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Diamonds in the Rust: *Ribes* Resistance to White Pine Blister Rust

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Abstract

White pine blister rust (WPBR), *Cronartia ribicola* Fischer, causes economic damage to white pines, *Pinus strobus* L., and infects leaves of some *Ribes* late in the summer after harvest. Susceptible *Ribes* and *Pinus* serve as obligate alternate hosts for this disease. The objective of this study was to determine the response of *Ribes* species and cultivars to WPBR under field conditions at Corvallis, OR, where inoculum is naturally present. In 1995 and 1996, 54 *Ribes* taxa from North and South America, Europe, and Asia, were visually evaluated August through October for the presence of uredia on the abaxial leaf surfaces. Plants with no observable uredia for the duration of the study were considered resistant. WPBR infection varied by year, within taxonomic sections, and between and within species. Uredia of WPBR were present on 22 *Ribes* taxa in one or both years, while 32 others were resistant, i.e., had no uredia. Some of the resistant *Ribes* species were native outside of eastern Russia, which is the native range of the rust. Resistant species may contain new sources of genes for developing additional rust-resistant commercial *Ribes* cultivars. The cultivation of resistant *Ribes* is an alternative to consider where state statutes banning the genus are under review.

Susceptible *Ribes* and *Pinus* serve as obligate alternate hosts for WPBR. White pine has been a valuable timber tree in the United States for the past 200 years and *Ribes*, the genus for currants and gooseberries, has been branded as a "culprit" in the transmission of this disease. The evolution of this heteroecious rust and its two obligate host genera is complex (6). The center of diversity for this rust and the original host genera lies in eastern Russia, from the Urals to the Caucasus Mountains (6). Several epiphytotic rust outbreaks occurred in Europe in the late 1800's (6). By 1900, WPBR had spread through eastern Europe. The first epiphytotic event in the United States occurred in 1906 (8) and, by 1937, the rust was found completely across the northern tier of North America (4). In 1995 and 1996, severe WPBR infection of western white pines, *Pinus monticola* Dougl., in New Mexico is causing some concern (Sutherland, personal communication).

The aeciospores produced by the rust-infected pines are airborn, are viable up to four months, can travel more than 560 km, and can only infect susceptible *Ribes* (1). The teliospores, which are produced by *Ribes* at the end of the summer, can travel about 275 m, and only infect five-needle pines, (1,11). After the federal *Ribes* ban was repealed in 1966 (5), some state regulations required eradication of any *Ribes* within about 300 m (1000 ft) of white pine, or the banning of *Ribes* cultivation. Recently, commercial interest in the production of black currants and other *Ribes* crops is increasing. State regulations which banned *Ribes* are being reviewed, revised, repealed or may not be enforced in some states (5). As of 1997, 17 states (DE, ME, MA, MI, MT, NH, NJ, NY, NC, OH, PA, RI, SC, TN, VT, VA, WV) continue to prohibit or restrict *Ribes*.

Although WPBR kills white pines, the disease is not usually lethal to *Ribes*, where infection is visible after harvest on leaves which are about to abscise. *Ribes* species and cultivars differ in their genetic susceptibility to WPBR (3).

The objective of this study was to determine which *Ribes* species were susceptible to white pine blister rust under field conditions at Corvallis, OR, where inoculum is naturally present. In 1995 and 1996, 54 *Ribes* taxa from North and South America, Europe, and Asia, were

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evaluated in August through October for presence of white pine blister rust. Abaxial leaf surfaces for at least three branches of each accession were visually observed for the presence of uredia. Those clones with no observable uredia for the duration of the study were considered resistant.

Results and Discussion

Climate affects WPBR infection on *Ribes* (1,11). Aeciospores require moisture, either rain or high humidity, to germinate through the stomata on the underside of *Ribes* leaves (11). In 1995, July and August were warm in Corvallis (9). During August, seven days had measurable precipitation for a total of 2.08 cm (9). WPBR uredia were observed on many species and cultivars in mid-August and throughout September 1995. Usually, uredia were first observed on apical leaves of a branch and spread to lower leaves as the summer progressed. In 1996, a hot July was followed by a very warm August (10). During August, only one day had measurable precipitation for a total of 0.35 cm (10) and uredia were not visible. Uredia were visible only on *R. nigrum* L. cvs. Ben Alder and Baldwin

Table 1. *Ribes* species observed in Corvallis, Ore., to host uredia of white pine blister rust (WPBR), *Cronartium ribicola* Fisch.

