and 'Wyoming' showed no symptoms.

The only disease on 'Klaus Jelitto' or any *S. laevis* cultivar was Rhizoctonia. Occurrences may be reduced by watering only the soil.

As *S. laevis* comes into bud, the leaves around the bud form a cup, which can trap water and lead to increased occurrences of stem rot.

No insect was a pest on *S. laevis*.

10. Postharvest Concerns

Plants should be shipped just before or right after the first flower opens.

Individual flowers on the plant remain open for 4-5 days, closing at night and reopening the following day. 'Klaus Jelitto' in the greenhouse continues to bloom for approximately 3 weeks.

11. *Stokesia laevis* Cultivars

All cultivars of *S. laevis* that we tested flowered in 9-11 weeks, except for 'Alba.' It was notably slower than other cultivars, taking 16 weeks to flower (Table 2).

Among cultivars, flowering percentages varied from 20% to 100%. This may have been associated with initial plant size. The cultivars received as small, single-eye divisions or in 128-cell plugs generally had lower flowering percentages than those shipped in $2^1/_2$-inch pots.

Flower number and plant height varied among cultivars. 'Mary Gregory' and 'Wyoming' were the shortest (11-13 inches), but they were also the least floriferous. 'Mary Gregory' produced an average of eight flowers per plant, while 'Wyoming' produced an average of six. 'Alba,' 'Blue Danube,' 'Klaus Jelitto,' and 'Purple Parasols' were tall – 15-20 inches (39-52 centimeters) at flower.

'Blue Danube' and 'Klaus Jelitto' were moderately floriferous (6-13 flowers per plant). Their flower number depended on the type of lighting. For these cultivars, flower number increased when HPS lamps were used for day extension rather than INC lamps.

'Blue Danube' was quite spindly and made a far less attractive potted plant than the multibranched 'Klaus Jelitto.' 'Alba' and 'Purple Parasols' were extremely floriferous and produced 17-24 flowers per plant. The flower number of 'Purple Parasols' was doubled when HPS lamps were used for day extension instead of INC lamps. **GG**

Formula For Success: 'Klaus Jelitto'

1. Provide at least 10 weeks of cold treatment at 41°F (5°C) for the most rapid, consistent, and uniform flowering.

2. Force plants at 64°-70°F (18°-21°C). Avoid temperatures above 70°F (21°C) because they cause decreased flowering percentages and lower plant quality.

3. During forcing, provide plants a photoperiod of 12-13 hours for the most rapid, consistent flowering.

4. Ship at first flower.

About the authors: Emily Clough is a graduate research assistant and Arthur Cameron, Royal Heins, and Will Carlson are professors, Department of Horticulture, Michigan State University, East Lansing, MI 48824. *Source: Ball Perennial Manual, Propagation and Production.*

Table 2. **Flowering characteristics of several cultivars of *S. laevis* after 15-week cold treatments**

Variety	Time to flower 68°F (20°C)	Plant height at first flower under a 16-hr. photoperiod (14 mol·m^{-2}·day^{-1})	Number of flowers per plant under a16-hr. photoperiod (14 mol·m^{-2}·day^{-1})
'Alba' 	16 weeks	15 inches (39 centimeters)	17
'Blue Danube' 	9 weeks	16.5 inches (42 centimeters)	9
'Klaus Jelitto' 	10 weeks	20 inches (52 centimeters)	13
'Mary Gregory' 	10 weeks	11 inches (27 centimeters)	8
'Purple Parasols' 	9 weeks	16 inches (41 centimeters)	24
'Wyoming' 	11 weeks	13 inches (32 centimeters)	6

– Crop By Crop –

FORCING PERENNIALS

SPECIES: *Veronica longifolia* 'Sunny Border Blue'
COMMON NAME: Speedwell

by ***ERIK S. RUNKLE, ROYAL D. HEINS, ARTHUR CAMERON,*** *and* ***WILL CARLSON***

Figure 1.

'Sunny Border Blue' makes an attractive flowering potted plant.

VERONICA is in the Scrophulariaceae, or snapdragon, family and contains more than 250 species of herbaceous annuals or perennials. Veronica longifolia is native to Europe and Asia but has naturalized in North America. It is a clump-forming perennial that grows 2-4 feet tall with white, pink, or deep-blue flowers. The cultivar 'Sunny Border Blue' has dense violet-blue spikes of flowers that rise above attractive, dark-green, opposite leaves. In 1993, 'Sunny Border Blue' was named Perennial Plant of the Year by the Perennial Plant Association. We have found that it makes an attractive flowering potted plant that can be enjoyed first indoors and later outdoors (Figure 1).

