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Evaluation of Container Grown Native Azaleas in Full Sun and 50% Shade in the Mid-Atlantic

Abstract

Deciduous azaleas *Rhododendron* spp. that are native to the Eastern United States have potential for increased adoption in the ornamental sector yet lack robust performance trials. This study evaluated nine species of container grown native azaleas using typical nursery practices. Plants were grown in full sun or 50% shade and were evaluated for growth index (GI), bloom phenology, and abiotic stress via normalized difference vegetation index (NDVI). Generally, GI was greater under 50% shade, no difference in cumulative flower counts between treatments, and NDVI was reduced in most species grown in full sun, indicating a higher degree of plant stress.

Abbreviations – Growth index (GI), Normalized difference vegetation index (NDVI)

Keywords – Extension, horticulture, landscape, native azaleas, nursery, ornamental

Introduction

There are seventeen species of deciduous azaleas (*Rhododendron* spp.) that are native to the eastern United States and some may have potential for increased adoption in the ornamental nursery and landscape market. Many of these species are native to the southeastern United States and have limited geographic distributions in the wild that are presently being threatened by development, increasing deer pressure, and climate change (McDonald, 2001). As the climate zones shift northward, there may be increased potential for developing these species as ornamental crops in the Mid-Atlantic region. While there is growing customer demand for native azaleas, plant availability is currently limited (Dumroese and Luna, 2016) and regional trials on the growth and performance of each species are lacking, though there are some existing sites such as the National Native Azalea Repository in North Carolina (Owings, 1992) and the Jenkins Arboretum in Pennsylvania (Sweetman, 2004). Despite some advances in native azalea propagation (Somerville, 1998; Jenkins, 2007), propagation is often still conducted by seed, as they can be challenging to produce vegetatively (Sommerville, 1998; Driskill, 2018). However, seed production can be a slower process with greater potential for genetic variability compared to vegetative propagation. Seed-grown liners are available for commercial nurseries to purchase and finish the plants, though quantities and suppliers are limited (Driskill, 2018).

Under optimum growing conditions, native azaleas can be low-input plants with minimal insect and disease issues in the landscape. There is even evidence that several native azalea species, especially *R. canescens* and *R. prunifolium* demonstrate an increased resistance to azalea lace bug relative to susceptible evergreen azaleas such as *R. mucronatum* ‘Delaware Valley White’ (DVW) (Braman and Pendley, 1992). However, they can also be susceptible to summer heat stress and phytophthora root rot, requiring well-drained soils with high organic matter and partial shade typical of their natural growing environments to thrive.

To determine which species may be better adapted to typical container nursery production practices in the Mid-Atlantic and to evaluate whether partial shade is required to reduce summer heat stress, trials were established to evaluate nine different species of native azaleas, including *R. arborescens, R. atlanticum, R. austrinum, R. canescens, R. cumberlandense, R. flammeum, R. periclymenoides, R. prunifolium,* and *R. vaseyi.* grown in both full sun and 50% shade conditions (Figure 1).

R. arborescens, also known as smooth azalea, grows best in full sun to partial shade with moist but well-drained soil. It can grow to a height of 8 to 12 feet and spreads by underground runners. It has fragrant flowers that may be pink, yellow, or white and attract pollinating insects and hummingbirds during the early summer, as well as foliage that turns red, orange, and purple in the fall (NC State, n.d.). In its native environment, *R. arborescens* can be found along stream banks, on Appalachian balds, and in moist woodlands throughout West Virginia, Tennessee, North Carolina, Georgia, and Alabama (McDonald, 2001).

R. atlanticum, the coastal azalea, is a compact species that typically grows to 3 feet tall and wide. It grows best in full sun to partial shade with well drained soils that are consistently moist. It can spread by stolons and produces fragrant flowers. At the northern end of its native range, New Jersey may be well adapted for *R. atlanticum,* especially as climate change causes its southern range to move northward. *R. atlanticum* crosses readily with other species and is used in breeding programs developing hybrid azaleas, which could increase the suitability of other species to the Mid-Atlantic region. This species is also regarded as having notable drought tolerance (Harris et al., 2021). As a coastal species, *R. atlanticum* may be threatened by development and increased deer pressure in densely populated areas, so increasing its use as an ornamental landscape species may contribute to its preservation.

