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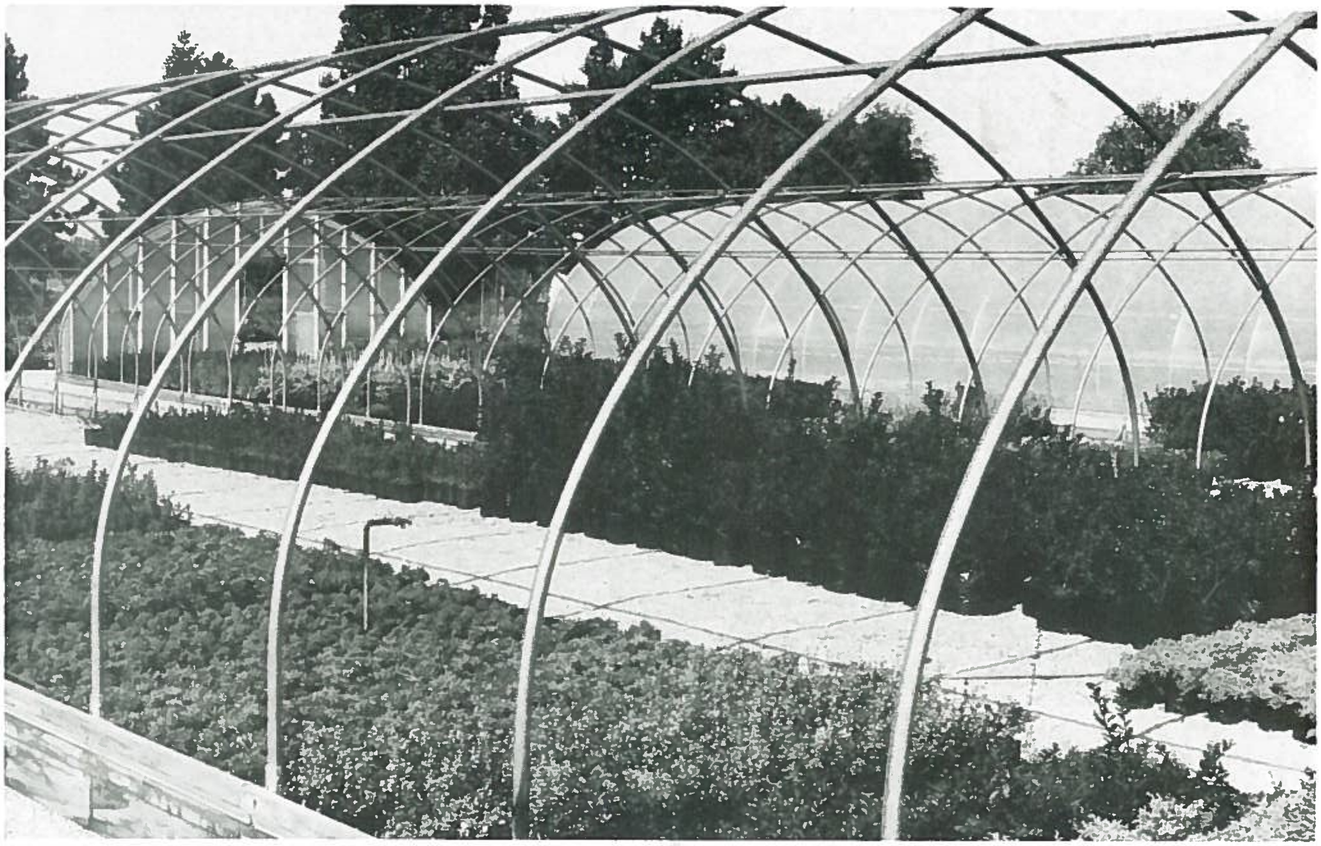

# Ornamental Plants

## A Summary of Research 1992

THE OHIO STATE UNIVERSITY



The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio

# Contents



**On the Cover:** The Ohio State University Nursery Research Facilities in Columbus. Recent greenhouse renovations were completed with industry support.

OARDC

Ohio Agricultural Research and Development Center

James H. Brown
Acting Director



1-92-2.2M

# A Two-Year Evaluation of Composted Municipal Sludge in the Landscape

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## Abstract

This research evaluated growth of 10 annual species produced in composted municipal sludge (CMS) amended mineral soil for a two-year period. The CMS from Akron, Ohio, was used as a soil additive, mulch and combination of both. Over the two years the best treatments were incorporated and incorporated plus mulch. The best individual treatment was the 1.5″ incorporated with 2.0″ mulch. Mulch levels over 2″ were unfavorable. CMS increased the growth of ageratum, begonia, chrysanthemum, dahlia, marigold, petunia, salvia and vinca. CMS is questionable for use with geranium and dusty miller.

## Introduction

Previous research (1-8, 10-11) has indicated the value of composted municipal sludge as an amendment for the production of container-grown landscape plants. The only published report of research with CMS as a supplement to landscape sites for the production of annual flowers is the work reported in the first year of this study (9). Trials the first year with CMS Akron, Ohio, indicated that the best growth was noted in the treatment of 1.5″ incorporated with a 2.0″ mulch. Mulch levels over 2.0″ were unfavorable. There were different responses by species of annuals. CMS was valuable for the production of begonia, chrysanthemum, dahlia, gomphrena, marigold, periwinkle and salvia. Aster, geranium and petunia did not respond positively to CMS incorporated or used as a mulch.

Research in the second year of the study evaluated plant growth of similar species of annuals in the CMS treatments that had been reapplied in the same plots. Specifically, researchers looked to see if two consecutive incorporated treatments of CMS, at identical rates, would have an adverse effect on plant growth.

## Materials and Methods

The study was conducted in Brookston silt loam soil in the research nursery on the campus of The Ohio State University. Treatments during both years of the study in 1989 and 1990 were: CMS incorporated at depths of 0.5″, 1.0″ and 1.5″, CMS mulched at depths of 2.0″, 3.0″ and 4.0″, and the combination of incorporated depths of 0.5″, 1.0″ and 1.5″ each with 2.0″ of mulch. The incorporated treatments were all rototilled to a depth of 4.0″ in soil that contained the same treatment as 1989. Each treatment measured 10′ x 30′. Across each treatment were planted 10 rows of annual flowers.

The species and cultivars of annuals grown included: Adriatic ageratum, Prelude Mix begonia, Allure chrysanthemum, Figaro White dahlia, Fidelio geranium, Golden Gate marigold, Silverdust dusty miller, Sky Cascade petunia, Cleopatra Violet salvia and Peppermint Cooler periwinkle.

The treatments were applied June 4, 1990 and the annuals planted and watered on June 6, 1990. No additional fertilizers were added to any of the plots to avoid introducing other factors that could influence plant growth.

In early September 1990, approximately 12 weeks after planting, plants were cut at the base, dried and weighed. Foliar samples for mineral analysis were taken of vinca and salvia. Soil samples were taken from each treatment.

## Results and Discussion

The growth of each species as expressed in dry weights of the species and cultivars of annuals grown in each of the treatments is presented in Table 1.

Ageratum responded positively to all treatments with significant growth increases in all nine treatments when compared to untreated controls. Growth was best in incorporated and incorporated plus mulch treatments. Ageratum replaced aster in last year's study because aster was definitely sensitive to CMS.

Begonia growth was significantly better in all nine treatments when compared to controls. This was also true the previous season. The most effective treatment was 1.5″ incorporated with 2.0″ mulch which represented one of the best treatments the previous season.

Chrysanthemum like ageratum and begonia responded significantly better in all compost treatments when compared to control plots. The most effective treatment was 1.5″ incorporated and 2.0″ mulch which was also one of the better treatments the previous year.

Dusty miller growth was inconsistent. Better growth was noted in 0.5″, 1.0″ and 1.5″ incorporated treatments along with 3.0″ mulch and the combination of 0.5″ incorporated and 2.0″ mulch. Growth in all other treatments was inferior to the control plots. Dusty miller was not included in last year's study and, in general, it appears to benefit from incorporated CMS, but not consistently from mulching or combination treatments.

Dahlia responded positively to eight of nine treatments with best growth recorded in the 1.5″ incorporated and 2.0″ mulch treatment. CMS resulted in similar growth responses with dahlia to all treatments in 1989.

The relatively wet growing season of 1990 resulted in poor geranium growth in most landscape plantings. This was true in this study as well. The best treatment was 1.5″ and 2.0″ mulch, however, the total growth in that plot was approximately one-third the growth in the control plots last year. In general, the incorporated treatments yielded the best growth however, consistent benefit from CMS over a two-year span is not clearly evident with geranium.

Marigold growth was greatest in 1990 and 1989 in incorporated treatments including the combination treatments.

Petunia responded significantly to all compost treatments in 1990 with the 1.0″ incorporated and 2.0″ mulch the best single treatment. Last year petunia did not respond consistently well to compost treatments.

Salvia responded significantly to all nine compost treatments in 1990 and seven of nine in 1989. The best treatments both years were 1.0″ incorporated and 2.0″ mulch and 1.5″ incorporated and 2.0″ mulch.

Vinca responded significantly to seven of nine treatments in 1990 and eight of nine in 1989. The most effective treatments were 0.5″ incorporated and 2.0″ mulch and 1.0″ incorporated and 2.0″ mulch.

Overall, from a plant growth perspective, the incorporated and incorporated plus mulch treatments were the most effective. The mulch-only treatments were not particularly effective. The treatment of 1.5″ incorporated and 2.0″ mulch resulted in the best growth of five of the 10 species with the 1.0″ incorporated and 2.0″ mulch treatment best for three species. These results were consistent with the first year of the study. The major difference in growth between years was that in 1989 seven of 10 species responded positively and in 1990 nine of 10 species responded positively to CMS treatments.

The nitrogen, phosphorus and potassium foliar analysis values of vinca and salvia are presented in Table 2. The nitrogen and potassium levels in the foliage of vinca were significantly higher in most all compost treatments. This was not true with phosphorus. In salvia the N, P, and K were generally higher in compost treatments. The treatment of 1.5″ incorporated and 2.0″ mulch resulted in significantly higher N, P and K values in salvia. Salvia growth was best in the same compost treatment.

The soil test data for pH, phosphorus, potassium, calcium, magnesium, and cation exchange capacity are presented in Table 3. The pH remained relatively stable between 6.2 and 6.7 which was slightly higher than last year (5.6-6.4). The pH of the untreated soil was 6.4 and the compost 6.7. Soil phosphorus was highest in the 1.5″ incorporated and 2.0" mulch treatment with a value of 1,005 lbs/acre well above the 100 needed for satisfactory growth. Potassium values were below the 400 needed for optimum growth in all compost treatments. There was little difference in Ca between treatments with all values above the 2000 lbs/Acre needed for growth. Magnesium was highest in control plots and in all cases above the 250 lbs/acre needed for satisfactory growth. There was little variation in CEC with the mulch treatments slightly higher.

**Table 1. The Dry Weight, in Grams, of Annuals Grown in Akron Composted Municipal Sludge Used as a Soil Conditioner and/or Mulch. Plants Harvested September, 1990.**

| Treatment | Ageratum | Begonia | Chrysanthemum | Dahlia | Dusty Miller |
|---|---|---|---|---|---|
| Check | 31.88e | 11.43e | 55.52f | 38.19g | 38.16e |
| 0.5″ Inc. | 46.69d | 29.54c | 82.97de | 46.63g | 51.62c |
| 1.0″ Inc. | 71.51a | 31.58c | 123.63b | 120.19c | 50.48c |
| 1.5″ Inc. | 69.71a | 41.23b | 125.09b | 142.57b | 62.84b |
| 0.5″ Inc.+2″ M | 58.08b | 45.72b | 122.59b | 118.21c | 68.10a |
| 1.0″ Inc.+2″ M | 72.35a | 42.35b | 120.32b | 108.80d | 30.49g |
| 1.5″ Inc.+2″ M | 59.72b | 52.80a | 135.59a | 162.43a | 34.33f |
| 2.0″ Mulch | 46.24d | 31.59c | 87.07cd | 107.60d | 32.74fg |
| 3.0″ Mulch | 53.41c | 28.80c | 77.97e | 82.25e | 46.85d |
| 4.0″ Mulch | 53.31c | 17.06d | 90.53c | 55.11f | 31.70fg |
| LSD @ .05 | 4.41 | 5.49 | 5.72 | 8.45 | 3.02 |

| Treatment | Geranium | Marigold | Petunia | Salvia | Vinca | Ave. |
|---|---|---|---|---|---|---|
| Check | 5.99cd | 59.12g | 8.11g | 2.39d | 21.99ef | 27.28 |
| 0.5″ | 8.73b | 78.19c | 31.88f | 6.77cd | 46.67d | 42.97 |
| 1.0″ | 9.68b | 88.33a | 70.53b | 17.45ab | 79.89c | 66.33 |
| 1.5″ | 9.33b | 83.43b | 71.23b | 17.67ab | 94.21b | 71.73 |
| 0.5″ Inc.+2″ M | 9.79b | 75.66d | 57.93c | 17.46ab | 100.29a | 67.38 |
| 1.0″ Inc.+2″ M | 9.30b | 68.51e | 75.64a | 23.33a | 103.04a | 65.41 |
| 1.5″ Inc.+2″ M | 14.10a | 79.66c | 72.09b | 23.10a | 77.45c | 71.13 |
| 2.0″ Mulch | 6.85c | 64.15f | 47.03d | 17.54ab | 50.17d | 49.10 |
| 3.0″ Mulch | 4.75d | 51.38h | 42.88e | 8.92c | 28.60e | 42.52 |
| 4.0″ Mulch | 6.69c | 51.58h | 31.01f | 11.17bc | 19.40f | 36.76 |
| LSD @ 0.5 | 1.47 | 2.35 | 3.24 | 6.50 | 6.06 | —— |

**Table 2. Foliar Analysis of Vinca and Salvia Harvested in September 1990 Following 12 Weeks of Growth in Akron Composted Municipal Sludge Used as a Soil Conditioner and/or Mulch. Values expressed in percentage.**

| | Vinca | | | Salvia | | |
|---|---|---|---|---|---|---|
| Treatment | Nitrogen | Phosphorus | Potassium | Nitrogen | Phosphorus | Potassium |
| Check | 2.32 e | .37 bcd | 1.36 e | 3.56 d | .27 c | 1.74 d |
| 0.5″ Inc. | 2.72 d | .38 abcd | 1.61 de | 3.03 e | .36 c | 2.12 cd |
| 1.0″ Inc. | 2.93 cd | .32 d | 1.74 cd | 4.02 c | .49 b | 3.04 ab |
| 1.5″ Inc. | 3.01 bcd | .32 d | 1.91 bcd | 4.24 bc | .54 b | 3.23 ab |
| 0.5″ Inc.+2″ M | 3.36 ab | .36 cd | 2.00 bc | 4.57 b | .66 a | 3.63 a |
| 1.0″ Inc.+2″ M | 3.72 a | .36 cd | 2.16 b | 4.37 bc | .70 a | 3.48 a |
| 1.5″ Inc.+2″ M | 3.26 bc | .37 bcd | 2.10 b | 4.81 a | .70 a | 3.93 a |
| 2.0″ Mulch | 3.01 bcd | .43 ab | 2.10 b | 4.24 bc | .72 a | 3.05 abc |
| 3.0″ Mulch | 2.89 d | .41 abc | 2.61 a | 4.55 b | .75 a | 2.41 bcd |
| 4.0 Mulch | 2.81 d | .43 a | 2.05 b | 4.18 bc | .77 a | 3.79 a |
| LSD @ 0.5 | .40 | .06 | .30 | .43 | .11 | .92 |

