Growth and Establishment of Pacific Ninebark (*Physocarpus capitatus*) and Atlantic Ninebark (*Physocarpus opulifolius* 'Center Glow') in Rain Gardens in the Pacific Northwest©

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Low impact development is an emerging concept for treating urban stormwater. Bioretention, an important tool to address this, utilizes the properties of plants, soil media, and microorganisms to infiltrate water and filter pollutants. Rain gardens, a form of bioretention, are shallow depressions in the landscape filled with soil media and plants. Plants are an essential rain-garden component. In order to expand the list of plants recommended for rain gardens in the Pacific Northwest, an Atlantic ninebark (*Physocarpus opulifolius* 'Center Glow') was planted in three rain-garden hydrologic zones: the wetter bottom, the dryer top, and the sloped transition zone. The Pacific ninebark (*P. capitatus*) was planted in the wet zone for comparison. Results after three growing seasons showed rain-garden zone did not affect growth or survival of Atlantic ninebark and there were no differences between the Pacific and Atlantic ninebarks. All plants grew well during the study.

INTRODUCTION

Stormwater runoff has traditionally been handled in urban areas with storm sewers. In many cities, these systems are aging and are not viable as the sole means of handling runoff. Urban areas have grown substantially, increasing the area of hardscape that funnels water to the storm sewers, thus increasing problems with volume as well as the level of pollutants in the runoff. Climate change increases the volume of water in single rain events, exacerbating these problems (Gill et al., 2007). The challenge is to develop new and more effective stormwater management techniques for protecting our fresh and marine water systems. The current structural engineering approaches to stormwater management have limitations for fully mitigating the flow and water quality impacts from development. Increasingly, stormwater engineers and designers are exploring and implementing distributed, low-impact development strategies that manage stormwater where it falls and in frequent, small contributing areas (Dietz, 2007). These new strategies use existing natural features and small-scale engineered hydrologic controls to better mimic natural processes allowing water to soak into soils and other pervious surfaces.

A critical tool in the low impact development approach and one of importance to the green industry is bioretention (Dietz, 2007). Bioretention cells, commonly known as rain gardens, are shallow depressions in the landscape filled with soil media and plants. They can be implemented on various scales from small residential lots to large commercial properties. Rain gardens use the biological, physical, and chemical properties of plants, soil media, and microorganisms to infiltrate water and filter pollutants and are intended to be long-term installations.

Plants are an essential component of rain gardens; they absorb nutrients, transpire water, and help maintain favorable soil infiltration and microbiological activity. The moisture status of plants within a rain garden can vary with season and location. In the Pacific Northwest, plants must tolerate wet winters as well as dry summers, preferably without supplemental irrigation. During wet seasons, rain gardens will have different hydrologic zones, varying from temporarily saturated, oxygen-deprived conditions in low areas to dry conditions in upper areas that merge with the existing landscape. For long-term success, identifying plants that will be healthy and viable under these widely varying conditions is crucial.

Most rain garden research has been done in the eastern USA, which has substantial rainfall in the summer, when evapotranspiration is high. The heavy winter rainfall and summer drought typical of the Northwest provide challenges for survival of rain garden plants and research is needed to evaluate the suitability of different plant species for use in different moisture zones within rain gardens. The purpose of this study was first, to evaluate the growth and survival of 'Center Glow', an Atlantic ninebark cultivar, in all three rain garden hydrologic zones: the wetter bottom, the dryer top, and the sloped zone that transitions between the top and bottom zones and second, to compare the growth of 'Center Glow' and the native Pacific ninebark in the wetter bottom zone.

MATERIALS AND METHODS

Sixteen identical rain garden cells were installed at the Washington State University Puyallup Research and Extension Center as part of a Low Impact Development stormwater research program partly funded by a Washington Department of Ecology grant (<www.puyallup.wsu.edu/stormwater/>). Each has approximately 256 ft^2 of surface area. A bioretention soil mix of 3 sand and 2 recycled yard-waste compost (v/v) was spread to a depth of 18 in. (Hinman, 2005). The cells had a flat bottom area (approximately 10×10 ft) and sloping edges. This created hydrologic zones of varying soil moisture (wetter in the bottom, dryer on the top and transitional on the slopes).

'Center Glow' was grown by the researchers from cuttings donated by Dr. Harold Pellett. The Pacific ninebark was obtained from a local native plant nursery. Both species were grown in #1 containers. Thirty-two 'Center Glow' and eight Pacific ninebark plants were selected for uniformity and transplanted to the rain garden cells using recommended planting procedures (Ophardt and Hummel, 2011). There were 12 'Center Glow' planted in the dry zones, 12 in the transition zones, and 8 in the wet zones. All eight Pacific ninebark were planted in the wet zones. Plants were spaced about 4½ ft on center. All plants were mulched to a depth of 3½ to 4 in. with arborists' wood chips.

