Response of Five Hydrangea Species to Foliar Salt Spray[1]

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Abstract

Hydrangeas are popular seaside plants; however, other than in anecdotal reports, there are no studies measuring their relative tolerance to salt spray. We examined response of ten cultivars and one subspecies of *Hydrangea* representing five species to foliar-applied salt solutions to recommend selections for seaside landscapes. Objectives were to determine whether there are differences in responses to salt spray among cultivars and species, and to determine whether varying concentrations of sodium chloride differentially damaged the plants. Plants were treated with a full-strength (ion concentration approximate to seawater) salt solution, a half-strength salt solution, or a control of tap water. Plants were rated after seven once-weekly applications based on percentage necrotic leaf area, an aesthetically and physiologically important symptom of damage. Cultivars of *Hydrangea macrophylla* and *Hydrangea serrata* were more tolerant of full-strength salt spray than cultivars of *H. paniculata*, *H. anomala* and *H. arborescens.* At half strength but not full strength, *H. anomala* ssp. *petiolaris* was most tolerant. *Hydrangea macrophylla* and *H. serrata* were the second most tolerant of half-strength applications. *Hydrangea macrophylla* or *Hydrangea serrata* should be planted where maritime salt spray will occur.

Index words: seawater aerosol, NaCl, Hydrangeaceae.

Species used in this study: Smooth hydrangea (*Hydrangea arborescens* L.) cultivars 'Annabelle', 'Dardom' White Dome®, 'Hayes Starburst'; bigleaf hydrangea (*Hydrangea macrophylla* (Thunb.) Ser.) cultivars 'Paris' (Cityline™ series), 'Nikko Blue', 'All Summer Beauty'; panicle hydrangea (*Hydrangea paniculata* Sieb.) cultivars 'Limelight', 'Tardiva'; *Hydrangea serrata* (Thunb.) Ser. cultivars 'Bluebird', 'Coerulea Lace'; climbing hydrangea (*Hydrangea anomala* ssp. *petiolaris* (Sieb. & Zucc.) E.M. McClint).

Significance to the Nursery Industry

The increasing popularity of hydrangeas in ornamental horticulture has resulted in increased availability of diverse species and cultivars. Foliar salt spray from seawater may be an important factor to consider when selecting taxa for use in coastal locations. Hydrangeas are particularly popular in coastal areas, where there is anecdotal evidence that they thrive. Selection of more taxa tolerant of salt spray is of concern to growers and nurserymen making recommendations to buyers regarding the most appropriate selections for their sites. We examined the tolerance of 11 popular selections to foliar salt spray. Cultivars of *Hydrangea macrophylla* and *Hydrangea serrata* exhibited less severe signs of injury from saline aerosol at a salt concentration equivalent to seawater than did *Hydrangea arborescens*, *Hydrangea anomala* ssp. *petiolaris* and *Hydrangea paniculata*. This information will be valuable for growers and landscape designers who seek to provide the best selections to their customers, and for home gardeners who wish to protect their investments.

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Introduction

Plants may be susceptible to damage from foliar exposure to seawater aerosols and aerosols from deicing salt solutions on roadways, although the degree of susceptibility varies. Grattan et al. (11) studied the relationship between saline aerosol and the degree of salt-related damage to crop plants and determined that necrosis resulting from salt deposition increased positively with deposition and time, and that foliar absorption of sodium and chloride ions was linearly related to the amount of salt deposition on leaves. Saltwater spray is one of the abiotic factors that influences growth and vigor of seashore plants (14). The majority of literature on the subject of seashore salt spray relates to its effect on non-ornamental plants in natural landscapes (2, 13, 14, 22). Numerous researchers have examined how seaside saltwater spray affected plant dispersal and dwarfism of costal dune species (14, 16, 22, 23). Griffiths and Orians (14), for instance, observed that maritime salt spray affected field distribution and zonation of existing *Solidago nemoralis*, *Myrica pensylvanica*, *Pinus rigida* and *Quercus* species in coastal environments, and that under experimental conditions in a greenhouse, treatment with salt spray resulted in leaf necrosis to a greater extent than did the control of deionized water. Damage was greater in non-heathland species than it was in *Myrica pensylvanica*, a common heathland species typically found close to the ocean.

