HortScience 16(5):675–676. 1981.

Comparison of Flower Bud Cold Hardiness of Several Cultivars of *Rhododendron* spp.[1,2]

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Additional index words. winter injury, winter hardiness

Abstract. **Five evergreen rhododendron cultivars were compared for flower bud cold hardiness in laboratory freezing studies on 6 dates. 'Roseum Elegans', 'Catawbiense Boursalt' and 'Boule de Neige' were more cold hardy on most sampling dates than 'America' and 'Lee's Dark Purple'. The relative cold hardiness of these 5 cultivars was consistent on several winter dates over several years. Injured florets were black and readily separated from uninjured white florets upon dissection of the inflorescence bud after freezing.**

Flower buds of some woody plants such as forsythia (1,3), flowering dogwood (3), and peach (9) are more sensitive to winter injury than stems. Flower buds of evergreen rhododendrons may be more tender than leaves or stems, but no controlled comparisons have been reported. We have observed dead flower buds on cultivar 'America' when foliage was uninjured and when flower buds and foliage of other cultivars were uninjured. The American Rhododendron Society has published the minimum temperature which each rhododendron cultivar will normally withstand (2), but the cold hardiness of flower buds and other plant parts were not differentiated.

Evergreen rhododendrons bloom from overwintering flower buds. The term flower bud in this paper refers to the inflorescence bud. Floret refers to an unexpanded flower in the bud. Our purpose was to compare the relative flower bud cold hardiness of 5 cultivars during the later stages of cold hardiness development when leaves and stems were reported to be winter injured (7).

Five evergreen rhododendron cultivars growing at the University of Vermont Horticultural Research Center in South Burlington and among the more cold hardy as reported by the American Rhododendron Society (2) were compared for flower bud cold hardiness on 6 dates in December and January from 1977 to 1980. The freezing dates were selected because leaves and stems of the same cultivars were injured by Vermont temperatures in 2 years during December or early January (7). Uniform flower buds with about 1 cm of stem were sampled from the top third of 1 to 1.5 m high plants. The buds were randomly assigned to 5 replicates of 5 test temperatures and 1 control temperature. The control samples were kept in a 4°C refrigerator while test samples were frozen. The test samples in stoppered test tubes, 1 bud per tube, were placed in a pre-cooled ethanol bath at 0° for 1 hr. The bath temperature was lowered 5° in the first 20 min of each hr for each test temperature and remained constant (±1°) for 40 min. This rate of temperature decline was reported not to be detrimental for azaleas (5). Copper-constantan thermocouples attached to a multipoint temperature recorder were used to monitor tissue and bath temperatures. The thermocouple junction was inserted into two flower buds during each freeze. The cooling curve profiles showed exotherms between –5 and –9°, but equipment was not sensitive enough to show smaller exotherms which Graham and Mullin associated with death of florets (5).

Test tubes containing samples were removed at each test temperature, placed into containers of ethanol from the bath to moderate the thawing rate, and put into a 4°C refrigerator for 24 hr. After thawing, the samples were incubated at 25° for 7 days with wet toweling over unstoppered tubes to prevent desiccation.

The buds were dissected and the florets evaluated as injured (black) or uninjured (white). The temperature at which 50% of the florets were injured (T_{50}) was calculated using a moving average procedure (K = 3 temperatures), a procedure used when control samples are injured and/or the lowest temperature did not kill all samples (4). The Z-test (8) was used to compare T_{50} values for 5 cultivars on 5 dates. The small sample distribution of the T_{50} was approximated by the normal distribution represented by the Z-test.

Florets of 'Roseum Elegans', 'Catawbiense Boursalt' and 'Boule de Neige' were more cold hardy on most sampling dates than those of 'America' and 'Lee's Dark Purple' (Table 1). The relationship in cold hardiness among cultivars was similar at a mid-stage in cold hardiness development (November 4, 1977) and near the height of cold hardiness on December and January sampling dates of several years.

When cultivars were ranked from lowest to highest T_{50} on each sampling date, they generally followed the same rank order (Table 1). 'Roseum Elegans' had the lowest T_{50} on 4 of 5 sampling dates followed in order by 'Catawbiense Boursalt', 'Boule de Neige', 'America' and 'Lee's Dark Purple'. Control samples of 'Lee's Dark Purple' on January 5, 1978 and 'America' on January 9, 1979 showed field injury to more than 10% of the florets (Fig. 1). These results are generally consistent with field results over several years at several sites in Vermont where 'Boule de Neige', 'Catawbiense Boursalt' and 'Roseum Elegans' were apparently about equal in winter flower bud cold hardiness and more hardy than 'America' (unpublished data).

