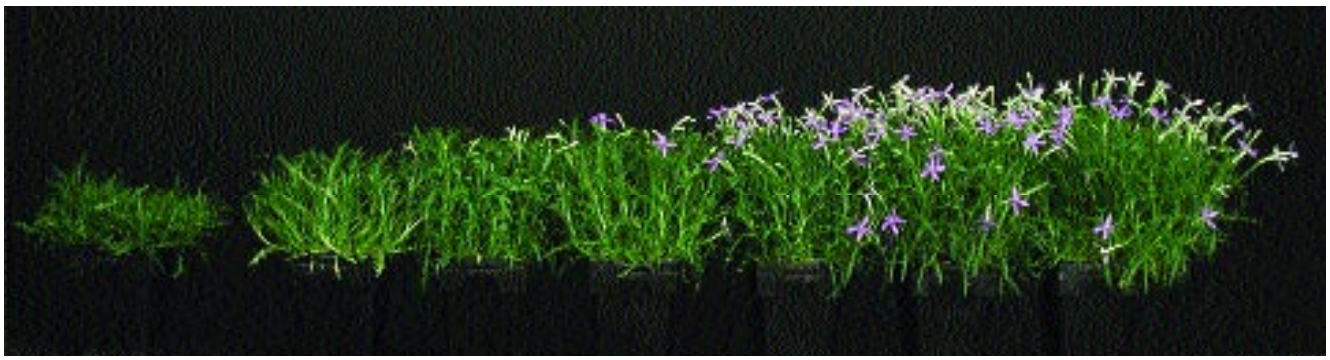


Some Perennials Like It Cold

Isotoma plants were chilled at 45°F for zero, 2.5, five, 7.5, 10, 12.5 and 15 weeks, and then grown under 16-hour-long days for nine weeks

by ART CAMERON, BETH FAUSEY, SONALI PADHYE and ERIK RUNKLE

HERBACEOUS perennials comprise a diverse group of plants from a variety of habitats around the world and, of course, many make great garden plants. While retail sales of perennials in flower continue to increase nationally, growers can be challenged to develop and utilize production protocols that will consistently result in scheduled flowering for many of these popular plants.

For the past several years, we have studied the flowering requirements for a wide range of herbaceous perennials, and it is clear that the most important environmental cues for growth and flowering are photoperiod, vernalization and light quantity. In this series of articles, we will focus on the vernalization or "chilling requirement" needed for flowering of many, but certainly not all, herbaceous perennials. We will attempt to summarize some of the new and old information on vernalization and describe how growers can adapt and utilize this information in various climates.

Vernalization

The textbook definition of vernalization is "the acquisition or acceleration of the ability to flower following a chilling treatment." It is somewhat of a confusing term in the sense that the definition comes from "vernal" (meaning spring), and hence the literal translation is "making spring." This phenomenon was originally described for food crops such as wheat and rye. For instance, winter and spring wheat are very closely related, but winter wheat must be planted in the fall or it will not flower. Spring wheat, as the name implies, can be planted in the spring and readily flowers in the first season. The only difference is that winter wheat has an obligate vernalization requirement (must be exposed to cold or it will not flower) whereas spring wheat does not. Early researchers learned that if they artificially provided cold to young plants or even imbibed seeds of winter wheat, they could, in essence, make spring, since the plants then would proceed to flower when planted. Current research has shown that a single gene can account for the presence or absence of a vernalization requirement.

Vernalization is relatively specific to biennials and herbaceous perennials. Still, not all herbaceous perennials have a vernalization requirement and the lack of this requirement does not necessarily relate to cold hardiness. For instance, Campanula carpatica, which is hardy at least to USDA hardiness Zone 3 (-40°F), will flower readily without a vernalization treatment provided it is given long-day photoperiods, while Isotoma axillaris, hardy only to zone 7 (0°F) has an obligate vernalization requirement.

In fact, one of the challenges in our research program over the past decade has been to establish which perennials have a vernalization requirement and which do not. Sometimes, the requirement is obligate (absolutely required, plants will not flower without cold) but often is facultative (merely beneficial,

Left: Improperly vernalized columbines. Right: campanula 'Birch Hybrid' stock plants after several months in greenhouse. These plants rarely flower.

plants benefit from but do not require a cold treatment). Other factors such as the amount of light that a plant receives in a day can also interact with the chilling treatment or even override the need for chilling and affect the final flowering of a specific plant. Other plants, such as achillea 'Moonshine' flower only for a specific duration in the garden and even deadheading does not cause a repeat bloom. Yet cuttings taken from these plants readily flower once rooted and there is no evidence that the block in flowering is related to vernalization.

Control Of Flowering In Nature

So exactly why do plants control flowering and why would they have a vernalization requirement? It is best explained by the fact that survival in the wild often depends on precise timing of flowering, which must be coordinated with pollinator activity and general weather conditions. In many cases, this involves the focusing of resources because flowering and subsequent seed production are expensive processes, requiring plenty of energy. Many herbaceous perennials have evolved specific mechanisms to focus flowering at a specific time of the year, some in the early spring while others are in the summer or even late fall. The most important environmental cues that govern precise flowering are usually thought to include photoperiod and vernalization. A vernalization requirement could prevent flowering late in the season, and thus prevent a reduction of stored energy reserves needed for overwintering.

One important aspect of vernalization is that herbaceous perennials do not enter or generally even leave the chilling period with a flower bud. The shift of the growing meristem from vegetative to floral actually can occur days or even weeks after exposure to the chilling temperatures. Thus, one interesting characteristic of the vernalization process is that the plant retains a "memory" of the cold and only later uses this information to guide in the timing of flower initiation. The nature of this "memory" is still under investigation by researchers, but it is known that it involves specific genetic signals at the molecular level. There is still a great deal to be discovered before we will understand why different plants require different lengths of exposure to cold or even have apparently different temperature optima for the chilling requirement.

