

Resistance of Evergreen Hybrid Azaleas to Root Rot Caused by *Phytophthora cinnamomi*

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ABSTRACT

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Of 73 evergreen azalea cultivars in 10 hybrid groups evaluated for resistance to root rot caused by *Phytophthora cinnamomi*, 20 were rated resistant, 25 were rated moderately resistant, and 28 had severe root rot. The hybrid groups, in order of increasing susceptibility, were Indian, Rutherford, Pericat, Glenn Dale, Whitewater, Satsuki, Back Acres, Gable, Kurume, and NCSU.

Root rot caused by *Phytophthora cinnamomi* is a major disease of evergreen hybrid azaleas (*Rhododendron* spp.) in nurseries and landscape plantings in North Carolina (1). Symptoms include chlorosis of the foliage, stunting, wilting, general low vigor, and root necrosis. Infected plants in landscape plantings may decline over a period of years or develop a "sudden death" syndrome. At present, no single control measure is available for *P. cinnamomi*; rather, disease prevention through sanitary, cultural (5), and chemical measures (1) is recommended. Azalea breeders select cultivars for early season flowering, flower color, growth habit, and winter hardiness and pay little attention to disease resistance (6). Although information is not available on cultivar resistance to *Phytophthora* root rot, Hoitink and Schmitthenner (4) reported on resistance of hybrid rhododendrons to *P. cinnamomi*. We evaluated the resistance of hardy- and forcing-type evergreen azaleas in the Back Acres, Gable, Glenn Dale, Indian, Kurume, Pericat, Rutherford, Satsuki, and Whitewater hybrid groups and in the newly released NCSU hybrids.

MATERIALS AND METHODS

Azalea cultivars were propagated from specimen plants at the Horticulture Farm, North Carolina State University, Raleigh, and from stock plants maintained in the Department of Plant Pathology.

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on proportionator.

One isolate of *P. cinnamomi* (A² mating type) from rhododendron in Ohio (supplied by H. A. J. Hoitink) and five isolates including 101 (1) from rhododendron and azalea in North Carolina (all A² mating type) were used as inoculum. Isolates were cultured singly for 30 days on autoclaved oat grains, then combined and mixed by hand. Three weeks after plants were transplanted, 30 gr of inoculum was placed in each of two holes around the edge of the plant root ball at a depth of 2-4 cm below the soil surface.

All pots were placed in saucers containing water to maintain moisture in the potting medium near field capacity. After 4 mo, root rot severity was determined by assigning a rating to each plant: 1 = healthy roots, 2 = fine roots

Plants (7-10 mo old) grown in peat-perlite (1:1, v/v) were transplanted into 15-cm diameter pots containing sand-soil-peat (1:1:1, v/v/v) with 3.8 kg/m³ lime and superphosphate. Final pH was 5.0. Plants were arranged in a randomized complete block design in the greenhouse. A 21-7-7 (N-P-K) liquid fertilizer (Robert B. Peters, Allentown, PA) at a rate of 1.8 µg/ml was applied biweekly with a hose-

Table 1. Resistance of azalea cultivars to root rot caused by *Phytophthora cinnamomi*

Cultivar	Hybrid group ^a	Number tested	Root rot rating ^b
Formosa	I	40	1.83 a
Fakir	GD	10	1.90 ab
Corrine Murrah	BA	20	1.90 ab
Merlin	GD	20	2.05 ab
Hampton Beauty	P	20	2.05 ab
Higasa	S	10	2.10 abc
Glacier	GD	10	2.10 abc
Rose Greeley	G	20	2.15 abc
Polar Seas	GD	20	2.15 abc
Redwing	I	30	2.20 abcd
Chimes	I	20	2.20 abcd
Alaska	R	20	2.20 abcd
New White	I	15	2.27 abcde
Shin-ki-gen	S	20	2.30 abcde
Rachel Cunningham	BA	10	2.30 abcde
Pink Gumpo	S	10	2.30 abcde
Eikan	S	10	2.30 abcde
Sweetheart Supreme	P	20	2.35 abcde
Pink Supreme	I	20	2.35 abcde
Morning Glow	K	20	2.35 abcde
Barbara Gail	P	20	2.40 abcdef
White Gumpo	S	20	2.40 abcdef
Rentschler's Rose	W	20	2.45 abcdef
Dorothy Gish	R	20	2.45 abcdef
White Gish	R	20	2.50 abcdefg
Pink Hiawatha	P	20	2.50 abcdefg
Margaret Douglas	BA	20	2.50 abcdefg
Gaiety	GD	10	2.50 abcdefg
Gloria	R	20	2.55 abcdefg
Kingfisher	W	19	2.56 abcdefgh
White Christmas	W	20	2.60 abcdefgh
Sensation	P	20	2.60 abcdefgh
Prince of Orange	I	10	2.60 abcdefgh

(continued on next page)

Table 1. (continued from preceding page)

