Herbaceous Perennials: Aquilegia (Columbine)

by CATHY WHITMAN, ART CAMERON, ERIK RUNKLE, and ROYAL HEINS

One of the best-known and well-loved garden plants, aquilegias (commonly known as columbine) are a wonderful spring flower, and irresistible when sold in bloom. Even short-growing cultivars have a "wildflower" appearance that is very appealing to the gardener. Aquilegia can be short lived, but they do make great container plants and garden plants, and have the added bonus that they attract butterflies and hummingbirds. Flower colors range from yellows to reds to purples and blues (Figure 1).

Aquilegias are a member of the ranunculus family (which includes delphinium, aconitum, anemone, and clematis). There are about 65 species in the Northern hemisphere, many native to the United States. Aquilegia caerulea, with its beautiful blue and white flower, is the state flower of Colorado and Aquilegia canadensis, with yellow and red flowers, ranges naturally from Texas to Nova Scotia. In the garden, species hybridize freely and there are many hybrids commercially available. The species range in cold hardiness from USDA zone 2 (A. sibirica) to zone 8 (A. discolor) and the hybrids are generally hardy from zones 4 to 6. The species and older columbine cultivars are inherently variable, with long juvenility periods and extended vernalization requirements. Although many make excellent garden plants, it is not uncommon for many of these selections to take a year or more from seed to first flower.

For growers who desire a quick-crop approach to columbine production, new selections have been released that are compact with shorter juvenility requirements and, in some cases, little if any vernalization (cold treatment) requirement. These include Aquilegia flabellata cultivars such as Mini-Star and the Cameo series. The primary production challenges with columbine are to ensure that plants have reached adequate maturity (size) before the cold period begins, and that they then receive adequate cold to fulfill their vernalization requirement. These size and cold requirements are different for different species and cultivars. New cultivars are constantly being released and we have observed that columbine cultivars marketed in the same series may have different juvenility or vernalization requirements. Still, when successfully forced, columbines make attractive container plants that can be enjoyed in the home before they are moved to the garden.

Propagation And Plant Size: The Juvenility Issue

Plants are available commercially as seeds, plugs, or as bare-root plants. Our research has been conducted with seedlings growing in plugs. All columbines are seed-propagated and after germination, seedlings are juvenile and will not

Schedule

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

Figure 2. These may be a familiar sight: Nonflowering columbines, despite lengthy cooling and plenty of time in the greenhouse. Plants from a large (LG; 50-cell) or small (SM; 128-cell) plug did not flower under long days (LD) or short days (SD).
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flower even after exposure to conditions that induce flowering in mature plants. All species have a juvenility phase, which in many cases can last for months.

If columbines are not old enough (mature) before the vernalization period, they simply will not flower (Figure 2). The plants need to be bulked, i.e. grown for a period of time allowing them to increase in size and attain maturity. In our experience, it is more effective if seedlings are transplanted and bulked in larger containers rather than bulking them in the plug trays, especially when the plug size is a 72 or smaller. Pot-cooled plants generally have a higher flowering percentage and are larger in flower (Figures 3 and 4).

One way to quantify plant maturity is by counting leaves. The exact leaf number needed to reach maturity varies among cultivars. For ‘Winky Double Red & White,’ nine to 12 leaves were needed before plants were capable of flower induction, and for ‘Origami Blue & White,’ seven to nine leaves were adequate. At 68°F, columbine plants take seven to eight days to unfold one leaf. Recommended leaf numbers before cooling are provided for some hybrids in Table 1.

Leaf count does not really tell the entire story; when we compared plugs and plants with the same leaf numbers, the flowering percentage for plug-cooled plants was lower than for pot-cooled plants. Evidently leaf number is not the only factor determining plant maturity. Even 50-cell plugs may not be large enough for some varieties. In one experiment, we compared bulking in 50-cell plug trays versus bulking in five-inch pots. Flowering of plants bulked in the 50-cell plug tray did not reach 100%, while all plants bulked in the five-inch pots did flower.

Cold Treatment

The majority of columbines require a cold treatment for flowering. In our experience, no native species will flower without vernalization, but several hybrids have been selected over the past decade with short cold requirements. Specific cooling durations for some of the hybrids are provided in Table 1.

Unfortunately, there is no reliable method to determine if a given columbine has received enough cooling. In warm winters, there is always a chance that plants will receive inade-
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aquilegia hybrids, which can
have detrimental effects on flowering. Try to err
on the side of over cooling if there is a choice.

