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# Effect of Overwintering Environment on the Survival of 30 Species of Herbaceous Perennials<sup>1</sup>

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## Abstract

There is increased interest in overwintering containerized perennials. However, there is little information available on overwintering success. The objective of this research was to determine overwinter survival and regrowth quality of 30 perennial species hardy in USDA zones 3, 4, or 5. Three overwintering treatments were used for each species: unprotected containers outside, containers in an unheated building, or in the ground. On April 16, 2004, and May 17, 2004, following overwintering, plant quality, plant height and flowering time were evaluated. Twenty-one species were successfully overwintered in an unheated building and 13 of those had quality ratings equal to or higher than those overwintered in-ground. *Ceratostigma plumbaginoides*, *Kniphofia* Pfitzer's Hybrid, *Leucanthemum* × *superbum* 'Snowcap', and *Stokesia laevis* 'Honeysong Purple' rated significantly higher when overwintered in containers stored inside than in the ground. Flowering time and height measurement differences were not significant. *Coreopsis* 'Limerock Ruby', *Diascia integerrima* CoralCanyon™ and *Gaura lindheimeri* 'Siskiyou Pink' did not survive in any treatment. None of the species tested, with the exception of *Sedum* 'Matrona', survived when overwintered unprotected outside. Overwintering certain species of containerized perennials inside an unheated building such as a garage is a viable option for homeowners to improve survival.

**Index words:** cold hardiness, containers.

**Species used in this study:** *Alchemilla mollis* (Buser) Rothm. 'Thriller'; *Anemone tomentosa* (Maxim.) 'Robustissima'; *Calamagrostis* × *acutiflora* (Schrad.) Rehb. 'Overdam'; *Ceratostigma plumbaginoides* (Bung.); *Coreopsis* (Nutt.) 'Limerock Ruby'; *Crococsmia* × *crococsmiiflora* (V. Lemoine ex E. Morr.) 'Lucifer'; *Diascia integerrima* (Benth.) Coral Canyon™; *Epimedium* × *rubrum* (C. Morr.); *Euphorbia amygdaloides* var. *robbiae* (L.); *Gaura lindheimeri* (Engelm. & A. Grey. Per.) 'Siskiyou Pink'; *Geranium sanguineum* (L.) 'Alpenglow'; *Heuchera americana* (L.) 'Palace Purple'; *Heuchera sanguinea* (Engelm.) 'Splendens'; *Hosta* (Tratt.) 'Francee'; *Hosta* (Tratt.) 'June'; *Hypericum calycinum* (L.); *Kniphofia* (Moench) Pfitzer's Hybrid; *Lamium galeobdolon* (Heist. E. Fabr.) 'Variegatum'; *Lamium maculatum* (L.) 'Anne Greenway'; *Lavendula angustifolia* (L.) 'Munstead'; *Leucanthemum* × *superbum* (L.) 'Snowcap'; *Nepeta* × *faassenii* (Bergmans ex Stearn) 'Dropmore'; *Panicum virgatum* (L.) 'Shenandoah'; *Phlox paniculata* (P. decussata) Lyon ex Pursh 'Mt. Fuji'; *Scabiosa caucasica* (Bieb. Per.) 'Butterfly Blue'; *Sedum* (L.) 'Matrona'; *Stachys byzantine* (K. Koch.) 'Big Ears'; *Stokesia laevis* (J. Hill) 'Honeysong Purple'; *Thymus serpyllum* (L.) 'Annie Hall'; *Veronica alpina* (L. Pers.) 'Alba'.

## Significance to the Nursery Industry

As the popularity of container gardening continues to grow, consumers are interested in finding new plants to vary their container gardens. Perennials can be used as container plants but tend to be more costly than annuals that have been the traditional choice for containers. However, if techniques to successfully overwinter them could be developed then this might increase their acceptability for use in containers. This research demonstrates that it is possible to overwinter many popular species of perennials with little to no loss of overall quality.

## Introduction

The popularity of perennial and container gardening in the United States has grown dramatically (18, 19). Increasingly, perennials have been combined with annual herbaceous and tropical taxa in mixed containers (19). The use of perennials in mixed containers has led to a higher level of interest in overwintering these plants. However, data for survival and regrowth quality after winter are not available. Some varieties have been developed with increased cold hardiness. But, research concerning the survivability of these perennials and the development of more hardy varieties for use in containers is lacking (8).