Salt spray tolerance in woody plants has been mostly limited to examinations of tolerance to deicing salt aerosol, and this issue has been widely documented. Lumis et al. (17), Dirr (6), Townsend (24) and Townsend and Kwolek (25) examined the damage, growth response, and survival of commonly planted roadside trees exposed to salt spray from deicing salts. Townsend (24) and Townsend and Kwolek (25) determined that *Pinus strobus* is exceptionally susceptible to damage from deicing salts aerosols, while *Pinus thunbergiana* is significantly more tolerant, and that other *Pinus* species show variable, moderate degrees of tolerance. Observational studies by Lumis et al. (17) and a literature review by Dirr (6) confirmed those findings. Salt spray tolerance of woody ornamental plants during the growing season has received relatively little attention. Bernstein et al. (1), Francois (9, 10) and Cassaniti et al. (3) examined the ability of containerized ornamental trees and shrubs (*Bougainvillea glabra*, *Viburnum dentatum*, *Pyracantha* 'Harlequin', *Liriodendron tulipifera*, and others) to withstand irrigation with saline water and used leaf necrosis as a metric to determine the level of damage due to salt exposure. Because salt spray is a significant factor determining the distribution of plants in the coastal environment, and because landscapes and gardens are often planted along the seacoast, and thus exposed to similar conditions, it would be useful to determine how salt spray affects woody ornamental plants.

The popularity and vigor of hydrangeas in coastal areas of New England and Long Island provides anecdotal evidence that they perform well under conditions where maritime salt spray occurs. Accounts suggest that *Hydrangea macrophylla* and *Hydrangea arborescens* perform well in coastal plantings (8, 15). Recently there has been a tremendous increase in the breeding of *Hydrangea*, leading to an increased variety of available cultivars with wide-ranging features.

For this study a sample of 10 popular cultivars and one subspecies representing five species of *Hydrangea* were selected: *Hydrangea arborescens* 'Annabelle', *H. arborescens* 'Dardom' White Dome®, *H. arborescens* 'Hayes Starburst', *Hydrangea anomala* ssp. *petiolaris*, *Hydrangea macrophylla* ' All Summer Beauty', *H. macrophylla* 'Nikko Blue', *H. macrophylla* 'Cityline Paris', *Hydrangea serrata* 'Bluebird', *H. serrata* 'Coerulea Lace', *Hydrangea paniculata* 'Limelight' and *H. paniculata* 'Tardiva'. The objectives of the experiment were to determine whether anecdotal evidence holds true, namely that hydrangeas are tolerant of foliar exposure to salt spray, to determine whether *H. macrophylla* and *H. arborescens* are, as accounts indicate, relatively more tolerant to salt spray than are other species of *Hydrangea*, and to determine whether the taxa react differently to different concentrations of salt. A scale rating of leaf scorch/necrosis was used as the metric to determine damage as a result of salt spray because necrosis is a direct result of an increased concentration of chloride ions in the leaf (2, 20).

Materials and Methods

Plant material and experimental design. In this experiment, rooted cuttings in 10 cm square containers of 11 taxa representing five species of *Hydrangea* were investigated. Spring Meadow Nursery of Grand Haven, MI, supplied all plant material. Plugs were transplanted into Pro-MiX® BX (Premier Horticulture Inc. Quakertown, PA) planting medium [*Sphagnum* peat-based (75–85%) with horticultural grade vermiculite and perlite, dolomitic limestone and endomycorrhizal inoculant] in plastic pots sized 1200 (14.3 liters: 27 cm diameter × 25 cm height; Nursery Supplies Inc.®) in the beginning of May 2007 and left to establish for three months at the trial site. The trial site was located on a gravel pad in full sun outside the Kenneth Post Laboratories on the Cornell University Campus in Ithaca, NY. Eighteen blocks of plants, each containing one randomly selected individual from each of the 11 taxa were placed in a split block arrangement in three rows and were spaced by 1 meter on center to allow for separation between each block. The 18 blocks were randomly assigned to one of the two salt treatments or to the control, so that there were six replications of all treatments, randomly distributed throughout the rows. The blocks were not obviously differentially affected by shade, wind, or weather. Plants were initially fertilized after potting in early May with three-month release Osmocote® 14-14-14 fertilizer (Scotts-Sierra Horticultural Products Company, Marysville, OH) at 40 g per plant and irrigated daily as necessary with tap water. One day after salt spray treatments, watering was done using an overhead breaker hose washing residual salt off of the leaves. Weeds were controlled by hand pulling. The day before treatments began, plants were visually rated in increments of 25% from 0–100% for the presence of any necrosis. Before each treatment, plastic discs were placed over the soil surface and around the base of each plant to prevent salt deposition in the soil by treatment sprays. The electrical conductivity of the soil media was tested on randomly selected plants in late August to confirm that deposition was not occurring. There was little difference in the conductivity of the media compared to that of tap water. EC of tap water was 0.36. Half strength salt treatment potting medium was 0.533. Full strength salt treatment potting media was 0.593 and the control potting medium was 0.633; all units in mmhos.