Little is known about specific tempera-
tures that are effective for ver-
nalization. It is likely that columbine can
perceive and accumulate “chilling” at
temperatures in the 50s (°F), but we
have not conducted specific experi-
ments to verify this. In all our experi-
ments, we have used 41°F as our stan-
dard vernalization temperature and
cooled plants in controlled chambers,
providing nine hours of light (25 to 50
footcandles) per day.

**Photoperiod**
Columbines are day-neutral and
will flower under short days or long
days. Photoperiod can affect stem
elongation and plants grown under
long days may be too tall. We suggest
forcing under natural daylengths.

**Media, Fertilization, And Irrigation**
Plants in our experiments per-
formed very well in a standard soil-
less medium. Nitrogen levels of 125
ppm N in a constant liquid feed pro-
gram were sufficient for healthy
growth. We maintained pH levels be-
tween 5.8 and 6.2.

**Lighting And Spacing**
Aquilegia prefers moderate light
levels. Supplemental light during pe-
riods of low light resulted in sturdier
plants with more flowers, but plants
grown without supplemental light
were of acceptable quality when
grown in the spring.

**Plant Height Control**
Some very compact columbine cul-
tivars are the *Aquilegia flabellata* types
that only grow about three to six inch-
es tall, and the *Biedermeier* strain with
a height of nine to 12 inches. Growth
regulators are generally not needed
for these varieties.

Other columbin has been to become quite
tall and growth regulators may be
needed. For *Aquilegia x hybrida* 'Music
Pink and White,' B-Nine at 5,000 ppm
or Sumagic at 15 ppm effectively con-
trolled stem elongation (Figure 5).

**Figure 6a** (top). Effect of bulking on flower-
ing of *Aquilegia flabellata* 'Mini Star: Plants
were either cooled in their 72-cell plug
trays (right), or established in five-inch
pots for two weeks before cold treatment
(left). Even though all plants flowered,
transplant and bulking prior to cold im-
proved plant appearance.

**Figure 5** (above). The effect of plant growth
regulators on height and flowering of
*Aquilegia x hybrida* 'Music Pink and White.'
The rates were: A-Rest at 100 ppm, B-Nine
at 5,000 ppm, Bonzi at 60 ppm, Cycocel at
1,500 ppm, Sumagic at 15 ppm, and Florel
at 500 ppm. Our objective in this experi-
ment was to determine which compounds
were effective for height control, not to de-
termine specific rates. Plants were sprayed
every two weeks until flowering. B-Nine,
Sumagic, and Florel delayed flowering by
two to four days.

**Figure 4** (top). Effect of bulking on flower-
ing of *Aquilegia flabellata* 'Mini Star: Plants
were either cooled in their 72-cell plug
trays (right), or established in five-inch
pots for two weeks before cold treatment
(left). Even though all plants flowered,
transplant and bulking prior to cold im-
proved plant appearance.

**Figure 6b** (bottom). Effect of forcing tempera-
ture (from 57°F to 79°F) on develop-
ment of *Aquilegia x hybrida* 'Blue
Jay: Plants flowered more quickly at higher
temperatures, but flower size was reduced.

Cycocel at 1,500 ppm caused severe
phytotoxicity. In our experiment, these
compounds were applied every two
weeks until flower. Our objective was

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to determine which chemicals were effective, not to determine specific rates. We encourage growers to perform their own trials to determine the best rates under their conditions.

Temperatures And Crop Scheduling
Once vernalized, columbine will go on to flower quite rapidly. Some varieties flower in as little as three weeks when forced at 60°F. Higher temperatures will hasten flowering, but temperatures above 80°F can delay flowering and may reduce flower number. We observed a dramatic decrease in flower size as temperature increased (Figures 6a and 6b). Therefore, a cool growing temperature will result in flowers with a greater impact. The majority of columbines are most attractive when forced at temperatures of 57°F to 68°F.

Disease And Insect Pests
We have had few problems with diseases or insects on aquilegia. Botrytis did appear on some plants in the cooler. Some spider mites and a few whiteflies were present on plants in the greenhouse. Columbines can be susceptible to root rot, so as with many perennials, use a well-drained medium.

Gardeners often have to contend with leaf miners on columbines. Certain species are reportedly more resistant, but some years, most varieties in our trial gardens are affected.

Postharvest Concerns
Columbine plants flower for two to six weeks and this is very temperature dependent. Plants should be sold when they are just starting to flower. Their appearance declines as plants age in the container, though some people find the seed pods attractive. Deadheading can extend the bloom time.