While USDA plant hardiness zones can be useful for plants grown and overwintered in the ground, what is unknown is the relationship to in-ground hardiness and hardiness in containers. Perennials rely on regenerative organs such as crowns, stolons, or rhizomes to survive and overwinter in colder climates (10). During the winter, the regenerative organs of plants grown in the ground are buffered from temperature extremes by the soil and by insulating snow cover. Plants grown in containers are not buffered from temperature fluctuations and extremes to the same extent.

Controlled freezing studies have determined the cold hardiness of various herbaceous perennials (22). *Achillea filipendulina* 'Parker's Variety', *Gaillardia* × *grandiflora* 'Monarch Strain', and *Lythrum salicaria* 'Robert' are considered 'hardy' to -11C (12F). Whereas tender species, such as *Kniphofia* Pfitzer's Hybrid was root hardy to -2.8C (27F). None of the species tested survived exposure to -14.4C (6F).

In a study conducted in Vermont, plants were classified as tender if severe injury occurred when media was -4.4C (24F) or below (18). Plants that were severely injured between -10C (14F) and -4.4C (24F) were classified as intermediate and hardy plants were severely injured at -11.1C (12F) or below. Perennials such as *Kniphofia* Pfitzer's Hybrid and *Geum* 'Mrs. Bradshaw' were considered tender. Intermediate plants included *Heuchera sanguinea* 'Chatterbox' and *Phlox paniculata* 'David', while *Achillea filipendulina* 'Coronation Gold' and *Campanula takesimana* were judged as hardy.

Commercial growers have used several techniques for overwintering perennials (7). The primary cause of dam-

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age during the winter to container grown perennials is root death following exposure to soil frozen solid in small containers (1). Studies by Still et al. (23), Perry (16, 17), and Iles (9), were directed towards strategies for overwintering containers in poly-covered greenhouses and protection with thermo-blankets and microfoam. However, the typical home gardener does not have greenhouse facilities or nursery poly houses. Presently, homeowners may utilize cold frames, bubblewrap, straw, or leaves for insulation or they may double pot the plants (11).

Various techniques have been utilized in the overwintering of perennials for the residential setting. The standard practice is to use the largest container possible. The greater substrate surround the plant roots is thought to act as insulation (1).

Trenching is another overwintering method (1). A trench is dug in the soil, and containers are laid on their side in the trench and lightly covered with soil. Loose mulch is then applied over the trench. Grouping containers together and covering with straw, compost, or mulch is another technique (13). Some home gardeners remove perennials from containers and plant them in their garden for the winter. The following spring the plants are dug up and placed back into a container (11).

Storing container grown herbaceous perennials in an unheated building such as a barn, shed, or garage is an-

other overwintering method (21). This technique provides the homeowner with an easy and convenient method of overwintering plants. Previous research has not focused on residential methods for overwintering herbaceous perennials in containers. A successful overwintering system should protect the plant from lethal minimum temperatures, buffer the plant from temperature fluctuations, and help avoid loss due to desiccation.

The objective of this research was to evaluate the survivability and quality of 30 perennial species with a USDA hardiness rating range of Zones 3–5 (Table 1) utilizing 3 different overwintering treatments. It was hypothesized that plants overwintered in containers inside would survive as well as the plants overwintered in-ground.

## Materials and Methods

Thirty perennial species were evaluated in a trial established in Columbus, OH, on June 16, 2003. Plants were purchased from a wholesale nursery on June 16, 2003 (Millcreek Gardens LLC, Ostrander, OH). Twenty-two perennials were sun tolerant selections and eight were shade tolerant plants (Table 1). Plants were established under 3 conditions: overwintering in outdoors containers (Treatment #1), overwintering in containers in an unheated building (Treatment

**Table 1. Re-growth quality of 30 sun and shade perennial species overwintered in-ground or in containers placed in unheated storage. Columbus, OH, 2003–2004.**