Plastic cloths were placed around plants during treatment to prevent spray contamination of adjacent blocks. Liquid Fence® deer repellent (The Liquid Fence® Company,

Table 1. Foliar necrosis rating scale.

Rating	Quantitative scale
1	0%
2	1–25%
3	26–50%
4	51–75%
5	>75%

Brodheadsville, PA) was applied to each plant in early June and repeated in early August and early September as per the manufacturer's recommendations. Arial sprays of each salt treatment and the control were applied beginning in late July and repeated at seven day intervals for seven consecutive weeks until mid-September. One week after the final treatment, the plants were observed for foliar necrosis of the leaf edge, progressing towards the center of the leaf blade. The rating scale is presented in Table 1.

Salt treatments. Solutions were made using Instant Ocean®, commonly used in salt water aquariums (Spectrum Brands, Inc. Atlanta, GA). The full-strength solution had an approximate salinity of 35 parts per thousand and a pH of 7.96, and closely approximated the sodium and chloride ion concentration of seawater (19). Sodium and chloride made up over 85% of the crystal form of Instant Ocean®, while smaller amounts of magnesium, sulfate, potassium, calcium and bicarbonate made up most of the rest. This method has been used in prior experiments (14). The control application consisted of spray to run-off with tap water, which had a pH of 8.15. Foliar sprays of salt solution were applied using a two gallon pressurized hand sprayer to run-off. Concentration levels were: 'full strength' — 39.5 g·liter^{-1} tap water (1/2 cup·gal^{-1}) and 'half-strength' — 19.8 g·liter^{-1} tap water (1/4 cup·gal^{-1}).

An analysis of variance ($P = 0.05$) was conducted on leaf necrosis data to determine treatment effects using Least Squares Means Difference Students t-test (JMP Statistical Software version 8.0).

Results and Discussion

At the same treatment level, there were no differences in necrosis for cultivars within the same species (data not presented). Cultivars of the same species were thus pooled for analysis. However, there were differences in scorch between species at the same treatment level. No block effect was observed. For all species, there was a progressive increase in necrosis from the control to the half-strength treatment to the full strength treatment (Table 2). All species showed at least some necrosis as a result of both the full- and half-strength treatments, but the severity of the damage varied. At the full-strength level, *H. serrata* and *H. macrophylla* showed statistically similar necrosis (2.92 and 2.67 respectively, or 26–50% leaf area showing signs of necrosis) and their performance was significantly better than the other three species, *H. paniculata, H. arborescens and H. anomala*, which showed statistically similar severe necrosis (5.00, 4.50 and 4.50, respectively, or 76–100% leaf area showing signs of necrosis). *Hydrangea paniculata* showed the most severe necrosis (4.42 or 76–100% leaf area showing signs of necrosis) at the half-strength level, followed by *H. arborescens* (3.50, or 51–75% leaf area showing signs of necrosis), and *H. serrata* and *H. macrophylla* (2.33 and 2.05 respectively, or 26–50% leaf area showing signs of necrosis). *Hydrangea anomala* ssp. petiolaris showed the least severe scorch (1.83, or 0–25% leaf area showing signs of necrosis) at that treatment level. Notably, the change in the response of *H. anomala* ssp. petiolaris between the half-strength and full-strength treatment was dramatic (1.83 and 4.50, respectively). This species performed best at the half-strength level, but it performed very poorly at the full-strength level. While no species was immune to salt spray, the physical appearance of plants with less than 50% of leaves showing necrosis was decidedly better than plants showing greater than 50% necrotic leaves, especially when the level of scorched leaves neared 100%. In addition to the decreased appearance of damaged plants, it is likely that there are underlying functional changes that would cause dwarfism of the leaves and decreases in photosynthetic rates that would eventually decrease growth and vigor over the life of the specimen between more and less tolerant species, although these were not measured within this seven-week test period (12, 21). Qualitative tolerance levels are presented in Table 3.