Flower Induction Requirements

The following recommended production information applies only to 'Sunny Border Blue.' Other Veronica species and cultivars may have different production schedules.

1. PLANT SIZE

'Sunny Border Blue' is propagated by stem cuttings. Rooted cuttings with at least two to three nodes will flower after cold treatment.

2. COLD TREATMENT

Rooted cuttings of 'Sunny Border Blue' taken from unchilled stock plants have an obligate cold (vernalization) requirement to flower. A 10-week cold period or longer at about 41°F (5°C) is recommended. Five weeks of cold will satisfy the requirement, but plants take approximately 2

Table 1. ***Veronica longifolia* 'Sunny Border Blue' Production Schedule**

Growing Time	Cultural Practice	Temperature	Photoperiod
2-3 weeks	Take cuttings ↓ Rooting OR purchase plugs	72°-77°F (22°-25°C)	Natural photoperiods
≥10 weeks	Cold treatment ↓ ↓	35°-45°F (1°-7°C)	9 hours of light
Begin Forcing. Pinch Tips.			Natural photoperiods
↓ ↓ ↓ 60°F (15°C) 12 weeks flower	↓ ↓ 65°F (18°C) 10 weeks flower	↓ 70°F (21°C) 8-9 weeks flower	**Visible Bud to Flower** 60°F (15°C) - 29 days 65°F (18°C) - 25 days 70°F (21°C) - 22 days

weeks longer to flower. Plants not provided with a cold treatment will not flower (Figure 2). Some rooted cuttings may flower without cold treatment if they were taken from cold-treated stock plants.

3. PHOTOPERIOD

'Sunny Border Blue' is a day-neutral plant; following cold, all plants flower regardless of photoperiod (Figure 3). Therefore, natural photoperiods are recommended.

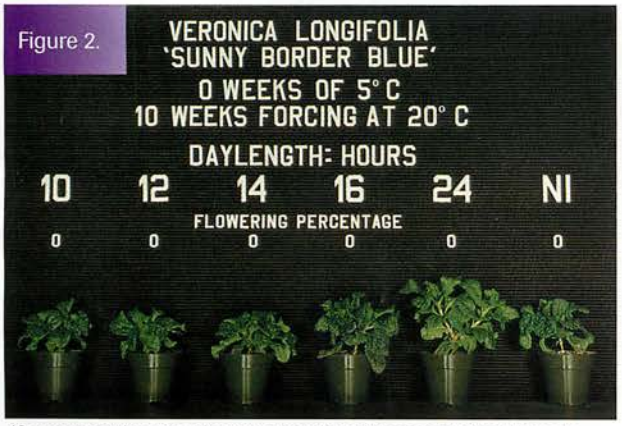
4. PROPAGATION

The only method of propagation is by cuttings. Stock plants should not be exposed to cold unless flowering of cuttings is desired. Cuttings with two to three nodes root readily within 2-3 weeks.

5. MEDIA AND FERTILIZATION

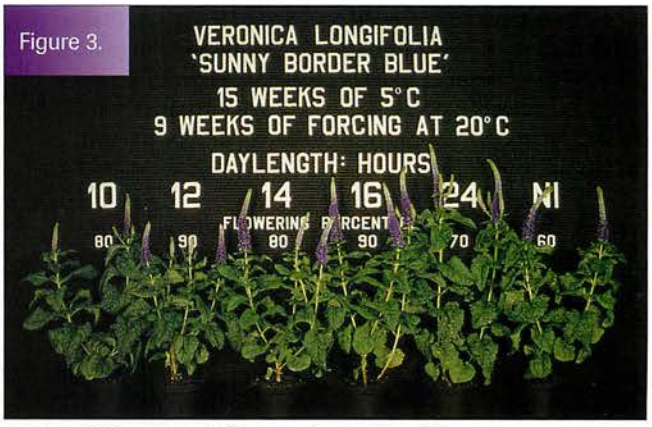
Plants prefer a moist, well-drained medium maintained at a pH of 5.5 -6.0. Constant fertilization of 100 to 150 ppm

Figure 2.