**Table 3. Soil Analysis from Akron Composted Municipal Sludge Amended Soils Taken September 1990. Mineral Element Values Expressed in Pounds Per Acre.**

| Treatment | pH | Phosphorus | Potassium | Calcium | Magnesium | CEC |
|---|---|---|---|---|---|---|
| Check | 6.37 ab | 69 g | 239 fg | 4167 bc | 762 a | 14.00 bc |
| 0.5″ Inc. | 6.77 a | 396 de | 211 g | 3970 c | 481 de | 12.00 d |
| 1.0″ Inc. | 6.73 a | 638 c | 264 ef | 4460 abc | 475 de | 13.67 c |
| 1.5″ Inc. | 6.63 ab | 851 b | 347 ab | 5037 a | 444 def | 15.00 bc |
| 0.5″ Inc.+2″M | 6.60 ab | 851 b | 295 abc | 4633 abc | 390 ef | 14.33 bc |
| 1.0″ Inc.+2″M | 6.63 ab | 939 ab | 334 abc | 4873 a | 392 ef | 14.67 bc |
| 1.5″ Inc.+2″M | 6.77 a | 1005 a | 328 abc | 4820 a | 373 f | 14.00 bc |
| 2.0″ Mulch | 6.40 ab | 418 d | 276 def | 4363 abc | 534 cd | 15.33 ab |
| 3.0″ Mulch | 6.23 b | 249 f | 319 bcd | 4427 abc | 611 bc | 16.67 a |
| 4.0″ Mulch | 6.43 ab | 289 ef | 371 a | 4683 ab | 645 b | 16.67 a |
| LSD @ .05 | .42 | 116 | 49 | 683 | 100 | 1.58 |

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# Efficacy, Phytotoxicity and Root Response of Container-Grown Landscape Plants to Repeat Applications of Pre-Emergence Herbicides

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## Abstract

This study evaluated weed control, foliage injury, and root toxicity from multiple applications of Ronstar, Rout, OH-2 and Gallery over two growing seasons on landscape plants. Weed control was excellent in all treatments, and foliar injury limited to spirea from Rout and Gallery. Rout injury was noted on azalea and spirea only from more than one application of Rout, OH-2 and Gallery.

## Introduction

Most large nursery producers of container-grown nursery stock use some form of chemical pre- or post-emergence weed control. Previous studies have indicated foliage phytotoxicity from herbicides (2-4), however, few reports indicate damage to roots. Determining root damage is difficult. However, growers often wonder if herbicide application affects roots.

This study was conducted to determine, what effects several common pre-emergence herbicides would have on weed control, foliar injury and root growth with multiple applications of popular pre-emergence herbicides.

## Materials and Methods

The plant materials selected for this two-year evaluation were *Rhododendron* 'Hershey Red', *Forsythia* 'Spring Glory', and *Spiraea* 'Gold Flame'. Each were planted in two-gallon containers in early May, 1990. The media was a mixture of pinebark and sand (1:1 by volume) which facilitated root washing, and plants were maintained as with commercial practices.

The herbicide treatments included Ronstar (Oxadiazon), Rout; (Oxyfluorofen and Oryzalin), OH-2 (Oxyfluorofen and Pendimethylin) Gallery (Isoxaben) and control. Herbicides were applied May 15, 1990, September 10, 1990 and April 30, 1991 to each of three groups of plants. One group, May 15, 1990, received one application, a second group, September 10, 1990, received two applications, and the third group April 30, 1991, received three applications.

Weed control and phytotoxicity evaluations were conducted periodically throughout the growing season of 1990 and 1991. Root evaluations were conducted September 11, 1990, May 1, 1991 and August 15, 1991. Root quality and root length were measured at all sampling dates and root mass measurements were conducted August 15, 1991.

The study was conducted in the container research nursery located on The Ohio State University campus. There were four plants/treatment, four replications of each treatment and a total of 720 plants in the study which was arranged in a randomized complete block design.

## Results and Discussion

All four herbicides resulted in excellent weed control during the growing season of 1990 (Table 1). Weed control the second growing season declined with only one application of each herbicide.

Throughout the two-year study there were no visual symptoms of foliar injury with forsythia or azalea. There were slight reductions in growth of 'Gold Flame' spirea from three applications of Rout and from both two and three applications of Gallery (Table 2). When compared to control plants, there was no reduction in length of roots of forsythia at any of the three sampling dates (Table 3).

The length of 'Gold Flame' spirea roots was not affected by Ronstar or OH-2. However, three applications of Rout and all treatments of Gallery in August of 1991 reduced root growth (Table 4).

'Hershey Red' azalea root in growth was reduced by OH-2 at one and two applications, Rout at two applications, and Gallery at all three applications as measured in August 1991.

The root mass or root ball after removal from the container of azalea and spirea was measured vertically in three locations from the top of the existing root mass to the base. The mean of this measurement is shown in Table 6, and represents that mass of roots remaining from herbicide treatment over two years. There was no root mass reduction from one application of any herbicide. Two and three applications of Gallery reduced the root mass of spirea. Two and three applications of Rout, OH-2 and Gallery reduced the root mass of azalea. The root mass of azalea was reduced by Gallery nearly 50 percent.

## Summary

Selected pre-emergence herbicides Ronstar, Rout, OH-2 and Gallery controlled weeds for two years with treatments in spring 1990, autumn 1990 and spring 1991. There was no foliar injury on forsythia or azalea and only slight injury with 'Gold Flame' spirea from Rout and Gallery.

Root length of forsythia was not affected by any herbicide at any sampling date. Length of spirea roots was affected by three applications of Rout and all treatments of Gallery. Azalea root length was inhibited by OH-2 at one and two applications, Rout at two and Gallery at all three applications.

Total root mass was not affected by one application of any herbicide. Two or more applications of OH-2, Rout and Gallery reduced root mass of spirea and azalea.

Table 1. Weed Control Over Two Seasons from Treatment with Pre-Emergence Herbicides.

| Herbicide Treatment | No. App. | 1990 7/25 | 1990 8/22 | 1990 9/24 | 1990 10/24 | 1991 5/15 | 1991 6/15 | 1991 7/15 | 1991 8/12 |
|---|---|---|---|---|---|---|---|---|---|
| Control | 1 | 8.75 | 8.0 | 9.5 | 8.0 | 8.5 | 8.3 | 8.3 | 8.3 |
| | 2 | 8.75 | 7.5 | 9.8 | 9.0 | 9.8 | 8.8 | 8.8 | 8.0 |
| | 3 | 8.75 | 8.0 | 9.3 | 8.8 | 9.8 | 8.8 | 8.8 | 8.5 |
| Ronstar | 1 | 10.0 | 9.5 | 10.0 | 9.5 | 10.0 | 9.5 | 9.0 | 8.8 |
| | 2 | 10.0 | 10.0 | 10.0 | 9.5 | 9.8 | 9.3 | 9.0 | 9.0 |
| | 3 | 9.8 | 10.0 | 10.0 | 9.5 | 10.0 | 9.3 | 9.5 | 9.5 |
| Rout | 1 | 10.0 | 10.0 | 10.0 | 9.3 | 10.0 | 9.8 | 9.3 | 8.5 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| OH 2 | 1 | 10.0 | 10.0 | 10.0 | 10.0 | 9.8 | 9.0 | 9.0 | 9.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 9.3 | 10.0 | 10.0 | 9.8 | 9.5 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Gallery | 1 | 9.8 | 9.8 | 9.8 | 9.3 | 9.8 | 8.3 | 7.8 | 7.5 |
| | 2 | 9.5 | 9.3 | 1.0 | 9.3 | 10.0 | 10.0 | 9.8 | 9.5 |
| | 3 | 9.8 | 9.0 | 10.0 | 9.3 | 10.0 | 9.8 | 10.0 | 10.0 |

Visual Scale: 10=100% weed control, 7=acceptable weed control and 1=no weed control.

Table 2. Phytotoxicity on 'Gold Flame' Spirea Over Two Seasons from Treatment with Pre-Emergence Herbicides.

| Herbicide Treatment | No. App. | 1990 7/25 | 1990 9/24 | 1990 10/24 | 1991 5/15 | 1991 6/15 | 1991 7/15 | 1991 8/12 |
|---|---|---|---|---|---|---|---|---|
| Control | 1 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Ronstar | 1 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Rout | 1 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 | 9.8 | 9.8 | 9.8 |
| OH 2 | 1 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| Gallery | 1 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 9.5 | 10.0 | 9.8 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 | 9.5 | 9.8 | 9.8 |

Visual Scale: 10=no injury, 7=acceptable injury and 1=complete death.

Table 3. Root Evaluation of 'Spring Glory' Forsythia Over Two Growing Seasons of Herbicide Treatments.

| Herbicide Treatment | No. App. | September, 1990 | | April, 1991 | | August, 1991 | |
|---|---|---|---|---|---|---|---|
| | | Length (cm) | Quality | Length (cm) | Quality | Length (cm) | Quality |
| Control | 1 | 17.13b | 4.00a | 38.75bc | 4.25a | 50.75a | 5.00a |
| | 2 | — | — | 47.50a | 3.75a | 50.75a | 5.00a |
| | 3 | — | — | — | — | 52.75a | 5.00a |
| Ronstar | 1 | 21.26a | 3.75a | 38.75bc | 4.50a | 49.00a | 4.75a |
| | 2 | — | — | 38.75bc | 4.25a | 49.00a | 4.50ab |
| | 3 | — | — | — | — | 49.50a | 5.00a |
| Rout | 1 | 21.95a | 4.00a | 38.75bc | 4.25a | 47.75a | 5.00a |
| | 2 | — | — | 41.25abc | 4.25a | 49.00a | 4.50ab |
| | 3 | — | — | — | — | 48.50a | 4.75a |
| OH 2 | 1 | 19.78a | 4.00a | 38.75bc | 3.75a | 50.75a | 4.75a |
| | 2 | — | — | 45.00ab | 4.00a | 48.50a | 4.00bc |
| | 3 | — | — | — | — | 47.00a | 4.50ab |
| Gallery | 1 | 21.95a | 4.00a | 38.75bc | 4.25a | 48.25a | 5.00a |
| | 2 | — | — | 36.25c | 4.00a | 50.00a | 4.75ab |
| | 3 | — | — | — | — | 48.75a | 3.75c |
| LSD @ 5.0% | | 6.51 | 0.282 | 8.05 | 0.920 | 8.75 | 0.585 |

Table 4. Root Evaluation of 'Gold Flame' Spirea Over Two Growing Seasons of Herbicide Treatments.

| Herbicide Treatment | No. App. | September, 1990 | | April, 1991 | | August, 1991 | |
|---|---|---|---|---|---|---|---|
| | | Length (cm) | Quality | Length (cm) | Quality | Length (cm) | Quality |
| Control | 1 | 10.63 | 4.00a | 16.50ab | 4.75ab | 19.50ab | 5.00a |
| | 2 | — | — | 16.25ab | 5.00a | 19.50ab | 5.00a |
| | 3 | — | — | — | — | 19.00bc | 5.00a |
| Ronstar | 1 | 11.02a | 3.75a | 16.50ab | 4.25ab | 19.50ab | 5.00a |
| | 2 | — | — | 13.75b | 4.25ab | 19.50ab | 5.00a |
| | 3 | — | — | — | — | 19.25ab | 5.00a |
| Rout | 1 | 11.32a | 3.75a | 16.00ab | 4.75ab | 18.75bcd | 5.00a |
| | 2 | — | — | 15.75ab | 5.00a | 19.25ab | 4.75ab |
| | 3 | — | — | — | — | 18.25cde | 4.50b |
| OH 2 | 1 | 10.83a | 4.00a | 17.25a | 4.00b | 20.00a | 4.75ab |
| | 2 | — | — | 15.75ab | 4.25ab | 19.50ab | 4.50b |
| | 3 | — | — | — | — | 18.75bcd | 4.75ab |
| Gallery | 1 | 11.02a | 3.75a | 16.50ab | 4.25ab | 17.75e | 4.50b |
| | 2 | — | — | 16.00ab | 4.50ab | 18.00de | 3.75c |
| | 3 | — | — | — | — | 17.75e | 3.25d |
| LSD @5.0% | | 4.16 | 0.415 | 2.18 | 0.779 | 0.937 | 0.498 |

Table 5. Root Evaluation of 'Hershey Red' Azalea Over Two Growing Seasons of Herbicide Treatments.

| Herbicide Treatment | No. App. | September, 1990 | | April, 1991 | | August, 1991 | |
|---|---|---|---|---|---|---|---|
| | | Length (cm) | Quality | Length (cm) | Quality | Length (cm) | Quality |
| Control | 1 | 5.51ab | 2.75a | 13.75ab | 4.50a | 18.75ab | 5.00a |
| | 2 | — | — | 12.25b | 4.00b | 19.25a | 5.00a |
| | 3 | — | — | — | — | 18.00abcd | 5.00a |
| Ronstar | 1 | 6.20a | 3.00a | 13.75ab | 4.75ab | 19.00a | 5.00a |
| | 2 | — | — | 11.75b | 4.00b | 18.25abc | 5.00a |
| | 3 | — | — | — | — | 17.75abcde | 5.00a |
| Rout | 1 | 4.92b | 3.00a | 14.50a | 5.00a | 19.00a | 4.75ab |
| | 2 | — | — | 13.00ab | 4.00b | 16.00defgh | 4.00cde |
| | 3 | — | — | — | — | 17.50abcdef | 4.00cde |
| OH 2 | 1 | 6.10a | 3.25a | 13.50ab | 4.75ab | 15.75efgh | 4.25bcd |
| | 2 | — | — | 12.75ab | 4.25ab | 16.25cdefg | 4.50abc |
| | 3 | — | — | — | — | 16.75abcdefg | 5.00a |
| Gallery | 1 | 6.30a | 2.75a | 12.50ab | 4.25ab | 15.00gh | 3.75cd |
| | 2 | — | — | 12.50ab | 4.50ab | 15.50fgh | 3.00f |
| | 3 | — | — | — | — | 14.00h | 3.50ef |
| LSD @5.0% | | 2.52 | 0.527 | 2.09 | 0.776 | 2.08 | 0.631 |

Table 6. Root Mass Measurements of 'Hershey Red' Azalea and 'Gold Flame' Spirea Following Two Years of Herbicide Treatment (August, 1991).

| Herbicide Treatment | No. App. | Azalea Height of Root Mass (cm) | Spirea Height of Root Mass (cm) |
|---|---|---|---|
| Control | 1 | 15.08a | 15.67ab |
| | 2 | 15.00a | 15.50ab |
| | 3 | 15.33a | 15.25b |
| Ronstar | 1 | 15.17a | 15.50ab |
| | 2 | 15.00a | 15.42ab |
| | 3 | 15.33a | 15.25b |
| Rout | 1 | 14.83a | 15.57ab |
| | 2 | 7.58de | 15.33b |
| | 3 | 6.67e | 14.33b |
| OH 2 | 1 | 14.92a | 15.92a |
| | 2 | 13.00bc | 15.25b |
| | 3 | 12.54c | 15.17b |
| Gallery | 1 | 14.00ab | 15.42ab |
| | 2 | 8.25d | 11.08c |
| | 3 | 7.75dc | 9.25d |
| LSD @ 5.0% | | 1.456 | 0.881 |

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# Tolerance of Herbaceous Perennials to Slow-Release Herbicide Tablets

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## Abstract

The effectiveness of slow-release herbicide tablets on container-grown herbaceous perennials was evaluated. The tablets contained oxyfluorfen (Goal) at 0.5 lbs active ingredient per acre (aia) metolachlor (Pennant) at 2.0 lbs aia and the surfactant Triton X-100 at 2 percent by volume.