Plant species	USDA Hardiness Zone <sup>a</sup>	In-ground plants rating <sup>b</sup> ± SD	Containers stored inside rating <sup>b</sup> ± SD
<b>Sun plants</b>			
<i>Calamagrostis</i> × <i>acutiflora</i> 'Overdam'	5	4.7 ± 0.34	4.1 ± 1.44
<i>Ceratostigma plumbaginoides</i> <sup>x</sup>	5	2.5 ± 0.35	3.8 ± 0.69
<i>Coreopsis</i> 'Limerock Ruby'	4	1.0 ± 0.00	1.0 ± 0.00
<i>Crocosmia</i> × <i>crocosmiiflora</i> 'Lucifer'	5	3.2 ± 1.18	3.1 ± 1.31
<i>Diascia integrifolia</i> Coral Canyon™	4	1.0 ± 0.00	1.0 ± 0.00
<i>Euphorbia amygdaloides</i> var. <i>robbiae</i>	5	3.3 ± 0.94	3.1 ± 1.35
<i>Gaura lindheimeri</i> 'Siskiyou Pink'	5	1.0 ± 0.00	1.0 ± 0.00
<i>Geranium sanguineum</i> 'Alpenglow'	3	4.7 ± 0.48	4.1 ± 0.63
<i>Heuchera sanguinea</i> 'Splendens'	3	3.4 ± 1.71	3.5 ± 1.39
<i>Hypericum calycinum</i> <sup>x</sup>	5	2.4 ± 1.20	1.0 ± 0.00
<i>Kniphofia</i> Pfitzer's Hybrid <sup>x</sup>	5	2.7 ± 1.43	4.7 ± 0.20
<i>Lavendula angustifolia</i> 'Munstead'	5	3.4 ± 1.64	1.7 ± 0.77
<i>Leucanthemum</i> × <i>superbum</i> 'Snowcap' <sup>x</sup>	5	1.0 ± 0.00	3.6 ± 1.22
<i>Nepeta</i> × <i>faassenii</i> 'Dropmore'	5	5.0 ± 0.00	5.0 ± 0.00
<i>Panicum virgatum</i> 'Shenandoah' <sup>x</sup>	5	4.6 ± 0.21	3.7 ± 0.46
<i>Phlox paniculata</i> 'Mt. Fuji'	4	5.0 ± 0.08	4.9 ± 0.17
<i>Scabiosa caucasica</i> 'Butterfly Blue'	3	1.2 ± 0.24	1.0 ± 0.00
<i>Sedum</i> 'Matrona'	3	4.7 ± 0.24	4.6 ± 0.15
<i>Stachys byzantina</i> 'Big Ears'	4	5.0 ± 0.14	5.0 ± 0.08
<i>Stokesia laevis</i> 'Honeyson Purple'	5	3.7 ± 1.49	4.8 ± 0.10
<i>Thymus serpyllum</i> 'Annie Hall' <sup>x</sup>	5	4.5 ± 0.71	1.0 ± 0.00
<i>Veronica alpina</i> 'Alba'	4	3.8 ± 1.26	2.5 ± 1.74
<b>Shade plants</b>			
<i>Alchemilla mollis</i> 'Thriller'	4	4.8 ± 0.12	4.7 ± 0.27
<i>Anemone tomentosa</i> 'Robustissima' <sup>x</sup>	5	4.3 ± 0.78	1.2 ± 0.25
<i>Epimedium</i> × <i>rubrum</i>	4	5.0 ± 0.08	4.8 ± 0.09
<i>Heuchera americana</i> 'Palace Purple'	4	4.7 ± 0.14	4.7 ± 0.28
<i>Hosta</i> 'Francee'	3	4.9 ± 0.17	5.0 ± 0.08
<i>Hosta</i> 'June'	3	4.8 ± 0.14	5.0 ± 0.00
<i>Lamium galeobdolon</i> 'Variegatum'	4	5.0 ± 0.08	4.8 ± 0.10
<i>Lamium maculatum</i> 'Anne Greenway' <sup>x</sup>	3	4.9 ± 0.08	1.6 ± 0.64

<sup>a</sup>U.S. Department of Agriculture. 1990. USDA Hardiness Zone Map. Agr. Res. Serv. Misc. Publ. No 1475

<sup>b</sup>Rating scale: 5 = survived, no damage, 4 = survived, mild damage, 3 = survived, moderate damage, 2 = survived, significant damage, 1 = did not survive.

<sup>x</sup>Statistical difference between treatments according to Fisher's Protected Least Significant Difference Test (P = 0.05).

#2), and overwintering plants in-ground beds (Treatment #3). Each species was replicated 4 times, 1 pot per plant, for a total of 360 plants. The experiment was set up in three separate randomized complete blocks (one under each condition).

During the week of June 16, 2003, plants from Treatments #1 and #2 were repotted into 30 cm square (28 liter) fluted plastic planters (Hummert International, Earth City, MO). All container plants were potted in Scotts Metro Mix 510™ (20–45% pine bark:15–30% medium grade horticultural vermiculite:20–35% sphagnum peat moss:5–25% processed ash bark (by vol), The Scotts Company, Marysville, OH).