'Sunny Border Blue' cuttings taken from unchilled stock plants will not flower without cold treatment.

Figure 3.



After cold treatment, 'Sunny Border Blue' flowers under all daylengths.

N, 10 to 20 ppm P, and 100 to 150 ppm K20 is recommended (for example, 20-10-20).

6. LIGHTING AND SPACING

Moderate to high light levels are recommended during forcing of 'Sunny Border Blue.' Supplemental lighting at 400-500 footcandles improves plant quality during winter.

7. IRRIGATION

Although 'Sunny Border Blue' is a relatively slow grower, plants have thick leaves and require frequent irrigation, especially when grown in small pots. Rapid wilting is of particular concern once plants have visible buds.

8. PLANT HEIGHT CONTROL

Pinched plants are naturally 12-16 inches tall. Pinching the tips of cuttings before forcing will induce lateral breaks, increasing the number of flower spikes and reducing plant height by a few inches. Growth retardants are recommended to control plant height only when plants are grown in 4-inch pots. Our research indicates that A-Rest, B-Nine, Bonzi, and Sumagic effectively reduce stem elongation and cause only slight flowering delay. If growth retardants are applied, spray after 2-3 weeks of forcing or when stems begin to elongate.

9. TEMPERATURES AND CROP SCHEDULING

Time to flower depends on forcing temperature (Figure 4). 'Sunny Border Blue' is most attractive when grown at daily averages of 60°-70°F (15°-21°C). Plants grown above 70°F (21°C) have light-green foliage and small inflorescences. Plants grown at 60°F (15°C) have the largest inflorescences but flower slowest. At 60°F (15°C), buds are visible after 8 weeks of forcing and begin to flower after 12 weeks. Plants grown at 65°F (18°C) reach visible bud after 6 weeks and flower within 10 weeks. Plants grown at 70°F (21°C) have visible buds after 5 weeks and begin to flower in 8 weeks.

10. DISEASE AND INSECT PESTS

Botrytis is often a problem on lower leaves. Spraying for Botrytis is recommended before and after cold treatment. Powdery mildew is also a frequent problem; fungicide applications are advised once symptoms become apparent. Starting with disease-free cuttings is a must.

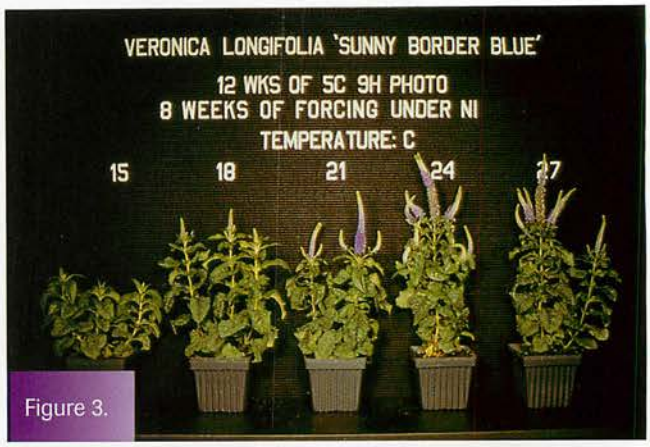


Figure 3.

'Sunny Border Blue' flowers faster under warm temperatures, but plants are more attractive when grown at daily averages of 60°-70°F (15°-21°C). Photo courtesy of Shi-Ying Wang.

Formula For Success: 'Sunny Border Blue'

1. Unchilled rooted cuttings should be given at least 10 weeks of cold at 41°F (5°C).
2. Pinch tips of cuttings at the beginning of forcing.
3. Force at 60°-70°F (15°-21°C) under natural daylengths. Supplemental lighting during winter improves plant quality.
4. Plants grown in 4-inch pots need to be irrigated frequently, especially once they have visible buds.
5. Apply growth retardants after 2-3 weeks of forcing if plants are grown in 4-inch containers.

11. POSTHARVEST CONCERNS

Plants should be shipped once the first flowers open. Spent flowers remain on the lower part of inflorescences, making plants less attractive. **GG**

About the authors: Erik S. Runkle is a graduate student, Catherine Whitman is a former graduate student, and Drs. Royal D. Heins, Arthur Cameron, and Will Carlson are professors, Department of Horticulture, Michigan State University, East Lansing, MI 48824. They would like to thank generous industry supporters and research contributors Shi-Ying Wang, Beth Engle, Paul Koreman, Mei Yuan, Cheryl Hamaker, Tom Wallace, and Cara Wallace.