Following 10 weeks of evaluation, weed control was very acceptable at 2 tablets/2 gallon containers. The addition of a third tablet was not particularly beneficial.

Phytotoxicity was evident on eight of 38 species and cultivars of herbaceous perennials. Among the eight species only two were considered unacceptable according to commercial standards.

## Introduction

Numerous studies (1-9) have been conducted recently to develop slow-release herbicide tablets, for container-grown nursery stock, that provide long lasting, wide spectrum weed control without phytotoxicity. Slow-release herbicides provide greater safety to the applicator, reduced volume of herbicides in the environment and more precise application.

Research in 1990 (7) indicated that the most effective herbicide tablets were larger (2.25 grams), softer (6.5 psi) and included twice as much surfactant (2 percent) as previous studies. These same criteria were utilized in the tablets in this study in order to increase the area of weed control within the container.

In the 1990 study, seven species of herbaceous plants were evaluated for phytotoxicity with slow-release herbicide tablets. All treated plants were found to be completely tolerant after 10 weeks of treatment.

The objectives of this evaluation were to continue to evaluate the weed control performance of the larger, softer tablet and to evaluate the tolerance of 38 herbaceous perennials.

## Materials and Methods

Herbicide tablets were blended with oxyfluorfen at 0.5 lbs. active ingredient per acre (aia) and metholachlor at 2.0 lbs. (aia). Triton X-100 was combined at 2 percent of the total volume. The pressure during the dry compression was 6.5 psi which is less than the 8.0—8.5 psi of previous studies. The herbicides and surfactant were combined with dicalcium phosphate and magnesium stearate and compressed with a Stokes single punch tablet machine. Finished tablets weighed an average of 2.2 grams compared to 1.25—1.75 in previous studies.

The plants were grown in two-gallon containers and treated with 0, 2 and 3 tablets/container. The larger and softer tablets represent one or two fewer tablets/container than previously utilized.

Thirty-eight species and cultivars of herbaceous perennials were evaluated.

There were three treatments, three plants/treatment and three replications for a total of 27 plants/species and 38 species for a grand total of 756 plants in the study.

Plants were produced in The Ohio State University container nursery randomized in a complete block design and maintained as for commercial nursery practices.

## Results and Discussion

Weed control after 10 weeks averaged for all 38 species and cultivars as follows:

| | | |
|---|---|---|
| 0 | tablets | 8.1 |
| 2 | tablets | 9.7 |
| 3 | tablets | 9.7 |

The values were based on a 10-point visual scale with 10=complete weed control, 7=acceptable weed control and 1=no control. In general, weed control was most satisfactory and indicates that acceptable control will last more than 2 months. Equally important, the additional one tablet per container does not enhance weed control.

Weeds controlled in this study included bittercress, crabgrass, chickweed, groundsel, oxalis, and wild lettuce.

Thirty of the 38 species and cultuivars of herbaceous perennials were completely tolerant on all sampling dates as indicated in table 1. Neither metolachlor or oxyfluorfen as commercial herbicide formulations are labelled for herbaceous plants, but combined into a slow-release tablet the expected phytotoxicity was not evident on these species.

Eight species and cultivars were injured to some degree, but only two, *Carex niger* and *Veronica incana* were injured beyond an acceptable commercial level. Among the eight perennials that were injured, four were ornamental grasses and sedges including *Carex grayii*, *Carex niger*, *Festuca ovina* and *Phalaris* 'Picta'. In each case, with the grasses and sedges, the injury was expressed as a reduction in vegetative growth with no indication of foliage injury. Injury to *Echinacea* 'Bright Star', Geum 'Mrs Bradshaw', *Iris* 'Caesars Brother', and *Veronica* incana was also primarily in the form of growth reduction.

In the 1990 study, *Achillea* 'Moonshine' *Artemisia* 'Silver Mound', *Aster* frikarti, *Coreopsis* 'Baby Sun', *Hosta* 'Antioch' and *Rudbeckia* 'Goldsturm' were not injured with the same tablet formulation. Basically, these same species and cultivars were completely tolerant for 10 weeks during 1991 as well. These results are encouraging because they represent some of the major groups of herbaceous perennials.

Table 1. Weed Control and Phytotoxicity of Slow-Release Herbicide Tablets on Herbaceous Perennials.

| Plant Materials | No. Tablets/ Container | Weed Control[1] 8/30 | Phytotoxicity[2] 7/26 | 8/16 | 8/30 |
|---|---|---|---|---|---|
| Achillea | 0 | 8.0 | 10.0 | 10.0 | 10.0 |
| 'Moonshine' | 2 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.7 | 10.0 | 10.0 | 10.0 |
| Achillea | 0 | 8.0 | 10.0 | 10.0 | 10.0 |
| 'Red Beauty' | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Artemisia | 0 | 10.0 | 10.0 | 10.0 | 10.0 |
| 'Silver Mound' | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Artemisia | 0 | 6.7 | 10.0 | 10.0 | 10.0 |
| stelleriana | 2 | 9.3 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.3 | 10.0 | 10.0 | 10.0 |
| Aster | 0 | 7.3 | 10.0 | 10.0 | 10.0 |
| frikarti | 2 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.0 | 10.0 | 10.0 | 10.0 |
| Campanula | 0 | 10.0 | 10.0 | 10.0 | 10.0 |
| carpatica | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Campanula | 0 | 8.3 | 10.0 | 10.0 | 10.0 |
| superba | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.3 | 10.0 | 10.0 | 10.0 |
| Carex | 0 | 6.0 | 10.0 | 10.0 | 10.0 |
| niger | 2 | 9.0 | 5.3 | 4.7 | 5.7 |
| | 3 | 8.3 | 4.7 | 4.7 | 5.3 |
| Carex | 0 | 6.3 | 10.0 | 10.0 | 10.0 |
| grayii | 2 | 8.3 | 7.3 | 7.0 | 8.3 |
| | 3 | 9.7 | 8.0 | 8.0 | 7.0 |
| Chrysanthemum | 0 | 9.0 | 10.0 | 10.0 | 10.0 |
| pacificum | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Chrysanthemum | 0 | 7.7 | 10.0 | 10.0 | 10.0 |
| 'Little Silver Princess' | 2 | 8.7 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Clematis | 0 | 6.7 | 10.0 | 10.0 | 10.0 |
| 'Ernest Markham' | 2 | 9.3 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.3 | 10.0 | 10.0 | 10.0 |
| Coreopsis | 0 | 8.0 | 10.0 | 10.0 | 10.0 |
| 'Baby Sun' | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Coreopsis | 0 | 8.7 | 10.0 | 10.0 | 10.0 |
| rosea | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.7 | 10.0 | 10.0 | 10.0 |

[1]Weed control values based on a visual scale with 10=100% control of all weed species, 7=acceptable weed control and 1=no control.
[2]Phytotoxicity values based on a visual scale with 10=no foliage injury, 7=acceptable plant injury and 1=plant death.

(continued)

Table 1. **Weed Control and Phytotoxicity of Slow-Release Herbicide Tablets on Herbaceous Perennials (continued).**

| Plant Materials | No. Tablets/ Container | Weed Control[1] 8/30 | Phytotoxicity[2] 7/26 | 8/16 | 8/30 |
|---|---|---|---|---|---|
| Echinacea 'Bright Star' | 0 | 5.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 8.7 | 9.7 | 9.7 | 9.0 |
| | 3 | 10.0 | 9.7 | 8.7 | 9.3 |
| Festuca ovina | 0 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.7 | 9.0 | 7.3 | 8.0 |
| | 3 | 9.7 | 9.3 | 7.3 | 7.0 |
| Gaillardia 'Baby Cole' | 0 | 8.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Geum 'Mrs. Bradshaw' | 0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 9.3 | 9.3 | 9.7 |
| | 3 | 10.0 | 9.0 | 9.7 | 9.0 |
| Gypsophila 'Perfecta' | 0 | 9.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Hemerocallis 'Magnificence' | 0 | 8.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Hosta 'Albo-marginata' | 0 | 9.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Hypericum calycinum | 0 | 9.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Iris 'Caesar's Brother' | 0 | 7.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.0 | 10.0 | 9.7 | 9.7 |
| | 3 | 10.0 | 10.0 | 9.7 | 9.0 |
| Lobelia cardinalis | 0 | 7.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Lobelia syphilitica | 0 | 9.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Monarda 'Cambridge Scarlet' | 0 | 7.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.7 | 10.0 | 10.0 | 10.0 |
| Panicum 'Haeuse Herms' | 0 | 8.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.3 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Pennisetum alopecuroides | 0 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |

[1]Weed control values based on a visual scale with 10=100% control of all weed species, 7=acceptable weed control and 1=no control.
[2]Phytotoxicity values based on a visual scale with 10=no foliage injury, 7=acceptable plant injury and 1=plant death.

(continued)

Table 1. Weed Control and Phytotoxicity of Slow-Release Herbacide Tablets on Herbaceous Perennials (continued).

| Plant Materials | No. Tablets/ Container | Weed Control[1] 8/30 | Phytotoxicity[2] 7/26 | 8/16 | 8/30 |
|---|---|---|---|---|---|
| Phalaris 'Picta' | 0 | 8.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 9.0 | 9.0 | 9.3 |
| | 3 | 10.0 | 9.0 | 9.0 | 8.7 |
| Phlox paniculata | 0 | 8.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.3 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Phlox stolonifera | 0 | 6.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.7 | 10.0 | 10.0 | 10.0 |
| Rudbeckia 'Goldsturm' | 0 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Sedum 'Autumn Joy' | 0 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Stachys byzantina | 0 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Veronica 'Crater Lake' | 0 | 8.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 3 | 10.0 | 10.0 | 10.0 | 10.0 |
| Veronica incana | 0 | 5.0 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.3 | 5.3 | 4.0 | 4.7 |
| | 3 | 6.7 | 5.3 | 4.3 | 4.3 |
| Thymus mentha | 0 | 8.7 | 10.0 | 10.0 | 10.0 |
| | 2 | 9.7 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.3 | 10.0 | 10.0 | 10.0 |
| Tricyrtis hirra | 0 | 7.3 | 10.0 | 10.0 | 10.0 |
| | 2 | 10.0 | 10.0 | 10.0 | 10.0 |
| | 3 | 9.7 | 10.0 | 10.0 | 10.0 |

[1]Weed control values based on a visual scale with 10=100% control of all weed species, 7=acceptable weed control and 1=no control.
[2]Phytotoxicity values based on a visual scale with 10=no foliage injury, 7=acceptable plant injury and 1=plant death.

The slow-release herbicide tablets are not yet commercially available. However, based on studies in 1990 and 1991 it appears that herbaceous perennials exhibit a fair degree of tolerance. More extensive trials are warranted.

## Summary

The objectives of this experiment were to evaluate weed control and phytotoxicity on 38 species of herbaceous perennials with slow-release herbicide tablets containing metolachlor, oxyfluorfen and triton X-100.

Weed control was acceptable in all treatments for 10 weeks. There were no phytotoxicity symptoms on 30 species, slight phytotoxicity on six species and severe injury on two species.

The potential for using these slow-release herbicide tablets on container-grown herbaceous perennials with good weed control and limited injury is encouraging.

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# An Evaluation of Stakeout, a Pre-Emergence Herbicide for Container-Grown Nursery Stock

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## Abstract

Stakeout, a new pre-emergence herbicide for nursery stock from the Monsanto Company is effective in controlling weeds for more than three months. Weeds controlled included lesser bittercress and oxalis both very troublesome species in container nurseries. This new product was completely non-phytotoxic to container-grown *Euonymus fortunei* 'Emerald N Gold', *Rhododendron* 'Elsie Lee' and Weigela 'Newport Red' at 1.0, 1.5 and 2.0 lbs. per acre.

## Introduction

A new pre-emergent herbicide for the nursery industry is under development by the Monsanto Chemical Company. A need exists for a product which yields season-long control, of a broad spectrum of weeds with little or no phytotoxicity to the desired crop (1). In previous unpublished work by the authors, Stakeout controlled weeds for 12 weeks with no phytotoxicity to the test species.

The objectives of this study were to compare weed control and phytotoxicity of Stakeout in comparison to similar pre-emergence herbicides on container-grown woody landscape crops.

## Materials and Methods

The plant materials used in this study were *Weigela* 'Newport Red', *Euonymus* 'Emerald' N Gold', and *Rhododendron* 'Elsie Lee'. The plants were potted and treated on May 1, 1991. The one-gallon containers were filled with a medium of pine bark, peat moss and sand in a ratio of (6:3:1) by volume.

The herbicides consisted of Stakeout at rates of 1.0, 1.5, and 2.0 lbs per acre, Snapshot at 3.75, Ronstar 4.0 and OH 2 at 3.0 lbs aia. Granular herbicides were applied with a hand-held spreader and liquids with a pressure type tank sprayer.

Data, expressed on a visual scale with 100 best, 70 acceptable and 10 dead, were collected at 30 (5/31/91), 60 (7/2/91), 90 (8/1/91) and 120 (8/31/91) days. Most herbicide treatments were no longer effective at the last evaluation date and the study was terminated at 120 days.

The study was conducted in the container research nursery on the campus of The Ohio State University. All plants were produced as for commercial nursery practices.

There were three treatments, three plants per species/treatment and three replications for at total of 27 plants/species. The plants were randomized in a complete block design.

## Results and Discussion

In a previous unpublished study there was no phytotoxicity from Stakeout and this year there was no visible injury to Weigela, Euonymus or Azalea at any time during the study. Since there was no injury there is no table to indicate that fact.

