What's Cookin' with Southern Rhododendrons?©

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INTRODUCTION

Root rot caused by the invasive soil fungus *Phytophthora cinnamomi* is a major source of mortality in *Rhododendron* and many other popular ornamental genera (Benson and Broembsen, 2001). The pathogen may also restrict the natural occurrence or horticultural use of *Rhododendron* species and cultivars in the Southern USA. *Phytophthora cinnamomi* is more problematic in warmer climates because it is susceptible to frost and thrives in warm, wet soils (Brasier, 1996; Marcais et al., 1996). Epidemiologists predict that global warming will increase both the activity and northward migration of the pathogen (Anderson et al., 2004; Bergot et al., 2004).

Genetically-conferred host resistance to *P. cinnamomi* offers an additional and sustainable method of disease management in additional to existing cultural and chemical controls. Among some *Rhododendron* subgenera — notably *Tsutsusi* (evergreen azaleas) — resistance is found at relatively high frequency (Benson, 1980), which may explain why this group of plants thrives in the warmer regions of the USA (e.g., the Gulf South). In contrast, resistance among large-leafed, elepidote rhododendrons (subgenus *Hymenanthes*) occurs at less than 3% frequency (Hoitink and Schmitthenner, 1974; Krebs and Wilson, 2002), and garden use of this group is restricted to more northern, cooler regions of the USA. A notable exception is the elepidote species *R. hyperythrum* from Taiwan — it is resistant to root rot and both the species and hybrids derived from it perform well in southern Louisiana (Thornton, 1990).

Recently, a new breed of rhododendrons has been introduced with the potential to overcome some of the limitations posed by root rot disease and warm climates to successful plant culture. Plant Development Services, Inc. has introduced five *R. hyperythrum* hybrids from Dr. John Thornton's Louisiana breeding program (www.azaleachapter.com/gulf_south.htm) into their Southern Living Plant Collection® under the Southgate™ brand. These rhododendrons have novel heat tolerance and are targeted for U.S.D.A. hardiness Zones 6-9. Because *R. hyperythrum* is also known to be resistant to *P. cinnamomi*, it is possible that the hybrids derived from it have some resistance. However, formal tests of root rot resistance were not part of the original field evaluations conducted by Dr. Thornton.

A rhododendron breeding program for root rot disease resistance was started at The Holden Arboretum in the late 1990s, with the goal of producing plants that were easier to grow for both producers and consumers. At that time, heat tolerance was not an objective, and the breeding strategy was based on transferring resistance from a small group of cold-hardy, resistant cultivars to a broader ornamental group of plants (Krebs and Wilson, 2002). However, the cultivar parent material proved to be marginally effective in producing the desired results, primarily due to sterility in some cultivars, poor breeding value for the resistance trait in others, or poor offspring (F_1) quality. By 2005, the main source of resistance for breeding shifted from rhododendron cultivars to the species *R. hyperythrum*, primarily due to the success of the Thornton hybrids in the USA. Gulf South, and the realization that the heat tolerance trait was commercially more valuable than root rot resistance because of the potential for an expanded geographic market. The association of heat tolerance and disease resistance in *R. hyperythrum* suggests that they may be functionally interdependent traits. Our working hypothesis for the breeding program maintains that disease resistance is a key component of heat tolerance (because *P. cinnamomi* pressure increases in warm, wet conditions) and that root rot resistant rhododendrons are more adapted to southern climates.

RESISTANCE BREEDING WITH *RHODODENDRON HYPERYTHRUM*

Although it is native to Taiwan, *R. hyperythrum* occurs at high enough elevations [1000-2000 m (3281-6562 ft)] to be considered a hardiness Zone 6 species (Cox, 1990). At Holden Arboretum's David G Leach Research Station in Madison, Ohio (Zone 5b), *R. hyperythrum* grows well in the field but exhibits some flower bud damage at winter temperatures below -13°C (8°F). In addition to root rot resistance, this species possesses a number of desirable ornamental attributes — thick, deep green glossy foliage, a mounded, dense growth habit, and a floriferous nature. It frequently covers its foliage with blooms, more like an evergreen azalea than a typical rhododendron (Fig. 1).


