

Evaluation of 'White Half Runner' Green Bean Breeding Lines for Yield, Quality, and Disease Resistance

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SUMMARY. 'White Half Runner' is a popular green bean (*Phaseolus vulgaris* L.) cultivar in the southern Appalachian region of the United States. The cultivar is highly susceptible to rust and virus diseases. Nine breeding lines with 'White Half Runner' parentage were compared to 'White Half Runner' for rust tolerance, yield, and pod quality in 1998 and 1999 field trials at Crossville, Tenn. The BelTenn selections were developed by USDA plant breeders and the UT selections were developed by University of Tennessee plant breeders. Selections 'BelTenn-RR-2', 'BelTenn 4-12028', 'BelTenn 4-12046', 'BelTenn 4-12053', 'BelTenn 5-2717' and 'UT-96-3' were resistant to rust. Only 'UT 96-4' had lower yields than 'White Half Runner' in 1999. The BelTenn lines had slightly smaller pods, and the UT selections had larger and rougher pods than 'White Half Runner'. 'BelTenn-RR-2' was

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released in 1995 as a breeding line with rust resistance and pod quality similar to 'White Half Runner'. Further selection of BelTenn-RR-2 by a private seed company led to the naming of a cultivar named 'Volunteer White Half Runner'.

White Half Runner has been a popular green-bean cultivar in the southern Appalachian region of the United States for many years. Prices for 'White Half Runner' beans are usually much higher than prices for bush stringless beans. Production costs are also greater for 'White Half Runner' as harvest is usually by hand. 'White Half Runner' plants have a medium length runner, but are usually grown as a bush bean. However, production is greater when the plants are grown as a pole bean. Some producers use black plastic mulch and drip irrigation to further enhance production and quality. 'White Half Runner' pods have a distinctive flavor, which is more desirable in southern food preparation. The pods have a string that must be removed before they can be used, which is rather time consuming. The string eliminates the usage of 'White Half Runner' as a commercial processing bean. 'White Half Runner' beans do not have a highly concentrated pod set. Hand harvests may be once-over, but often three or four harvests are made for high yields and optimum pod quality. Some Tennessee producers machine harvest 'White Half Runner' pods, but breakage and trash in the form of leaves are somewhat excessive in the harvested pods. Separating usable whole pods from the trash and broken pods is a labor intensive endeavor.

Plants of 'White Half Runner' bean are highly susceptible to diseases, especially bean rust (*Uromyces appendiculatus* (Pers.: Pers.) Unger) and viruses. 'White Half Runner' was used as a rust susceptible check cultivar in eastern U.S. regional rust trials, and had severe rust infestation at most trial locations (Stavelly, 1999). Numerous strains of rust have been identified and certain strains commonly found in the eastern U.S. attack 'White Half Runner'. The problem is very severe in the late fall season in Tennessee and surrounding states. The numbered selections have not been tested under severe virus conditions and their virus

tolerance has not been determined. However, laboratory tests have indicated that the BelTenn selections are homozygous for the I gene for resistance to common bean mosaic virus.

Eight to ten named strains of 'White Half Runner' bean are available, most notably 'Mountaineer' and 'State' (Reddick and Schwartz, 1987). No known breeding efforts to improve the cultivar had been conducted for several years prior to 1990. Breeding programs were initiated independently by University of Tennessee researchers using 'State White Half Runner' as a parent line and USDA researchers using 'Mountaineer White Half Runner' as a parent line. The objective of each program was to incorporate disease tolerance into 'White Half Runner' type selections. 'White Half Runner' was crossed with bush and pole beans with varying degrees of rust and virus tolerance, and several backcrosses were made. Over 100 selections from the crosses of each program were evaluated in initial field screening trials at The University of Tennessee Plateau Experiment Station at Crossville, Tenn. A major objective was to maintain 'White Half Runner' flavor and incorporate as much disease resistance as possible into the selections. Informal taste tests were a part of the selection process, and lines were selected based on flavor similar to 'White Half Runner'. A secondary objective was to select for possible lines with a bush type plant growth habit and a stringless 'White Half Runner' type pod for adaptability to machine harvest and commercial processing. Many selections were eliminated, and in 1995, three of the superior selections from the USDA program were released as rust resistant breeding lines. Several lines remaining from each program were evaluated in sequential trials. Nine numbered selections were evaluated in performance trials at Crossville in 1998 and 1999.

The objective of this study was to compare yield, plant and pod quality, and disease tolerance of the nine breeding lines to 'White Half Runner'. The tests were conducted in the fall season, when rust infestation was expected to be most severe.