The weed control data is shown in Table 1. The most effective treatment was Stakeout at 2.0 lbs aia. However, four additional treatments yielded acceptable weed control for more than three months, including Stakeout at 1.0 and 1.5 lbs aia, Ronstar at 4.0 lbs aia and OH 2 at 3.0 lbs aia.

No single treatment effectively controlled weeds for 120 days from treatment date.

Weeds controlled by Stakeout in this study included: annual grasses, common groundsel, lesser bittercress (although it became a problem after 90 days), oxalis and wild lettuce.

When Stakeout becomes labeled for the nursery industry, growers are urged to give this product a fair trial because in our limited studies it does a reasonable job of controlling weeds and is non-phytotoxic to a number of woody landscape crops.

## Literature Cited

Smith, Elton M. 1991. Chemical weed control in commercial nursery and landscape plantings. MM-297 OCES and The Ohio State University 24 pgs.

**Table 1. Weed Control in Container-Grown Woody Crops from Stakeout, a New Pre-Emergence Herbicide.**

| | | % Weed Control | | | |
|---|---|---|---|---|---|
| Treatment | Rate aia | 30 Days | 60 Days | 90 Days | 120 Days |
| Stakeout | 1.0 lbs | 97 | 97 | 83 | 50 |
| Stakeout | 1.5 lbs | 97 | 87 | 77 | 53 |
| Stakeout | 2.0 lbs | 100 | 100 | 90 | 60 |
| Snapshot | 3.75 lbs | 80 | 63 | 50 | 33 |
| Ronstar | 4.0 lbs | 97 | 90 | 77 | 47 |
| OH 2 | 3.0 lbs | 97 | 93 | 80 | 60 |
| Control | — | 80 | 67 | 50 | 23 |

Weed control values based on a visual scale with 100=best control, 70=acceptable control and 10=no control.

# Evaluation of Flowering Crabapple Susceptibility to Apple Scab in Ohio—1991

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## Abstract

The 1991 growing season began with more than ample rainfall during April and early May and apple scab was a problem early in the season. From the middle of May throughout the remainder of the summer, rainfall was below normal throughout the state and apple scab did not become nearly as serious as in 1990 and 1989. In a survey of Ohio arboretums, 113 selections of flowering crabapple were found to be resistant or highly resistant while only 69 selections were susceptible or highly susceptible. This compares to 91 resistant and 100 susceptible selections in 1990.

## Introduction

*Venturia inequalis*—apple scab is a fungus disease which infects *Malus* species and cultivars. The disease is first manifested by olive gray spots on the foliage followed by yellowing and defoliation of susceptible selections of flowering crabapple. Continued defoliation will most likely weaken trees, reduce bloom in succeeding years and contribute towards greater winter injury.

Apple scab can be reduced or eliminated by planting resistant selections. The disease can be controlled by fungicides but this is a continual process requiring application every two weeks from late April until autumn.

This study evaluated flowering crabapples in Ohio arboretums for tolerance to apple scab. A statewide evaluation is valuable because it allows growers, retailers and landscapers to know which selections have proven to be resistant and which are susceptible to this disease of flowering crabapple in Ohio.

## Materials and Methods

In August 1991, a survey of flowering crabapples was conducted in Ohio arboretums. Apple scab severity was rated and the presence of other diseases such as fireblight, cedar apple rust and frog eye leaf spot were also noted. Since the severity of the latter three diseases are usually not serious enough in Ohio to discontinue planting, ratings were not given.

The infestation of apple scab was rated as follows: HR=highly resistant—no indication of disease; R=resistant—mild infection with no defoliation; S=susceptible— medium infection with only slight defoliation; HS=highly susceptible—heavy infection often accompanied by considerable defoliation of 25 percent or more.

More than one rating may appear in Table 1 for a given selection as severity of infection varied among locations. The variation was most likely due to differences in time and amount of rainfall as well as average relative humidity.

## Results and Discussion

Variability in apple scab exists from year to year based on previous observations by the authors (2, 3, 4 and 5). Rainfall between mid-May and August was well below normal in 1991.

In the survey there were 113 selections rated highly resistant or resistant while 69 were susceptible or highly susceptible. Comparing other seasons there were 94 selections resistant and 100 susceptible in 1990 (4). In 1988, the most recent dry spring and summer, there were 89 selections resistant and 82 susceptible (4).

In 1991, among the most disease resistant selections to apple scab, fireblight, cedar apple rust and frog eye leaf spot were: *Malus* baccata cultivars, 'Beverly', 'Bob White', 'Centennial', 'Christmas Holly', 'David', 'Dolgo', *floribunda*, 'Golden Hornet', 'Golden Gem', M. halliana Parkmanii 'Liset', 'Makamik', 'Mary Potter',*micromalus*, 'Ormiston Roy', 'Prairiefire', *prunifolia* 'Pendula', 'Red Jade', 'Red Jewel', *robusta* selections, *sargenti*, 'Selkirk', 'Sentinel', sieboldi 'Fuji' 'Strawberry Parfait', 'Sugartyme', *tschonoksi*, 'White Angel', *yunnanensis* selections and *zumi* 'Calocarpa'.

Flowering crabapples rated highly susceptible to apple scab in 1991 were: 'Almey', 'Amisk', *arnoldiana*, 'Arrow', 'Barbara Ann', 'Dorothea', 'Evelyn', 'Flame' 'Dupont Henry', 'Hopa', 'Katherine', 'Pink Weeper', 'Purple Wave', 'Eleyi', 'Radiant', 'Red Silver', and 'Tanner'. Due to the severity of apple scab in this and previous years (2, 3, 4, and 5) these selections should be discontinued from planting in Ohio.

To obtain information relative to cultural requirements and descriptions of recommended flowering crabapples consult the publication titled, "The Flowering Crabapple—A Tree For All Seasons" (1) available from county Extension Service offices. Additional information can be obtained by visiting one of several arboretums in Ohio in late April —early May. Outstanding collections of flowering crabapples are located in the Dawes Arboretum in Newark, Holden Arboretum in Kirkland Hills, the Secrest Arboretum in Wooster, and in other Ohio arboretums.

Table 1. Susceptibility of Flowering Crabapples to Apple Scab—1991.

| Species, Hybrid or Cultivar | Apple Scab Rating HR | R | S | HS | Other Diseases Noted |
|---|---|---|---|---|---|
| 'Adams' | | X | X | | |
| 'Almey' | | | | X | |
| 'Amberina' | | | X | | |
| 'Amisk' | | | | X | |
| 'American Beauty' | | | | X | |
| 'Anne E' | X | | | | |
| 'Arnold Arboretum' | X | | | | |
| M. x arnoldiana | | | | X | |
| 'Arrow' | | | | X | |
| 'Autumn Glory' | X | | | | |
| M. baccata | X | | | | |
| M. baccata 'Ceratocarpa' | | | | X | Fireblight |
| M. baccata columnaris | X | | | | |
| M. baccata 'Jacki' | X | | | | |
| M. baccata 'Mandshurica' | X | | | | |
| M. baccata 'Midwest' | X | | | | |
| M. baccata 'Walters' | X | | | | |
| 'Beverly' | X | | | | |
| 'Blanche Ames' | X | | | | |
| 'Bob White' | X | | | | |
| 'Brandywine' | X | | | | |
| M. brevipes | | | | X | |
| 'Burgundy' | | X | | | |
| 'Canary' | | X | | | |
| 'Candied Apple' | | | X | | |
| 'Centennial' | X | | | | |
| 'Centurion' | | | | X | |
| 'Cheal's Crimson' | | | | X | |
| 'Chestnut' | X | | | | |
| 'Chilko' | X | | | | |
| 'Christmas Cheer' | X | | | | |
| 'Christmas Holly' | X | | | | Fireblight |
| 'Coralburst' | X | | | | |
| M. coronaria 'Nieuwlandiana' | | | X | | |
| 'Cowichan' | | | X | | |
| 'Crimson Brilliant' | | | | X | |
| 'Dainty' | | X | X | | |
| 'David' | X | X | | | |
| 'Dawsoniana' | | X | X | | |
| 'Dolgo' | X | | | | |
| 'Donald Wyman' | | X | | | |
| 'Dorothea' | | | | X | |
| 'Dorothy Rowe' | X | | | | |
| 'Edna Mullins' | X | | | | |
| 'Ellen Gerhart' | | | X | X | |
| 'Evelyn' | | | | X | |
| 'Exzellenz Thiel' | | | | X | |
| 'Flame' | | | | X | |
| 'Flexilis' | X | | | | |
| M. floribunda | X | | | | |
| 'Fusca' | X | | | | |

HR=Highly Resistant, R=Resistant, S=Susceptible and HS=Highly Susceptible. (continued)

**Table 1. Susceptibility of Flowering Crabapples to Apple Scab—1991 (continued).**

| Species, Hybrid or Cultivar | Apple Scab Rating HR | R | S | HS | Other Diseases Noted |
|---|---|---|---|---|---|
| 'Girard's Dwarf Weeping' | X | | | | |
| 'Geneva' | X | | | | |
| 'Goldfinch' | X | | | | |
| M. glaucescens | | X | | | |
| M. gloriosa | | | | X | |
| 'Golden Gem' | X | | | | |
| 'Golden Hornet' | X | | | | |
| 'Gorgeous' | X | | | | |
| 'Gwendolyn | X | | | | |
| M. halliana | X | | | | |
| M. halliana 'Parkmanii' | X | | | | |
| 'Harvest Gold' | | | X | X | Fireblight |
| 'Henningi' | | | X | X | |
| 'Henrietta Crosby' | | | | X | |
| 'Henry Dupont' | | | X | | |
| 'Hopa' | | | | X | |
| 'Hopa Austrian' | | X | X | | |
| 'Hopa Rosea' | | | X | | |
| M. hupehensis | X | X | | | Fireblight |
| 'Indian Magic' | | | | X | |
| 'Indian Summer' | | X | | | |
| M. ioensis | | X | X | | |
| M. ioensis 'Palmeri' | X | | | | |
| 'Irene' | | | | X | |
| 'Klehms Improved' | X | | | | |
| 'Jay Darling' | | | | X | |
| 'Joan' | X | | | | |
| 'Jewelberry' | | | X | | |
| 'Katherine' | | | X | | |
| 'Kirghisorum' | X | | | | |
| M. 'Lancifolia' | X | X | | | |
| 'Leslie' | X | | | | |
| 'Liset' | X | | | | |
| 'Madonna' | | X | | | |
| M. x magdeburgensis | X | | | | |
| 'Makamik' | X | | | | |
| 'Marshall Oyama' | X | | | | |
| 'Mary Potter' | X | | | | |
| 'Masek' | | | | X | |
| M. x micromalus | X | | | | |
| 'Milton Barron' | X | | | | |
| 'Molton Lava' | X | | | | |
| 'Neville Copeman' | | | | X | |
| 'Oakes' | X | | | | |
| 'Oekonomierat Echtermeyer' | | | | X | |
| 'Oporto' | | | | X | |
| 'Ormiston Roy' | X | | | | |
| 'Park Centre' | X | | | | |
| 'Patricia' | | | | X | |

HR=Highly Resistant, R=Resistant, S=Susceptible and HS=Highly Susceptible.

(continued)

Table 1. Susceptibility of Flowering Crabapples to Apple Scab—1991 (continued).

| Species, Hybrid or Cultivar | Apple Scab Rating HR | R | S | HS | Other Diseases Noted |
|---|---|---|---|---|---|
| 'Pink Beauty' | X | | | | |
| 'Pink Cascade' | | | X | X | |
| 'Pink Dawn' | X | | | | |
| 'Pink Perfection' | X | | | | |
| 'Pink Satin' | | X | X | | |
| 'Pink Weeper' | | | X | | |
| 'Prairie Rose' | X | | | | |
| 'Prairiefire' | X | | | | |
| Prince Georges' | X | | | | |
| 'Profusion' | | X | X | | |
| 'Prof. Sprenger' | X | | | | |
| M. prunifolia | | | | X | |
| M. prunifolia 'Fastigiata' | X | | | | |
| M. prunifolia 'Pendula' | X | | | | |
| M. pumila 'Elise Rathke' | | X | | | |
| M. pumila 'Niedzwetzkyana' | | | | X | |
| M. pumila 'Paradise Foleus Aureus' | X | | | | |
| 'Purple Wave' | | | | X | |
| M. purpurea | | | | X | |
| M. purpurea 'Aldenhamensis' | | | X | | |
| M. purpurea 'Eleyi' | | | | X | |
| M. purpurea 'Lemoinei' | | | X | X | |
| M. Pygmy | | X | | | |
| 'Radiant' | | | | X | |
| 'Ralph Shay' | | X | | | |
| 'Red Baron' | | X | X | | |
| 'Red Edinburgh' | | | | X | |
| 'Red Flesh' | | | X | | |
| 'Red Jade' | X | X | | | |
| 'Red Jewel' | X | | | | |
| 'Red Swan' | X | | | | |
| Red Silver' | | | | X | |
| 'Red Splendor' | X | | | | |
| 'Ringo' | | X | | | |
| 'Robinson' | | X | X | | |
| M. x robusta | X | | | | |
| M. x robusta 'Erecta' | | X | | | |
| M. x robusta 'Leucocarpa' | | | | X | |
| M. x robusta 'Persicifolia' | X | | | | |
| 'Rosseau' | X | | | | |
| 'Royal Ruby' | | | X | | |
| 'Royalty' | | | X | X | |
| 'Ruby Luster' | | | | X | |
| M. sargentii | X | | | | |
| M. sargentii 'Candymint' | | X | X | | |
| M. sargentii 'Rosea' | X | | | | |
| M. sargentii 'Rose Low' | X | | | | |
| M. x scheideckeri | | | | X | |
| M. x scheideckeri 'Hilleri' | | | X | X | |

HR=Highly Resistant, R=Resistant, S=Susceptible and HS=Highly Susceptible.