Fig. 1. Vegetative (left) and floral (right) characteristics of *Rhododendron hyperythrum.*

The tendency to set a high number of flower buds is due to an unusually high number of axillary shoots or "breaks" that are formed below the current year's flowers. This also helps maintain a dense habit. Flower color in *R. hyperythrum* is invariably pink in bud opening to white, and the inflorescence or "truss" is usually somewhat open or lax due to long peduncles.

The main breeding strategy with *R. hyperythrum* has been to cross it with cultivars that have more cold hardiness, more saturated flower colors (pink, red, purple, and yellow), and a well-formed inflorescence (typically a ball-shaped or pyramidal truss). However, this usually means crossing the species with a plant that is susceptible to root rot, because there are very few resistant, hardy cultivars with deep flower colors (Hoitink and Schmitthenner, 1974; Krebs and Wilson, 2002). Fortunately, another key attribute of *R. hyperythrum* is its high breeding value, an ability to transmit a high level of root rot resistance to F_1 progeny in a resistant × susceptible cross. Numerous breeding experiments using disease screens have demonstrated large average gains in resistance in F_1 progeny compared to the susceptible parent (Fig. 2). Large single generation gains are important in woody plant breeding because the time from seed to flowering can be prolonged (average of 4 years in rhododendrons).

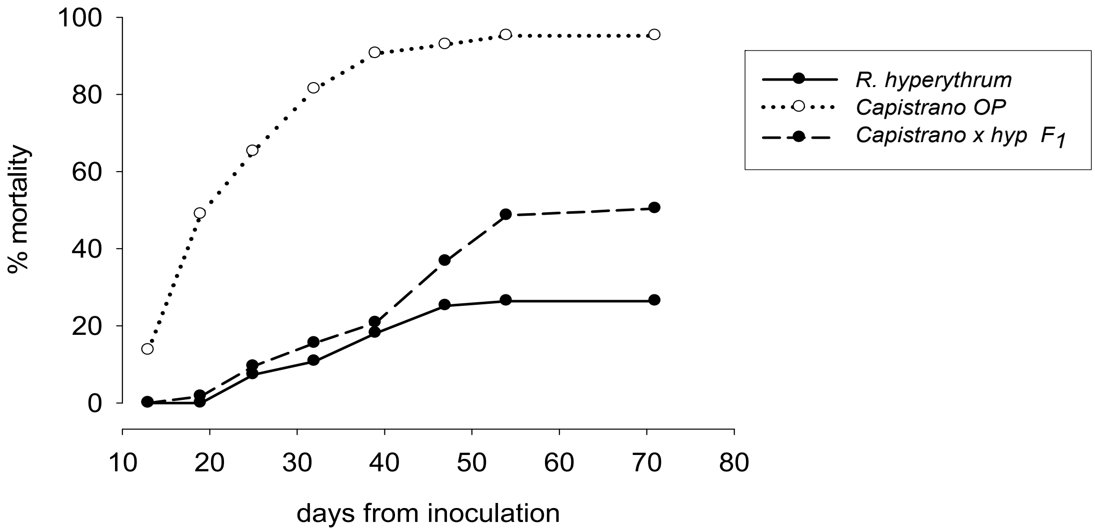

Fig. 2. Disease progress plots resulting from inoculations of *R.* 'Capistrano' open-pollinated seedlings (S=susceptible seed parent), *R. hyperythrum* species seedlings (R=resistant parent), and F_1 seedlings from the cross *R.* 'Capistrano' × *R. hyperythrum*. The plots are used to calculate the area under each curve (AUC), and gain from selection is estimated as $[AUC_S - AUC_{F1}] / [AUC_S - AUC_R] * 100 = 83\%$ in this example.