Perennials in treatment #3 were planted in the ground in trial beds at the Ohio State University campus in an area measuring approximately 28 m<sup>2</sup>. The soil was a Brookston silty clay loam. Plants in all treatments received a top dressing of 62 g (2.2 oz) Scott's Osmocote 14–14–14™ (The Scotts Company, Marysville, OH). In-ground received 5 cm (2 in) of garden mulch (1:1 (by vol) composted yard waste/leaf compost, Kurtz Brothers, Westerville, OH).

Shade species from Treatments #1 and #2 were placed under a 67% black knit shade cloth (model no. A.23, PAK Unlimited, Inc., Cornelia, GA) erected over the in-ground plants and container plants. All containers in sun and shade species in Treatments #1 and #2 were irrigated with 0.21" daily via an automated overhead watering system, while the in-ground plants in Treatment #3 were watered by hand to avoid moisture stress. Weeds were controlled by hand.

On November 14, 2003, 120 plants comprising treatment #2 were placed into an unheated building on the Agricultural Campus of The Ohio State University. All 3 treatments were irrigated and then sensors were installed to measure soil temperature, air temperature, and soil moisture in each treatment (Spectrum Technologies Watchdog Model 425 Dataloggers, with Spectrum Technologies Watermark Soil Moisture Sensor and External Temperature Sensor). A radiation shield was applied to each of the 3 monitors, with one monitor per treatment. Readings were logged every 15 minutes. Data was extracted from the dataloggers and uploaded into a PC containing Spectrum Technologies, Inc. (Plainfield, IL) using Specware 6.01 Software.

On March 17, 2004, plants in Treatment #2 began to grow. The unheated structure allowed only minimal light to reach the perennials, and the decision was made to move them to an unheated polyhouse. Plants in Treatment #2 were watered for the first time since November 14, 2003, after being relocated to the polyhouse. Temperature readings continued to be monitored.

Plants were evaluated on two occasions (mid-April and mid-May 2004) by 3 evaluators. Individual plant evaluations were scored on a 1–5 rating scale as follows: 5 = Survived, no damage; 4 = Survived, mild damage; 3 = Survived, moderate damage; 2 = Survived, significant damage; or 1 = Did not survive. In addition to the plant evaluations, individual plant height measurements were taken in mid-April and in mid-May 2004. Flowering time was also recorded through May 2004. Plant evaluation data was analyzed using the Proc GLM procedure of SAS statistical software (SAS Institute, 1990). Separations of means were based on Fisher's protected least significance difference test at  $P \leq 0.05$  (5).

## Results and Discussion

**Environmental data.** The monthly mean temperature was approximately 1C above the long term mean temperature

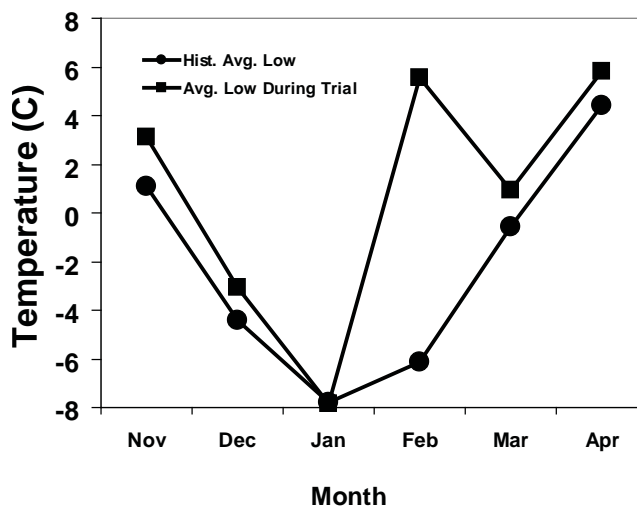


Fig. 1. Historical average low temperature in comparison to winter 2003–2004 actual average low temperatures for Columbus, OH.

during the months of November, December, March, and April (Fig. 1). The monthly mean temperature in January was slightly below the historical normal and the month of February was approximately 12C above normal. The daily air temperature fluctuation (Fig. 2) and the minimum air temperature recorded during the experiment were identical between the in-ground plants and the containers outside. The air temperature fluctuation was less and the minimum air temperature was higher for the containers stored inside (Fig. 2). The soil temperature fluctuation and the minimum soil temperature recorded were similar for the in-ground treatments and the containers inside. At no time during the experiment did the soil temperature of the containers stored inside go below freezing. The soil temperatures of the in-ground treatments never went below freezing on 7 days, but on 6 of these, the temperature was –1C. The minimum temperature of the in-ground soil treatments was –2C. The temperature fluctuation was greater and the minimum temperature recorded was lower for the containers stored outside.