(continued)

**Table 1. Susceptibility of Flowering Crabapples to Apple Scab—1991 (continued).**

| Species, Hybrid or Cultivar | Apple Scab Rating HR | R | S | HS | Other Diseases Noted |
|---|---|---|---|---|---|
| 'Scugog' | X | | | | |
| 'Selkirk' | X | | | | |
| 'Sentinel' | X | | | | |
| 'Shakespeare' | | | | X | |
| M. sieboldi | X | | | | |
| M. sieboldi 'Arborescens' | X | | | | |
| M. sieboldi 'Fuji' | X | | | | |
| M. sikkimensis | X | | | | |
| 'Silver Moon' | X | | | | Fireblight |
| 'Simcoe' | | | X | | |
| 'Sinai Fire' | X | | | | |
| 'Sissipuk' | X | | | | |
| 'Snowcloud' | | X | X | | |
| 'Snowdrift' | | | X | X | |
| 'Snowmagic' | | X | X | | |
| M. x soulardii | X | X | | | |
| 'Sparkler' | | X | X | | |
| M. spectabilis | | X | X | | |
| M. spectabilis 'Albi-Plena' | | X | | | |
| M. spectabilis 'Riversii' | X | | | | |
| M. spectabilis 'Van Eseltine' | X | X | | | |
| 'Spring Snow' | | X | | | |
| 'Spring Song' | X | | | | |
| 'Strathmore' | | | | X | |
| 'Strawberry Parfait' | X | | | | |
| M. x sublobata | X | | | | |
| 'Sugartyme' | X | | | | |
| 'Sundog' | X | | | | |
| M. sylvestris 'Plena' | X | | | | |
| 'Tanner' | | | | X | |
| M. toringoides | | X | X | | Fireblight |
| M. toringoides 'Macrocarpa' | | | X | X | |
| 'Trail' | X | | | | |
| M. tschonoski | X | | | | |
| 'Turesi' | | | | X | |
| 'Valley City #4' | | | X | | |
| 'Vanguard' | | | | X | |
| 'Velvet Pillar' | | | X | X | |
| 'Wabiskaw' | | | | X | |
| 'White Angel' | X | | | | |
| 'White Candle' | | | X | | Fireblight |
| 'White Cascade' | | | X | X | |
| 'Wilson' | X | | | | |
| 'Winter Gem' | X | | | | |
| 'Winter Gold' | | | X | X | Fireblight |
| 'Wooster No. 1' | X | | | | |
| M. yunnanensis 'Veitchi' | X | | | | Fireblight |
| M. zumi | | X | X | | |
| M. zumi 'Calocarpa' | X | | | | |
| 'Zumarans' | X | | | | |

HR=Highly Resistant, R=Resistant, S=Susceptible and HS=Highly Susceptible.

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# An Evaluation of Pre- and Post-Emergence Herbicides on Herbaceous Perennials

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## Abstract

This study evaluated weed control and phytotoxicity of pre- and post-emergence herbicides on container-grown herbaceous perennials.

All herbicides effectively controlled weeds for 12 weeks. Pennant E. C. was safe on all but Rudbeckia. Pennant G was relatively safe on all crops with slight injury on Stachys. Surflan injured three of eight species including Geum, Stachys and Veronica.

Fusilade slightly injured Gypsophila, while Poast slightly injured Gypsophila and Stachys.

## Introduction

Only a limited number of pre-emergence herbicides are labelled for use with herbaceous perennials and none control nutsedge, a problem species throughout most of North America. Poast and Fusilade, post-emergence herbicides, are registered for use over-the-top on a fair but not extensive range of perennial species. The perennial nursery industry would like to reach a point in production where pre-emergence herbicides can be applied prior to or immediately after planting with a follow-up program as needed, of post-emergence herbicides similar to the program used by producers of woody landscape species.

The biggest obstacle to that procedure has been the grower concern of phytotoxicity to herbaceous plants from both pre- or post-emergence herbicides (2).

This study evaluated weed control and phytotoxicity on container-grown herbaceous perennials from both pre- and post-emergence herbicides.

## Materials and Methods

Two pre-emergence herbicides were applied to the containers in this study. Surflan (oryzalin) is currently labelled for only six or seven species of herbaceous perennials and Pennant (metolachlor) is not labelled for herbaceous perennials (1).

The post-emergence herbicides applied over-the-top to control grasses only, included Poast (sethoxydim) and Fusilade (fluazifop butyl). The pre-emergence herbicides were applied to weed-free containers on April 30 and the post-emergence herbicides were sprayed on the same date.

The herbicide rates were as follows:

| Pre-emergence | Post-emergence |
|---|---|
| Pennant EC 4.0 aia | |
| Pennant EC 8.0 aia | Fusilade 0.375 aia |
| Pennant G 4.0 aia | Fusilade 0.75 aia |
| Pennant G 8.0 aia | Poast 0.50 aia |
| Surflan A.S. 2.0 aia | Poast 1.0 aia |
| Surflan A.S. 4.0 aia | |

**The herbaceous perennials included:**

Achillea 'Moonshine'
Campanula carpatica
Coreopsis 'Baby Sun'
Geum 'Mrs. Bradshaw'
Gypsophila 'Perfecta'
Rudbeckia 'Goldsturm'
Stachys byzantina
Veronica 'Crater Lake'

The plant materials were produced in two-gallon containers in a mix of pine bark, peat moss, and sand (6:3:1 by volume) with 5.0 lbs of lime/cu yd. The plants were placed in containers April 20, 1991, fertilized with slow-release fertilizer and maintained under commercial practices.

Plants were located in a randomized block design with three plants/treatment, and four replications with a total of 1,056 total perennials in the study.

Evaluations were conducted every two weeks using a visual scale of 1-10 with 10- best, 7- acceptable, and 1- worst for both weed control and phytotoxicity.

## Results and Discussion

Weed control after six and 12 weeks is shown in Table 1. Twelve weeks from treatment all pre-emergence herbicides were effectively controlling weeds at a high level of efficiency. The same level of grass control was observed with Poast and Fusilade.

The pre-emergence herbicides were effectively controlling annual grasses, groundsel, wild lettuce and most of the lesser bittercress.

There was some phytotoxicity associated with all herbicides as noted in Table 1.

Wettable Pennant was reasonably safe to use with all crops except Rudbeckia 'Goldstrum', which was damaged within a matter of days from treatment. Granular Pennant can be used with a reasonable degree of safety on all perennials included in this evaluation.

Surflan A.S. was injurious to three of the eight species including Geum, Stachys and Veronica. Surflan is not labelled for any of these species, therefore, injury could be expected. Neither is Surflan labelled for Achillea, Campanula, Coreopsis, Gypsophila or Rudbeckia. This indicates that additional research is warranted with these five crops to obtain labelling with Surflan.

Fusilade was generally safe as an over-the-top spray with all crops except gypsophila. The ratings considered commercially acceptable were borderline injury at both six and 12 weeks suggesting some caution with this grass-like genera.

**Table 1. Weed Control and Phytotoxicity on Herbaceous Perennials from Pre and Post Emergence Herbicides at 6 and 12 weeks.**

| Treatment | Rate | Weed Control | | Phytotoxicity: Achillea | | Campanula | | Coreopsis | | Geum | | Gypsophila | | Rudbeckia | | Stachys | | Veronica | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 12 | 6 | 12 | 6 | 12 | 6 | 12 | 6 | 12 | 6 | 12 | 6 | 12 | 6 | 12 | 6 | 12 |
| Pre-emergence | | | | | | | | | | | | | | | | | | | |
| Pennant W. | 4.0 | 10 | 9.5 | 9.5 | 9.3 | 10 | 10 | 10 | 10 | 10 | 10 | 9.3 | 9.0 | 7.3 | 8.5 | 8.5 | 9.0 | 9.3 | 9.3 |
| Pennant W. | 8.0 | 9.5 | 9.5 | 9.3 | 9.5 | 9.3 | 9.8 | 10 | 10 | 9.2 | 9.9 | 8.5 | 8.3 | 5.8 | 6.5 | 7.8 | 8.1 | 9.0 | 9.5 |
| Pennant G. | 4.0 | 10 | 9.0 | 9.8 | 9.4 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9.5 | 9.8 | 8.8 | 9.8 | 9.3 | 9.3 |
| Pennant G. | 8.0 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 8.8 | 9.0 | 8.3 | 7.5 | 8.8 | 9.0 |
| Surflan A.S. | 2.0 | 10 | 9.8 | 10 | 10 | 9.8 | 10 | 10 | 10 | 5.8 | 5.0 | 9.3 | 8.8 | 10 | 10 | 6.6 | 5.8 | 7.2 | 6.3 |
| Surflan A.S. | 4.0 | 9.8 | 9.8 | 9.8 | 9.8 | 9.5 | 10 | 10 | 10 | 5.5 | 4.5 | 9.5 | 8.8 | 8.8 | 8.8 | 5.8 | 4.3 | 6.0 | 5.3 |
| Post-emergence | | | | | | | | | | | | | | | | | | | |
| Fusilade | .375 | 10 | 9.8 | 10 | 10 | 10 | 10 | 10 | 10 | 8.8 | 9.0 | 7.8 | 7.5 | 10 | 10 | 9.5 | 8.5 | 9.3 | 9.5 |
| Fusilade | .75 | 10 | 9.8 | 10 | 10 | 10 | 10 | 10 | 10 | 9.7 | 9.8 | 7.3 | 7.8 | 10 | 10 | 9.3 | 8.7 | 9.8 | 10 |
| Poast | .50 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9.0 | 8.8 | 10 | 10 | 9.3 | 8.8 | 9.3 | 9.0 |
| Poast | 1.00 | 9.8 | 9.5 | 10 | 10 | 9.8 | 9.6 | 10 | 10 | 9.6 | 9.6 | 8.0 | 1.0 | 10 | 10 | 9.4 | 8.0 | 9.5 | 9.3 |
| CHECK | — | 9.0 | 7.3 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9.0 | 10 | 10 | 10 | 10 | 9.6 | 9.3 |

Values based on a visual scale with 10=best, 7=acceptable and 1=worst.

Poast was also found relatively safe as an over-the-top treatment with only two exceptions, Gypsophila and Stachys.

More research is definitely needed with herbicides on container-grown herbaceous perennials. However, results from the study and previous work by the authors would indicate a degree of safety with a number of species.

## Summary

All pre- and post-emergence herbicides effectively controlled weeds for the 12 weeks of the experiment.

Achillea, Campanula, and Coreopsis were tolerant of the five herbicides at the X and 2X rates. Geum was tolerant to all but Surflan, Gypsorphila was tolerant to all pre-emergence herbicides, Rudbeckia was tolerant to all but Surflan, and Veronica was tolerant to all but Surflan. Therefore, selection of herbicides for use with herbaceous perennials must be on a crop-by-crop basis.

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# An Evaluation of Water Stress Tolerance of 37 Flowering and Foliage Pot Plants

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## Introduction

The increased popularity of foliage and flowering plants has led to the introduction of many new species of potted plants in interior landscapes. Much of what we know about the culture and maintenance of these plants has been derived through trial and error. Research to provide accurate, specific information relating to the culture, care and handling of potted plants is limited.

Maintenance of interior foliage plants is more than just watering plants. Knowledge of the plant material, interior environmental conditions, and the proper use of tools and equipment are necessary to maintain plant health and longevity. Watering plants is just one of the tasks that must be performed on a routine basis. When stress is induced on the plant as the result of inadequate watering practices, the result can be a decline in plant and flower quality.

Water lost from a plant, or transpiration, is the process of evaporation of water vapor from plant tissue into the surrounding air. The rate of water loss from plants is influenced by the plant's anatomy and physiology. Other factors include light, relative humidity, temperature, air movement, and availability of soil moisture (4, 7, 8, 9). Water loss from plants in interior landscape sites will also be affected by growing medium, and size and type of container used.

Information related to the impact of water stress on the quality of many flowering and foliage pot plants is extremely limited and recommendations are vague at best. "Water often enough to keep the soil evenly moist," and, "Severe dryness causes older leaves to yellow and die," are two examples of typical information found in current plant manuals.

Among the research dealing with water stress of interior plants, only three plant species have been carefully studied. This research indicates water stress can lead to leaf spotting (2) and leaf abscission (3, 11), as well as reduced growth and transpiration of tropical foliage plants (6). This information void and the serious impact of water stress upon pot plants prompted this evaluation of water stress tolerance of 37 species of flowering and foliage pot plants.

## Materials and Methods

Plants were grown in 10 cm plastic pots containing a soil:peat:perlite (1:1:1) growing medium. Constant fertilization of 200 mg/l (Peters 15-15-15) was applied at each watering during production. Adequate growing media moisture levels were maintained to avoid water stress conditions. When plants reached a commercially marketable size, 20 plants from each species were thoroughly watered with tap water and allowed to drain for two hours. Plants were randomly placed on benches in a controlled environment chamber. Conditions in the chamber were: temperature 24.5+1 C, and 40 percent $\pm$5 percent RH. Light levels of 15 $\mu$mol m$^{-2}$ s$^{-1}$ of cool white fluorescent light provided for 12 hours of light every 24 hour cycle.

The growing medium in which 10 of the 20 plants of each species were established was kept uniformly moist by daily application of tap water throughout the study and served as the control treatment. The remaining 10 plants of each species were stressed by withholding water to the point of wilting. When the condition of plants was judged to be very near the permanent wilting point (based upon preliminary work and subjective evaluations) plant water potential measurements were taken for the stressed and control plants within each species. One shoot per plant was excised and plant water potentials were quantified using a Plant Water Status Console (Model 3005, Soilmoisture Equipment Corporation) (1).

Stressed plants were then watered and monitored for four additional weeks for evaluation on the following parameters: plant quality, leaf color, leaf drop, necrosis, flower longevity, flower quality, flower drop and length of time before any adverse response due to water stress was observed. Plant quality was rated on a scale of 0 to 5 with 5 being the highest quality. The use of such a scale was modeled after work by Conover and Poole (3) and Harbough and Waters (5). Plants with quality ratings of 1.99 or less were considered intolerant to a single water stress event, those 2.00 to 2.99 as slightly tolerant, those 3.00 to 3.99 as moderately tolerant and those 4.00 to 5.0 as highly tolerant.

## Results and Discussion

There was wide variation in tolerance of water stress among species (Table 1). Seventeen species were found intolerant, 10 slightly tolerant, four moderately tolerant, and six highly tolerant.

Species judged to be intolerant of water stress (except *Chlorophytum* and *Chrysanthemum*) lost 50 percent or more of their foliage over the four-week evaluation period. *Chlorophytum* and Chrysanthemum received low ratings due to other adverse reactions such as leaf burn, necrosis and rapid floral senescence.