Firing Up Perennials – Beyond 2000

By **ART CAMERON, BETH FAUSEY, ROYAL HEINS,** and **WILL CARLSON**

"THERE'S no denying that perennials are hot!" we wrote in our first article in this series more than five years ago. And little has changed, except that more and more herbaceous perennials are being sold in flower. Perennials are not only beautiful in the garden, but they also can be irresistible when flowering in a container.

Flowering perennial sales have risen dramatically the last few years. The current challenge is providing a uniform crop of superior quality plants to garden centers and retail nurseries. High quality plants in bloom command a premium price that more than compensates for increased production costs. A flower is a powerful sales tool.

In addition to the more than 30 perennial articles we published in GG, we have tested hundreds of other perennials, many of which hold great promise for forcing in a container. In the tables that follow, we list the herbaceous perennials from our studies that are suitable for controlled growth and flowering. These studies haven't been as in-depth as those we've previously published, but we're certain this information will be useful to you as a starting point for further trials and research.

Not all of the perennials we've tested have proven suitable for container production. Some that haven't made the grade include *Dianthus deltoides, Helenium autumnale, Lewisia cotyledon, Monarda didyma,* some *Penstemon spp., Potentilla, Sidalcea,* and *Solidago.* Some container production limitations include growth variability, bad-smelling foliage, floppy growth habit, incomplete flowering, and poor flower quality. Producing these perennials in larger containers may be the solution, and further information is needed on flower induction requirements.

The following tables provide general information needed to grow a wide range of perennials for scheduled sales during the growing season. Remember certain groups of perennials have similar flowering requirements. **GG**

Perennials that force in six weeks or less at 68°F

■ assuming that induction requirements have been met

Achillea 'Moonshine'
Aquilegia flabellata 'Mini Star' and 'Cameo'
Aquilegia x hybrida Many to choose from
Campanula 'Birch Hybrid'
Gaura lindheimeri 'Whirling Butterflies'
Heuchera sanguinea 'Bressingham Hybrids'
Oenothera fructicosa 'Youngii-Lapsley'
Salvia nemorosa 'May Night'
Salvia x superba 'Blue Queen'
Saxifraga umbrosa 'Aureo-punctata' and 'London Pride'
Scabiosa caucasica 'Butterfly Blue'
Tiarella wherryi

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Formula For A Successful Forcing Program

1. Select superior perennials that look good in containers and perform well in the garden.
2. Know your starting material. The size and character of your starting material will impact the plant's final quality.
3. Provide the right amount of cold – between 32 to 41°F, in most cases. Plants may not perceive adequate cold with naturally occuring warm fall and spring temperatures.
4. Provide proper cultural conditions during the cold treatment. Most perennials require some light during the cooling process.
5. Provide proper cultural conditions during production: monitor and control pH (5.8 to 6.2) and salts (EC of 1 to 2); use a well-aerated soil mix; maximize light quantity; and grow with an average daily temperature in the 60s for best quality.
6. Check for buds to gain information on the marketing window.
7. When possible, market perennials when they first flower so customers can enjoy them longer. This also helps ensure a shorter plant.
8. Many fantastic perennials are grown not for flowers, but for foliage. Hostas, heucheras, lamiums, artemesias, and vincas can strengthen interest and salability of any perennial collection.
9. Keep your eyes open! There's an increasing number of fantastic perennials available these days. Give some a try. You may just like them.
10. Increase your marketing window. Perennial sales aren't limited to spring, and many growers have marketed perennials right through the summer and into the fall.

Table 1.