**Species.** The differences in temperature fluctuation and temperature extremes resulted in significant differences in the overall quality of the 30 perennial species when evaluated in spring. The in-ground treatment resulted in the highest mean visual quality (3.67 on a 1 = dead to 5 = ideal scale). Plants overwintered inside had a mean visual rating value of 3.33, which was statistically, though not practically, different from the in-ground treatments. Many of the plants overwintered in containers outside did not survive, with the exception of *Sedum* 'Matrona'. The mean visual rating value for the container treatments overwintered outside was 1.18. However, one species, *Sedum* 'Matrona' was rated 4.60 after overwintering in containers outside.

Twenty-one of the 30 species tested survived over winter inside the unheated building. Thirteen of these were rated equal to or higher than the in-ground treatment (Table 1). Herbaceous perennial species successfully overwintered in an unheated building included both sun and shade tolerant plants of varying sizes that are hardy in USDA zones

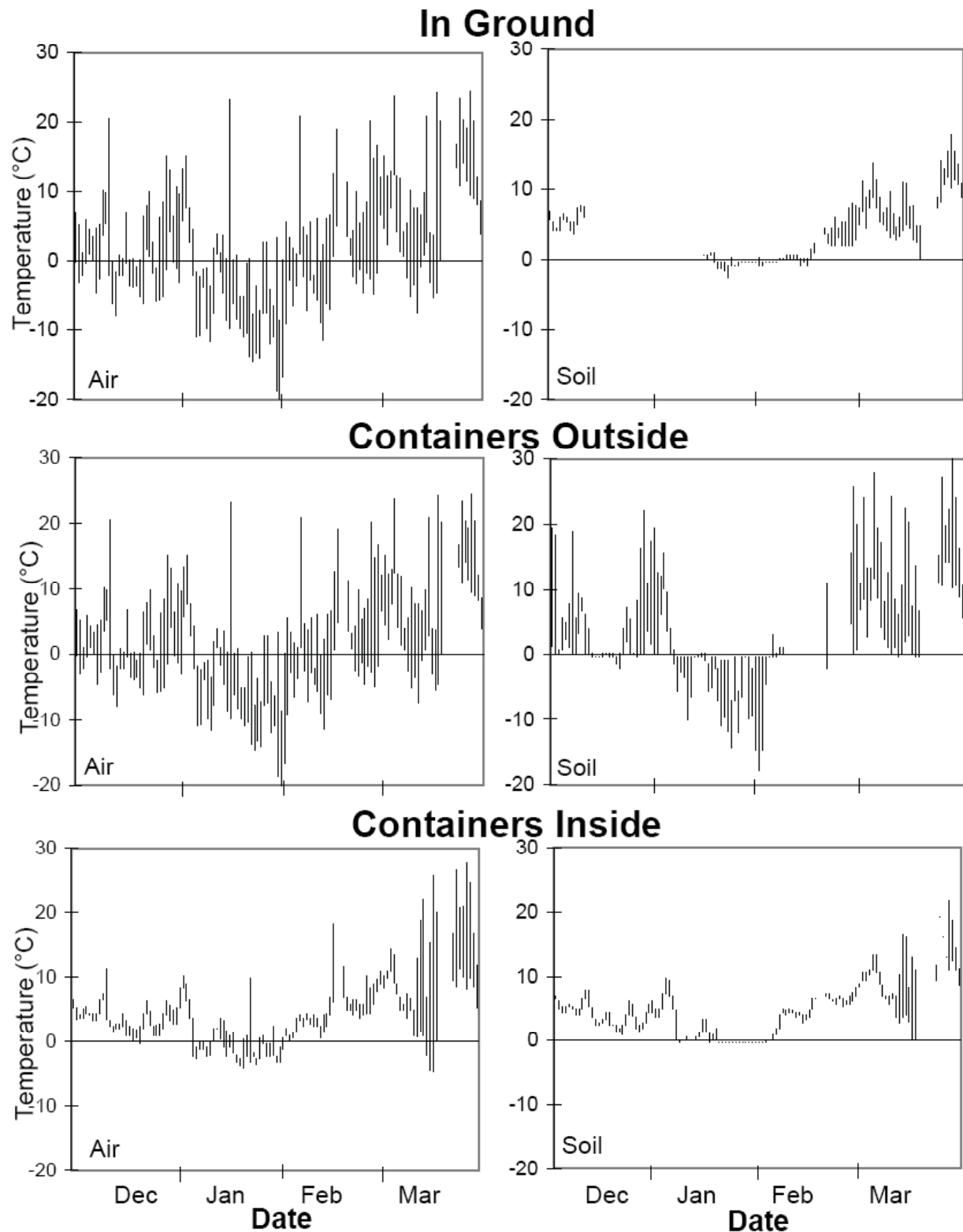


Fig. 2. Air and soil temperatures recorded during plant hardiness experiments conducted at Ohio State University in 2003–2004. Missing soil temperature data from mid-December to mid-January due to physical damage to data logger.

3, 4, and 5. Low growing species such as *Ceratostigma plumbaginoides*, *Geranium sanguineum* ‘Aplenglow’, and *Epimedium × rubrum* were highly rated. Taller species such as *Phlox paniculata* ‘Mt. Fuji’, *Kniphofia* Pfitzer’s Hybrid, and *Calamagrostis × acutiflora* ‘Overdam’ also received a

high rating. The difference in minimum soil temperature during the experiment was 0.5°C and the daily fluctuation in soil temperature was much less than observed in the outside containers, and these moderated environments may have contributed to the higher overwintering success.



*Environment and species.* There was a difference in overwintering success among species in the different environments. *Hypericum*, *Panicum*, *Thymus*, *Anemone*, and *Lamium* were rated higher in the in-ground treatment. *Ceratostigma*, *Kniphofia*, and *Leucanthemum* had a higher rating in the container treatment overwintered inside. *Coreopsis*, *Diascia*, *Gaura*, and *Scabiosa* did not survive any of the three treatments (Table 1).

*Hypericum* was rated 2.4 in-ground. It did not survive in either container treatment (Table 1). *Hypericum* is a drought tolerant species and thrives in poor, sandy soil. The in-ground treatment plot soil was slow draining and may explain the poor rating for the in-ground treatment. Commercial growers have found that *Hypericum* overwinters better if it is not cut back in the fall (15). All plants in this research were cut back in the fall, which may explain why *Hypericum* did not survive the inside container treatment and may have also influenced the in-ground rating.