Those species slightly tolerant of water stress lost between 5 and 30 percent of their foliage during the four-week evaluation period. *Crassula* lost 5 percent of its foliage over the four week evaluation period, but both the foliage and the

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Table 1. Evaluation of characteristics and quality following severe water stress of 37 flowering and foliage pot plants.

| Species | Plant Water Potential (bars) | Plant Quality rated 4 wks. after Stress[1] | Comments |
|---|---|---|---|
| **HIGHLY TOLERANT** | | | |
| **Aeschynanthus marmoratus** | | | |
| Control | −1.8 | 4.8 | 0% of foliage was lost after stress. Foliage |
| Stressed | 13.0 | 4.0 | very attractive. |
| T-Test | S[2] | S | |
| **Epipremnum aureum** | | | |
| Control | −1.26 | 5.0 | 5% defoliation within 3 wks. of stress. |
| Stressed | −9.74 | 4.2 | Remaining foliage attractive. |
| T-Test | S | S | |
| **Peperomia obtusifolia** | | | |
| Control | −2.52 | 5.0 | 5% defoliation within 3 wks. of stress. Loss |
| Stressed | < −30.00 | 4.2 | of foliage not noticeable. Remaining foliage |
| T-Test | S | S | attractive as control. |
| **Plectranthus australis** | | | |
| Control | −1.0 | 4.8 | 5% defoliation within 3 wks. after stress. Loss |
| Stressed | −8.8 | 4.5 | of foliage not detrimental to attractiveness. |
| T-Test | S | S | |
| **Sansevieria trifasciata** | | | |
| Control | 0.20 | 4.8 | 5% defoliation within 4 wks. of stress. |
| Stressed | −8.4 | 4.4 | |
| T-Test | S | S | |
| **Tolmiea menziesii** | | | |
| Control | −1.10 | 5.0 | No defoliation after stress. Foliage appeared |
| Stressed | −28.00 | 4.8 | as attractive as control plants. |
| T-Test | S | NS[3] | |
| **MODERATELY TOLERANT** | | | |
| **Pellionia pulchra** | | | |
| Control | −0.61 | 5.0 | 20% defoliation within 3 wks. of stress. |
| Stressed | −10.44 | 3.5 | |
| T-Test | S | S | |
| **Philodendron oxycardium** | | | |
| Control | −0.98 | 4.8 | 5% defoliation within 4 wks. of stress. |
| Stressed | −7.60 | 3.5 | Remaining foliage attractive as contol. |
| T-Test | S | S | |
| **Leea coccinea** | | | |
| Control | −0.80 | 5.0 | 12% defoliation within 1 wk. of stress. 10% of |
| Stressed | −15.60 | 3.8 | foliage on both control and stressed plants |
| T-Test | S | S | had marginal leaf burn. |

[1] Quality rating as based on a scale of 0 to 5 (best).
[2] S=Significant T-test.
[3] NS=Non significant T-test.

(continued)

Table 1. Evaluation of characteristics and quality following severe water stress of 37 flowering and foliage pot plants (continued).

| Species | Plant Water Potential (bars) | Plant Quality rated 4 wks. after Stress[1] | Comments |
|---|---|---|---|
| **Saintpaulia 'California'** | | | |
| Control | −0.20 | 4.5 | 5% defoliation and all flowers died 4 wks. after |
| Stressed | −15.00 | 3.5 | stress. |
| T-Test | S | S | |
| **SLIGHTLY TOLERANT** | | | |
| **Aglaonema 'Silver King'** | | | |
| Control | −2.06 | 5.0 | 30% defoliation within 3 wks. of stress. |
| Stressed | −20.00 | 2.8 | Remaining foliage attractive but smaller when |
| T-Test | S | S | compared to control. |
| **Begonia 'Catalina'** | | | |
| Control | −2.46 | 5.0 | 50% defoliation within 2 wks. of stress. All |
| Stressed | −11.12 | 2.0 | flowers and buds died within 1 wk. after stress |
| T-Test | S | S | Remaining foliage attractive but smaller when compared to control. No new flowers opening 4 wks. after stress. |
| **Croton 'Aucubaefolium'** | | | |
| Control | −1.24 | 5.0 | 15% defoliation within 3 wks. of stress. |
| Stressed | −11.36 | 2.9 | Remaining foliage attractive, just smaller |
| T-test | S | S | then control. |
| **Crassula argentea** | | | |
| Control | −1.98 | 4.0 | 5% defoliation 2 wks. after stress. Foliage |
| Stressed | −11.20 | 2.5 | appeared distorted compared to control. |
| T-Test | S | S | |
| **Exacum atropurpureum 'Jill'** | | | |
| Control | −0.74 | 5.0 | All flowers and 25% of foliage died within 3 |
| Stressed | −18.28 | 2.0 | wks after stress. Marginal leaf burn was |
| T-Test | S | S | observed. |
| **Pilea cadierei** | | | |
| Control | −2.40 | 5.0 | 50% defoliation within 3 days after stress. |
| Stressed | < −30.00 | 2.0 | |
| T-Test | S | S | |
| **Fuchsia 'Swing Time'** | | | |
| Control | −1.18 | 3.9 | All flowers, buds, and 15% of foliage died 1 wk. |
| Stressed | −15.50 | 2.6 | after stress. No flower buds at end of 4 wk. |
| T-Test | S | S | evaluation period. |
| **Hedera helix 'Manda's Crested'** | | | |
| Control | −1.14 | 3.2 | 5% defoliation within 3 wks of stress. 14% of |
| Stressed | −17.16 | 2.3 | of foliage had marginal leaf burn. Foliage very |
| T-Test | S | S | unattractive. |

[1] Quality rating as based on a scale of 0 to 5 (best).
[2] S=Significant T-test.
[3] NS=Non significant T-test.

(continued)

Table 1. Evaluation of characteristics and quality following severe water stress of 37 flowering and foliage pot plants (continued).

| Species | Plant Water Potential (bars) | Plant Quality rated 4 wks. after Stress[1] | Comments |
|---|---|---|---|
| **Hemigraphis 'Exotica'** | | | |
| Control | −4.22 | 4.0 | 22% defoliation within 4 wks. of stress. All flowers died with no flower buds developing. |
| Stressed | <−25.00 | 2.8 | |
| T-Test | S | S | |
| **Hibiscus rosa-sinensis 'Scarlet'** | | | 13% of foliage and all flower buds died within 2 wks. of stress. Remaining foliage attractive. No flower buds developing at end of 4 wk. evaluation period. |
| Control | −4.92 | 4.9 | |
| Stressed | <−35.00 | 2.2 | |
| T-Test | S | S | |
| **INTOLERANT** | | | |
| **Brassaia actinophylla** | | | |
| Control | −1.80 | 5.0 | 50% defoliation within 3 wks. of stress. Remaining foliage attractive. |
| Stressed | −11.00 | 1.9 | |
| T-Test | S | S | |
| **Chlorophytum comosum picturatum** | | | |
| Control | −2.98 | 5.0 | 20% defoliation 2 wks. after stress. Remaining foliage cracked and exhibiting mid-vein and marginal leaf burn. |
| Stressed | −12.14 | 1.9 | |
| T-Test | S | S | |
| **Chamaedorea elegans** | | | |
| Control | −4.08 | 5.0 | 80% defoliation within 2 wks. of stress. |
| Stressed | <−30.00 | 1.2 | |
| T-Test | S | S | |
| **Chrysanthemum morifolium 'Bright Golden Anne'** | | | |
| Control | −2.04 | 5.0 | 30% defoliation within 3 wks. of stress. Flowers completely senesced within 4 wks. post stress whereas the control flowers did not. |
| Stressed | −22.34 | 1.9 | |
| T-Test | S | S | |
| **Cissus antarctica 'Minima'** | | | |
| Control | −3.80 | 4.8 | 20% of plants died within 2 wks. of stress. Plants smaller than control. |
| Stressed | −25.82 | 1.1 | |
| T-Test | S | S | |
| **Citrus mitis** | | | |
| Control | −1.52 | 4.0 | 50% defoliation within 2 wks. of stress. Plants smaller than control. |
| Stressed | −17.94 | 0.5 | |
| T-Test | S | S | |
| **Coleus bluemi** | | | |
| Control | −0.78 | 3.0 | 30% of plants died. Remaining plants had lost 51% of their foliage when water stress conditions were relieved. |
| Stressed | −24.30 | 1.2 | |
| T-Test | S | S | |

[1] Quality rating as based on a scale of 0 to 5 (best).
[2] S=Significant T-test.
[3] NS=Non significant T-test.

(continued)

Table 1. Evaluation of characteristics and quality following severe water stress of 37 flowering and foliage pot plants (continued).

| Species | Plant Water Potential (bars) | Plant Quality rated 4 wks. after Stress[1] | Comments |
|---|---|---|---|
| **Dieffenbachia 'Exotica'** | | | |
| Control | −0.32 | 5.0 | 10% of plants evaluated died. Remaining plants had 50% defoliation within 2 wks. of stress. |
| Stressed | < −35.00 | 1.2 | |
| T-Test | S | S | |
| **Euphorbia pulcherrima 'Brilliant Diamond'** | | | |
| Control | −2.56 | 4.7 | 50% defoliation 3 days after stress. Remaining foliage had yellow color and was unattractive. All flowers died. |
| Stressed | < −25.00 | 1.8 | |
| T-Test | S | S | |
| **Ficus benjamina** | | | |
| Control | −0.70 | 5.0 | 60% defoliation within 2 wks. of stress. |
| Stressed | −7.32 | 1.9 | |
| T-Test | S | S | |
| **Impatiens sultanii 'Pink Novette'** | | | |
| Control | −2.74 | 3.7 | 75% of foliage and all flowers and buds died within 2 wks. of stress. No flower buds were developing at end of 4 week evaluation period. |
| Stressed | −10.42 | 0.9 | |
| T-Test | S | S | |
| **Maranta leuconeura massangeana** | | | |
| Control | −1.46 | 5.0 | 55% defoliation within 2 wks. of stress. |
| Stressed | −25.42 | 0.9 | |
| T-Test | S | S | |
| **Nephrolepis exaltata bostoniensis** | | | |
| Control | −1.08 | 5.0 | 100% defoliation within 2 wks. of stress. At end of 4 wk. evaluation period, all but 3 plants had new growth. |
| Stressed | < −20.00 | 0.5 | |
| T-Test | S | S | |
| **Peperomia caperata 'Emerald Ripple'** | | | |
| Control | −0.59 | 3.6 | 50% defoliation occurred before water stress conditions were relieved. No more foliage died once water stress conditions wre releived. |
| Stressed | < −30.00 | 1.9 | |
| T-Test | S | S | |
| **Rhododendron 'Red Ruffels'** | | | |
| Control | −3.00 | 4.5 | All plants died within 3 wks. of stress. 5% defoliation occurred on control plants within 1 wk. after placed in controlled environment. |
| Stressed | −21.36 | 0 | |
| T-Test | S | S | |
| **Syngonium podophyllum atrovirens** | | | |
| Control | −2.20 | 5.0 | 75% defoliation within 4 wks. of stress. |
| Stressed | < −30.00 | 1.0 | |
| T-Test | S | S | |
| **Zebrina pendula** | | | |
| Control | −1.38 | 5.0 | 70% defoliation occurred before water stress conditions were releived. No defoliation after stress. |
| Stressed | −10.00 | 1.1 | |
| T-Test | S | S | |

[1] Quality rating as based on a scale of 0 to 5 (best).
[2] S=Significant T-test.
[3] NS=Non significant T-test.

plant shapes were distorted and were lower quality than the control plants. *Hedera*, considered slightly tolerant, lost 5 percent of its foliage but the remaining foliage had extensive marginal leaf necrosis. The flowers on stressed *Begonia, Exacum, Fuchsia, Hemigraphis,* and *Hibiscus* plants senesced and abscised. All control plants retained most of their flowers which gradually senesced during the evaluation period. There was continued development of new flowers on some species.

Species judged to be moderately tolerant of a severe water deficit lost between 5 and 20 percent of their foliage during the evaluation period. *Leea* was considered moderately tolerant because 12 percent of its foliage was lost and the remaining foliage displayed a slight marginal leaf burn. *Saintpaulia* lost only 5 percent of its foliage but all flowers and flower buds abscised within one week, whereas *Saintpaulia* control plants bloomed continuously.

Species found highly tolerant of water stress lost between 0 and 5 percent of their foliage during the evaluation period. Among all species stressed and evaluated, *Tolmiea* had the highest plant quality rating at the end of the evaluation period. It was rated 4.8, as compared to its control plant rated 5.0. All other species in the highly tolerant group had quality ratings of 4.0 or higher.

This study provides specific, detailed information about the tolerance of interior plants exposed to a single, severe incidence of water stress. It is evident that stress is a primary factor triggering leaf and flower abscission which supports Peterson, Sacalis and Durkin (11) that water stress causes extensive defoliation for *Ficus benjamina*. This current study demonstrates the water stress/leaf abscission relationship in many other species. It additionally demonstrates a relationship between water stress and rapid flower bud senescence and abscission for some flowering potted plants.

It is clear that water stress at any stage in the growth and maintenance of interior foliage plants can have long-term effects on the quality and longevity of the plant. These results suggest that a single maintenance program for interior plants may not adequately meet the water needs of many plants currently being used or being considered for use as permanent plantings and flowering plant rotational displays. Reduced plant quality because of water stress can lead to higher replacement costs and dissatisfaction of clients.

Plants used in interior plantscapes are usually chosen on the basis of their light requirements and the available light in the installation site (10). With information available about water use and water-stress tolerance, plant selections might be based not only on light requirements but also water use and water-stress tolerance characteristics as well, thus enhancing installation quality and longevity. Also, an assortment of plants might be selected which would fit an overall low maintenance program of tolerance to water stress and having a low rate of water use. Light might remain the primary determinant of whether a plant would be appropriate for an installation, but water stress tolerance and water use rate could improve the selection process.

This information will also be beneficial in the maintenance of interior plantscapes. Time spent watering plants can be organized in a manner so as to maximize labor efficiency and reduce water stress which otherwise would lead to diminished plant quality and longevity.

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# Recurrent Bloom Characteristics of Old Garden Roses

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## Abstract

Old garden roses that produced showy flowers during the late summer and early fall of the 1991 growing season were observed. The flower color, amount of flowering and the size of the individual flowers were recorded as an indicator of their late season landscape value. The most floriferous groups of recurrent blooming roses were the Hybrid Perpetuals and Semi-Climbing Musks.

## Introduction

Old garden roses are noted for their profusion of bloom in late spring and early summer. During June, collections of these older roses grown in Ohio attract considerable attention for their romantic beauty and fragrance. As the season progresses, there is a sharp decline in the amount of flowers. July and early August are times when a garden of old-fashioned roses has little color.

Many old garden roses only bloom once during the warm months of the year, while others bloom periodically from May to October. Those plants which develop flowers throughout the season are identified as recurrent bloomers. These plants are in the minority when considering all the plants grown in The Garden of Legend and Romance on the campus of the Ohio Agricultural Research and Development Center (OARDC) in Wooster.

The frequency and showiness of the late season flowering varies with cultivar and the growing conditions. During periods of prolonged drought, such as that experienced in Wooster,Ohio during the 1991 growing season, slower and less vigorous growth occurs. This reduces the frequency and amount of reblooming.

This study identified those cultivars of old garden roses growing in the OARDC rose garden which produced significant bloom during the late summer season. The color, flower diameter and number of flowers per plant were also recorded.

## Materials and Methods

From August 15 to September 15, 1991, approximately 500 species and cultivars of old garden roses in the OARDC rose garden were examined to determine those plants which produced significant late summer bloom. Three plants of a species or cultivar are arranged in triangular groupings with 3′ to 5′ centers. The plants are grown in mulched landscaped beds and are given standard cultural practices (1). Mid-summer cut back was practiced on those plants which are known not to rebloom. Some pruning was also done to keep bushes within the bounds of the designated bed. Flower color, number of flowers/plant and individual flower diameter on those plants showing color during the mid-August to mid-September period were recorded. Weekly observations were averaged to give the results reported.