R. austrinum, the Florida azalea, can grow to 8 feet tall and wide and has a southern native range that includes the Florida panhandle, Georgia, Alabama, and Mississippi. Partial shade that protects the plants from afternoon sun is ideal, along with moist, but well-drained soils (NC State, n.d.).

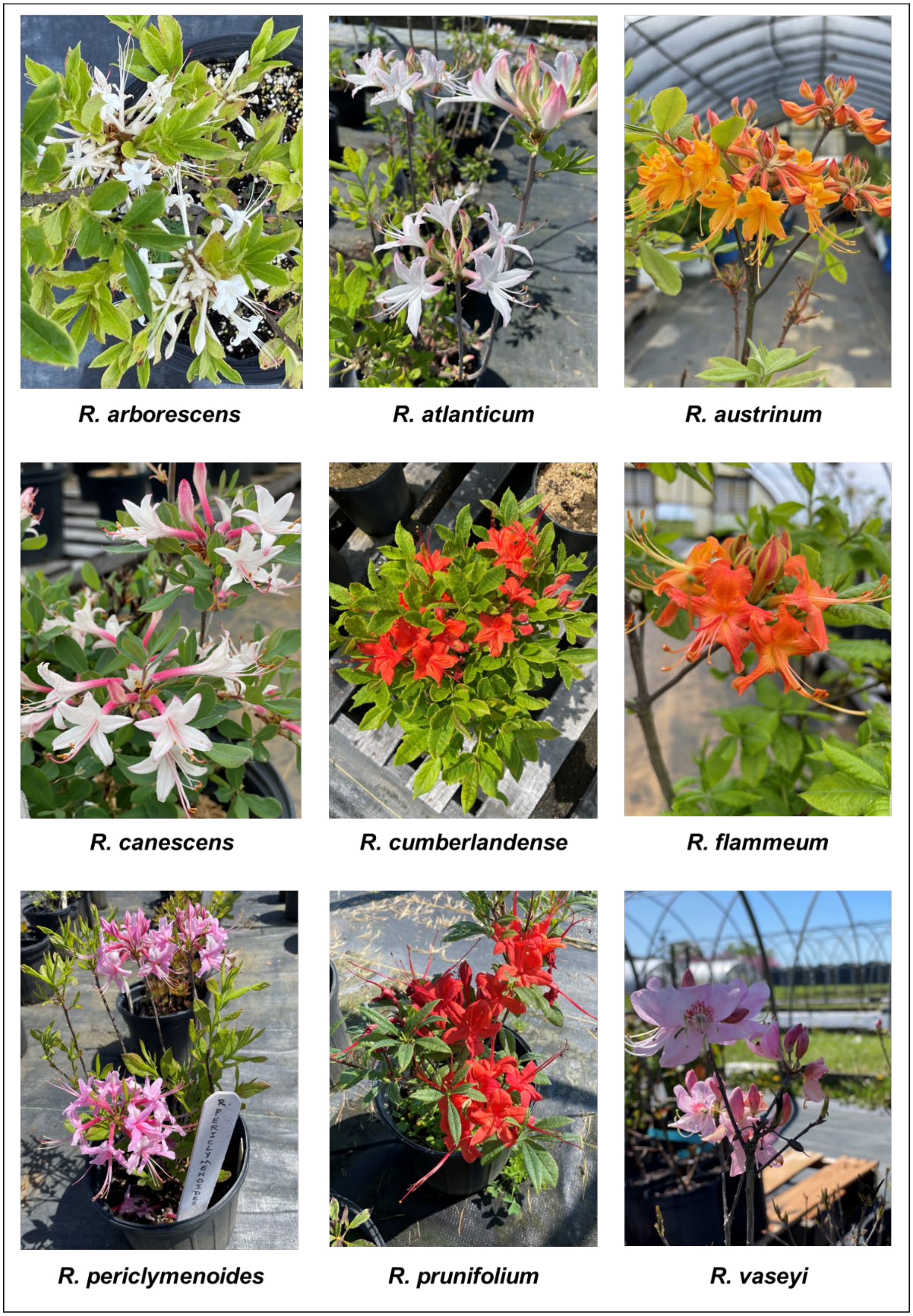

Figure 1. Nine species of native azaleas (*Rhododendron* spp.) were evaluated for growth and flowering under full sun or 50% shade at the Rutgers Specialty Crop Research and Extension Center, Cream Ridge, NJ, during year three of container production. Open flowers for each species shown at or approaching full bloom.