*Panicum* was rated 4.6 in-ground, and 3.7 for the inside container treatment (Table 1). The cultivar ‘Shenandoah’ grows to 122 cm (48 in) in height (6). All plants were of similar size in the fall. Container size limited the post overwintering re-growth of this species, which led to its lower rating. Similar findings in a study at the University of Minnesota found container size significantly influenced growth of five ornamental grasses grown in containers (14). The overall quality of the species in both treatments was high.

The in-ground treatment of *Thymus* rated 4.5/5.0 (Table 1). Neither container treatment survived overwintering. The cultivar ‘Annie Hall’ has a prostrate form which reaches a height of 10–15 cm (3.9–5.9 in) (2). This low growing species has a shallow root system which may be subject to damage by extreme temperatures when grown in containers. Roots closer to the surface of the container do not benefit from insulation provided by the soil.

*Anemone* in the ground treatment was rated significantly higher than in inside containers (Table 1). The ideal growing condition for this species is a moist humus rich environment (2). Poor performance of the inside container treatment of *Anemone* may be due to the confinement of the container. *Anemone* is also considered very difficult to store for extended periods (12). Container confinement and extended storage may have contributed to the poor rating for *Anemone* overwintered in containers inside.

*Lamium* in the ground performed significantly better than in containers (Table 1). *Lamium* is another shallow rooted species. Root damage may have occurred as a result of the roots being closer to the surface of the soil resulting in less insulation. Overwinter container dryness may have also been a contributing factor to the poor performance of the inside container treatment of *Lamium*.

*Ceratostigma* was rated significantly higher when grown in containers overwintered inside than in the ground (Table 1). This species prefers well drained soil and cannot tolerate soggy conditions (24). The foliage of *Ceratostigma* also emerges late in the spring (24). The inside container treatment was subject to warmer conditions throughout the winter with a minimum air temperature of –3.3C (26F). Warmer overwintering conditions and late spring emergence may account for the differences observed. A container study of *Ceratostigma* indicated a 25% saleable rate when overwintered at 3C (37F) (8). The plants had been weakly rooted into the transplant medium, which might explain its poor

performance. Our findings indicated that *Ceratostigma* is at least hardy to –1C (31F).