Unfortunately, columbine will rarely reflower the first year in the garden, but survival and performance in subsequent years have been excellent.

About the authors: Cathy Whitman is a research technician, Art Cameron is a professor, Erik Runkle is an assistant professor and extension specialist, and Royal Heins is a professor, Department of Horticulture, Michigan State University, East Lansing, MI 48823. The authors wish to extend their thanks to former graduate student Leslie Finical for her research contributions. They also thank Beth Faussey, Dave Joeright, Mike Olrich, and generous industry supporters who made this work possible.

Keys To Success
1. Select appropriate cultivars for your operation – for quick-cropping, choose cultivars with a shorter juvenile phase and reduced vernalization requirement.
2. Seedlings can be started in plugs, but transplant and bulk the plants in the final container before giving cold treatment when possible, if you wish to sell in flower.
3. Grow plants long enough (until they have enough leaves) before cold so that they pass the end of the juvenile phase. This is a tricky part because there are no obvious clues to tell a grower when the plants are nature and hence ready for vernalization.
4. Provide an adequate duration of cooling, which can vary markedly among selections.
5. Force at cooler temperatures and moderate to short daylengths for best quality and largest flowers.
6. Research the flowering requirements of each specific cultivar, not just the series.
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AQUILEGIA TABLES

Table 1  **Columbine tables – cultivars we have studied in our research program.**

Columbine species hybridize freely. The last several years, breeders have emphasized uniformity, compact size, and shorter cold requirements. Cold treatment listed is the duration we have observed necessary for mature plants to rapidly and uniformly flower after the cold treatment.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Description</th>
<th>Height</th>
<th>Leaf # before cold</th>
<th>Weeks of cold (41°F)</th>
<th>Special considerations for flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aquilegia flabellata</em></td>
<td>'Cameo Blue &amp; White'</td>
<td>3-5&quot;</td>
<td>25</td>
<td>9</td>
<td>Flowers readily, even without cold – through cold hastened flowering and increased flower. Very tiny if not bulked.</td>
</tr>
<tr>
<td><em>Aquilegia flabellata</em></td>
<td>'Mini Star'</td>
<td>6-8&quot;</td>
<td>7-9</td>
<td>9</td>
<td>Required cold for complete flowering – can cool as plug, but performance improved when cooled in final container.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'Bluebird'</td>
<td>13-16&quot;</td>
<td>12-16</td>
<td>3</td>
<td>Best to transplant and bulk 4-6 weeks prior to cold treatment – when bulked, even 3 weeks at 41°F induced 100% flowering.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'Crimson Star'</td>
<td>14-18&quot;</td>
<td>7-9</td>
<td>8</td>
<td>Performance improved when cooled in final container.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'Origami Blue &amp; White'</td>
<td>14-20&quot;</td>
<td>5</td>
<td></td>
<td>Short cold requirement – though it can flower w/o cold. Probably safer to bulk and then give 6 weeks cold. Very uniform.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'Swan Burgundy &amp; White'</td>
<td>20-24&quot;</td>
<td>12-14</td>
<td>3</td>
<td>Performance improved when cooled in final container.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'Swan Yellow'</td>
<td>12-16&quot;</td>
<td>12-14</td>
<td>3</td>
<td>Performance improved when cooled in final container.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'White Christmas Star'</td>
<td>11-13&quot;</td>
<td>9-12</td>
<td>10</td>
<td>Required bulking and 10 weeks cold to reach 100% flowering. Performance improved when cooled in final container.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'Music White'</td>
<td>12-16&quot;</td>
<td>12-14</td>
<td>12</td>
<td>Requires long periods of bulking and cold. Cold treatment &lt; 12 weeks may be adequate, but we have not tested this yet.</td>
</tr>
<tr>
<td><em>Aquilegia x hybridia</em></td>
<td>'McKana Giants'</td>
<td>15-20&quot;</td>
<td>12</td>
<td>12</td>
<td>Requires long periods of bulking and cold.</td>
</tr>
</tbody>
</table>