Some very high quality plants have been obtained among the variable F_1 progeny. Selection at the Madison, Ohio, site is made for plants that have good vigor and foliage quality in the open field, winter hardiness (U.S.D.A. hardiness Zone 5b), and well-shaped inflorescences with good flower color. Flower color and patterning in F_1s from white × red, white × yellow, or white × purple crosses is variable, often ranging from white, to intermediate colors, to occasional saturated colors. Examples of superior flowers from these populations are shown in Figure 3. Characteristics of an exceptional hybrid include a dense mounded habit, dark green glossy foliage, and saturated red flower color that are most desirable in a commercial plant (Fig. 4).

Fig. 3. Floral attributes of F_1 selections from *Rhododendron hyperythrum* breeding populations.

Fig. 4. An example of an F_1 selection with superior floral and vegetative attributes.

STRESS TESTS ON *RHODODENDRON HYPERYTHRUM*

While greenhouse breeding combined with controlled *P. cinnamomi* inoculations can be used to identify and select for root rot resistance progeny, the actual field resistance of these individuals may vary once planted outside. Abiotic stresses such as salinity, ozone, and extremes of temperature or moisture can predispose plants to disease and reduce resistance. In rhododendrons, for example, it was demonstrated that pre-stressing the resistant cultivar *R*. 'Caroline' with drought or flooding and subsequently inoculating with *P. cinnamomi* resulted in high susceptibility to root rot disease (Blaker and MacDonald, 1981). Similarly, resistant chrysanthemums were rendered more susceptible to root rot by exposing their roots to higher soil temperatures prior to inoculation (MacDonald, 1991).

In 2011, we completed a field flooding trial of rhododendrons that included root rot susceptible checks, several resistant cultivars (benchmarks), *R. hyperythrum*, and a group of *R. hyperythrum* derivatives (F_1s) that included the SouthGate™ cultivars. The plants were exposed to repeat flooding and draining episodes throughout one field season, All the resistant benchmark cultivars were dead or severely diseased by the end of the season, while the species *R. hyperythrum* and all of its hybrids survived. However, they exhibited more disease than under non-flooding conditions (Krebs, 2013). Presence of *P. cinnamomi* in symptomatic tissue was confirmed at the end of the field trial. The key finding from this work was that *R. hyperythrum* is significantly less predisposed to root rot disease under flooding conditions (compared to resistant plants, including *R*. 'Caroline', that lack *R. hyperythrum* in their genetic background), and that this trait is heritable and can be transmitted to offspring in a breeding program. This is a valuable characteristic for field growers of rhododendrons and for consumers who often plant into poorly drained soils around their homes.

The predisposing effect of heat stress on root rot disease in rhododendrons is in the process of being determined both in the greenhouse and in the field. In the greenhouse experiment, the root systems of pot-grown plants are immersed in a hot water bath set at a target temperature (30 min exposure), then cooled down, inoculated, and assessed for symptoms over a 2-3 month period.

Treatment temperatures ranged from 25-30°C (77-86°F), which span values relevant to hardiness Zone 8 maximum summer soil temperatures [≈40°C (104°F)] or black container mixes exposed to summer sun [≈50°C (122°F)]. Preliminary data from this experiment suggest that *R. hyperythrum* is less predisposed to root rot disease by heat stress than the resistant cultivar *R*. 'Ingrid Mehlquist', which lacks *R. hyperythrum* in its genetic background.

Additional information on heat stress and disease will be obtained from a field trial of F_1 selections in southern Louisiana managed by Buddy Lee (Plant Development Services, Inc.). Over 160 selections from the Ohio breeding program were propagated and planted in a replicated, randomized trial in Spring 2013. At this time (Fall 2013) there has already been some mortality among plants, and by the end of the 2nd year of southern exposure (Fall 2014), there may be enough information to identify the superior performers and set them on track for commercial introduction. The field being used is an old nursery site, so it is highly likely that *P. cinnamomi* is present. This can be confirmed by isolating the pathogen from symptomatic tissue on affected plants. The results from the Louisiana field trial may also provide a test of our original hypothesis that disease resistance (to root rot in this instance) is a key component of heat tolerance and warm climate adaptation in plants. Because the F_1 progeny vary in resistance, their performance in hardiness zone 8 may vary accordingly. If our hypothesis is correct, the best performing plants in those conditions will also be the most resistant to root-rot disease.

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