Materials and methods

'White Half Runner' breeding line performance trials of the nine lines were conducted in 1998 and 1999 at

Crossville. 'White Half Runner' was included in the trials as the check cultivar. 'BelTenn-RR-2', a superior breeding line release, was used for comparison to the newer selections. Single row plots 10 ft (3.65 m) long and 3 ft (0.9 m) wide were established. Within row spacing was approximately 2 inches (5.1 cm). Planting date was 25 June 1998 and 21 June 1999. Plots were arranged in a randomized complete-block design with four replications. The bean selections were grown unstaked following current recommendations. Metolachlor was applied preemergence at 2 lb a.i./acre (2.24 kg·ha⁻¹) for weed control in 1998 and one cultivation was made in 1999 for weed control. One application of a recommended insecticide was made at full bloom each year. Overhead irrigation was used to provide 0.5 inches (1.25 cm) of water on 11 Sept. 1998.

Harvest was once-over by hand on 23 Sept. 1998 and 29 Sept. 1999. Snap beans are usually harvested when the center seed from ten of the most mature pods total 3.5 to 3.9 inches (90 to 100 mm) in length. Pods in this study were harvested at a more mature stage, and when the center seed from ten of the most mature pods totaled 4.5 to 4.9 inches (115 to 125 mm) in length which is near commercial harvest maturity for this type of green bean. 'White Half Runner' pods have a larger seeds than most green beans, but the pods remain tender when seeds are relatively large. Plant height and plant width measurements, and leaf rust ratings were made at harvest. Yields were recorded at harvest, and pod length and diameter of 25 pods per plot were measured soon after harvest. Ratings were made for pod curvature and smoothness, and notes were made on conformity of fresh and cooked pods to 'White Half Runner'.

All data were subjected to analysis of variance and Duncan's multiple range test ($\alpha = 0.05$) (SAS, 1987). Since some variables were significantly different due to year, data will be presented for individual years.

Results

The plant type of all breeding line selections was very similar to 'White Half Runner', and plant height of all lines was near 16 inches (40.6 cm) both years. Differences in plant height, width, and type of growth habit were not visually apparent due to selection.

Table 1. Rust ratings and yields of 'White Half Runner' and related breeding lines at Crossville, Tenn., 1998–99.

Selection	Rust rating (%) ^z		Pod yield (bushel/acre) ^y	
	1998	1999	1998	1999
White Half Runner	20 a ^x	65 b	121 a	302 ab
BelTenn-RR-2	0 b	0 e	146 a	313 ab
BelTenn 4-12028	0 b	0 e	136 a	265 bc
BelTenn 4-12046	0 b	0 e	137 a	313 ab
BelTenn 4-12053	0 b	0 e	146 a	311 ab
BelTenn 5-2717	0 b	0 e	157 a	300 ab
UT 96-1	23 a	75 a	173 a	266 bc
UT 96-2	35 a	53 c	235 a	334 ab
UT 96-3	0 b	2 e	162 a	355 a
UT 96-4	0 b	25 d	149 a	227 c

^zPercentage leaf surface covered by rust symptoms.

^yNumber of bushel [30-lb (13.6-kg)] boxes per acre; 1 bushel/acre = 33.6 kg·ha⁻¹.

^xMeans in the same column followed by the same letter are not significantly different ($P = 0.05$), according to Duncan's multiple range test.

Table 2. Pod length and diameter of 'White Half Runner' and related breeding lines at Crossville, Tenn., 1998–99.

Selection	Pod length (inches) ^z		Pod diam (inches)	
	1998	1999	1998	1999
White Half Runner	3.7 ab ^y	4.7 a	0.46 b	0.49 ab
BelTenn-RR-2	3.8 ab	4.5 ab	0.45 b	0.45 c
BelTenn 4-12028	3.5 b	4.0 e	0.45 b	0.45 c
BelTenn 4-12046	3.5 b	4.0 e	0.45 b	0.45 c
BelTenn 4-12053	3.6 ab	4.3 bcd	0.45 b	0.48 abc
BelTenn 5-2717	3.8 ab	4.1 de	0.44 b	0.46 bc
UT 96-1	4.0 a	4.4 b	0.50 a	0.50 a
UT 96-2	4.0 a	4.4 b	0.51 a	0.49 ab
UT 96-3	4.0 a	4.4 b	0.51 a	0.50 a
UT 96-4	3.9 ab	4.2 cde	0.44 b	0.45 c

^z1 inch = 2.54 cm, measurements of most mature pods.

^yMeans in the same column followed by the same letter are not significantly different ($P = 0.05$), according to Duncan's multiple range test.

Table 3. Pod smoothness and curvature ratings of 'White Half Runner' and related breeding lines at Crossville, Tenn., 1998–99.