The inside container treatment of *Kniphofia* was also rated higher than the in-ground treatment (Table 1). *Kniphofia* requires well drained soil. Heavy wet soil, especially in winter, can be fatal to this species (24). Perennial growers consider it a tender species (7). Disabato-Aust found *Kniphofia* saleable after exposure to –2.7C (27F) soil temperatures (7). Soil temperature in our study remained higher than –2.7C (27F), with the in-ground treatment reaching –1.1C (31F), while the inside container treatment was –1C (31F). Heavy soil in the in-ground plot could account for the lower rating for the in-ground treatment.

*Leucanthemum* was rated significantly higher after overwintering in indoor containers (Table 1). The in-ground treatments did not survive. *Leucanthemum* is another perennial species that requires well drained soil, especially in winter, and tends to be short lived north of USDA Zone 5 (24). Drainage may have been a factor in the poor in-ground treatment rating of this species. Good drainage within the inside container treatment allowed *Leucanthemum* to overwinter successfully.

*Species differences.* Significant differences in regrowth quality were observed among the species ( $P < 0.0001$ ) (Table 1). *Sedum* ‘Matrona’ was the only species to survive all three treatments. The in-ground treatment mean was 4.7, while the container treatment overwintered inside was rated 4.6 (Table 1).

The genus *Sedum* is an extremely tough plant with a USDA Zone 3 hardiness rating given to many species. *Sedum* is extremely drought tolerant and can be grown in any well drained soil (24). A container study found ‘Autumn Joy’ was killed at –27C (–16F) (10). Outside container treatment soil reached a minimum low of –18.2C (–1F), which was well above the temperature found by Iles and Agnew (10). This may explain the survival of *Sedum* ‘Matrona’ in all three treatments.

The genus *Diascia* has only recently been available in the United States (3). It includes both annuals and perennials of which many are native to the cape region of South Africa (3). *Diascia* prefers excellent drainage and cold tolerance of many species of *Diascia* is questionable north of USDA zone 7 (3). *Diascia integerrima* Coral Canyon™ is considered hardy to USDA Zone 4 (15). Drainage and cold hardiness issues may have contributed to the poor performance of this species.

*Gaura lindheimeri* is a species of herbaceous perennial native to Louisiana, Texas, and Mexico (24). This plant requires full sun and well drained soil, and with its long tap root, is very drought tolerant (24). *Gaura* is also tolerant of heat and humidity (3). Commercial growers have found *Gaura* difficult to overwinter (15). Plantings of *Gaura* in the Learning Garden on the campus of The Ohio State University, Columbus, OH, overwintered poorly (4). Lack of cold tolerance may be the reason *Gaura* did not survive any treatment. This species also requires good drainage and slow draining soil may have contributed along with cold to the demise within the in-ground treatment.

*Scabiosa caucasica* ‘Butterfly Blue’ requires full sun and well drained fertile soil (24). Mulch is also beneficial since this plant prefers cool, humid climates (24). Excellent winter drainage is necessary for survival (15). Slow drainage in the in-ground treatment may have impacted negatively on the