## Results and Discussion

Results relative to late summer flowering of 27 cultivars of old garden roses is listed in Table 1. The roses are grouped into recognized categories based on their heritage. Most of the late season color was found among the Hybrid Perpetuals and Semi-Climbing Musk roses. Some Bourbons and Floribundas were colorful even though fewer cultivars of these groups are grown in the OARDC rose garden. Other groups such as the Gallicas, Centifolias, Albas, Mosses and species roses were devoid of color at this time of year. Therefore most of these groups do not appear on Table 1.

Although fewer representative cultivars of the Old Hybrid Tea, Bourbon and Floribunda roses are grown in the garden, cultivars such as 'Betty Prior' (Floribunda) and 'Mme. Scipion Cochet' (Bourbon) were especially heavily flowered. 'Reichsprasident Von Hindenberg' (Old Hybrid Tea) displayed less floriferous in the number of blooms per plant but was impressive in the size and quality of the individual blossoms.

The climbing rose which provided the most late season color included the reliable rebloomer, 'New Dawn'. The shell pink flowers were produced more sparingly and of smaller size than has been observed in most previous growing seasons. It is likely the persistent long season drought during the 1991 growing season had an effect on this response.

Late-season blooms were of high quality compared with those produced during the intense heat and long, bright days of summer. Higher petal count, increased substance in both flowers and foliage, and more intense coloration probably reflected higher carbohydrate levels in the plant. Longer and cooler nights reduce respiration, while sunny days allow photosynthesis to occur at a good rate. Late-season flower observations are likely to be affected by the lower light intensity which results when the sun's rays strike the plants at a lower angle during summer and fall.

Late-summer and early-fall bloom on old garden roses may be combined with other plant characteristics to give heightened enjoyment to the viewer. The sparse blooms of *Rosa rugosa* are found in concert with ripening fruit called hips and foliage beginning to take on autumn color. The large blossoms of 'Reichsprasident Von Hindenberg' has an intense fragrance which seems more pronounced in the early autumn.

Those roses which rebloom are worthy of special attention in the landscape. They extend the season during which the plant can be enjoyed and offer an element of excitement in the garden as late season flowers develop.

Table 1. Characteristics of Late-Season Bloom in Old Garden Roses—1991.

| | Color | Amount of late summer bloom (Flowers/Plant) | Diameter of individual flowers (CM) |
|---|---|---|---|
| **HYBRID PERPETUALS** | | | |
| 'General Washington' | Deep Crimson | Light | 7.3 |
| 'Marquise Bocella' | Soft Pink | Light | 7.3 |
| 'Mrs. John Laing' | Pink | Light | 9.0 |
| 'Nuria de Recolons' | White | Light | 6.7 |
| 'Paul Neyron' | Pink | Light | 7.7 |
| 'Symphony' | Flesh Pink | Moderate | 7.7 |
| 'Waldfee' | Red | Moderate | 9.0 |
| **BOURBONS** | | | |
| 'Mme. Scipion Cochet' | Cherry Rose | Heavy | 5.0 |
| 'Souv. de la Malmaison' | Creamy Pink | Heavy | 5.0 |
| **CHINENSIS** | | | |
| 'Hermosa' | Blushing Pink | Light | 5.7 |
| 'Hofgartner Kolb' | Carmine Rose | Moderate | 5.0 |
| **SEMI-CLIMBING MUSK** | | | |
| 'Ballerina' | Bright Soft Pink | Moderate | 2.7 |
| 'Belinda' | Soft Pink | Light | 2.3 |
| 'Nastrana' | White Tinged Pink | Moderate | 4.3 |
| 'Nymphenburg' | Salmon Pink | Light | 7.7 |
| 'Sangerhausen' | Light Carmen Red | Light | 6.0 |
| 'Will Scarlet' | Scarlet | Light | 6.3 |
| **RUGUSA** | | | |
| *Rosa rugosa* | Pink | Light | 4.7 |
| 'Hansa' | Reddish Violet | Light | 5.0 |
| **MOSSES** | | | |
| 'Alfred de Dalmas' | Blush Pink | Light | 4.7 |
| **SUPPORT-CLIMBING** | | | |
| 'City of York' | White | Light | 6.3 |
| 'Handel' | Deep Rose Pink | Light | 6.7 |
| 'New Dawn' | Shell Pink | Light | 6.7 |
| **FLORIBUNDA** | | | |
| 'Bety Prior' | Carmine Pink | Heavy | 6.0 |
| 'Iceburg' | White | Moderate | 6.7 |
| **OLD HYBRID TEA** | | | |
| 'La France' | Silvery Pink | Moderate | 6.3 |
| 'Reichsprasident Von Hindenberg' | Pink | Moderate | 8.0 |
| **SPECIAL PURPOSE ROSES** | | | |
| 'The Fairy' | Pink | Heavy | 2.7 |

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# Evaluation of Form and Growth Characteristics of *Juniperus* Cultivars at the Secrest Arboretum

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## Abstract

This study developed a listing of *Juniperus* cultivars for the landscape. Sixty-five *Juniperus* cultivars were replicated, randomized, and evaluated in an open-field plot in the Secrest Arboretum to determine form and growth characteristics of the genus. The cultivars were categorized into the following forms: disk, mound, ovoid, sphere, cylinder, ellipsoid, cone or pyramid. Growth was designated according to branching habits of procumbent, horizontal, arched, ascending, fastigiate or convergent. All plants were also evaluated for growth characteristics of open or closed outline.

## Introduction

A comparative list of form and growth characteristics of *Juniperus* cultivars provides the plant specialist with an evaluation tool for selecting *Juniperus* cultivars for the landscape. Desired form and growth characteristics for the landscape can be ascertained by selecting from a comparative plant list of form and growth characteristics.

The idea of establishing a juniper evaluation at the Secrest Arboretum originated as a result of an earlier evaluation of the genus *Taxus* (1). Lists of *Juniperus* cultivars as described in this study cannot be assembled from descriptions in nursery catalogs or plant manuals. Such references often involve as much variation in terminology to describe characteristics as there is among individual plants. Nurserymen or authors of reference manuals often do not have a significant collection of unpruned *Juniperus* growing in proximity to each other to compare and contrast various form and growth characteristics. A juniper evaluation at the Secrest Arboretum provides such plants.

## Materials and Methods

Cultivars studied were selected from those grown by the nursery industry. Cultivar names followed the International Code of Nomenclature for Cultivated Plants (2, 3, 4). Sixty-five cultivars were selected and planted in an open field during the Springs of 1986 and 1987. Five replicates of each selection were planted on a fully exposed landscape site and were arranged in a completely randomized design. The evaluation involved an assessment of natural growth characteristics, hardiness to USDA Zone 5, and vulnerability to insects and diseases.

Terminology was developed for evaluating plants characteristics by referencing literature that stated basic principles of planting design (5,6) and reviewing basic geometry.

During the summer of 1991, determinations of form and growth characteristics four and five years after establishment were made. Plants had not been pruned after planting in the field.

## Results and Discussion

The following is a compiled list of *Juniperus* cultivars categorized by methods used in this study.

## Listing of *Juniperus*

### Categorization of *Juniperus* according to form and growth characteristics:

**Disk with procumbent branching and closed outline**

*Juniperus horizontalis* 'Bar Harbor'
*Juniperus horizontalis*'Emerald Spreader'
*Juniperus horizontalis* 'Jade River'
*Juniperus horizontalis* 'Prince of Wales' (small crown in center of plant mass)
*Juniperus horizontalis* 'Webberi'
*Juniperus horizontalis* 'Wiltonii'
*Juniperus horizontalis* 'Blue Mat'

**Disk with horizontal branching and moderately open outline**

*Juniperus sabina* 'Broadmoor' (small crown in center of plant mass)
*Juniperus sabina* 'Buffalo'
*Juniperus horizontalis* 'Blue Chip'

**Disk with arched branching and moderately open outline**

*Juniperus conferta* 'Blue Pacific'

(continued)

## Categorization of *Juniperus* according to form and growth characteristics (continued):

### Mound with arched branching and open outline

*Juniperus horizontalis* 'Hughes'

*Juniperus sabina* 'Monna' Calgary Carpet ™ (dwarf)

*Juniperus sabina* 'Skandia'

### Mound with arched branching and moderately open outline

*Juniperus communis depressa* 'Effusa'

*Juniperus sabina tamariscifolia*

*Juniperus sabina* 'Tam's New Blue'

### Mound with arched branching and closed outline

*Juniperus procumbens* 'Greenmound'

*Juniperus horizontalis* 'Youngstown'

*Juniperus horizontalis* 'Wilms'

*Juniperus chinensis sargentii*

*Juniperus chinensis sargentii* 'Viridis'

### Mound with ascending branching and open outline

*Juniperus horizontalis* 'Blue Forest' (dwarf)

### Mound with horizontal branching and moderately open outline

*Juniperus chinensis* 'San Jose'

*Juniperus davurica* 'Expansa'

*Juniperus virginiana* 'Silver Spreader'

### Mound with ascending and horizontal branching and moderately open outline

*Juniperus chinensis sargentii* 'Glauca'

### Sphere with ascending branching and moderately open outline

*Juniperus chinensis* 'Pfitzeriana Nana'

*Juniperus chinensis* 'Armstrongii'

### Sphere with ascending branching and open outline

*Juniperus chinensis* 'Kohankie's Compact'

*Juniperus chinensis* 'Sea Green'

*Juniperus scopulorum* 'Tabletop'

### Sphere with arched branching and closed outline

*Juniperus squamata* 'Blue Star' (dwarf)

### Ellipsoid with horizontal branching and moderately open outline

*Juniperus chinensis* 'Gold Coast' P.P.2491

*Juniperus chinensis* 'Saybrook Gold' P.P.5014

*Juniperus chinensis* 'Owen's Compact'

*Juniperus chinensis* 'Bakaurea' Gold Star®

*Juniperus chinensis* 'Ozark's Compact'

*Juniperus chinensis* 'Fruitlandii'

*Juniperus chinensis* 'Pfitzeriana Aurea'

*Juniperus chinensis* 'Moraine'

### Ellipsoid with ascending branching and moderately open outline

*Juniperus chinensis* 'Aquazam' Aquarius ®

### Ellipsoid with ascending branching and open outline

*Juniperus communis* 'Depressa Aurea'

### Ellipsoid with arched branching and open outline

*Juniperus virginiana* 'Grey Owl'

### Cylinder with ascending and convergent horizontal branching and open outline

*Juniperus virginiana* 'Canaertii'

*Juniperus chinensis* 'Keteleeri'

*Juniperus chinensis* 'Hetz's Columnaris'

*Juniperus scopulorum* 'Admiral'

(continued)

## Listing of *Juniperus*

### Categorization of *Juniperus* according to form and growth characteristics (continued):

**Cylinder with ascending and horizontal branching and moderately open outline**

*Juniperus virginiana* 'Corcorcor' Emerald Sentinel®

**Cylinder with moderately fastigiate branching and moderately open outline**

*Juniperus chinensis* 'Ames'
*Juniperus chinensis* 'Hooks'
*Juniperus virginiana* 'Burkii'

**Cylinder with fastigiate branching and closed outline**

*Juniperus chinensis* 'Spartan'
*Juniperus chinensis* 'Spearmint'
*Juniperus virginiana* 'Skyrocket'
*Juniperus virginiana* 'Hillspire'
*Juniperus scopulorum* 'Gray Gleam'

**Cone with fastigiate branching and closed outline**

*Juniperus chinensis* 'Blue Point'
*Juniperus scopulorum* 'Wichita Blue'
*Juniperus scopulorum* 'Pathfinder'

**Pyramid with ascending and convergent horizontal branching and open outline**

*Juniperus chinensis* 'Mission'
*Juniperus virginiana* 'Manhattan Blue'

**Ovoid with ascending branching and moderately open outline**

*Juniperus chinensis* 'Blaauw'

It is possible to classify various juniper cultivars via. form and growth characteristics. Changes in *Juniperus* catagories can be made as additional data are accumulated during the next five years or new cultivars are introduced. Cultivar characteristics could change as plants mature and climatic and edaphic conditions vary.

A listing of *Juniperus* can be utilized in formulating landscape design decisions, but additional information should be considered. Local climate and soil conditions are important to the survival and appearance of plants. *Juniperus chinensis* 'Torulosa' was deleted from the evaluation because of severe winter injury during 1988 and 1989. *Juniperus chinensis* 'Saybrook Gold' P.P.5014 experienced winter injury during 1989, but remains in the evaluation because of full recovery. Susceptibility to pests was considered in another study of the cultivars and should be a factor when making selections (7).

Plant form and growth characteristics may differ from those presented in this evaluation because of specific growing conditions on a given site.

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# Evaluation of Junipers For Mite, Disease and Insect Incidence: Secrest Arboretum—1991

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## Abstract

An evaluation of juniper twig stunting and diebacks was initiated in September, 1990 and again in May, 1991. Ratings of tip dwarfmite (*Trisetacus* sp., Eriophyidae) damage, presence of spruce spider mites (*Oligonychus ununguis*), juniper plant bugs (Miridae) and incidence of fungal tip blight disease (*Phomopsis* sp.) were made for 64 juniper selections in 1991. Juniper midge (*Contarinia juniperana*, Cecidomyiidae) larvae and pupae were found in 1991 after not being found in 1990. Apparent tip dwarfmite damage was identified on 46 of the selections, 30 selections averaged more than 20 spruce spider mites per sample, 45 selections averaged more than 2 plant bugs per sample, and juniper midge was confirmed on nine selections. Selections were found which did not have these insect and mite pests. Suspected fungal tip blight was field observed on 32 selections but was only positively identified in the laboratory in four samples.

## Introduction

This juniper evaluation was initiated in 1990 and is to be conducted over a five-year span using an interdisciplinary team including entomology, plant pathology, and horticulture specialists. This is a report of the findings for the second year. Sixty-four selections in the genus *Juniperus* planted in the Secrest Arboretum in the Spring of 1986 and 1987 were evaluated for mite, disease and insect incidence in May, 1991. The previous evaluation (4) was performed in September, 1990.

Plants are completely randomized in fully exposed sites in the arboretum. Plants were provided by various Ohio nurserymen who were interested in studies of tip dieback problems on juniper. Nurserymen are encouraged to visit the evaluation plots in the Secrest Arboretum at the Ohio Agricultural Research and Development Center in Wooster, Ohio.

Pennsylvania research (6) lists and describes a large number of insect and mite pests of Pennsylvania junipers. The Pennsylvania survey was based on inspections of plant material in nurseries and landscapes but little reference was made concerning the incidence of these pests on particular juniper selections.

