Michigan State University researchers’ seven-part series on herbaceous perennials covers topics from Phlox paniculata to chemical height control.

**June:** Phlox paniculata
**July:** Delphinium
**August:** Plant Growth Retardants
**September:** Digitalis
**October:** Aquilegia
**November:** Campanula
**December:** Summary Tables

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GREENHOUSE STRUCTURES

Digitalis

Digitalis grandiflora, the yellow foxglove, resembles the common foxglove but is a dwarf perennial species reaching two to three feet tall. This species has creamy yellow to apricot flowers with rusty markings on the throat and is fully hardy to USDA zone 4. 'Carillon' is a charming cultivar with pale yellow flowers above compact clumps of dark green foliage.

Digitalis obscura, the willow leaf foxglove, is a half-hardy Spanish species with narrow, dark green foliage that grows to two feet tall. Plants form erect clumps that bear short, tubular flowers in various shades of yellow and orange with red markings. This unusual species is reportedly hardy to USDA zone 6, but has been described as difficult to grow.

D. hapsi is a delightful species native to Portugal and Spain. This foxglove has downy, gray-green foliage that complements brightly colored flowers. 'Spanish Peaks' is a selection from the Colorado State University and Denver Botanic Gardens Plant Select series. Its bright purple flowers and small habit make it attractive in a container and garden setting.

Propagation

Most foxglove species and cultivars are propagated from seed. The seed of biennial foxgloves is traditionally sown in the spring or after flowering in the summer. Plants are grown the remainder of the season and the basal rosette is overwintered to flower in the second year, a lengthy process. Foxgloves can also be forced to flower out of season or for early season sales. Plants grown from seeded plugs will flower in as little as 15 to 18 weeks, depending on the cultivar. Seeds should remain uncovered once sown and placed at 65°F to 75°F (18°C to 22°C), where they germinate readily in five to 10 days. A 128-cell plug tray will finish in eight weeks from seeding when grown at 68°F (20°C). In addition to seed-propagated plugs, perennial foxgloves can be divided and are often available as bare-root material from commercial sources.

Plant Size

Three of the four foxgloves we evaluated flowered completely when grown from small seedlings (128-cell...
Production requirements for foxglove cultivars and species

<table>
<thead>
<tr>
<th>Digitalis species and cultivar</th>
<th>Average minimum leaf # for flowering</th>
<th>Recommended</th>
<th>Photoperiod</th>
<th>Response to Light Quantity</th>
<th>Crop Timing at 68°F</th>
<th>Plant Height in flower</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>purpurea</em> &quot;Foxy&quot;</td>
<td>12-15</td>
<td>0 weeks with LD and more than 10 mol·m⁻²·d⁻¹; otherwise 5+ weeks</td>
<td>LD beneficial</td>
<td>Greater flowering %, more flowers, reduced time to flower</td>
<td>9-10 weeks</td>
<td>24-36&quot;</td>
</tr>
<tr>
<td><em>grandiflora</em> &quot;Spanish Peaks&quot;</td>
<td>35</td>
<td>10 weeks</td>
<td>LD beneficial</td>
<td>Greater leaf and flower %</td>
<td>8-9 weeks</td>
<td>12-15&quot;</td>
</tr>
<tr>
<td>&quot;Carillon&quot;</td>
<td>20</td>
<td>0 weeks Cooling not required but beneficial</td>
<td>Day neutral</td>
<td>Greater flower %</td>
<td>7-8 weeks (10 without cold)</td>
<td>7-9 weeks</td>
</tr>
<tr>
<td><em>obscura</em></td>
<td>60</td>
<td>5 weeks</td>
<td>Day neutral</td>
<td>Greater flower %</td>
<td>7-9 weeks</td>
<td></td>
</tr>
</tbody>
</table>

Figure 2. Digitalis ‘Foxy’ plugs can be transplanted directly into five-inch or one- or two-gallon containers (left to right).

