BARC-Rust Resistant-Bush, Fresh-market Green Bean Germplasm Lines

J.R. Stavelly¹

Microbiology and Plant Pathology Laboratory, Beltsville Agricultural Research Center, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, MD 20705-2350

R.T. McMillan, Jr.²

Florida Tropical Research and Education Center, University of Florida, Homestead, FL 33031

Additional index words. *Phaseolus vulgaris*, *Uromyces appendiculatus* var. *appendiculatus*

BARC-Rust Resistant (RR) -17, -18, -23, -24, -25, -26, and -27 are the first fresh-market, shipping-type green bean (*Phaseolus vulgaris* L.) germplasm lines adapted for the southern Florida winter-spring season that are homozygous resistant to all 55 available races of the bean rust pathogen *Uromyces appendiculatus* (Pers.) Unger var. *appendiculatus* [*U. phaseoli* (Reben) Wint.]. All seven lines are tolerant to the southern Florida root-rot pathogens; resistant to bean common mosaic virus; and have white seeds; fibrous shipping-type, stringless edible pods; and a type I (CIAT classification; van Schoonhoven and Pastor-Corrales, 1987) bush growth habit. Pod fiber is desirable in market green beans for maintenance of fresh appearance during shipping. Lines -17 and -18 were approved for release in Apr. 1987, lines -23 and -24 in May 1988, and -25, -26, and -27 in Sept. 1989 by the Agricultural Research Service/U.S. Dept. of Agriculture and the Florida Agricultural Experiment Station.

Bean rust is a major, epidemic disease problem in many areas of the world (Stavelly and Pastor-Corrales, 1989). It is often a serious disease problem in the winter-spring, fresh-market shipping areas of green bean production in southern Florida. Cultivars that have been grown in southern Florida are highly susceptible to rust, making fungicide use necessary to minimize losses. One of the major fungicides used for rust control was withdrawn in 1989; thus, fungicidal control has become more expensive.

Uromyces appendiculatus is highly variable in pathogenicity. Field collections from

bean production areas in North America and elsewhere yielded 55 races of the pathogen that have been purified, described, and placed in liquid nitrogen storage at Beltsville, Md. These races include the only defined races that are virulent on several of the more broadly rust-resistant beans (Mmbaga and Stavelly, 1988; Stavelly, 1984b; Stavelly and Batra, 1991; Stavelly et al., 1989).

Sources of rust resistance

B-190, the major source of rust resistance in these releases, has the same resistance to most races of *U. appendiculatus* and susceptibility to the rarely found races 49-51, 58, 65, 67, 73, and 78 as the *U. appendiculatus* race-differentiating cultivar Mexico 309 (Stavelly, 1984a). Resistance of B-190 to races 38, 39, and 77, of which 38 and 39 are the predominant races on bush, edible-podded beans, is expressed as tiny necrotic spots. Resistance in B-190 to races 75, 79, 80, and 81, of which 79, 80, and 81 are the only three from Europe in the Beltsville collection, is expressed as tiny, faint, chlorotic spots. Resistance of B-190 to the remaining 41 races in the Beltsville collection is expressed as restriction of uredinial size to <0.3 mm in diameter. In response to infection by races 40, 44, 48-51, 54, 62-66, 69-71, 73-76, 78, 81, and 82, the parental edible-podded cultivars BBL 47, Green Giant 447, Sprite, and Triumph are hypersensitively re-

sistant, developing necrotic spots up to 1.0 mm in diameter and no sporulation (Stavelly, 1984b; Stavelly and Batra, 1991; Stavelly et al., 1989). This resistance is apparently controlled by the single, dominant *Up²* gene for all of these races (Christ and Groth, 1982; Stavelly et al., 1989). These cultivars are very susceptible to races 38, 39, and 72, developing uredinia >1.0 mm in diameter. But, they are moderately resistant or moderately susceptible, developing small to moderate-size uredinia, to all remaining races (Mmbaga and Stavelly, 1988; Stavelly, 1984b; Stavelly and Batra, 1991; Stavelly et al., 1989).

Origin

BARC-RR -17, -18, -23, -24, -25, -26, and -27 were developed by pedigree and backcross breeding. The objective was to combine resistance to all available races of *U. appendiculatus* into market, green, edible-podded bean germplasm lines adapted for southern Florida and that have desirable yield, plant, and pod qualities on determinate, bush plants of type I growth habit. All progeny from crosses, backcrosses, and selfs were tested for rust resistance in each generation using eight to 12 key individual races of *U. appendiculatus* (Stavelly, 1983). The seven released lines have the same initial pedigree (Fig. 1). Green bean cultivar Bush Blue Lake (BBL) 47 was crossed with a rust-resistant *F₂* plant of Green Giant 447 × B-190. *F₁* plants that contained the desired rust resistance were selected and backcrossed with 'BBL 47' for four more generations and then for three generations with market green bean cultivar Sprite to produce BARC-RR-17 and -18. 'Sprite' has been popular for winter-market, green bean production in southern Florida for many years. After another backcross with 'Sprite', market cultivar Triumph, more recently popular in southern Florida, was used in two or three more backcrosses for BARC-RR-23 through -27. 'Triumph', 'Sprite', and 'BBL 47' are white-seeded and were used as female parents in all crosses. B-190 is a black-seeded, high-yielding, tropical dry bean breeding line developed and released by G.F. Freytag.