R. canescens, the piedmont azalea, is hardy to zone 5 and can be found throughout the southeastern United States, from Illinois and North Carolina south to Texas and Florida (McDonald, 2001). It grows 6 to 8 feet tall and produces pink and white flowers. In its natural environment, *R. canescens* is found growing along stream banks, in the forest understory, or in clearings, requiring well drained soils that remain moist and partial shade. Leaves from this species will turn burgundy red in the fall (NC State, n.d.).

R. cumberlandense, the Cumberland azalea, is a southeastern species that grows along the Cumberland Plateau, ranging from Kentucky to Tennessee, North Carolina, Alabama, and Georgia (McDonald, 2001). It can grow up to 7 feet tall with a similar spread and has orange flowers. *R. cumberlandense* is reported to thrive in full sun in northern climates and prefer partial shade in more southern locations (NC State, n.d.).

R. flammeum, also known as the Oconee azalea, is generally regarded as a more heat and drought tolerant species that grows in Georgia and South Carolina in upland woods and slopes (NYBG, 2024). It can grow 6 to 8 feet tall and wide and produces excellent orange, yellow, and red flowers.

R. periclymenoides, the pinxterbloom azalea, is a woodland understory species that grows up to 6 feet tall in upland woods, slopes, and stream banks. It is a naturally more northern adapted species, growing from Vermont and Massachusetts southwest to Tennessee and along the Atlantic Coastal Plain south to Georgia (McDonald, 2001). There is high population density and increased development in its native range, especially in coastal areas, *R. periclymenoides* is becoming less frequent in its natural habitat (McDonald, 2001).

R. prunifolium, commonly known as the plumleaf azalea, has a small natural range along the border of Georgia and Alabama, and due to its rarity *R. prunifolium* is being considered for the Endangered Species List (Jenkins, 2021). It is found growing along stream banks and in pine-hardwood forests (McDonald, 2001). This species can grow 8 to 12 feet tall and prefers partial shade that protects from the afternoon sun (NC State, n.d.).

R. vaseyi, the pinkshell azalea, is quite rare in the wild, growing in bogs and along stream banks in the Piedmont region of North Carolina (NYBG, 2024). It can grow up to 15 feet tall and produces unique pinkish white flowers that lack the tubular shape of most other native azaleas and have seven to ten stamens instead of five. The leaf shape of *R. vaseyi* is also longer than other species and turns deep red, burgundy, and purple in the fall, especially in the sun (NC State, n.d.).

The objectives of this study were to evaluate growth, bloom phenology, and summer stress tolerance of nine container grown native azalea species under full sun or 50% shade treatments in Central New Jersey. Growing the plants in full sun contributes to increased light levels and higher temperatures, which may result in abiotic stress. This potential stress was assessed by measuring Normalized Difference Vegetation Index (NDVI). NDVI quantifies stress by using a sensor to measure near-infrared (NIR) and infrared wavelengths of the leaves of the plant and calculating an index based on NIR minus red radiation divided by NIR plus red radiation (Huang et al., 2021; Kriegler, 1969). This NDVI data can be used to estimate chlorophyll concentration in leaves (Pastor-Guzman et al., 2015) and is widely used as an indicator of abiotic stress (Chavez et al., 2016).