‘Foxy’ is the largest of the four foxgloves evaluated, and plugs filled five-inch containers after eight weeks at 68°F. Plants were too large for the five-inch container after 15 weeks in the greenhouse. Due to the robust growth habit and large leaf size of ‘Foxy,’ small plugs also filled one- and two-gallon containers in a similar amount of time as the five-inch container (Figure 2).
Forcing ‘Foxy’ in these larger containers could have a greater market value than if grown in smaller containers.

Forcing to Flower

Cold Treatment. Foxgloves generally require or benefit from exposure to low temperatures of 35°F to 45°F (2°C to 7°C) before forcing. The requirement for cold varies with foxglove cultivar and species (Table 1). In many cases, foxgloves may flower without cold; however, flowering is generally hastened and more uniform following five to 15 weeks at 41°F (Figure 3a, b). ‘Spanish Peaks’ was the only foxglove tested that did not flower without cold (Figure 4a, b). Digitalis purpurea ‘Foxy’ reportedly has no cold requirement for flowering. Plants flowered completely under LD after cooling for zero, one, two, three, four, and five weeks at 41°F with no differences in flower timing.

In a separate experiment, ‘Foxy’ plants were grown under a nine-hour (h) SD and LD following zero, five, 10, or 15 weeks at 41°F. Plants did not flower under SD with zero or five weeks of cooling (Figure 5a). Flowering percentages increased under SD following 10 and 15 weeks of cold but never reached 100%.

Cold can be delivered year-round in a lighted cooler or during the winter months in a minimally heated greenhouse. Plugs of each of these species can be successfully stored for 15 weeks at 41°F, and in many cases longer. For example, we have stored ‘Foxy’ for 24 weeks in a 128-cell tray before forcing.

Photoperiod. Foxgloves vary in their photoperiodic requirements for flowering. Digitalis purpurea has previously been classified as a quantitative long day (LD) plant where flowering is hastened under long days compared to short days (SD) (Figure 3b). ‘Spanish Peaks’ is also a quantitative LD plant while D. obscura and ‘Carillon’ are day neutral plants and flowering was not affected by day length.

Light Quantity. Although often considered a shade plant, Digitalis pur-
perennials will thrive in full-sun locations with adequate moisture and cool temperatures. Flowering percentage of digitalis ‘Foxy’ was highly dependent on the greenhouse light environment and increased when plants were grown under elevated daily light integrals (DLIs) (Figure 6). To determine the effects of DLI on flowering of ‘Foxy’, plugs were cooled for zero or five weeks at 41°F and then grown under a 16-h LD with varying light quantities (measured as DLI). Flowering of ‘Foxy’ ranged from 0% to 100% when plants were grown under DLI less than 10 mol·m⁻²·d⁻¹. All noncooled and cooled ‘Foxy’ plants flowered under LD when the DLI was 10 mol·m⁻²·d⁻¹ or greater.

DLI also influenced crop timing of ‘Foxy.’ Average time to visible flower bud was delayed by two weeks when plants were grown under a DLI of 5 mol·m⁻²·d⁻¹ compared to 10 mol·m⁻²·d⁻¹ and by one week for plants grown under a DLI of 10 compared to 18 mol·m⁻²·d⁻¹.

Growing ‘Foxy’ under SD or LD with
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low light levels (5-10 mol m⁻² d⁻¹) will result in incomplete flowering of non-cooled plants. Therefore, providing supplemental lighting when greenhouse light levels are naturally low is recommended to improve flowering percentage and plant quality. Cooling plants for a minimum of 10 weeks at 41°F is recommended when forcing during the winter months and long days cannot be provided.