After the last backcross, progeny were selectively advanced to the *F₅* generation to

Fig. 1. Pedigrees of BARC-Rust Resistant-17, -18, -23, -24, -25, -26, and -27 bush, fresh-market green bean germplasm lines.

Received for publication 29 July 1991. Accepted for publication 18 Mar. 1992. Contribution of Agricultural Research Service, U.S. Dept. of Agriculture (USDA), in cooperation with the Florida Agricultural Experiment Station. We appreciate bean common mosaic virus indexing by M.J. Silbernagel, USDA; technical assistance from Eugene Frazier; and photographic assistance from James S. Plaskowitz. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

¹Research Plant Pathologist.

²Associate Professor.

Table 1. Horticultural characteristics of BARC-Rust-Resistant fresh-market green bean germplasm lines and their parents.^a

Line	Plant traits			Pod traits				
	Ht (cm) ^b		Habit ^c	Length ^d (cm)	Curvature	Placement ^e	Fiber ^f	Pubescence
	Fla.	N.J.						
-17	29	36	Erect	14.3	Sl	Very good	High	Pr
-18	25	35	M erect	14.2	St	Excellent	High	Pr
-23	28	37	M erect	14.2	St	Excellent	High	Pr
-24	27	35	M erect	13.6	St	Very good	M	Sl
-25	20	36	Sl erect	14.3	Sl	Very good	M	Sl
-26	26	42	Sl erect	15.6	Sl	Very good	M	Sl
-27	19	35	M erect	14.2	Sl	Very good	M	Sl
Smite	14	37	M erect	13.8	Sl	Good	High	Pr
Triumph	17	36	Erect	14.5	Sl	Fair	M	Sl

^aAbbreviations are M = moderate, Pr = profuse, Sl = slight, and St = straight.

^bMeans of four representative plants in each of two replicates per location and year in Florida (1988) and New Jersey (1988-90).

^cHabit evaluated in New Jersey from 1988 to 1990; considered erect if the plants maintained erectness, and slightly erect if about half become procumbent.

^dMean total length of six representative pods/replicate per location per year in New Jersey.

^eDesirable placement occurs when the pods are distributed toward the outer perimeter of the plants. Fiber is relative toughness to withstand shipping.

Fig. 2. Plants of BARC-Rust Resistant (RR)-17 (left front) and BARC-RR-18 (left rear) were more vigorous than those of 'Sprite' (right front and rear) in Apr. 1988 in the field plot in which they were initially selected in Homestead, Fla. Growth of these BARC-RR lines was nearly twice that of 'Sprite' in this plot, where *Rhizoctonia* infestation levels were high.

identify homozygosity for rust resistances. The F_1 progeny from 38 of these F_2 plants in 1986, 92 in 1987, and 68 in 1988 were planted in February and evaluated in April of each year at the Tropical Agricultural Research and Education Center, Homestead, Fla., in a field plot containing high levels of the *Rhizoctonia* and *Macrophomina* bean root and stem pathogens. In 1986, 1987, and 1988, five, nine, and ten of the F_1 lines, respectively, were selected in Florida and then re-evaluated in the same generation at the Rutgers Research and Development Center, Bridgeton, N.J., before final selections for releases were made. All of the released lines, plus 'Sprite' and 'Triumph', were field-evaluated in Florida in Apr. 1988 and June 1989 and in New Jersey in 1988, 1989, and 1990.

Description

The combined rust resistances of B-190 and the bush, edible-podded cultivars are expressed identically in all seven of these market shipping lines. Their resistance to each specific race is similar to that of BARC-RR lines released earlier (Stavely and Steinke, 1990). The rust resistance of B-190 appears to be conditioned entirely by single, dominant genes, one per race, that are linked in coupling and epistatic to the Up^2 gene (Stavely, 1984a). The linked resistance genes in the released lines are expressed as in B-190. Homozygosity for the Up^2 gene in all seven of these BARC-RR lines results in production of a hypersensitive necrotic spot that is up to 1.0 mm in diameter, and no sporulation occurs in response to infection by races 49-51, 65, 73, and 78. They are moderately resistant to races 58 and 67, developing small 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 resistant to air pollution-induced leaf bronzing.