Herbaceous Perennials for a Forcing Program

Perennial Species	Appropriate Container Size	Cold Duration (<45° F)	Long Days Required	Weeks to Flower at 68°F	Garden Rebloom Potential the 1st Yr.	Comments
Achillea 'Moonshine'	5-inch and up	No	Yes	4	Yes	Very nice garden perennial, very showy in color in a container. 'Anthea' and 'Coronation Gold' have similar flowering requirements. 'Moonshine' is perhaps best for visual impact in a container.
Achillea millefolium 'Fireland,' 'Galaxy,' 'Paprika,' 'Terra Cotta,' 'Apple Blossom'	5-inch and up	For some	Yes, for most	6-9	Yes	Generally very good garden perennials that look fantastic in containers. Flower colors on these selections are showy. Some get tall and top heavy for smaller containers.
Anemone hupehensis	5-inch and up	6+ weeks	Yes	13	Yes	Very nice garden perennial, but slow in the greenhouse with some variability. Other hybrid anemones are also great as pot plants. Flower longevity during retailing can be a problem. Best as summer-produced crop for late summer and fall sales.
Aquilegia flabellata 'Cameo'	3- to 4-inch	6 weeks	No	4	No	A cute dwarf columbine – only grows to six inches tall with sturdy, leathery leaves. Needs about six weeks bulking in the pot or large plug cell before cooling, or else finished plant is very small.
Aquilegia flabellata 'Mini Star'	4- to 5-inch	6 - 9 weeks	No	4	No	A great dwarf Columbine, growing to about eight to 10 inches. It's a long bloomer with lavender/blue flowers. A great potted perennial. It needs some bulking before cooling, although not as much as 'Cameo.'
Aquilegia x hybrida 'Crimson Star'	5-inch and up	6 - 9 weeks	No	5	No	Striking crimson and white flowers are eye-catching, especially for hummingbirds! Nice fragrance and dense foliage. Plants are best overwintered in a pot or large plug (50-cell and up) due to juvenility factor.
Aquilegia x hybrida Musik series 'White'	5-inch and up	6 - 9 weeks	No	5	No	This columbine has pure white, fragrant flowers. Looks great in a pot. Plants are compact (12" tall) with dense foliage. Due to juvenility factor, plants are best overwintered in a pot or large plug (50-cell and up).
Aquilegia x hybrida Songbird series 'Bluebird'	5-inch and up	6 - 9 weeks	No	5	No	A taller columbine with large, showy, blue and white flowers. Nice fragrance. Due to juvenility factor, plants are best overwintered in a pot or large plug (72-cell and up).
Armeria x hybrida 'Dwarf Ornament Mix'	4-inch	10 weeks	No	12	Little	Variable when started as seedlings. Flowered inconsistently in our trials, but it's very nice when it does flower. Some armerias are already marketed as pot crops in Europe. Great potential with further work.
Asclepias tuberosa	5-inch and up	No	Yes	8	Yes	Keep under LD continuously from seed to final product. Do not expose to short days or it will go dormant within a short period. Pinch to promote branching. Do not overwater. Susceptible to some vascular wilts.
Aster dumosis 'Purple Dome'	5-inch and up	10 - 15 weeks	No	8	Perhaps if spring produced	Great potential but had some variability.
Astilbe chinensis 'Superba'	5-inch and up	10 weeks	No	7 to 9 depending on cultivar	Little	Don't let it dry out. Most astilbes are not as good in pots as in the garden. They are very popular with the gardening public.
Astilbe chinensis pumila	4-inch and up	15 weeks	Yes	11	Yes	A dwarf astilbe with showy blooms. More tolerant of sun and drought than arendsii hybrids, but still relatively sensitive.
Campanula 'Birch Hybrid'	4-inch and up	6+ weeks	Yes	6	Yes, if it's not too hot in the garden	A great pot plant. With extended chilling, it becomes day neutral. It also benefits from supplemental light.
Campanula carpatica 'Blue Clips,' 'White Clips', other cvs.	4-inch and up	No	Yes	7	Yes	A great pot plant. Fast, easy, colorful, and popular in Europe. This should become an important pot crop in the U.S. Growers will sell all they force.
Coreopsis auriculata 'Nana'	4-inch and up	6 weeks	No	4	Yes	Easy to flower, but tends to be pretty small. It doesn't give the profusion of flowers of the other coreopsis, but it's nice.
Coreopsis grandiflora 'Baby Sun'	4-inch and up	10 weeks	Yes	7	Yes	Nice as a small pot crop. Expect very good sales. Has great rebloom potential.
Coreopsis grandiflora 'Early Sunrise'	5-inch and up	No	Yes	7	Yes	No cold needed for this coreopsis. Looks good in a container, very easy to force, and has a great rebloom potential.
Coreopsis grandiflora 'Sunray'	5-inch and up	10 - 15 weeks	Yes	7	Yes	Has a great color, and is very good in a forcing program. It fills larger containers with no problem, and has a great rebloom potential.
Coreopsis verticillata 'Moonbeam' and 'Zagreb'	4-inch and up	No	Yes	8	Yes	Bulk it under short days or use larger plugs to get bigger final product. Cold isn't necesary for flowering, but can be held at cool temperatures. Force at cooler temperatures for best results.
Delphinium 'Blue Mirror,' 'Belladonna' and others	4-inch and up	5 weeks	No	9	Yes , if in a cool garden	A great pot plant, though it can be difficult to grow well. Some of the smaller delphiniums have weak stems. Force at cooler temperatures if possible, and let plants dry out before watering.
Echinacea purpurea 'Magnus' and 'Bravado'	5-inch and up	No	Yes	14	Yes	Sells quickly when in flower, but too tall for most containers. Florel has helped in preliminary studies. Larger containers are more appropriate. Has a long postharvest life. The 1998 Perennial Plant of the Year.
Gaillardia x grandiflora 'Goblin' and 'Baby Cole'	4-inch and up	10+ weeks	Yes	7	Yes, if deadheaded	This plant could be great if there was less seedling variation. Can't count on 100% flowering in our experience. Breeders need to work on this one.
Gaura lindheimeri 'Whirling Butterflies,' 'Siskyou Pink,' and others	5-inch and up	No	Yes	6	Yes	Very good in a container, especially when combined with Purple Fountain Grass. Has a fantastic rebloom potential, propagates easily, and comes back into flower quickly.