**Table 2. In-ground and inside container mean plant height in centimeters on April 15, 2004, and May 17, 2004.**

Plant species	Date			
	April 15, 2004		May 17, 2005	
	Plant height (cm)			
	Inside	In-ground	Inside	In-ground
Sun plants				
<i>Calamagrostis</i> × <i>acutiflora</i> ‘Overdam’	29	40.5	47	66
<i>Ceratostigma plumbaginoides</i>	11	3.5	26	10.5
<i>Coreopsis</i> ‘Limerock Ruby’	NA <sup>z</sup>	NA	NA	NA
<i>Crocsmia</i> × <i>crocosmiiflora</i> ‘Lucifer’	13	25	42	44.5
<i>Diascia integerrima</i> Coral Canyon™	0	0	0	0
<i>Euphorbia amygdaloides</i> var. <i>robbiae</i>	15.5	13	23	17
<i>Gaura lindheimeri</i> ‘Siskiyou Pink’	0	0	0	15
<i>Geranium sanguineum</i> ‘Alpenglow’	9.5	11	19	22.5
<i>Heuchera sanguinea</i> ‘Splendens’	10	15	21	20
<i>Hypericum calycinum</i>	NA	NA	NA	NA
<i>Kniphofia</i> Pfitzer’s Hybrid	32.5	20	52	42
<i>Lavendula angustifolia</i> ‘Munstead’	11	15.5	19.5	30
<i>Leucanthemum</i> × <i>superbum</i> ‘Snowcap’	7	0	18.5	0
<i>Nepeta</i> × <i>faassenii</i> ‘Dropmore’	21	28	48	67.5
<i>Panicum virgatum</i> ‘Shenandoah’	7.5	18	49	54
<i>Phlox paniculata</i> ‘Mt. Fuji’	26	43.5	44.5	61
<i>Scabiosa caucasica</i> ‘Butterfly Blue’	NA	6	NA	9
<i>Sedum</i> ‘Matrona’	24	28	32.5	46
<i>Stachys byzantina</i> ‘Big Ears’	21	15	24	24
<i>Stokesia laevis</i> ‘Honeysong Purple’	20	11.5	35	22
<i>Thymus serphyllum</i> ‘Annie Hall’	NA	4	NA	8.5
<i>Veronica alpina</i> ‘Alba’	11	8	26.5	16
Shade plants				
<i>Alchemilla mollis</i> ‘Thriller’	12	19	28	28
<i>Anemone tomentosa</i> ‘Robustissima’	7	14	8	21
<i>Epimedium</i> × <i>rubrum</i>	21	26	25	23
<i>Heuchera americana</i> ‘Palace Purple’	16	19	29.5	23.5
<i>Hosta</i> ‘Francee’	11	20	35.5	26.5
<i>Hosta</i> ‘June’	13	19	22	20
<i>Lamiastrum galeobdolon</i> ‘Variegatum’	19	27	30	27.5
<i>Lamium maculatum</i> ‘Anne Greenway’	4	14.5	11.5	18.5

<sup>z</sup>NA — Rating not taken, 100% mortality.

plants ability to survive. *Scabiosa* overwinters better for commercial growers if it is not cut back in the fall (15). Research plants were cut back in the fall before overwintering treatments. The cultivar ‘Butterfly Blue’ flowers continuously from early summer until frost (24). Energy required for the production of the prolific amount of blooms that this species produces, may shorten the plants life.

**Plant heights.** Height measurements were recorded on April 16, 2004, and May 17, 2004 (Table 2). No discernable patterns were observed between the in-ground treatment and the container treatment overwintered inside. Some species such as *Calamagrostis* × *acutiflora* ‘Overdam’ and *Phlox paniculata* ‘Mt. Fuji’ were taller in-ground than in the container treatment overwintered inside. Other species such as *Ceratostigma plumbaginoides* and *Kniphofia* Pfitzer’s Hybrid measured taller in the inside container treatment than in the ground (Table 2).

An overwintering study of five species of ornamental grasses found container size significantly influenced growth (14). Height and crown diameter showed a significant increase as the container size increased. This result can explain the shorter height of the inside container treatment of some

of the larger species, such as *Calamagrostis* × *acutiflora* ‘Overdam’ and *Phlox paniculata* ‘Mt. Fuji’ when compared to their in-ground counterparts. The in-ground plants were not limited by space.

The container treatment plants overwintered inside were exposed to warmer temperatures throughout the winter than the in-ground treatment plants. We speculate that the warmer conditions may have resulted in the less winter stress or injury. This may explain the taller heights of *Ceratostigma plumbaginoides* and *Kniphofia* Pfitzer’s Hybrid inside container treatment plants compared to the in-ground treatment plants.

Our results indicate that overwintering certain species of perennials inside an unheated building such as an unheated garage is a viable option for homeowners to improve their survival. In our study, we found that in-ground temperatures were about the same as soil in a container in an unheated garage. In contrast, we found that the soil in containers stored outside was very close to the actual air temperature. Eighteen of the thirty species of herbaceous perennials evaluated in this trial overwintered successfully in containers, with few differences between them and plants overwintered in the ground. Zone hardiness, while an important factor in over-

wintering survival, is only one parameter to consider when choosing an herbaceous perennial species for overwintering in a container. Cultural conditions such as drainage and fertility needs also play a role as to how well a plant will overwinter. Future studies should investigate the impact of soil moisture status on the survivability of perennials overwintered in containers in an unheated building.

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