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BARC-Rust Resistant Bush Wax Bean Germplasm Lines

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BARC-Rust Resistant (RR) -13, -14, -15, -16, -19, -20, -21, and -22 are the first wax bean (*Phaseolus vulgaris* L.) germplasm lines homozygous for resistance to the 33 available North American races of the bean rust pathogen *Uromyces appendiculatus* (Pers.) Unger var. *appendiculatus* [= *U. phaseoli* (Reben) Wint.]. The lines have white seeds, edible pods, and a bush growth habit. The first four were approved for release in July 1987 and the second four in June 1988 by ARS/USDA and the New Jersey Agricultural Experiment Station.

Rust is a major disease of bean in many production areas (Stavely and Pastor-Corrales, 1989). Most wax (yellow, edible podded) bean cultivars are so susceptible to rust that in some production areas, such as southern New Jersey, they are not grown during the late summer and early fall when rust epidemics are most likely. The bean rust fungus is highly variable in pathogenicity (Stavely, 1984b; Stavely and Pastor-Corrales, 1989; Stavely et al., 1989). The 33 available pathogenic races of *U. appendiculatus* (numbered 38 through 70) that have been identified from North America in recent years include the only defined worldwide races that are virulent for several of the most broadly rust-resistant beans (Stavely, 1984b; Stavely et al., 1989).

Origin

BARC-RR-13, -14, -15, -16, -19, -20, -21, and -22 were developed by pedigree and backcross breeding with the objective of combining resistance to all available races of the bean rust fungus into wax bean germplasm lines having desirable pod quality,

yield, and placement for mechanical harvest on determinate, bush plants of type I growth habit (CIAT classification) (van Schoonhoven and Pastor-Corrales, 1987). Progeny from crosses, backcrosses, and selfs were tested for rust resistance in each generation with eight to 12 individual races of *U. appendiculatus* (Stavely, 1983). A rust-resistant F₂ plant of Green Giant (GG) 447 × B-190 was backcrossed with GG447. F₁ plants that contained the desired rust resistance were selected and sequentially backcrossed in suc-

ceeding generations with: 1) 'Eagle', 2) and 3) 'Slenderette', and 4) and 5) 'Goldrush' wax. After the second backcross with 'Goldrush', the pedigrees of the released lines vary. Sib F₁ plants from the second backcross with 'Goldrush' were backcrossed (one to several sequential times) with the wax cultivars 'Goldrush' or 'Golden Rod', or the wax germplasm line G1869 from M.H. Dickson (Table 1). Edible podded cultivars or lines were used as female parents for all backcrosses. 'Slenderette' and 'Eagle' are popular, green, edible podded cultivars and GG447 is a commercial breeding line of the same class. 'Goldrush' and 'Golden Rod' are popular, high-yielding-cultivars. Pods of 'Goldrush' are in the preferred sieve size range for processing and are placed toward the outer perimeter of the plant, which is preferable for mechanical harvest. 'Golden Rod' was used as a parent due to its uniform, golden yellow pods and its small leaflet size. G1869 has an erect growth habit and tends to produce its pods in the upper portion of the plant. All of these edible-podded parental cultivars and lines are hypersensitively resistant, developing necrotic spots up to 1.0 mm in diameter, without sporulation, in response to infection by *U. appendiculatus* races 40, 44, 48-51, 54, 62-66, 69, and 70 (Stavely,

Fig. 1. Pods of bean cultivar Goldrush (top), BARC-Rust Resistant-14 (center), and BARC-Rust Resistant -15 (bottom).

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Table 1. Final backcross parents and certain horticultural characteristics of BARC-Rust Resistant wax bean germplasm lines and their parents in New Jersey.^a

Line	Recent parents	Plant traits			Pod traits	
		Ht (cm)	Habit	Leaflet size	Curvature	Placement
-13	Grsh (2)	40	Erect	M	Sl	Excellent
-14	G1869(1)	43	Erect	M	Sl	Very good
-15	Grsh (1)	38	Erect	M	M	Very good
-16	Grsh (1)	42	M sprawl	M	Sl	Excellent
-19	G Rod(1), Grsh (3)	36	M sprawl	M-Sm	Sl	Excellent
-20	G Rod(2), Grsh (3)	35	M sprawl	Sm	M	Good
-21	G Rod(2), Grsh (3)	38	Erect	M-Sm	Sl	Excellent
-22	G Rod(2), Grsh (3)	39	Erect	M-Sm	M	Very good
Grsh	---	40	Sprawl	M	Sl	Excellent
G Rod	---	46	M sprawl	Sm	Sl	Fair
G1869	---	40	Erect	M	Sl	Fair

^aRecent parents were used as female parents for successive backcrosses (the indicated number of times) with selected sib plants with the pedigree Grsh (2) x Slenderette (2) x Eagle x Green Giant 447 x (Green Giant 447 x B-190) F₂. Abbreviations are Grsh = Goldrush, G Rod = Golden Rod, M = moderate, Sm = Small, and Sl = Slight. Pod placement was rated fair to excellent for the degree of desirable distribution toward the outer perimeter of the plants.