Methods

Uniform seed-grown one-year old liners of each of the nine different species of azaleas were obtained from Carolina Native Nursery (Burnsville, NC) and transplanted into one-gallon containers filled with Pro-Mix BK55, containing sphagnum peat moss (25-35%), processed southern pine bark (55%), perlite, limestone, a wetting agent, and starter fertilizer, with a pH range of 5.2 to 6.2 at the Rutgers Specialty Crop Research and Extension Center in Cream Ridge, New Jersey (40.117920 N, -74.519500 W). The plants were potted up into 3-gallon containers at the beginning of the second growing season and were evaluated for two subsequent seasons. Overhead irrigation was applied as needed, to supply approximately 0.5 acre inches per day (Bilderback et al., n.d.) and the plants were fertilized by top dressing with Caliber-cote ® controlled release fertilizer (18 N – 6 P2O5 – 12 K2O) in the beginning of the season, supplemented with Plant Marvel Nutriculture ® General Purpose water-soluble fertilizer (20 N –10 P2O5 – 20 K2O) applied three times during the growing season at a rate of 100 ppm N (Mangiafico and Johnson, 2009). Electroconductivity (EC) was monitored using a Hanna GroLine Direct Soil Conductivity Tester and pH was monitored using a Hanna GroLine pH Tester, remaining within an acceptable range of 5.0 to 6.0 for native azaleas (Harris et al., 2021). Six replicates (n=6) of each species were grown in both full sun and 50 % shade conditions. Growth metrics (Height, Width1, Width2) were measured weekly for each plant during the growing season, where Width1 was measured as the widest part of the plant and Width2 was measured perpendicular to Width1. These measurements were used to calculate the growth index (GI) for each plant [$GI = \pi \times (\text{Average}(W1, W2)/2)^2 \times H$] (Rezazadeh et al., 2015). Cumulative open flower counts and flowering dates were measured weekly per plant during year three and compared across full sun and 50% shade treatments. Normalized difference vegetation index (NDVI) data was collected as a measure of plant health, to evaluate the degree of stress that was induced by exposing each species to full sun conditions relative to 50% shade. NDVI was measured weekly by using a PlantPen NDVI 310 handheld NDVI meter (Photon Systems Instruments, Drásov, Czech Republic) (Hlavinka et al., 2013) to take readings from four young, fully expanded leaves per plant in full sun and 50% shade conditions.

Statistical analyses for NDVI and GI were determined using analysis of variance according to the general linear model procedure of SAS (version 9.4; SAS institute, Cary, NC, USA). A Shapiro-Wilk test was used to confirm normality of the data and differences between the means were distinguished by Fisher’s protected least significant difference (LSD) test at $p \leq 0.05$. Mean cumulative open flower comparisons, per species per light level treatment, were conducted with an independent samples *T*-test (Jamovi Project (version 2.5)). Homogeneity of Variance (Levene’s) was checked prior to statistical analysis (Fox and Weisberg, 2020).

Results

Growth index

Six of the nine species demonstrated a higher GI when grown under 50% shade, relative to full sun. *R. arborescens, R. atlanticum, R. canescens, R. flammeum, R. periclymenoides,* and *R. vaseyi* all put on more growth when produced in 50% shade. *R. austrinum, R. cumberlandense*, and *R. prunifolium* did not exhibit significant differences in GI when grown in full sun or 50% shade. *R. atlanticum* grown in 50% shade put on the most growth, followed by shade-grown *R. arborescens,* while *R. prunifolium* plants were the smallest of the nine species after 3 years of production (2024) (Table 1; Figure 2).

Table 1. Growth index (GI) [GI = π x (Average (W1, W2)/2)^2 x H] of nine native species of azaleas (*Rhododendron spp.*) grown in 3-gallon containers in full sun or 50% shade after three years of growth. Comparisons of GI were made for each treatment individually amongst species and combined treatments per species. (Letters per column identify means separation, dissimilar letters indicate significance at *p*≤0.05, * indicates significant difference between treatments per species per row at *p*≤0.05)

***Rhododendron* spp.**	**Treatment**	**Mean GI**	*Means Separation*		
			Full Sun	***50% Shade***	***Full Sun + 50% Shade***
R. arborescens	Full Sun	0.064	CD	-	FGHI *
	50% Shade	0.147	-	AB	AB *
R. atlanticum	Full Sun	0.122	A	-	BCD *
	50% Shade	0.162	-	A	A *
R. austrinum	Full Sun	0.057	CD	-	GHI
	50% Shade	0.089	-	DE	DEFG
R. canescens	Full Sun	0.074	BC	-	EFGHI *
	50% Shade	0.138	-	ABC	ABC *
R. cumberlandense	Full Sun	0.067	BCD	-	FGHI
	50% Shade	0.087	-	DE	DEFGH
R. flammeum	Full Sun	0.097	AB	-	DEF *
	50% Shade	0.123	-	ABCD	BCD *
R. periclymenoides	Full Sun	0.052	CD	-	GHI *
	50% Shade	0.111	-	BCD	BCDE *
R. prunifolium	Full Sun	0.037	D	-	I
	50% Shade	0.049	-	E	GHI
R. vaseyi	Full Sun	0.067	BCD	-	FGHI *
	50% Shade	0.101	-	CD	CDEF *
			LSD = 0.0327	*LSD = 0.0433*	*LSD = 0.0389*

Figure 2: *Rhododendron arborescens* grown in 50% shade (two plants on right) had an increased Growth Index (GI) as compared to full sun treated plants (two plants on left).