Table 2  **Columbine tables – species we have studied in our research program.**

<table>
<thead>
<tr>
<th>Species</th>
<th>Description</th>
<th>Height</th>
<th>Special considerations for flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aquilegia alpina</em></td>
<td>Beautiful cool-blue flowers with hooked spurs – heat tolerant</td>
<td>18-24&quot;</td>
<td>Flowered irregularly – apparently a long juvenility requirement. Great garden plant in Michigan, but slow and difficult to force.</td>
</tr>
<tr>
<td><em>Aquilegia caerulea</em></td>
<td>State flower of Colorado – great blue and white flowers.</td>
<td>12-24&quot;</td>
<td>Flowered irregularly – apparently a long juvenility requirement. Slow and difficult to force.</td>
</tr>
<tr>
<td><em>Aquilegia canadensis</em></td>
<td>Native to the eastern U.S. – a great red and yellow flower.</td>
<td>15-20&quot;</td>
<td>Flowered irregularly – increasing cold durations increased flowering percentage and greatly decreased time to flower. Transplant into larger containers before cold treatment.</td>
</tr>
<tr>
<td><em>Aquilegia chrysantha</em></td>
<td>A wonderful yellow flower with long spurs.</td>
<td>15-20&quot;</td>
<td>Flowered irregularly – increasing cold durations increased flowering percentage and greatly decreased time to flower. Transplant into larger containers before cold treatment.</td>
</tr>
</tbody>
</table>

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Columbine tables – cultivars we have studied in our research program.

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<th>Description</th>
<th>Height</th>
<th>Leaf # before cold</th>
<th>Weeks of cold (°F)</th>
<th>Special considerations for flowering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquilegia flabellata</td>
<td>Very compact, performs great in a 4-5&quot; container.</td>
<td>3-5&quot;</td>
<td>≥5</td>
<td>9</td>
<td>Flowers readily, even without cold – though cold hastened flowering and increased flowering. Very shy if not bulked.</td>
</tr>
<tr>
<td>'Cameo Blue &amp; White'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia flabellata</td>
<td>Very compact, cute in 4-5&quot; container.</td>
<td>6-8&quot;</td>
<td>7-9</td>
<td>9</td>
<td>Required cold for complete flowering – can cool as plug, but performance improved when cooled in final container.</td>
</tr>
<tr>
<td>'Mini Star'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Colorful and reliable bloomer – they forced readily as long as starting material was beyond juvenile stage.</td>
<td>13-16&quot;</td>
<td>12-16</td>
<td>3</td>
<td>Best to transplant and bulk 4-6 weeks prior to cold treatment – when bulked, even 3 weeks at 41°F induced 100% flowering.</td>
</tr>
<tr>
<td>'Bluebird'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Reliable old favorite with striking large red and white flowers.</td>
<td>14-18&quot;</td>
<td>≥12</td>
<td>6</td>
<td>Performance improved when cooled in final container.</td>
</tr>
<tr>
<td>'Crimson Star'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Large lavender-blue and white flowers; very floriferous and showy.</td>
<td>14-20&quot;</td>
<td>7-9</td>
<td>5</td>
<td>Short cold requirement – though it can flower w/o cold. Probably safest to bulk and then give 5 weeks cold. Very uniform.</td>
</tr>
<tr>
<td>'Origami Blue &amp; White'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Large dramatic flowers on tall plants; very striking.</td>
<td>20-24&quot;</td>
<td>12-14</td>
<td>3</td>
<td>Performance improved when cooled in final container.</td>
</tr>
<tr>
<td>'Swan Burgundy &amp; White'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Many clear sunny yellow flowers, moderately tall.</td>
<td>12-16&quot;</td>
<td>12-14</td>
<td>3</td>
<td>Performance improved when cooled in final container.</td>
</tr>
<tr>
<td>'Swan Yellow'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Lots of charming double flowers with short spurs. Compact sturdy plants, very uniform.</td>
<td>11-13&quot;</td>
<td>9-12</td>
<td>10</td>
<td>Required bulk and 10 weeks cold to reach 100% flowering. Performance improved when cooled in final container.</td>
</tr>
<tr>
<td>'Whirly Double Red &amp; White'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Lovely pure white flowers on moderately tall plants.</td>
<td>12-16&quot;</td>
<td>≥14</td>
<td>12</td>
<td>Requires long periods of bulking and cold. Cold treatment &lt; 12 weeks may be adequate, but we have not tested this yet.</td>
</tr>
<tr>
<td>'Musk White'</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aquilegia x hybrids</td>
<td>Classic favorite variety, a mix of colors.</td>
<td>15-20&quot;</td>
<td>≥12</td>
<td>≥12</td>
<td>Requires long periods of bulking and cold.</td>
</tr>
<tr>
<td>'McKane Giants'</td>
<td></td>
<td></td>
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