(continued on page 142.)

Perennials appropriate for production in three- to four-inch pots

■ These are smaller-sized plants

Aquilegia flabellata 'Cameo' and 'Mini Star'
Armeria x hybrida 'Dwarf Ornament Mix'
Delphinium 'Blue Mirror' and other dwarfs
Saxifraga - many to choose from

Perennials appropriate for production in four-inch pots and up

■ Many of these can be easily adapted to larger containers either by increasing the number of plugs per pot and/or using larger starting material.

Astilbe chinensis pumila
Campanula 'Birch Hybrid'
Campanula carpatica 'Blue Clips' and 'White Clips'
Coreopsis grandiflora 'Baby Sun'
Coreopsis verticillata 'Moonbeam'
Delphinium 'Blue Mirror' and other dwarfs
Gaillardia x grandiflora 'Goblin' and 'Baby Cole'
Geranium dalmaticum
Heucheras - many to choose from
Lavandula angustifolia 'Hidcote,' 'Munstead,' and others
Leucanthemum x superbum 'Snow Cap' and other dwarfs
Saxifraga umbrosa 'Aureo-punctata' and 'London Pride'
Scabiosa caucasica 'Butterfly Blue'
Sedum 'Autumn Joy'
Tiarella wherryi

Perennials that force in seven to 10 weeks at 68°F

■ assuming that induction requirements have been met

Asclepias tuberosa
Aster dumosis 'Purple Dome'
Astilbe chinensis 'Superba'
Campanula carpatica 'Blue Clips' and 'White Clips'
Coreopsis grandiflora 'Sunray,' 'Baby Sun,' and 'Early Sunrise'
Coreopsis verticillata 'Moonbeam'
Delphinium 'Blue Mirror' and 'Belladonna'
Gaillardia x grandiflora 'Goblin' and 'Baby Cole'
Geranium dalmaticum
Hemerocallis 'Stella De Oro'
Hosta 'Tokudama,' 'Francee,' 'Golden Scepter,' and 'Golden Tiara'
Lavandula angustifolia 'Hidcote' and 'Munstead'
Leucanthemum x superbum 'Snow Cap'
Lobelia x speciosa 'Compliment Scarlet'
Penstemon digitalis 'Husker Red'
Veronica longifolia 'Sunny Border Blue'