1984b; Stavely et al., 1989). This reaction is apparently controlled by the single, dominant Up³ gene for all of these races (Christ and Groth, 1982). The cultivars are very susceptible to races 38 and 39, the predominant races on edible podded beans in the United States, and are moderately resistant or moderately susceptible to the remaining races (Mmbaga and Stavely, 1988; Stavely and Pastor-Corrales, 1989). Lines G1869 and GG447 have necrotic, hypersensitive resistance to *U. appendiculatus* races 38 and 39, but the same moderate reactions as the cultivars to the remaining races. B-190 is a black-seeded, high-yielding, tropical dry bean breeding line developed and released by G.F. Freytag that has the rust resistance of 'Mexico 309' (Stavely, 1984a). This resistance is expressed as tiny uredinia, <0.3 mm diameter, with 25 *U. appendiculatus* races, and as tiny necrotic spots with races 38 and 39 (Stavely, 1984b; Stavely et al., 1989). B-190 is susceptible to races 49-51, 58, 65, and 67 that are rarely found in nature (Stavely, 1984b; Stavely et al., 1989).

After the last backcross, progeny were selectively advanced to the F₃ generation to identify homozygosity for rust resistances. The F₃ progeny from 178 of these F₂ plants in 1986 and from 214 in 1987 were evaluated at the Rutgers Research and Development Center in Bridgeton, N.J. In 1988, all of the released lines were again evaluated at Bridgeton by us and at Twin Falls, Idaho, and San Juan Bautista, Calif., by commercial bean breeders.

Descriptions

The rust resistances of B-190 and the edible podded cultivars are combined and expressed identically in all eight of these wax lines. Their resistance to each specific race

is like that in the green, edible podded, BARC-Rust Resistant lines released earlier (Stavely and Steinke, 1985). The resistance of B-190 appears to be entirely conditioned by single, dominant genes, one per race, that are linked in coupling and epistatic to the Up³ gene (Stavely, 1984a). Therefore, resistance to most races in the BARC-RR waxes is expressed as tiny uredinia, <0.3 mm diameter, to races 38 and 39 as tiny necrotic spots, <0.3 mm diameter, and to races 49-51 and 65 as necrotic spots up to 1.0 mm in diameter. They are moderately resistant to races 58 and 67, developing uredinia <0.5 mm in diameter. All of the lines are homozygous for the dominant I gene for bean common mosaic virus resistance and are moderately tolerant, like 'Goldrush' and 'Golden Rod', to air pollution-induced leaf bronzing.

Each of the eight lines produces an abundant, early yield of well-placed, stringless pods of desirable sieve size for U.S. edible podded, processing beans. These characteristics for these lines compare favorably with those of 'Goldrush' when rust is not present and they are superior to 'Goldrush' in yield when rust occurs. Pods of 'Goldrush', BARC-RR-14, and BARC-RR-15 are shown in Fig. 1. The eight lines vary in height and erectness of plants, leaflet size, degree of pod curvature, and desirability of pod placement (Table 1). Plants of these lines generally resemble those of 'Goldrush' in height, although the plants of -14 and -16 are slightly taller and those of -15, -19, -20, and -21 are slightly to moderately shorter. All of the lines produce a good proportion of sieve-4 pods, with -13 having the highest proportion of the larger sieve-5 pods and -19, -21, and -22 having a higher proportion of sieve-5 than the remaining lines. BARC-RR-14 produces slightly oval pods, but those

of the rest of these lines are round in cross section. Pod length on most lines is close to that of 'Goldrush' (average 13.8 cm in New Jersey in these plots), although the pods of -14 and -19 average ≈1 cm longer and those of -15 and -20 tend to be <1 cm shorter. Rate of seed development is slowest in -16, but similar to that in the cultivars in the other lines. Pod color of the four lines released in 1988 is golden yellow, whereas that of those released in 1987 is pale yellow. BARC-RR-13 had the best overall pod quality in New Jersey in 1988. Over all characteristics, the most preferred lines in Idaho and California were 1) -14, 2) -16, 3) -13, and 4) -22. All eight lines were rated highly in Idaho, California, and New Jersey.

BARC-RR-13, -14, -15, -16, -19, -20, -21, and -22 were released as bulked F₃ seed from all of the F₂ plants from single homozygous rust-resistant F₂ plants. They are homozygous for the indicated disease resistances, but may still be segregating for some characteristics. We recommend that those who obtain seed make single-plant selections for another generation.

Availability

A limited supply of seed of BARC-RR -13, -14, -15, -16, -19, -20, -21, and -22 is available upon written request to us.

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