Species	No. Accessions Evaluated	No. Infected 1995	No. Infected 1996
R. americanum Miller	2	1	0
R. aureum Pursh	3	1	0
R. bracteosum Douglas	2	2	0
R. cruentum Greene	4	1	0
R. curvatum Small	3	1	0
R. cynosbati L.	1	1	0
R. dicantha Pallas	9	4	0
R. divaricatum Douglas	1	1	0
R. echinellum (Coville) Rehder	2	2	0
R. howellii Greene	9	9	1
R. janczewski Pojark	2	2	2
R. laxiflorum Jancz.	10	10	0
R. nigrum L.	83	70	27
R. niveum Lindley	8	1	3
R. oxyacanthoides L.	6	4	1
R. rubrum L.	44	7	0
R. sanguineum Pursh	16	0	1
R. speciosum Pursh	1	1	0
R. valdivianum Phil.	1	1	1
R. viscosissimum Pursh	3	1	0
R. wolfii Rothr.	1	1	0
R. x *nidigrolaria* Bauer	16	2	0

Table 2. *Ribes* species with no observed uredia of white pine blister rust (WPBR), *Cronartium ribicola* Fisher. during 1995 and 1996 in Corvallis, Ore.

Species	No. Accessions Evaluated
R. alpinum L.	3
R. binominatum A.A. Heller	2
R. burejense F. Schmidt	1
R. californicum var *hesperium* (McClatchie) Jepson	1
R. cereum Douglas	3
R. cereum var. *colubrinum* C. Hitchc.	1
R. ciliatum Humb. & Bonpl.	1
R. coloradense Coville	3
R. erythrocarpum Coville & Leiberg	2
R. fasciculatum v. chinensis Maxim.	4
R. glandulosum Grauer	3
R. hirsuta L.	1
R. hirtellum Michaux	1
R. hudsonianum Richards	3
R. komarovii Pojark.	11
R. lacustre (Pers.) Poir.	4
R. leptanthum A. Gray	1
R. maximowiczianum V. Komarov	3
R. menziesii Pursh	2
R. montigenum McClatchie	1
R. odoratum Wendl f.	4
R. orientale Desf.	5
R. pauciflorum Turcz.	1
R. petraeum var. *carpathicum* (C.A. Mey.) Jancz	6
R. quercetorum Greene	1
R. rotundifolium Michaux	2
R. stenocarpum Maxim	1
R. triste Pallas	19
R. uva-crispa L. (*R. grossularia* L.)	49
R. velutinum var. *gooddingii* (M. Peck) C. Hitchc.	2
R. velutinum var. *velutinum* Greene	1
R. watsonianum Koehne	1

by September 15, 1996. Uredia began to develop and the collection was examined for uredia on September 30 through October 5, 1996. Leaf fall (after which WPBR infection does not occur) for much of the collection began shortly thereafter.

Susceptibility to WPBR differed by species and by year (Tables 1, 2). Fewer accessions were infected in 1996 than in 1995, probably because of the dry weather in July and August. Infection ranged from severe, i.e., many uredia on many leaves, to light, i.e., one uredium on one leaf. Species in the section Coroesma, i.e., black currants, varied in susceptibility. More than 84% of the *R. nigrum* L. accessions had leaves covered with uredia during 1995, the wetter year (Table 1, 3). Brennan (3) stated that *R.*

Table 3. Clonally propagated *Ribes* cultivars observed to be infected with uredia of white pine blister rust, *Cronartium ribicola* Fisher. during 1995 or 1996 in Corvallis, Ore.

Black Currants, *Ribes nigrum* L., selections or hybrids.		
Alagan	Goliath	Raven
Amos Black	Golubka open pollinated	RI-82-1/RE
August Reward	Hatton Giant	Royal de Naples
Baldwin	Invigo	Saunders
Barchatnaja	Invincible Giant Prolific	Seabrook's Black
Ben Alder	Jet	Seabrook's Seedling
Ben Lomond	Kantata 50	Silvergieters Zwarte
Ben More	Karlstein Longbunch	Sopiernik
Ben Nevis	Kerry	Stor Klas
Ben Sarek	Kirovchanka	Strata
Black Reward	Laxon	Swedish Black
Black Tony	Laxton's Grape	Tadd
Blackdown	Laxton's Nigger	Tenah
Blacksmith	Laxton's Standard	Tinker
Bogatyr	Lissil	Topsy
Boskoop Giant	Magnus	Tough Champion
Brodtorp	Mopsy	Tsema
Champion	Neosypujastaja open poll.	Viola
Coronation	Noir de Bourgogne	Wassil
Cotswold Cross	Ojebyn	Wellington XXX
Daniel's Black September	Ontario	Westwick Choice
Davidson's Eight	Onyx	Westwick Triumph
Eagle	Otello	
French Black	Pinot Debourksanof	
Red, White and Pink Currants, *R. rubrum* L. selections and hybrids		
Blanka		
Masons		
New York 37		
Primus		
Red Lake		
White Dutch		
Wilder		
Gooseberries and hybrids		
Spinefree (R. oxyacanthoides L.)		
Open Pollinated seedlings of ORUS 6 (*R.* x *nidigrolaria* Bauer)		