Cultivar	Hybrid group ^a	Number tested	Root rot rating ^b
White Jade	BA	20	2.70 bcdefgh
Copperman	GD	20	2.70 bcdefgh
Hexe	K	30	2.73 bcdefgh
Massasoit	K	10	2.80 bcdefghi
Martha Hitchcock	GD	10	2.80 bcdefghi
China Seas	G	20	2.80 cdefghi
Warbler	W	20	2.85 cdefghi
California Sunset	I	20	2.85 cdefghi
Amaghosa	S	20	2.85 cdefghi
Pride of Summerville	I	20	2.90 cdefghi
Hinodegiri	K	20	2.90 cdefghi
Flanders Field	P	20	2.90 cdefghi
Robinhood	GD	10	3.00 cdefghij
Hershey Red	K	20	3.00 cdefghij
Herbert	G	10	3.00 cdefghij
Fortune	P	20	3.00 cdefghij
Catawba	GD	10	3.00 cdefghij
Marian Lee	BA	20	3.05 defghij
Snow	K	40	3.08 defghij
Royalty	G	10	3.10 defghijk
Kow-ko-ku	S	20	3.15 efghijk
Rosebud	G	10	3.20 efghijk
Mrs. G. G. Gerbing	I	20	3.20 efghijk
Coral Bells	K	10	3.20 efghijkl
Treasure	GD	10	3.30 fghijkl
Pat Kraft	BA	20	3.30 ghijkl
Saint James	BA	10	3.40 ghijkl
Carror	N	9	3.44 ghijkl
Purple Spendour	G	20	3.50 hijkl
Pinocchio	GD	10	3.50 hijkl
General MacArthur	K	10	3.50 hijkl
Pink Pearl	K	10	3.60 ijkl
Johga	S	10	3.70 ijklm
Sunglow	N	10	3.80 jklm
Hino Crimson	K	10	3.90 klm
Elaine	N	10	4.10 lmn
Emily	N	8	4.25 lmn
Pink Cloud	N	4	4.50 lmn
Adelaide Pope	N	10	4.60 mn
Jane Spaulding	N	7	5.00 n

^aBA = Back Acres, G = Gable, GD = Glenn Dale, I = Indian, K = Kurume, N = NCSU, P = Pericat, R = Rutherford, S = Satsuki, W = Whitewater.

^b1 = healthy roots, 2 = fine roots necrotic, 3 = coarse roots necrotic, 4 = crown rot, 5 = dead plant. Ratings followed by the same letter are not significantly different ($P = 0.05$).

Table 2. Evergreen azalea hybrid group response to root rot caused by *Phytophthora cinnamomi*

Hybrid group	Cultivars tested	Number tested	Root rot rating ^a
Indian	9	195	2.41 a
Rutherford	4	80	2.43 ab
Pericat	7	140	2.54 ab
Glenn Dale	11	140	2.56 ab
Whitewater	4	79	2.62 abc
Satsuki	8	120	2.66 abc
Back Acres	7	120	2.71 bc
Gable	6	90	2.91 cd
Kurume	10	180	3.00 d
NCSU	7	58	4.19 e

^a1 = healthy roots, 2 = fine roots necrotic, 3 = coarse roots necrotic, 4 = crown rot, 5 = dead plant. Ratings followed by the same letter are not significantly different ($P = 0.05$).

necrotic, 3 = coarse roots necrotic, 4 = crown rot, and 5 = dead plant (3). Cultivars usually were replicated 10 or 20 times in inoculated treatments and five times in noninoculated treatments. Experiments were repeated three times, but not all cultivars were available for each experiment.

RESULTS AND DISCUSSION

No azalea cultivar tested was immune from infection by *P. cinnamomi* (Table 1). Hoitink and Schmitthenner (4) reported similar results for hybrid rhododendron. Twenty of the cultivars (27%) were rated resistant (1.83–2.35). These included Formosa, Fakir, and

Corrine Murrah; Formosa, an Indian hybrid, grows quite well in wet planting sites that otherwise would favor root rot development but is not very hardy to cold. The noninoculated cultivars always had root rot ratings of less than 1.5. Twenty-five of the cultivars (34%) were rated moderately resistant (2.4–2.9); on poorly drained planting sites, these cultivars would probably show decline symptoms if infection occurred. Twenty-eight of the cultivars (38%) had severe root rot, ie, ratings of 3 or higher; even on well-drained planting sites, these cultivars would probably show decline symptoms.

When root rot ratings were averaged according to hybrid group, all groups were moderately resistant (2.4–2.9) except the Kurume and NCSU hybrids, which had severe root rot (Table 2). The Kurume hybrids, which include Coral Bells, Hinodegiri, and Snow, are popular among nurserymen because of early-season flowering and winter hardiness. The susceptibility of the Kurume and NCSU hybrids to *P. cinnamomi*, however, indicates a need to include the more resistant cultivars in other hybrid groups in the nursery trade.

Hoitink and Schmitthenner (4) found that 94% of the rhododendron hybrids inoculated (more than 320 hybrids) with *P. cinnamomi* developed severe root rot. Although we tested only 73 of the more than 4,000 described azalea cultivars (6), our results suggest that azalea cultivars vary in susceptibility toward *P. cinnamomi* and that azaleas may be more resistant to *Phytophthora* root rot than rhododendrons.

We tested two azalea species, *Rhododendron poukhanense* Leveille (rating = 1.6) and *R. mucronatum* 'Delaware Valley White' (rating = 2.4). Hoitink and Schmitthenner (4) rated *R. poukhanense* 1.8, using a different type of inoculum (hemp broth cultures). *R. poukhanense* is a vigorous growing and very hardy evergreen plant with good flower qualities (2). Attempts to find more resistant germ plasm among azaleas should concentrate at the species level and then incorporate resistance into acceptable horticultural cultivars.

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