The initial selection and subsequent testing of the released lines in the plot infested with root- and stem-infecting fungi at Homestead suggest that the released lines are about

as tolerant as 'Sprite' and 'Triumph' to *Macrophomina* and that they are more tolerant than these cultivars to *Rhizoctonia*. *Rhizoctonia* was the major pathogen in Florida in each April when the initial field selections were made there. Measurements of plant heights (Table 1) and visual comparisons (Fig. 2) show that the BARC-RR lines grew taller than 'Sprite' when harvest maturity in Florida was reached in April. However, in the June 1989 test in the same Florida plot, when *Macrophomina* was more prevalent, root-rot tolerance of the released lines, as reflected by height and apparent yield, was superior to that of susceptible 'Green Giant 447', similar to that of 'Sprite' and 'Triumph', and less than that of B-190.

Plant habit of the seven lines varies from slightly erect to erect. All seven lines produced an abundant yield of well-placed, stringless pods of appropriate sieve size, straightness, and fiber content for market shipping green beans. Although the pods were not harvested for weighing at the optimal picking stage, visual observation indicated that pod concentration and apparent yield compared favorably with those of 'Sprite' and 'Triumph' in the absence of disease and were superior when disease was present. The plant habits, pod lengths, and pod curvatures are from measurements in New Jersey where there was no root and stem disease (Table 1). Pod placement, fiber, and pubescence were similar in the two locations. All of the lines produce a good proportion of sieve-4 pods (9.0 mm in diameter), with -18 and -26 having the highest proportion of the larger sieve-5 (10.0 mm in diameter) pods. Pods of all seven lines are slightly to moderately oval, as are those of 'Sprite' and 'Triumph'. The pods of -17, -18, -24, -25, -26, and 'Sprite' are less oval than those of -23, -27, and 'Triumph'. Compared to 'Sprite' and 'Triumph', rate of seed development is slower in -26 and -27; similar in -17, -23, -24, and -25; and slightly faster in -18. BARC-RR-26 is unique among these lines and parental cultivars in having the darkest green foliage and pods, longest pods, and later harvest maturity (2 to 4 days). The other lines were close to 'Sprite' and 'Triumph' in these characteristics.

BARC-RR-26 had less common bacterial blight and powdery mildew than the other lines and parental cultivars when these diseases occurred in the Florida plot. Although all seven lines were rated highly in Idaho, California, and southern Florida by commercial breeders, -17 and -18 appear to have been favored over the others.

BARC-RR-17, -18, -23, -24, -25, -26, and -27 were released as bulked F_5 seed from all of the F_4 plants, which were derived from single, homozygous, rust-resistant F_3 plants. They are homozygous for the indicated rust and common mosaic resistances and root and stem disease tolerances 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-17, -18, -23, -24, -25, -26, and -27 is available from J.R.S.

Literature Cited

- Christ, B.J. and J.V. Groth. 1982. Inheritance of resistance in three cultivars of beans to the bean rust pathogen and the interaction of virulence and resistance genes. *Phytopathology* 72:771-773.
- Mmbaga, M.T. and J.R. Stavely. 1988. Pathogenic variability in *Uromyces appendiculatus* from Tanzania and rust resistance in Tanzanian bean cultivars. *Plant Dis.* 72:259-262.
- Stavely, J.R. 1983. A rapid technique for inoculation of *Phaseolus vulgaris* with multiple pathotypes of *Uromyces phaseoli*. *Phytopathology* 73:676-679.
- Stavely, J.R. 1984a. Genetics of resistance to *Uromyces phaseoli* in a *Phaseolus vulgaris* line resistant to most races of the pathogen. *Phytopathology* 74:339-344.
- Stavely, J.R. 1984b. Pathogenic specialization in *Uromyces phaseoli* in the United States and rust resistance in beans. *Plant Dis.* 68:95-99.
- Stavely, J.R. and L.R. Batra. 1991. Recently identified new pathogenic variability in *Uromyces appendiculatus*. *Phytopathology* 81:704. (Abstr.)
- Stavely, J.R. and M.A. Pastor-Corrales. 1989. Rust, p. 159-194. In: H.F. Schwartz and M.A. Pastor-Corrales (eds.). *Bean production problems in the tropics*. Centro Internacional de Agricultura Tropical, Cali, Colombia.
- Stavely, J.R. and J. Steinke. 1990. BARC-Rust Resistant bush wax bean germplasm lines. *HortScience* 25:1451-1452.
- Stavely, J.R., J.R. Steadman, and R.T. McMillan, Jr. 1989. New pathogenic variability in *Uromyces appendiculatus* in North America. *Plant Dis.* 73:428-432.
- van Schoonhoven, A. and M.A. Pastor-Corrales. 1987. Standard system for the evaluation of bean germplasm. Centro Internacional de Agricultura Tropical, Cali, Colombia.