Table 4. Clonally propagated *Ribes* cultivars which had no observed uredia of white pine blister rust, *Cronartium ribicola* Fisher. during 1995 and 1996 in Corvallis, Ore.

Black Currants, *Ribes nigrum* L., selections or hybrids unless otherwise noted.	
Ben Tirran	Mendip Cross
Consort	Pilot Aleksandr Mamkin
Coronet	Polar
Crandall (*R. odoratum* Wendl. f.)	Titania
Crusader	Risager
Kosmiczeskaja	RI-82-3/RE
Malvern Cross	Willoughby

Red, White and Pink Currants, *R. rubrum* L. selections and hybrids		
Cascade	Minnesota 71	Rovada
Cherry	Mulka	Rubina
Detvan	London Market	Stanza
Diploma	New York 68	Stevens
Fay	New York 72	Tatran
Gloire de Sablons	Perfection	Viking
Heros	Pomona	Weisse aus Juteborg
Johkeer Van Tets	Portal Ruby	White Currant 1301
Laxton No. 1	Raby Castle	White Imperial
London Market	Rolan	White Pearl
Malling Redstart	Rondom	White Versailles
Minnesota 52	Rosa Hollandische	
Minnesota 69	Rosetta	

Gooseberries. *R. uva-crispa* L. = *R. grossularia* L. selections and hybrids, unless noted.		
Achilles	Hinnomaen Keltainen	O.T. 126
Blood Hound	Houghton	Oregon
Captivator	Hoennings Fruehest	Perkins
Careless	Howard's Lancer	Pixwell
Clark	Industry	Poorman
Columbus	Jahns Prairie	Red Jacket
Crown Bob	(*R. oxyacanthoides* L.)	Rolan
D. Young	Josselyn	Rosco
Downing	Jubilee Careless	Ross
Early Sulphur	Jumbo	Schultz
Fredonia	Keepsake	Speedwell
Friedl	Lancaster Lad	Surprise
Glenton Green	Lepaa punainen	Sylvia
Gem	Lord Elco	Weisse Voltragende
Glenndale	Malling Invicta	White Lion
Golda	Mt. Ennis	Whitesmith
Greenfinch	O-273	Worchesterberry

Black Currant x Gooseberry, *R.* x *nidigrolaria* Bauer		
Josta	ORUS 4	ORUS 8
ORUS 1	ORUS 5	ORUS 9
ORUS 2	ORUS 6	ORUS 10
ORUS 3	ORUS 7	ORUS 11

Flowering currants *Ribes sanguineum* Pursh selections		
Claremont	Hanneman's White	Pokey's Pink
Elk River	King Edward VII	

nigrum is one of the most susceptible species to WPBR. Thirteen of the newer *R. nigrum* hybrids, some of which were bred and selected for rust resistance, had no uredia (Table 4). *R. odoratum* Wendl. f. cv. Crandall, a black-fruited currant which is in the golden currant section, had no uredia (Table 4). Of two *R. americanum* Miller clones, one had no uredia either year, the other had a few uredia in 1995 (Table 1). Brennan (3) and growers in eastern United States (Reich, personal communication) describe *R. americanum* as resistant. Of the Pacific Northwest black currant natives, *R. bracteosum* Doug. was susceptible (Table 1) while *R. hudsonianum* Richards was resistant (Table 2).

Seven clones in section *Ribes,* the red and white currants, *Ribes rubrum* L. cvs. Blanka, Masons, New York 37, Primus, Red Lake, White Dutch, and Wilder, had uredia (Tables 1, 3) although 37 cultivars were resistant (Table 4). All accessions of *R. petraeum* var. *carpathicum* (C.A. Mey.) Jancz. and *R. triste* Pallas were resistant (Table 2). *Ribes rubrum* cv. Viking (= Red Dutch, Rosa Hollandishe) was resistant (Table 4) in agreement with Anderson (2).