Selection	Pod smoothness rating ^y		Pod curvature rating	
	1998	1999	1998	1999
White Half Runner	4.0 a ^z	3.8 c	4.08 abcd	4.05 cd
BelTenn-RR-2	4.1 a	3.8 c	4.25 a	4.10 bcd
BelTenn 4-12028	3.7 abc	4.0 a	4.15 abc	4.50 a
BelTenn 4-12046	3.9 ab	4.0 a	4.20 ab	4.20 abcd
BelTenn 4-12053	4.0 a	4.9 a	4.23 a	4.43 abc
BelTenn 5-2717	3.8 ab	4.0 ab	4.20 ab	4.50 a
UT 96-1	3.3 d	4.0 ab	4.00 bcd	4.45 ab
UT 96-2	3.4 cd	3.8 c	3.98 cd	4.05 cd
UT 96-3	3.5 bcd	3.4 d	3.90 d	3.83 d
UT 96-4	3.9 ab	4.0 a	3.90 d	4.00 d

^zRatings on a scale of 1 to 5, 5 = most acceptable.

^yMeans in the same column followed by the same letter are not significantly different ($P = 0.05$), according to Duncan's multiple range test.

No lines with bush plant type and stringless 'White Half Runner' type pods were observed in plant populations from the original crosses.

Rust was more severe in 1999 than in 1998 (Table 1). Both growing seasons were relatively dry, but humidity was higher in 1999, which may account for the rust differences among years for the rust susceptible selections. The BelTenn selections have parentage from USDA bean lines that are immune to all known races of rust. The BelTenn selections did not develop any rust in either year of the study. They are classed as rust resistant lines. Plants of 'White Half Runner', 'UT 96-1', and 'UT 96-2' had significantly more in both years of the trials than the resistant selections. Plants of 'UT 96-4' developed significantly more rust in 1999, and plants of 'UT 96-3' were comparable to the resistant lines in both seasons.

Yields were not significantly different due to selection in 1998 (Table 1). Line 'UT 96-3' produced higher yields than 'BelTenn 4-12028', 'UT 96-1', and 'UT 96-4', and only 'UT 96-4' had lower yields than 'White Half Runner' in 1999. The other numbered selections maintained the relatively high yield levels associated with 'White Half Runner'.

'UT 96-1', 'UT 96-2', and 'UT 96-3' had longer pods than 'BelTenn 4-12028', and 'BelTenn 4-12046' in 1998 (Table 2). 'White Half Runner' had longer pods than all selections except 'BelTenn-RR-2' in 1999. Pods were longer in 1999 than in 1998, probably due to differences in weather conditions. Stress from heat and/or drought usually results in a shorter pod length of green beans. All selections including 'White Half Runner' had relatively short pods for green snap beans which is usually in the 5 to 6 inch (12.7 to 15.2 cm) range. Pod diameter was generally smaller for 'BelTenn-RR-2', 'BelTenn 4-12028', 'BelTenn 4-12046', and 'UT 96-4' than for most other selections.

Pods of 'White Half Runner' are relatively bumpy and somewhat rough due to the large seed size attained in mature pods. Selections with the least smoothness in 1998 were 'UT 96-1', 'UT 96-2', and 'UT 96-3' (Table 3). Selections with the least smoothness in 1999 were 'White Half Runner', 'BelTenn-RR-2', 'UT 96-2', and 'UT 96-3'. Pods of 'BelTenn-RR-2' and

'BelTenn 4-12053' had less curvature than pods of 'UT 96-1', 'UT 96-2', 'UT 96-3', and 'UT 96-4' in 1998 (Table 3). Selections with the least curvature in 1999 were 'BelTenn 4-12028' and 'BelTenn 5-2717'.

Conclusions

Progress has been made in achieving rust resistance in several 'White Half Runner' type green bean selections. Yields and pod characteristics of many of the breeding lines were similar to those of 'White Half Runner'. The UT selections tended to produce slightly larger and rougher pods, and the BelTenn selections tended to have slightly shorter and smaller pods than 'White Half Runner'. None of the unreleased numbered selections had superior performance to 'BelTenn-RR-2' which was released in 1995 as a rust resistant 'White Half Runner' type breeding line. 'BelTenn-RR-2' was evaluated in limited commercial grower and home

gardener trials from 1994 through 1997.

A selection of 'BelTenn-RR-2' was increased by a commercial seed company and was released as 'Volunteer White Half Runner'. 'Volunteer White Half Runner' performed well in grower trials in Tennessee, North Carolina, and Virginia in 1999, and appeared to have considerable commercial potential as a rust resistant 'White Half Runner' type cultivar. A limited supply of seed was available commercially for 2000 and seed availability should increase in future years if the cultivar is successful.

Literature cited

- Reddick, B. and K. Schwartz. 1987. Reactions of Half Runner snap beans to virus infection. *Tenn. Farm Home Sci.* 143:22-23.
- Stavely, R. 1999. Bean rust in the United States in 1998. *Annu. Rpt. Bean Improvement Coop.* 42:113-114.