Seasonal Flowering Of Herbaceous Perennials And Vernalization Response

Periodic or episodic flowering are terms that are used to describe flowering habits of many herbaceous perennials. It is this trait that contributes to the continual change in a well-designed perennial bed throughout the growing season. Early blooming perennials such as Phlox subulata (creeping phlox), iberis (candytuft), Euphorbia epithymoides (cushion spurge) and Anemone pulsatilla (Pasque flower) are among the many that brighten gardens early in the spring but then remain vegetative the rest of the summer, rarely if ever producing another flower. These are typically species that require vernalization. Then come the many late spring flowering perennials such as coreopsis 'Sunray,' campanula 'Birch Hybrid,' Aquilegia spp. (columbines), Oenothera fruticosa (evening primoses), astilbe and Lavandula angustifolia (lavender). Many of these species have a vernalization requirement and perhaps even an added long-day photoperiod requirement. Most late summer and fall-blooming species such as rudbeckia, echinacea (coneflower) and even mums do not typically respond to vernalization but are usually strongly photoperiodic.

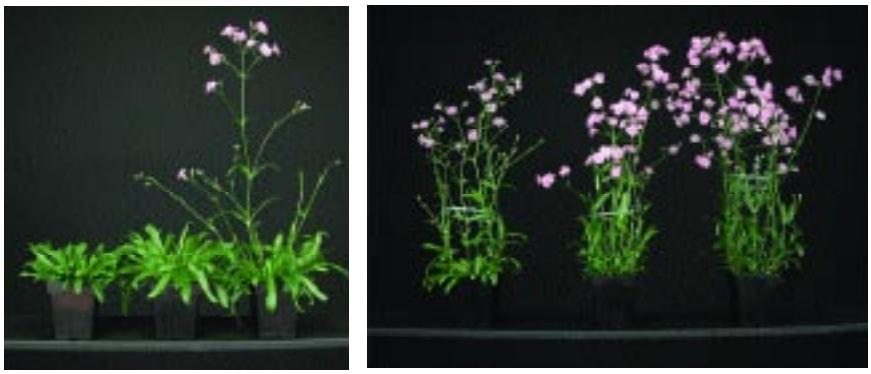
Empirical Determination Of Vernalization Requirements

We have now studied nearly 500 herbaceous perennials and have attempted to determine for each the vernalization and photoperiodic requirements for flowering. Generally, we start with rooted cuttings or seedlings. We then grow one group under nine-hour short days, 16-hour long days or 16-hour long days with substantial supplemental light. A second group of the same plants are put at 41°F for 15 weeks. After this period, the plants are potted and grown under the three growing environments. This relatively simple approach permits us to study the flowering response to vernalization, photoperiod and light quantity.

Stachys 'Hummelo' before and after 15 weeks at 41°F. From left to right: nine-hour short days, 16-hour long days and 16-hour long day with extra supplemental lighting.

Major Response Categories For Herbaceous Perennials

In the tables online (see "Continued Online"), we have listed the herbaceous perennials that require or at least benefit from a vernalization or chilling treatment. We have found that most fall into just a



Lychnis 'Jenny' before and after 15 weeks at 41°F. From left to right: nine-hour short days, 16-hour long days and 16-hour long days with extra supplemental lighting.

few major categories:

• Cold required – day neutral – rapid flowering after cold. These are day-neutral perennials that typically flower early in the spring. In fact, most of these flower so fast, that if they are cooled as small plants (for instance in a plug tray), they do not gain adequate size and are really not appropriate for retail sales. Since they have an obligate chilling requirement, they will not bloom again until they are again exposed to cold.

• Cold required – day neutral – slower to flower. These are the few day-neutral perennials that we have discovered are slow enough to flower such that they can gain in size rather appreciably after the end of the chilling period. These can be chilled in the plug tray and the final plant quality will be satisfactory for most growers.

• Cold – required – long-day plants. The plants in this category have a more complex flower induction strategy and require both chilling and long days to flower. These typically flower a bit later in the season, and can usually be chilled in the plug tray with satisfactory final plant quality.

• Facultative cold requirement – mostly long-day plants. This is an interesting category that includes plants that do not absolutely require cold to flower. They may flower without cold if given long days or perhaps high light. However, they may flower even under short days after vernalization or might flower faster or more profusely. In general, most perform after a cold treatment. The interaction between length of day, quantity of light and vernalization requirement is of great interest, and further research may unearth clues as to how plants monitor and respond to complex changes in the environment.

• No cold required. You may find that some of your favorite perennials may not appear on any of these lists. It is probable that they do not require cold. Though we have not listed them here, it is somewhat surprising how many herbaceous perennials tolerate and survive severe winters, but do not require cold for future flowering. In many cases, this is one of the intriguing aspects of studying the flowering behavior of this diverse and fascinating group of plants.

Future Articles In This Series

In subsequent articles in this series, we will cover some of the details about the chilling requirement of herbaceous perennials and how growers can adapt this knowledge for improved production techniques. We will cover many related topics including the most effective temperatures and durations for maximum responses on a plant by plant basis, interactions of light quantity and a primer on some of the underlying mechanisms of how plants perceive and even measure cold. GG

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Campanula 'Cherry Bells' before and after 15 weeks cold – short days, long days and long days with supplental lighting. Note that this requires cold and long days to flower.

Agastache for comparison. Agastache is a plant that does not require chilling to flower.

Continued Online

To see crop tables related to this article, please log on to www.greenhousegrower.com/grower_tools/html. There you will find:

• Table 1. Major crop categories responsive to vernalization.

Stay tuned to Greenhouse Grower for more perennial vernalization articles in the November and December issues.