Cultivars with the more hardy leaves or stems may not have the most hardy flower buds. Holt (7) compared the cold hardiness of leaf and stem tissues of these same cultivars. 'Lee's Dark Purple' had more cold hardy leaf and stem tissues than other cultivars in the earlier study, but less cold hardy florets in this study. 'America' generally had less cold hardy florets as well as less hardy tissues than other cultivars. 'Boule de Neige' and 'Catawbiense Boursalt' had florets, leaves and stems among the most cold hardy in both studies.

This laboratory freezing procedure can be useful in comparing the flower bud cold-hardiness of rhododendron selections or culti-

Table 1. Laboratory temperature[z] (°C) resulting in 50% injury (T_{50}) to rhododendron florets on 6 sampling dates and ranks of T_{50} ( ) on each date.

Cultivar	Sampling dates: Nov. 4 1977	Dec. 14 1977	Jan. 5 1978	Jan. 9 1979	Dec. 13 1979	Jan. 10 1980	Sum of ranks
Roseum Elegans	−12.3a[y]	−23.9b	−28.9a	---[x]	−22.9a	−28.2a	
	(1)	(2)	(1)		(1)	(1)	6
Catawbiense	−11.7a	−25.4a	−23.1b	---	−22.8a	−25.8b	
Boursalt	(3)	(1)	(2)		(2)	(2)	10
Boule de Neige	−11.8a	−23.5b	−22.1b	---	−21.3b	−22.7c	
	(2)	(3)	(3)		(3)	(3)	14
America	−9.2b	−18.4c	−17.3c	−10.4	−18.7c	−22.6c	
	(4)	(4)	(4)		(5)	(4)	21
Lee's Dark Purple	−7.8b	−17.8c	−15.0d	−16.0	−19.9bc	−20.1d	
	(5)	(5)	(5)		(4)	(5)	24

[z]Based on 5 inflorescence buds at each of 6 temperatures.
[y]Mean separation within columns by Z-test, 5% level.
[x]T_{50} could not be calculated because of missing data at −25°C. These 3 cultivars had less than 50% injury at −20°, but were all injured at −30°.

[1]Received for publication March 16, 1981. Vermont Agriculture Experiment Station Journal Article No. 471.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.
[2]Partially funded by a grant from the Vermont Plantsmen's Association.
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vars. Flower bud injury was easily discernible because injured florets were either black (injured) or white (uninjured) after freezing in the laboratory or freezing injury in the field. This procedure requires more plant material to determine flower bud cold hardiness than the freezing curve method (6), but it requires less expensive laboratory equipment.

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HortScience 16(5):676–677. 1981.

Effects of Application Methods of Controlled-release Fertilizers on Growth and Quality of *Rhododendron obtusum* 'Hinodegiri' Grown in Various Media[1]

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Additional index words. container culture, controlled-release fertilizer, media, ornamental plants

***Abstract. Rhododendron obtusum* (Lindl.) Planch. 'Hinodegiri' responded to the different fertilizer sources and application methods similarly regardless of growing media. Plants top-dressed with Osmocote 18N-3P-10K had a significantly higher growth index, larger stem caliper and increased fresh weight than plants top-dressed with Pro-Grow 24N-3P-10K. Incorporation of either fertilizer source resulted in reduced plant growth and quality. The best fertilization method was a surface application regardless of fertilizer source or media.**

Various studies have demonstrated the necessity for evaluating fertilizer sources (2, 4, 6, 10), levels, and methods of application (1, 2, 5, 11), in container production. However, results may be variable due to different plant species response, fertilizer sources, methods of application and rates, particularly in different types of media (7, 8, 9). Furuta (2) suggested the use of controlled-release fertilizers for production of container-grown ornamentals was the best alternative to other nutritional programs. *Rhododendron* spp. obtained the best growth response when fertilized with controlled-release as compared to liquid fertilizer regardless of application method (6). Gouin (3) reported a surface application of 18N-3P-10K over the propagating medium of 1 peat:1 sand (v/v) resulted in better rooted cuttings of *R. obtusum* (Lindl.) Planch. *japonicum* than when incorporated. Coleman et al. (1) showed similar growth when fertilizer was either incorporated into the medium or surface applied. The objectives of this study were to evaluate growth and quality of *R. obtusum* 'Hinodegiri' as influenced by growing media, sources of controlled-release fertilizers, and methods of application.