Bloom phenology and cumulative open flower counts

All species produced flowers by the third year of production. *R. periclymenoides* and *R. vaseyi* were the earliest bloomers, starting the last week of April and continuing through mid-May. *R. atlanticum*, *R. austrinum*, *R. canescens*, and *R. flammeum* all had their blooms concentrated in May, while *R.* cumberlandense started blooming in mid-May and continued through mid-June. The latest bloomers were *R. arborescens* (mid-June through early-July) and *R. prunifolium* (early through late-July) (Figure 3). Most species bloomed for three weeks, with peak blooms produced in the second week of the bloom period. *R. periclymenoides* and *R. prunifolium* each bloomed for four weeks. *R. atlanticum* was the most prolific bloomer, followed by *R. cumberlandense, R. canescens,* and *R. arborescens*, respectively. *R. prunifolium* and *R. vaseyi* produced the fewest average blooms per plant. There was no significant difference in cumulative open flower counts between plants grown in 50% shade or full sun, except for *R. prunifolium* that produced significantly more flowers in 50% shade (p=0.003) (Table 2).

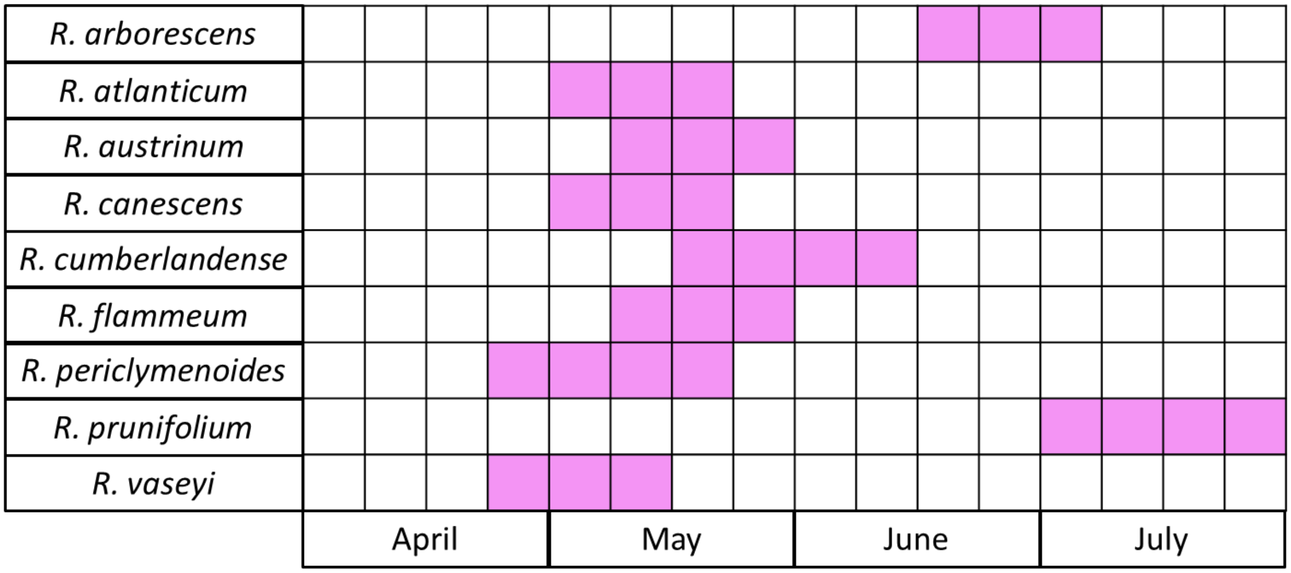

Figure 3: Bloom times for native azaleas (*Rhododendron spp.*) lasted from late April though the end of July, with the most species blooming during the month of May during 2024.

Table 2. Mean cumulative open flowers per native azalea (*Rhododendron spp.*) grown in full sun or 50% shade during the third year of production (2024). Treatments not sharing same letter(s) within each species row are statistically different ($p<0.05$).