Perennials suitable for five- to six-inch pots, one-gallon, and up

Achillea 'Moonshine,' 'Terra Cotta,' and many others
Anemone hupehensis and cultivars
Aquilegia x hybrida 'Musik White'
Aquilegia x hybrida Songbird series and 'Bluebird'
Aquilegia x hybrida 'Crimson Star'
Asclepias tuberosa
Aster dumosis 'Purple Dome' and related
Astilbe chinensis 'Superba' and cultivars
Coreopsis grandiflora 'Sunray'
Coreopsis grandiflora 'Early Sunrise'
Echinacea purpurea 'Magnus' and 'Bravado'
Gaura lindheimeri 'Whirling Butterflies' and 'Siskyou Pink'
Gypsophila paniculata 'Double Snowflake' and others
Hemerocallis 'Stella De Oro' and others
Hibiscus moscheutos 'Disco Belle Hybrids'
Hosta 'Francee,' 'Tokudama,' 'Golden Tiara,' 'Golden Sceptor,' and more
Lobelia x speciosa 'Compliment Scarlet' and others
Oenothera fructicosa 'Youngii-Lapsley' and others
Pennisetum setaceum 'Rubrum' and other cultivars
Penstemon digitalis 'Husker Red' and other species
Perovskia atriplicifolia
Rudbeckia fulgida 'Goldsturm'
Salvia nemorosa 'May Night'
Salvia x superba 'Blue Queen'
Sedum 'Autumn Joy'
Stokesia laevis 'Klaus Jellito' and others
Veronica longifolia 'Sunny Border Blue' and 'Red Fox'

No Cold Treatment Required

■ In some cases these can tolerate cold storage

Asclepias tuberosa
Campanula carpatica 'Blue Clips' and 'White Clips'
Coreopsis grandiflora 'Early Sunrise'
Coreopsis verticillata 'Moonbeam'
Gaura lindheimeri 'Whirling Butterflies'
Hibiscus moscheutos 'Disco Belle Hybrids'
Hosta plantaginea 'Royal Standard'
Pennisetum setaceum 'Rubrum'
Sedum 'Autumn Joy'

Cold treatment of four to six weeks

Achillea 'Moonshine'
Aquilegia flabellata 'Cameo'
Campanula 'Birch Hybrid'
Delphinium 'Blue Mirror' and 'Belladonna'
Geranium dalmaticum
Hosta – most cultivars
Leucanthemum x superbum 'Snow Cap'
Lobelia x speciosa 'Compliment Scarlet'
Penstemon digitalis 'Husker Red'
Perovskia atriplicifolia