A 4 x 4 factorial experiment in a randomized block design was established on May 28, 1979, to test 4 growing media and 4 fertilizer treatments. Treatments were replicated 6 times with 1 plant/pot as an experimental unit. Media treatments were 100% peat, 1 peat:1 pine shavings, 1 peat:1 pine bark, and 1 peat:1 builders sand (by volume). All media treatments were amended with dolomite to adjust the pH to 5.2 and FTE 503 (micronutrient source) added at 1 kg/m^3. Fertilizer treatments were 4.8 kg/m^3 Osmocote 18N-3P-10K incorporated (OSI), 6 g/15 cm diameter pot Osmocote 18N-3P-10K surface applied (OSS), 3.5 kg/m^3 Scott's Pro-Grow 24N-3P-10K incorporated (PGI) and 6 g/15 cm diameter pot Scott's Pro-Grow 24N-3P-10K surface applied (PGS).

Established liners of uniform size were potted 1 per 15 cm diameter pot and grown in the different media and fertilizer treatments. Plants were produced under partial shade (42 klx light maximum) with temperatures of 16°C minimum and 32°C maximum. Indi-

Table 1. Effects of application methods of controlled-release fertilizers on growth and quality of *Rhododendron obtusum* 'Hinodegiri' grown in various media.

Treatment[z]	Growth index[y] (cm)	Stem caliper (mm)	Side shoots (No/plant)	Fresh wt (g)	Foliar[x] color	Plant[w] grade
Peat						
OSS	24.3 a[v]	9.8 a	10.7 a	70.7 a	4.3 a	4.7 a
OSI	20.5 b	8.0 b	9.2 b	58.5 b	4.0 a	4.1 b
PGS	20.2 b	7.6 b	9.3 b	51.3 b	3.3 b	4.0 b
PGI	16.7 c	6.7 c	7.0 c	37.8 c	3.2 b	3.3 c
Peat:shavings						
OSS	22.7 a	8.9 a	8.5 a	56.7 a	4.3 a	4.2 a
OSI	20.0 b	7.8 b	8.4 a	46.2 b	4.1 a	3.9 a
PGS	19.2 b	7.4 b	8.3 a	44.3 b	3.3 b	3.7 a
PGI	16.1 c	6.1 c	7.0 b	24.5 c	2.5 c	2.7 b
Peat:bark						
OSS	22.5 a	8.9 a	9.0 a	56.3 a	4.2 a	4.1 a
OSI	19.6 b	7.5 b	8.2 a	44.3 b	3.9 a	3.9 a
PGS	20.2 b	7.5 b	8.7 a	45.8 b	4.0 a	3.3 b
PGI	18.1 c	6.8 c	7.9 a	38.7 c	3.0 b	3.3 b
Peat:sand						
OSS	21.7 a	7.9 a	8.7 a	49.5 a	3.3 a	4.0 a
OSI	19.1 b	7.0 b	7.9 ab	43.1 b	3.3 a	4.0 a
PGS	18.3 b	6.8 b	7.0 b	37.2 b	3.5 a	3.0 b
PGI	17.7 b	6.5 b	6.7 b	31.0 c	2.8 b	2.8 b

[z]OSS = Osmocote (18N-3P-10K) surface at 6 g/15 cm diameter pot, OSI = Osmocote (18N-3P-10K) incorporated at 4.8 kg/m^3, PGS = Pro-Grow (24N-3P-10K) surface at 6 g/15 cm diameter pot, PGI = Pro-Grow (24N-3P-10K) incorporated at 3.5 kg/m^3.

[y]Plant height + maximum plant width ÷ 2.

[x]1 = light green, 3 = medium green and 5 = dark green.

[w]1 = poor, not salable; 3 = good, salable; and 5 = excellent quality.

[v]Mean separation within medium treatment groups in columns by Duncan's multiple range test, 5% level.

[1]Received for publication March 16, 1981. Mississippi Agricultural and Forestry Experiment Station Article No. 4780.

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