In the ornamental currants, section Calobotrya, only one clone of *R. sanguineum* Pursh. had uredia; the other 15 accessions, including the named cultivars, had no uredia (Tables 2, 4). These data differ from Pscheit's (7) report that *R. sanguineum* was very susceptible. *R. viscosissimum* Pursh, and *R. wolfii* Rothr. had uredia (Table 1). Accessions of the native American wax currant, *R. cereum* Doug., and the Mexican currant, *R. ciliatum* Humb. & Bonpl., were resistant (Table 2).

Of the dwarf currants, Heritera, *R. howellii* Greene hosted uredia (Table 1) but *R. erythrocarpum* Coville & Leiberg, *R. laxiflorum* Jancz. and *R. glandulosum* Grauer were resistant (Table 2). In the spiny currants, Grossularioides, *R. lacustre* (Pers) Poir. had uredia present (Table 1) but *R. montigenum* McClatchie was resistant (Table 2).

Of the alpine currants, Berisia, *R. dicantha* Pallas was susceptible (Table 1) and *R. alpinum* L., *R. orientale* Desf. and *R. maxmowiczii* V. Komarov were resistant (Table 2). In the section Parilla, the Andean currant, *R. valdivianum* Phil. from Chile, was covered with uredia in both years (Table 1), while *R. faciculatum* Maxim. from China was resistant (Table 2).

Among section Grossularia, the main cultivated species *R. uva-crispa* L. (= *R. grossularia* L.) and *R. hirtellum* Michaux were resistant (Tables 2, 4). None of the cultivated clones of these species had uredia (Tables 2, 4). However, several native American gooseberry taxa, such as *R. divaricatum* Doug., *R. echinellum* (Coville) Rehder, *R. speciosum* Pursh, *R. oxyacanthoides* L., and the European *R. cynosbati* L., had uredia (Table 1). *Ribes oxyacanthoides* clones were variable; cv. Spinefree and three other wild accessions of this species had uredia (Table 3) while *R. oxyacanthoides* cv Jahns Prairie had none (Table 4). The black currant x gooseberry hybrids, *R. nidigrolaria* Bauer cvs. Josta, and ORUS 1 through ORUS 11 were resistant. Two open pollinated seedlings of ORUS 6 had uredia in 1995.

In summary, WPBR infection varied between years, taxonomic sections, and between and within species. During this study, 22 *Ribes* taxa were host to WPBR, while 32 others were not. Although 70 *R. nigrum* cultivars had uredia, 13 of the newer releases were resistant. For the red currants, 7 cultivars of *R. rubrum* had uredia; 37 were resistant. Each of the *R. petraeum* and *R. triste* accessions were resistant. The only susceptible gooseberry cultivar in this study was *R. oxyacanthoides* cv. Spinefree; Forty-nine gooseberry cultivars of *R. uva-crispa* were resistant as was *R. oxyacanthoides* cv. Jahns Prairie. Twelve *R.* x *nidigrolaria* selections were resistant although two of their open pollinated seedlings had uredia. Some of the resistant *Ribes* species are native outside of eastern Russia, which is the center of diversity for

WPBR. These species may provide new genes to develop additional rust-resistant commercial fruit cultivars. The cultivation of WPBR-resistant *Ribes* should be considered in states where statutes banning the genus are under review. Observations of white pine blister rust in *Ribes* in Corvallis, OR, will continue as additional cultivars and species are received.

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Actinidia arguta — Characteristics Relevant to Commercial Production

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Abstract

Six cultivars of *Actinidia arguta* (Sieb. *et* Zucc.) Planch. ex Miq. were grown in south coastal British Columbia and evaluated for yield fruit development and quality characteristics. Over four years, the average flowering date was May 28, about six weeks after the average last spring frost. 'Issai' and 'Ananasnaya' were regarded as 'late maturing', attaining their peak on-vine sugar content at the end of October, while 'Geneva', 'National Arboretum', 'Dumbarton Oaks', and '74-75' attained their peak sugar content one month earlier. All cultivars yielded over 15 kg per vine (five year vines), except for 'National Arboretum' which only yielded 6.9 kg. 'Geneva', 'Dumbarton Oaks', and '74-55' had the largest fruit sizes (7.7 g, 7.6 g, and 7.9 g, respectively). 'Issai' had a very high vitamin C content (155 mg/100 g). 'Geneva', 'Ananasnaya', and 'Dumbarton Oaks' were generally preferred by a panel who evaluated flavour and appearance.

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