All plants were manually irrigated once at transplant in the fall of 2010 and then relied on natural rainfall until the summer of 2011. Drainage of the rain gardens in this study was excellent and no standing water was observed during the winter months. An overhead sprinkler irrigation system was installed and from June to September 2011 all rain gardens were irrigated as needed to prevent plant water stress. After September 2011, no supplemental irrigation was applied to the rain gardens. Precipitation during the time of this experiment was collected by a WSU AgWeatherNet station (<http://weather.wsu.edu/awn.php>) located about one-half mile from the rain gardens.

Plant height and two canopy widths, the widest width and the width perpendicular to the widest, were measured at the end of the 2012 growing season. After the 2013 growing season, plant height and the two canopy widths were measured again. Yearly increase in height and widths was determined. From these data, the yearly plant growth increase was calculated as the incremental shoot growth index (ISGI) using the following formula: ISGI = [(widest width increase + perpendicular width increase)/2 + height increase]/2 (Hummel et al., 2013). In fall 2013 plant survival was evaluated and plant visual quality was rated on a scale from 5 (a superior plant) to 1 (a poor quality plant), with a rating of 3 considered an acceptable landscape plant. Data were subjected to analysis of variance (ANOVA; PROC GLM; SAS 9.1, SAS Institute Inc., Cary, North Carolina) and means separations were done with a protected Tukey's Studentized range test. A Student's t-test was used to compare the two species.

RESULTS AND DISCUSSION

Recorded rainfall for WSU Puyallup was 0.78 in. in July and 0.34 in. in August of 2011 (Table 1). During that summer, plants were closely monitored and irrigated to prevent water stress. No supplemental irrigation was applied to the rain gardens after September 2011. In the summer of 2012, August and September were extremely dry with no rainfall and 0.01 in., respectively, and some plants exhibited water stress symptoms such as wilting and marginal leaf burn.

Table 1. Monthly precipitation recorded at the WSU Puyallup Research and Extension Center during the rain garden study.

Month	2010 cm (in.)	2011 cm (in.)	2012 cm (in.)	2013 cm (in.)
January	16.36 (6.44)	11.07 (4.36)	12.78 (5.03)	7.06 (2.78)
February	8.51 (3.35)	8.13 (3.2)	7.85 (3.09)	3.84 (1.51)
March	9.73 (3.83)	16.97 (6.68)	15.60 (6.14)	6.55 (2.58)
April	6.99 (2.75)	12.12 (4.77)	7.80 (3.07)	11.15 (4.39)
May	9.73 (3.83)	11.18 (4.4)	6.45 (2.54)	8.61 (3.39)
June	7.85 (3.09)	4.06 (1.6)	5.28 (2.08)	3.91 (1.54)
July	1.27 (0.5)	1.98 (0.78)	3.12 (1.23)	0.00 (0)
August	1.02 (0.4)	0.86 (0.34)	0.00 (0)	3.71 (1.46)
September	7.32 (2.88)	2.90 (1.14)	0.03 (0.01)	19.20 (7.56)
October	10.26 (4.04)	9.63 (3.79)	14.22 (5.6)	4.06 (1.6)
November	11.25 (4.43)	13.87 (5.46)	16.13 (6.35)	8.76 (3.45)
December	11.66 (4.59)	6.68 (2.63)	16.26 (6.4)	3.61 (1.42)

Rain garden hydrologic zone had no significant influence on survival, growth or quality of ‘Center Glow’ ninebark plants measured in the fall of 2013 (Table 2). One of the 12 plants in the transition zone died, but all other plants were surviving in the fall of 2013 and their quality was good to excellent. In Fall 2013, plant heights ranged from 6.1 to 6.9 ft and spreads from 5.6 to 6.4 ft. The Atlantic ninebark hybrid, ‘Center Glow’ is reported to grow to 6 to 8 ft (1.8 to 2.5 m) in height and spread (U.S. Plant Pat.).

Table 2. Effect of rain garden hydrologic zone on survival, height, width, incremental shoot growth index (ISGI), and quality of *Physocarpus opulifolius* ‘Center Glow’.

Rain garden hydrologic zone	Number of plants	Survival (%)	Height cm (ft)	Width[z] cm (ft)	ISGI[y] cm (ft)	Quality[x]
Dry	12	100	185.1 (6.1)	171.5 (5.6)	19.6 (0.6)	5.0
Transition	12	92	196.3 (6.4)	195.3 (6.4)	29.8 (1.0)	4.6
Wet	8	100	208.9 (6.9)	186.1 (6.1)	28.8 (0.9)	5.0
		NS[w]	NS	NS	NS	NS

[z]Width = (widest width + perpendicular width)/2.