Juniper tip dwarfmite (*Trisetacus* sp.) causes stunting of new growth and feeding injury at the base of juniper foliage (2). Infested tips often have twisted, deformed, wavy foliage. Spruce spider mite (*Oligonychus ununguis* Jacobi) is a common cool-season mite causing yellowing and bronzing of foliage on junipers and other conifers. The juniper midge (*Contarinia juniperana* Felt) and juniper tip midge (*Oligotrophus betheli* Felt) are commonly reported cecidomyiid pests of juniper but were not confirmed in 1990. These midges cause dieback symptoms which resemble the tip blight diseases. Additional research (6) mentions two plant bugs (Miridae) commonly found on junipers. In 1990, Ohio State University researchers detected low numbers of the plant bug, *Dichrooscytus elegans* Heidemann, and suspected that this species was responsible for the elongate eggs inserted into juniper stems. These ovipositions seemed to result in tip dieback.

Fungal dieback and tip blights of juniper are caused by *Phomopsis juniperovora* Hahn, *Kabatina juniperi* Schneider and Arx, and *Sclerophoma pythiophila* (Cda.) Hohn (1,3,5). It is common that diagnosis of these diseases is made solely on the basis of field observations of brownish to ashen-gray areas of discoloration on spring growth (*Phomopsis* sp.), and late summer/early fall growth (*Kabatina* sp.), coupled with the observed presence of fungal fruiting bodies associated with the affected areas. This study examined whether plant tissue typically field-evaluated as tip blight of juniper was truly infected by *Phomopsis* sp. or whether other pathogens or causes were involved.

## Materials and Methods

On May 8, 9, 10 and 23, 1991, sixty-four juniper selections were evaluated at Secrest Arboretum. Tip dwarfmite damage was rated on a 0-5 scale as follows:

0—No tip dwarfmite damage detectable (less than 10% of stems with stunting).
1—10-30% of stems with stunting.
2—30-50% of stems with stunting.
3—50-80% of stems with stunting. Unacceptable horticulturally.
4—80-90% of stems with stunting. Unacceptable horticulturally.
5—90-100% of stems with stunting. Unacceptable horticulturally.

Spruce spider mite counts were made by rapping a randomly-selected juniper branch four times on an 8.5×11 inch piece of white paper and counting the mites. Populations of more than 40 mites were counted as 40+. Plant bugs were also counted on the white paper while oribatid mites, aphids, and other insects were simply noted. Juniper midges were diagnosed in the field by opening stems which appeared to be affected. Hollowed stems, larvae or pupae of the midge were noted.

For fungal tip blights, junipers were given initial field ratings. Samples from branches suspected of having tip blight were then taken for laboratory microscopic examination.

Each juniper selection was usually represented by five randomized single-plant replications. Results are reported as averages of the replications with the number of infested plants reported in parentheses (Table 1). For several of the selections, some of the replications were missing due to plant death.

## Results and Discussion

Apparent tip dwarfmite damage was present on 46 of the 64 selections rated in the study (33 of 64 in 1990) with four selections exhibiting damage on over 50 percent of the stems (seven in 1990). Damage was greatest on selections of *J. chinensis*, *J. scopulorum* and *J. virginiana* with little or no injury on *J. horizontalis* and *J. sabina*. This was the same as surveyed in 1990. Eighteen selections had no apparent tip dwarfmite damage. Approximately 20 samples exhibiting symptoms of dwarfmite attack were taken for microscopic examination. Only four samples had active mites though the temperatures in May were above normal and could have caused the mites to lay dormant eggs which are difficult to observe.

Spruce spider mite activity was more prominent in May, 1991 than in September, 1990. Of the 64 selections sampled, 30 averaged 20 or more spruce spider mites per sample (three in 1990). This level of infestation is considered by the industry to be the number that triggers an acaricide spray recommendation. Only three of the selections exceeded this threshold in 1990. Four selections had no spider mites and six others had only one replicate with an infestation.

Plants with considerable dead foliage often contained large numbers of oribatid mites. It is suspected that these mites are feeding on fungi and decaying organic matter. These mites may be confused with spruce spider mites in casual field testing. Occasional plants also had populations of *Pentamerismus* sp. (Tenuipalpidae, false spider mites) which are small, bright red mites.

The plant bug, *D. elegans*, was very common in May, 1991 with adults and nymphs being present. Nine of the selections had no plant bugs present while 12 selections had an average of more than 10 bugs per sample and 45 selections averaged over two per sample. Plant bug populations seemed to be highest on selections of *J. chinensis*, *J. davurica*, *J. scopulorum* and *J. virginiana*, while *J. communis*, *J. confera*, *J. procumbens*, and *J. squamata* had few or no bugs per sample.

Juniper tip midges (*O. betheli*) were not found. However, the juniper midge (*C. juniperina*) was identified on nine junipers with *J. virginiana* selections appearing most susceptible. Injury was suspected in 1990 but no midges could be found in September. It is obvious that the spring or early summer is a better survey period for this pest.

Considerable tip dieback was noted on many of the juniper selections. Positive field ratings (based on symptoms) of fungal tip dieback were made on 32 of the selections (33 in 1990), but subsequent laboratory examination confirmed a pathogen (*Phomopsis* sp.) on only four samples (*J. horizontalis* 'Blue Chip'—two samples, *J. horizontalis* 'Prince of Wales' and *J. sabina* 'Broadmoor'). In 1990, *J. chinensis* 'Gold Coast' P.P. 2491, *J. horizontalis* 'Blue Chip', *J. sabina tamariscifolia* and *J. sabina* 'Tam's New Blue' had positive infections. Other fungal pathogens, such as *Kabatina* sp. and *Sclerophoma* sp. were not identified on the samples.

As was noted in the 1990 evaluations, visual field observations are not adequate for proper diagnosis of fungal twig diebacks of junipers or tip dwarfmite infestations. Laboratory examination is essential. Damage from winter injury, moisture stress, midge damage, other insect problems, and even tip dwarfmite injury may be misdiagnosed as fungal diseases. There seem to be distinct differences between spring and fall pest populations. Most notable are the higher spider mite infestations, plant bug populations and midge larvae and pupae in stems. These pests are easier to diagnose in the spring.

**Table 1. Averages of Tip Dwarfmite Ratings, Spruce Spider Mite Counts, Plant Bug Counts and Juniper Midge Activity.**

| ***Juniper* Selection (# plants)** | **Tip Dwarfmites[1]** | **Spruce Spider mites[2]** | **Plant Bugs[3]** | **Midge[4]** |
|---|---|---|---|---|
| *Juniperus chinensis* 'Ames'(4) | 2.25(4) | 14.00(3) | 6.50(4) | – |
| *Juniperus chinensis* 'Aquazam' Aquarius(5)® | 1.00(3) | 40.00(5) | 0.20(5) | – |
| *Juniperus chinensis* 'Armstrongii'(5) | 2.40(5) | 35.40(5) | 17.60(5) | – |
| *Juniperus chinensis* 'Blaauw'(5) | 2.00(5) | 12.60(3) | 8.20(5) | +(2) |
| *Juniperus chinensis* 'Blue Point'(5) | 2.40(5) | 28.20(5) | 5.40(5) | – |
| *Juniperus chinensis* 'Fruitlandii'(4) | 1.75(4) | 24.50(4) | 2.25(3) | – |
| *Juniperus chinensis* 'Gold Coast'(4) | 2.25(4) | 13.00(2) | 16.50(4) | – |
| *Juniperus chinensis* 'Bakaurea' Gold Star(4)® | 0.25(1) | 21.25(3) | 3.75(3) | – |
| *Juniperus chinensis* 'Hetz's Columnaris'(5) | 2.60(5) | 34.40(5) | 7.40(5) | – |
| *Juniperus chinensis* 'Hooks'(5) | 2.40(5) | 0.60(1) | 6.60(5) | – |
| *Juniperus chinensis* 'Keteleeri'(4) | 2.75(4) | 33.25(4) | 6.25(4) | – |
| *Juniperus chinensis* 'Kohankie's Compact'(5) | 1.20(5) | 31.80(5) | 12.00(5) | – |
| *Juniperus chinensis* 'Mission'(5) | 2.40(5) | 11.60(4) | 3.20(5) | – |

(Continued)

**Table 1. Averages of Tip Dwarfmite Ratings, Spruce Spider Mite Counts, Plant Bug Counts, and Juniper Midge Activity (continued).**

| *Juniper* Selection (# plants) | Tip Dwarfmites[1] | Spruce Spider mites[2] | Plant Bugs[3] | Midge[4] |
|---|---|---|---|---|
| *Juniperus chinensis* 'Moraine'(5) | 0.80(2) | 40.00(5) | 7.60(5) | – |
| *Juniperus chinensis* 'Owen's Compact'(5) | 1.60(3) | 40.00(5) | 9.40(5) | – |
| *Juniperus chinensis* 'Ozark's Compact'(4) | 1.00(4) | 40.00(4) | 6.50(4) | – |
| *Juniperus chinensis* 'Pfitzeriana Aurea'(5) | 1.60(5) | 40.00(5) | 14.40(5) | – |
| *Juniperus chinensis* 'Pfitzeriana Nana'(5) | 2.60(5) | 40.00(5) | 9.40(5) | – |
| *Juniperus chinensis* 'San Jose'(5) | 1.00(2) | 18.20(4) | 8.60(4) | – |
| *Juniperus chinensis sargentii*(5) | 0 | 3.20(2) | 0 | – |
| *Juniperus chinensis sargentii* 'Glauca'(5) | 0 | 27.20(4) | 5.40(5) | – |
| *Juniperus chinensis sargentii* 'Viridus'(3) | 0 | 27.67(3) | 2.00(1) | – |
| *Juniperus chinensis* 'Saybrook Gold' P.P.5014(5) | 0 | 8.80(2) | 11.40(5) | – |
| *Juniperus chinensis* 'Sea Green'(5) | 2.00(5) | 33.20(5) | 8.00(5) | – |
| *Juniperus chinensis* 'Spartan'(5) | 2.40(5) | 33.00(5) | 10.20(5) | +(3) |
| *Juniperus chinensis* 'Spearmint'(4) | 1.75(4) | 19.75(4) | 7.75(4) | +(2) |
| *Juniperus chinensis* 'Torulosa'(4) | 2.00(2) | 3.25(2) | 3.75(3) | – |
| *Juniperus communis* 'Depressa Aurea'(4) | 0 | 0.50(1) | 2.50(2) | – |
| *Juniperus communis* 'Depressa Effusa'(4) | 0 | 3.75(2) | 0 | – |
| *Juniperus conferta* 'Blue Pacific'(5) | 0 | 0.40(1) | 0 | – |
| *Juniperus davurica* 'Expansa'(5) | 0 | 19.20(5) | 7.80(5) | – |
| *Juniperus horizontalis* 'Bar Harbor'(5) | 0.20(1) | 3.20(4) | 0.20(1) | – |
| *Juniperus horizontalis* 'Blue Chip'(5) | 0 | 0 | 0 | – |
| *Juniperus horizontalis* 'Blue Mat'(5) | 1.00(1) | 1.00(1) | 0 | – |
| *Juniperus horizontalis* 'Emerald Spreader'(3) | 0 | 1.00(1) | 0 | – |
| *Juniperus horizontalis* 'Hughes'(5) | 0.80(3) | 23.20(5) | 1.60(2) | +(1) |
| *Juniperus horizontalis* 'Jade River'(5) | 0 | 5.80(2) | 0.20(1) | – |
| *Juniperus horizontalis* 'Prince of Wales'(5) | 0 | 12.20(3) | 0.20(1) | – |
| *Juniperus horizontalis* 'Wilms'(5) | 0.40(2) | 19.60(4) | 8.40(5) | – |
| *Juniperus horizontalis* 'Youngstown'(5) | 0.20(1) | 14.40(4) | 5.40(4) | – |
| *Juniperus horizontalis* 'Webberi'(5) | 0.20(1) | 2.60(1) | 0 | – |
| *Juniperus horizontalis* 'Wiltonii'(5) | 0 | 3.00(2) | 0.20(1) | – |
| *Juniperus horizontalis* 'Blue Forest'(5) | 0 | 33.80(5) | 0.40(1) | – |
| *Juniperus procumbens* 'Greenmound'(3) | 0 | 0 | 0 | – |
| *Juniperus sabina* 'Broadmoor'(5) | 0.20(1) | 7.60(2) | 1.20(2) | – |
| *Juniperus sabina* 'Buffalo'(5) | 1.00(3) | 0 | 1.40(4) | – |
| *Juniperus sabina* 'Monna' 'Calgary Carpet'(5)™ | 0 | 2.00(2) | 0.20(1) | – |
| *Juniperus sabina* 'Skandia'(5) | 0.20(1) | 6.80(2) | 5.20(5) | – |
| *Juniperus sabina tamariscifolia*(4) | 0 | 11.25(2) | 1.00(2) | – |
| *Juniperus sabina* 'Tam's New Blue'(5) | 0.60(2) | 21.00(3) | 5.40(5) | – |
| *Juniperus scopulorum* 'Admiral'(4) | 3.00(4) | 40.00(4) | 9.00(4) | – |
| *Juniperus scopulorum* 'Gray Gleam'(5) | 2.20(5) | 22.00(4) | 8.60(5) | – |
| *Juniperus scopulorum* 'Pathfinder'(5) | 3.00(4) | 25.20(5) | 3.60(5) | – |
| *Juniperus scopulorum* 'Tabletop'(5) | 1.00(5) | 5.60(3) | 10.20(5) | – |
| *Juniperus scopulorum* 'Wichita Blue'(5) | 2.20(4) | 31.80(5) | 12.20(5) | – |
| *Juniperus squamata* 'Blue Star'(4) | 0 | 0 | 0 | – |
| *Juniperus virginiana* 'Burkii'(5)[5] | 2.40(5) | 15.2(4) | 5.80(5) | +(2) |
| *Juniperus virginiana* 'Canaertii'(4) | 2.75(4) | 24.75(4) | 4.50(3) | – |
| *Juniperus virginiana* 'Corcorcor' 'Emerald Sentinel'™(5)[5] | 3.20(5) | 27.00(5) | 9.20(4) | +(1) |
| *Juniperus virginiana* 'Grey Owl'(6)[5] | 1.67(5) | 31.67(6) | 20.17(6) | – |
| *Juniperus virginiana* 'Hillspire'(5) | 3.20(5) | 16.20(5) | 5.20(5) | +(2) |
| *Juniperus virginiana* 'Manhattan Blue'(4)[5] | 1.75(4) | 19.25(4) | 4.50(4) | +(2) |
| *Juniperus virginiana* 'Silver Spreader'(5) | 2.20(5) | 31.00(5) | 9.60(5) | – |
| *Juniperus virginiana* 'Skyrocket'(5) | 2.80(5) | 24.40(4) | 12.20(5) | +(3) |

[1]Average juniper tipdwarf mite damage rating as described in text and (# of plants exhibiting symptoms).
[2]Average number of spruce spider mites counted on sampling board and (# of plants infested).
[3]Average number of plant bug nymphs and adults counted on sampling board and ( # of plants infested).
[4]Presence (+) or absence (–) of juniper midge larvae or pupae in twigs and (# of plants infested).
[5]Cedar-apple or cedar-hawthorn rust galls noted on plant.

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