Rhododendron Species	**Treatment**	**Open Flowers**	***p value***
R. arborescens	Full Sun 50% Shade	39.0 a 48.3 a	0.708
R. atlanticum	Full Sun 50% Shade	98.3 a 83.8 a	0.367
R. austrinum	Full Sun 50% Shade	23.8 a 34.8 a	0.497
R. canescens	Full Sun 50% Shade	61.5 a 69.7 a	0.816
R. cumberlandense	Full Sun 50% Shade	58.7 a 57.7 a	0.948
R. flammeum	Full Sun 50% Shade	28.3 a 23.5 a	0.644
R. periclymenoides	Full Sun 50% Shade	11.0 a 20.7 a	0.121
R. prunifolium	Full Sun 50% Shade	9.5 **b** 18.7 **a**	0.003*
R. vaseyi	Full Sun 50% Shade	14.0 a 10.7 a	0.481

NDVI (Normalized Difference Vegetation Index)

NDVI was reduced in seven out of the nine species for at least one of the weekly sampling dates when they were exposed to full sun conditions in comparison to 50% shade, indicating a higher degree of plant stress. *R. arborescens, R. atlanticum, R. cumberlandense, R., flammeum, R. periclymenoides,* and *R. prunifolium* all demonstrated higher NDVI for several weeks during the growing season when grown in 50% shade. *R. canescens* grown in full sun only had reduced NDVI for one week, while *R. vaseyi* did not exhibit differences in NDVI, and *R. austrinum* had higher NDVI on two dates when grown in full sun (Figure 6).