Temperature And Crop Scheduling

Foxgloves are considered cool season garden plants and generally perform best when grown with moderate to cool greenhouse temperatures. Growth and flowering of 'Foxy' was evaluated at 54°F to 79°F (14°C to 26°C). Noncooled plants flowered in 13 weeks at 59°F (14°C), in 11 weeks at 64°F, 73°F, and 79°F (17°C, 23°C, and 26°C) and in 10 weeks at 68°F (20°C) (Figure 7). Five weeks of cooling hastened flowering by four weeks at 59°F, three weeks at 64°F, and two weeks at 73°F and 79°F (Figure 6). From the start of the long day photoperiod, digitalis 'Foxy' flowered in nine to 10 weeks at 68°F (20°C), regardless of cooling duration. Plant quality was optimum at temperatures less than 73°F (23°C) and flower abnormalities and flower bud abortion were common for plants grown at warmer temperatures.

Total crop time from the start of propagation to first flower is about 17 to 18 weeks at 68°F (20°C). Because foxgloves are propagated from seed, one can expect variability in flowering percentage and timing within individual crops. For example, flowering of 'Foxy' plants in our studies varied from four to 13 days from the average date of flowering. This can be advantageous when scheduling plants to bloom over a period of several weeks. However, a greater number of plants must be grown to ensure a sufficient number are marketable when forcing plants to flower for a specific date.

Media, Fertilization, And Irrigation

All foxgloves performed well when grown in a well-drained, peat-based medium at a pH between 5.8 and 6.2, with moderate fertility levels of 100 to 150 ppm N, 15 to 20 ppm P, and 100 to 150 ppm K delivered at each watering.

Plant Height Control

Shorter foxgloves such as 'Spanish Peaks,' 'Carillon,' and D. obscura (all 12 to 15 inches at first open flower) do not require height control. For larger cultivars such as 'Foxy,' plant
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**Digitalis purpurea 'Foxy'**

- 10 weeks at 68°F (20°C)
- Average DLI (mol-m²-d⁻¹)
  - 50% Shade
  - Ambient
  - HPS 100

**Figure 6.** Flowering of Digitalis purpurea 'Foxy' is influenced by light quantity. Flowering percentages under long days increase with increasing daily light integral (DLI).

**Digitalis purpurea 'Foxy'**

- 8 weeks at 68°F (20°C)
- 11 weeks forcing

**Figure 7.** Digitalis 'Foxy' flowers most quickly at 68°F. Plants should be grown with average daily temperatures less than 73°F for optimum flower quality.

**Disease, Insect, And Postharvest Concerns**

Foxgloves are relatively insect and pest-free. Individual flowers open from the base of the inflorescence upward and may remain open for five to 10 days, depending on temperature. Spent flowers generally drop into the foliage or on the bench top where they may harbor Botrytis if not removed. Ideally, plants should be marketed for sale when inflow growth regulators (PGRs) can be used to maintain compact rosettes of foliage and are also important in controlling inflorescence height. In our trials, A-Rest, Bonzi, and Sumagic were effective in controlling plant height (Figure 8). However, 'Foxy' bolts rapidly after visible flower buds appear in the base of the rosette. Thus, PGRs should be applied just as the inflorescence begins to elongate.
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Keys To Success

1. Cooling is not essential for flowering under long days but is recommended when flowering plants under naturally short day lengths when photoperiod control is not possible. Plugs can be stored in a lighted cooler or cooled naturally in a greenhouse at 41°F (5°C) until forcing begins.

2. 128-cell or larger plugs with four to six leaves can be directly transplanted into five-inch or larger containers for the duration of forcing. Small plugs will adequately fill one- or two-gallon containers in nine weeks. Plants unfold a minimum of eight to 12 leaves before flowering.

3. After transplanting, provide long days (16 h) and supplemental lighting if DLI is less than 10 mol m⁻² d⁻¹ to maximize light intensity for optimum plant quality.

4. Maintain cool to moderate greenhouse temperatures of 59°F to 68°F (14°C to 20°C).

5. Apply growth retardant sprays when plants begin to bolt to maintain compactness and control inflorescence height.

About the authors: Beth Fausey is a research technician, Arthur Cameron and Royal Heins are professors, and Erik Runkle is an assistant professor and extension specialist, Department of Horticulture, Michigan State University, East Lansing, MI.