All species were variably susceptible to salt spray damage. It was not within the scope of this experiment to evaluate the concentration of chloride ions present in the necrotic leaves, as has been done by Cassaniti (3) and Griffiths and Orians (14). Landscape value is largely determined by the physical appearance of individual plants and plants with necrotic tissue are not attractive in gardens and landscapes (1). Plants showing damage due to salt stress are inherently of less value than plants without such damage, regardless of the concentration of ions causing the necrosis. It has yet to be determined

Table 2. Mean necrosis rating by species for each treatment.

Species[z]	Control (N[y])	½-strength (N)	Full strength (N)
H. anomala ssp. petiolaris	1.00[x] (*5*)ba[w]	1.83 (*6*)dc	4.50 (*6*)ji
H. arborescens	1.50 (*18*)cb	3.50 (*18*)h	4.50 (*18*)ji
H. macrophylla	1.28 (*18*)cba	2.05 (*18*)ed	2.67 (*18*)gf
H. paniculata	1.00 (*12*)a	4.42 (*12*)i	5.00 (*12*)j
H. serrata	1.10 (*10*)ba	2.33 (*12*)fe	2.92 (*12*)hg

[z]Species with more than one cultivar in experiment have been pooled, because no cultivar effect was observed.

[y]N = number of plants of a given species at a given treatment level.

[x]Necrosis rating scale is as follows: 1 = 0%, 2 = 1–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%.

[w]Necrosis ratings can be compared throughout the table. Ratings not connected by the same letter are significantly different ($P = 0.05$).

Table 3. Tolerance level of each species.[z]

Species	Tolerance		
	Control	Half strength	Full strength
H. anomala	Very Good	Moderate	Poor
H. arborescens	Good	Fair	Poor
H. macrophylla	Very Good	Moderate	Moderate
H. paniculata	Very Good	Poor	Poor
H. serrata	Very Good	Moderate	Moderate

[z]Very Good > Good > Moderate > Fair > Poor.

how severe a problem maritime salt spray is to ornamental plants as a function of their distance from the sea. Edwards and Claxton (7) determined that as one moves farther from the coast, the amount of salt spray was significantly reduced. Furthermore, topographic characteristics of the shoreline, wind patterns and velocity, and the presence or absence of windbreaks also affected the relative severity of salt spray (7, 18). While the present study does confirm anecdotal evidence that cultivars of *H. macrophylla* cultivars are more tolerant of salt spray than are cultivars of *H. paniculata*, *H. arborescens*, and *H. anomala*, the anecdotal evidence that *H. arborescens* is among the more tolerant species was not confirmed. Rather, *H. serrata* appears to be as tolerant of salt spray as *H. macrophylla* and more tolerant than the other species studied, including *H. arborescens*, even though *H. serrata* is not mentioned in anecdotal accounts. The similar responses of *H. macrophylla* and *H. serrata* may be explained by the fact that they are closely related (5). The underlying mechanisms of salt spray tolerance were not investigated in this study. One might presume that cuticle thickness or degree of waxiness on the leaf surface may protect leaves from salt damage. In fact, leaves of *H. macrophylla* have a noticeable waxy sheen. This is an area for further research that we did not investigate. As with any abiotic factor affecting a landscape, site-specific assessments should be completed to determine the vulnerability of a given site to salt exposure. On sites where salt spray is known to pose a problem to landscape plants, we recommend planting *H. macrophylla* or *H. serrata* instead of *H. paniculata*, *H. arborescens* or *H. anomala* ssp *petiolaris.*

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