[y]ISGI = [(widest width increase + perpendicular width increase)/2 + height increase]/2.

[x]Quality was rated on a scale ranging from 5 (a superior plant) to 1 (a poor quality plant), with a rating of 3 considered an acceptable landscape plant.

[w]NS indicates non-significance at the P=0.05 level using a protected Tukey’s Studentized range test.

Atlantic ninebark is native to central and eastern North America where it can be found growing along stream banks and in moist thickets as well as on rocky hillsides and woodland edges (Hoss, 2001; Missouri Botanic Garden, 2014). Hoss (2001) indicated Atlantic ninebark is adaptable to a very wide range of site and soil conditions from moist to dry, acid to alkaline and gravelly to heavy clay. It was recommended to gardeners as a fast-growing, drought-tolerant plant that can grow in harsh conditions (Missouri Botanic Garden, 2014). In addition to 'Center Glow', there are a number of other *P. opulifolius* cultivars available with varying foliage colors and plant growth habits.

In the rain garden wet zone there was 100% survival of both 'Center Glow' and Pacific ninebark and there were no significant differences between the two species in growth or quality (Table 3). Pacific ninebark is native to Western Washington where it is typically found growing in wet open places along streams, rivers or lakes, in marshlands or along moist forest edges (Pojar and MacKinnon, 1994; Washington Native Plant Society, 2007). Pacific ninebark is a large, erect-to-spreading shrub that can grow to 13 ft (4 m) tall. Pacific ninebark performed similarly to Atlantic ninebark in the rain garden wet zone in this study. While some consider it to have low drought tolerance (USDA NRCS, 2007), others report that it is also occasionally found growing on drier sites (Pojar and MacKinnon, 1994); it is possible that it would have performed similarly to Atlantic ninebark in drier zones of the rain gardens, but that was not examined in this study.

Results of this study indicated the Atlantic ninebark hybrid 'Center Glow' grew and survived in all three rain garden zones. Survival and growth of the Northwest native Pacific ninebark and 'Center Glow' were similar in the wetter bottom zone. Both species survived the dry summer months. Both species grew rapidly from #1-container-sized plants in fall of 2010 to an average height of 6½ ft for 'Center Glow' and 7½ ft for Pacific ninebark, with nearly equal spreads. In the Pacific Northwest, both species could be recommended for use in the wet zones of rain gardens and Atlantic ninebark could be recommended in any rain garden hydrologic zone.

Table 3. Comparison of Pacific ninebark (*Physocarpus capitatus*) and *Physocarpus opulifolius* 'Center Glow' survival, height, width, incremental shoot growth index (ISGI), and quality in the wet rain garden hydrologic zone.

Species	Number of plants	Survival (%)	Height cm (ft)	Width[z] cm (ft)	ISGI[y] cm (ft)	Quality[x]
Center Glow ninebark	8	100	208.9 (6.9)	186.1 (6.1)	28.8 (0.9)	5.0
Pacific ninebark	8	100	229.1 (7.5)	211.4 (6.9)	25.5 (0.8)	4.6
		NS[w]	NS	NS	NS	NS

[z]Width = (widest width + perpendicular width)/2.
[y]ISGI = [(widest width increase + perpendicular width increase)/2 + height increase]/2.
[x]Quality was rated on a scale ranging from 5 (a superior plant) to 1 (a poor quality plant), with a rating of 3 considered an acceptable landscape plant.
[w]NS indicates non-significance at the P=0.05 level using a Student's t-test.

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QUESTIONS AND ANSWERS

Patrick Peterson: Has anyone looked at, particularly in parking lot situations, the influence of pollutants?

Rita Hummel: That work is currently being done. What they're finding is that even though run-off containing hydrocarbons are entering the rain gardens the system still seems to work. Pollutant levels are below what's allowed for organic use of compost. One of the questions being asked is whether edible plants can be grown in a rain garden. Right now, the answer to that question is not known.

Douglas Justice: First questions, when you're establishing the rain gardens are they irrigated in the beginning and/or subsequently? Second, has anyone actually tracked the costs related to the installation and maintenance over those years?

Rita Hummel: There's a relatively old publication I can provide that details installation costs for rain gardens. In our rain garden we irrigated the plants at transplant and the first summer after that. Then we stopped any irrigation. I believe that was a mistake so I currently recommend irrigating plants in a rain garden for two entire growing seasons. We're also recommending to plant lots of plants close together to minimize the need for weeding the rain gardens.