Table 1. **Herbaceous Perennials for a Forcing Program *(cont'd)***

Perennial Species	*Appropriate Container Size*	*Cold Duration (<45° F)*	*Long Days Required*	*Weeks to Flower at 68°F*	*Garden Rebloom Potential the 1st Yr.*	*Comments*
Geranium dalmaticum	4-inch and up	6 weeks	Yes	7	No	Nice plant and a great garden performer in Michigan. It has pink, showy flowers on a small plant. It's easy to flower, but needs to be bulked before cold.
Gypsophila paniculata 'Double Snowflake'	5-inch and up	12 - 15 weeks	Yes	12	No	It likes a larger container, and has a great impact in the garden center. It may need staking.
Hemerocallis 'Stella De Oro'	5-inch and up	15 weeks for bare root crown	No	8	Yes	This sells quickly, even in bud. This has a great name recognition.
Heuchera sanguinea	4-inch and up	10 weeks	No	6	Depends on cultivar	Flowering heucheras seem to be underrated these days. Flowering forms have a great potential as a pot crop.
Hibiscus moscheutos 'Disco Belle Hybrids'	5-inch and up	No	Yes	12 or 9 at 75°F	Yes	This is best if grown at higher temperatures (one of the few), shorter if grown under water stress, and it needs adequate light for flower buds to continue developing. Seed supply has been limited.
Hosta 'Tokudama'	5-inch and up	6 weeks	Yes	6-8	Yes	Nice in 5-inch pot, as are many other hostas. Thick leaves give these plants substance. Flowers are a bonus, but not a necessity for hostas.
Hosta 'Francee,' 'Golden Tiara,' and 'Golden Sceptor'	5-inch and up	3 weeks	Yes	8	Yes	Petite size is good for borders or edging. Starting material should be larger than a one-eye division for adequate size.
Hosta plantaginea 'Royal Standard'	5-inch and up	No	Yes	14+	Yes	Very fragrant! A taller species in need of a 1-gallon container. This has some potential as a pot crop although it's slow to flower.
Lavandula angustifolia 'Hidcote' and 'Munstead'	4-inch and up	10-15 weeks	Yes	7	Yes	Cut plants back at planting. Larger plants are better for forcing. 'Hidcote' has nice dark blue flowers on a short plant. Other species of lavender may not be hardy, but can be very showy in containers.
Leucanthemum x superbum 'Snow Cap'	4-inch and up	6 weeks	Yes	7	Limited	A nice, short, showy cultivar with uniform flowering. One drawback is it smells. Other traditional cultivars are very tall and floppy in containers.
Lobelia x speciosa 'Compliment Scarlet'	5-inch and up	6 weeks	Yes	9	Limited	Great red flowers, but tall and still needs effective PGRs. It has sold very well in flower in Michigan the last few years.
Oenothera fructicosa 'Youngii-Lapsley'	5-inch and up	3 weeks	Yes	5	No	This and other fructicosa types are very showy in bloom. It has good postharvest life as potted plant in the interior environment.
Oxalis crassipes 'Rosea'	5-inch and up	No	Yes	5-6	Yes	It's probably a zone 6-7 perennial and has great potential as a hanging basket plant. It performed well in our trials and seems to be sterile.
Pennisetum setaceum 'Rubrum'	4-inch and up - versatile	No	Yes	11	Zone 9 perennial	Great tender perennial, but not winter hardy. A very showy plant that walks out the door in flower even with substantial price tags.
Penstemon digitalis 'Husker Red'	5-inch and up	9 weeks	Yes	7	Limited	Nice, but maybe not that nice. Clonal material is superior to seed . It's a past Perennial Plant Of The Year.
Perovskia atriplicifolia	5-inch and up	5 weeks	No	11	No	It's a very good perennial in gardens! It can get tall in a container. Sumagic is quite effective for height control. 'Filagran' is a nice cultivar.
Phlox paniculata	5-inch and up	No	Yes	10	Yes	Garden phlox are still very popular with consumers. Start with disease-free material and pinch to promote branching. It can come straight from rooted cuttings.
Physostegia virginiana	5-inch and up	10+	Yes	10	Yes	It can be tall and leggy, so select compact cultivars for container culture. It will spread quickly in the garden, and deadheading is necessary for continuous bloom.
Platycodon grandiflorus 'Sentimental Blue'	5-inch and up	No	Yes	11	Yes	Nice, dwarf, naturally compact cultivar with blue flowers. Pinching produces fuller plants.
Pulmonaria cvs.	4-inch and up	Yes	No	2-3	No	Really not grown as much for flowers as for foliage. New cultivars hit the market daily. There are some great cultivars to choose from.
Rudbeckia fulgida 'Goldsturm'	5-inch and up	10 weeks	Yes	13	Yes	A great perennial with lots of color. Too tall for many growers when in full flower.
Salvia nemerosa 'May Night'	5-inch and up	9 weeks	No	4	Yes	A nice plant and a past PPA Perennial Plant Of The Year selection. It's easy to force and likes lots of light.
Salvia x superba 'Blue Queen'	5-inch and up	9 weeks	Yes	5	Yes	A nice and easy forcing perennial, and is uniform with proper cooling. Blue flowers make a colorful impact.
Saxifraga arendsii 'Triumph'	4-inch and up	9+ weeks	Yes	4	No	A great plant for 5-inch pots. It benefits from about 6 weeks bulking prior to cold, and prefers well-drained soils.
Scabiosa columbaria 'Butterfly Blue'	4-inch and up	No	No	5	Yes	Another great PPA Perennial Plant Of The Year selection for 2000. It looks good in a container and is day neutral, so doesn't need lighting. It will rebloom when cut back, and flowers faster if cold treated.
Sedum 'Autumn Joy'	2-inch and up	No	Yes	12	Yes	Looks nice in a container. If planted in flower in May, you can have new blooms by fall. It makes an interesting 2-inch novelty plant as rooted cuttings.
Stokesia laevis 'Klaus Jellito'	5-inch and up	10+	Yes 12-13 hours	10	No	A great pot plant and best for large containers. Flowers close in evening, which limits indoor home use.
Tiarella wherryi	4-inch and up	15 weeks	No	2	Yes	An easy, long-blooming perennial that is nice in a pot. It's also a great shade plant in the garden.
Veronica longifolia 'Sunny Border Blue'	5-inch and up	10+	No	9	Limited	A nice perennial but has problems with diseases, especially powdery mildew.

The 2000 Edition

GREENHOUSE GROWER and Michigan State University (MSU) researchers bring you all three series on forcing perennials. What sells perennials better than a perennial in bloom? In this series, researchers in the Department of Horticulture at Michigan State University tackle what growers need to know to force perennials into bloom for early season sales.

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Research Rolls On

Part of the proceeds generated by the sale of *Firing Up Perennials: The 2000 Edition* goes toward funding further perennial research at Michigan State University.

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