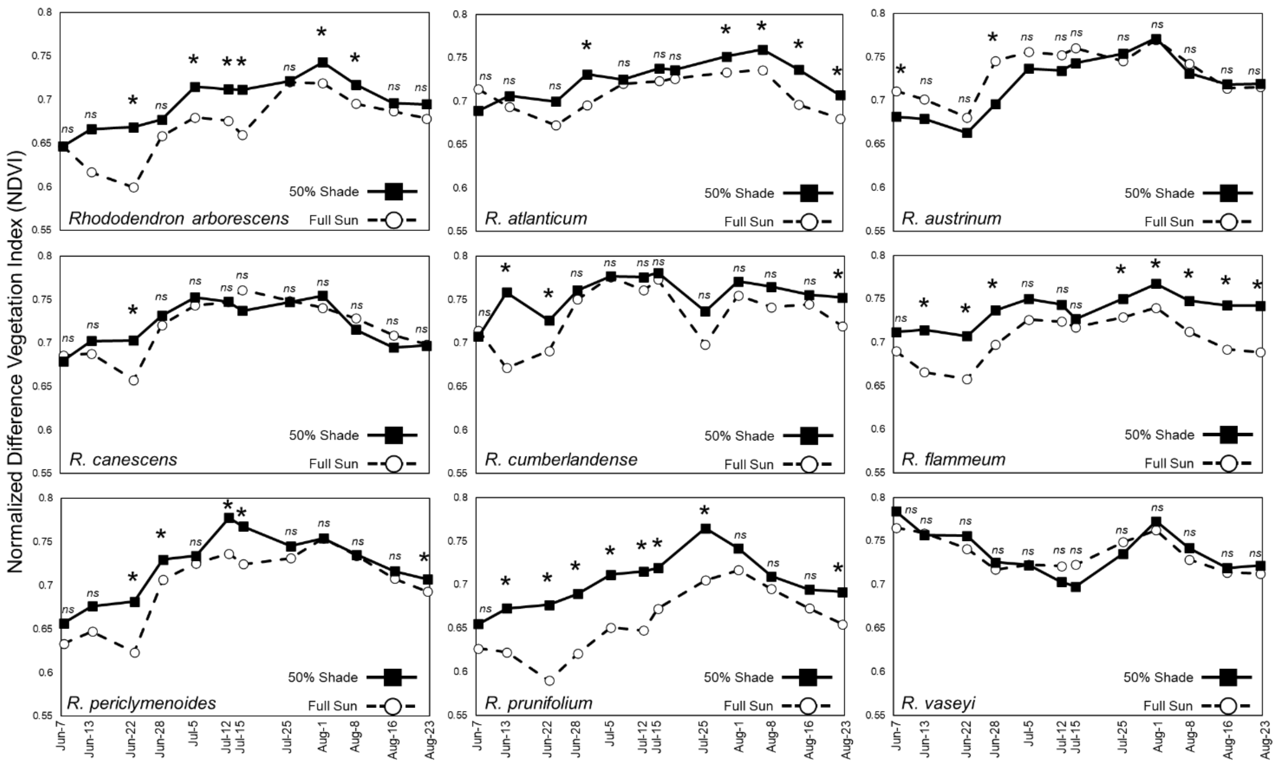

Figure 6: Normalized difference vegetation index (NDVI) for nine species of native azaleas (*Rhododendron* spp.) were collected with a PlantPen NDVI 310 handheld NDVI meter (Photon Systems Instruments, Drásov, Czech Republic) and compared weekly during the third year of growth (2024), in both full sun and 50% shade treatments. Note; NDVI is a measure of plant health, the significant treatment with the greatest NDVI value per time point indicates the greatest chlorophyll concentration in leaves, thus healthier tissues. (* indicates significant difference at $p \leq 0.05$ per time point)

Discussion

The species of native azaleas evaluated in this trial produced saleable 3-gallon plants by the end of their second year and bloomed in their third year, suggesting that these species have potential for ornamental production in the Mid-Atlantic. Generally, these species when grown in 50% shade had greater NDVI and GI values, and consistent cumulative open flower counts, indicating that plants grown under 50% shade are not detrimentally impacted. Rather, in some species, performed better than their full sun treatment counterparts across specific metrics. *R. arborescens, R. atlanticum, R. canescens, R. flammeum, R. periclymenoides,* and *R. vaseyi* all exhibited significantly higher GI and *R. prunifolium* produced significantly more flowers when grown in 50% shade. Reductions in NDVI, suggesting abiotic stress, were also noted in seven of the nine species evaluated when grown in full sun, including *R. arborescens, R. atlanticum, R. canescens, R. cumberlandense, R., flammeum, R. periclymenoides,* and *R. prunifolium.* Overall, *R. atlanticum* performed better than others, especially when grown in 50% shade, putting on more growth and producing more blooms under the given production practices. Developing a better understanding of the native growing conditions of each specific species may help to inform best management practices for producing container-grown native azaleas as each species grows in a different natural environment.

R. arborescens performed well in this trial, especially when grown in 50% shade, as significant growth reduction occurred when grown in full sun. It produced some of the highest average blooms per plant and was the second latest blooming species, which can help to extend the sales season for retail nurseries and providing for a longer azalea bloom season in the landscape when combined with other species in a mixed planting. NDVI levels for *R. arborescens* were higher in plants grown in 50% shade for 6 of the 12 weeks measured during the growing season, suggesting a degree of abiotic stress was experienced by this species when grown in full sun.

R. atlanticum has a native range that extends from the coastal plain of New Jersey to Pennsylvania and south to Georgia (McDonald, 2001; NC State, n.d.), which may be why this species was the top performer in these trials, having the highest GI and the greatest number of blooms. Overall growth and NDVI values for 5 out of 12 weeks were reduced when plants were grown in full sun, particularly from late July through August, indicating that summer heat stress may impact *R. atlanticum* later in the season, especially as average temperatures continue to increase in the Mid-Atlantic.

R. austrinum, a southern adapted species, performed well during the summer stress of Central New Jersey and showed less impacts on growth and NDVI than some other species grown in full sun. *R. austrinum* was also the only species to demonstrate higher NDVI on two dates early in the season when grown in full sun, suggesting that it may have a degree of heat stress tolerance that enables it to endure the summers of the Mid-Atlantic region.

R. canescens, when grown in full sun, demonstrated reductions in growth relative to 50% shade, but its NDVI levels were only reduced on one date early in the season, suggesting that *R. canescens* grown in northern regions may be able to tolerate more sun than some other species, though it may result in a reduced growth habit or slower growth. This species started blooming in early May and continued for 3 weeks in the Mid-Atlantic trials with comparable bloom counts across light level treatments.

R. cumberlandense were the third latest to bloom in this trial, lasting four weeks, from mid-May through mid-June. The plants grown in this trial did experience some reductions in NDVI on three dates when grown in full sun, though GI and total blooms were not affected. Given the increasing high summer temperatures experienced in the Mid-Atlantic, this species will likely still benefit from partial shade, especially in the afternoon.

R. flammeum bloomed throughout May in this trial. *R. flammeum* showed significant reductions in NDVI in 8 out of 12 weeks when grown in full sun conditions and reductions in growth, suggesting at least some degree of stress was experienced in full sun, and that partial shade is the optimum growing environment even in the Mid-Atlantic. Given its orange showy blooms, *R. flammeum* may be a strong option for increased ornamental production in northern regions, especially as wild populations have seen a decline in Georgia due to encroaching suburbs surrounding the city of Atlanta (McDonald, 2001).

R. periclymenoides was the first to bloom, producing pink flowers the last week of April that continued through May in this trial. This species grew better in 50% shade as indicated by a significantly higher growth index and higher number of blooms in shade-grown plants. NDVI was also higher for shade grown plants on four dates through July, suggesting that this northern adapted species may be more sensitive to summer stress than some of the southern species, especially as climate zones shift northward.

R. prunifolium was the latest blooming species in this trial, producing orange/red flowers throughout the month of July. The late flowers may be a beneficial trait for nurseries or landscapes looking to extend their azalea blooming season and offer a pollen and nectar source to pollinators when other species of azalea are not in flower. *R. prunifolium* demonstrated significant reductions in NDVI in 8 out of 12 weeks when grown in full sun, suggesting that this species will perform best in partial shade. This was also the slowest growing species in the trial, producing the smallest plants after three seasons of growth. However, the plants were still of a saleable size, and their late blooms may increase their sales later in the season. Because of its rarity and limited distribution in the wild, *R. prunifolium* is being considered for the Endangered Species List (Jenkins, 2021), thus nurseries may want to consider growing this species commercially to help ensure its continued existence in the American landscape.

R. vaseyi was one of the first species to bloom in this trial, starting the last week in April and continuing through mid-May. NDVI values were similar for plants grown in full sun and 50% shade, and blooms comparable for both treatments though some reduction in growth was observed when they were grown in full sun. The leaf shape of *R. vaseyi* is also longer than other species and turns deep red, burgundy, and purple in the fall, especially in the sun, which may be of particular interest for ornamental growers.

While there are limited studies focusing specifically on container production of native azaleas, previous work on non-native evergreen azaleas has demonstrated 163% greater above-ground biomass characterized by increases in leaf, stem, and shoot dry weight, as well as a greater number of flowers when the plants were grown under 50% shade compared to full sun (Henning et al, 2012). Andersen et al. (1991) similarly found that *Rhododendron* × ‘Pink Ruffles’ grown in full sun were chlorotic and dwarfed, with reduced leaf, stem and, root dry weights and reduced chlorophyll concentrations relative to plants grown in varying degrees of shade. The sun-grown Pink Ruffles also failed to grow one year after they were transplanted into the field. Plants grown in 29% and 53% shade demonstrated the best performance, however, too much shade also detrimentally impacted the plants, as those grown under 71% shade did not exhibit a desirable compact growth habit. Driskill (2018) similarly reports success growing native azaleas commercially using 30% shade. While a general recommendation of 30-50% shade for producing container-grown native azaleas may be sufficient, future studies evaluating the physiological effects of varying degrees of shade specific to individual species may help to reduce summer stress and optimize best management production practices. Driskill (2018) has published production methods for native azaleas that have been successful in a commercial operation. These protocols can serve as a starting point for other growers who may be interested in producing native azaleas.

Conclusion

This preliminary trial evaluated nine species of azaleas native to the Eastern United States for commercial container production using standard nursery practices. All species in the trial have potential for increased ornamental production in the Mid-Atlantic. Most species performed better in 50% shade, resulting in greater GI and NDVI, without reducing blooms, though several species appeared to be less affected by full sun exposure. *R. atlanticum* was the top performer in the trial and may be a good recommendation for growers who are interested in starting to produce native azaleas using standard growing practices. Future work focusing on additional species, optimizing substrates, fertilizer types and amounts, irrigation methods and frequency, and propagation protocols for each species should be conducted to produce high quality native azalea plants more efficiently for the ornamental horticulture market. Cost analyses and enterprise budgets should also be investigated to determine the economic feasibility and price points for commercial production. Survey data on consumer preferences and willingness to purchase native azaleas could also support nurseries in making decisions about production and marketing of native azaleas.

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