Effect of Rust on Yield of Susceptible and Resistant Asparagus Cultivars

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ABSTRACT

Johnson, D. A., and Lunden, J. D. 1992. Effect of rust on yield of susceptible and resistant asparagus cultivars. Plant Dis. 76:84-86.

The effect of rust, caused by *Puccinia asparagi*, on yield of two slow-rusting and two rust-susceptible cultivars of asparagus (*Asparagus officinalis*) was determined in two consecutive years in the field. Rust was or was not controlled with a fungicide. Rust reduced total weight and number of spears produced by the susceptible cultivars but not by the resistant cultivars. Weight per spear was reduced only after the second consecutive year of rust infection in the susceptible cultivar Mary Washington. The second year of infection reduced relative yields more than the first year for the susceptible cultivars.

Resistance in asparagus (*Asparagus officinalis* L.) to rust (*Puccinia asparagi* DC. in Lam. & DC.) has been known for many years. Since the early 1900s, efforts have been directed toward identifying and using resistance in asparagus to manage rust (3,4,12,17). However, the only type of resistance found in the genus *Asparagus* has been quantitative, rather than qualitative, resulting in differences in the intensity of infection (3,4,6,10,17). In Washington State, asparagus cultivars Jersey Giant, Jersey Centennial, Delmonte 361, and UC-157 rusted more slowly in the field than did cultivars Mary Washington, Wash T2, and WSU-1 (5). The resistance in these cultivars has been termed "slow-rusting" (5) and is similar to the slow-rusting resistance in small grains and other crops (1,8,16). Quantitative resistance has been used to maintain yields of small grains infected with rust (9,11,15). However, no information is available on the usefulness of slow-rusting in asparagus in maintaining yield during rust epidemics. Rust epidemics, which are associated with rain or frequent dews, affect the fern growth after spears are harvested in the spring (10). When rust is severe, asparagus foliage senesces prematurely and carbohydrate storage in the crown is reduced, resulting in less yield the following spring (10). In this study, we compared the effect of rust on yield of slow-rusting and susceptible asparagus cultivars in the field.

MATERIALS AND METHODS

Seed of WSU-1 was received from the Washington Asparagus Growers Association, Sunnyside, WA; seed of Mary Washington was produced by Glen Smith, Sunnyside, WA; seed of Jersey Giant came from J. H. Ellison, Rutgers University, New Brunswick, NJ; and seed of UC-157 came from California Asparagus Seed and Transplants, Inc., Davis, CA.

Plant Pathology New Series 0099, Project 0678, College of Agriculture and Home Economics, Research Center, Washington State University, Pullman, WA 99164.

Accepted for publication 12 August 1991 (submitted for electronic processing).

Asparagus cultivars Jersey Giant, UC-157, Mary Washington, and WSU-1 were established in the field from seedlings transplanted in April 1985 to a fine sandy loam soil at the Irrigated Agriculture Research and Extension Center near Prosser, WA. Plots were three rows wide and contained 24 seedlings per row spaced 30 cm apart in furrows 15–17 cm deep. Rows were spaced 1.37 m apart. Plots were kept rust-free in 1985 and 1986 with sprays of the fungicide triadimefon (Bayleton). Treatments were arranged in a split-plot, randomized complete block design, with fungicide-treated vs. untreated as the main factor in 1987 and 1988 and cultivars as the subplot factor. The number of replicates was five. Rust was prevented from developing in the treated plots with sprays of triadimefon (279 g a.i./ha) every 2 wk during the growing seasons in 1987 and 1988. Ammonium nitrate was applied during early spring at 112 kg of nitrogen per hectare during 1986–1988 and at 56 kg of nitrogen per hectare in 1989. Weeds were controlled with commercial herbicides and by hand.

In 1987 and 1988, plots were irrigated with sprinklers at night for 8–12 hr at 10- to 14-day intervals to induce development of rust. Rust severity was estimated as the proportion of surface area of the foliage of each plot covered with uredinia by using the modified Cobb's scale for cereal stem rust (13). Rust severity was estimated six times at 14- to 15-day intervals beginning 14 July 1987, and five times at 14- to 17-day intervals beginning 27 July 1988. The area under the disease progress curve (AUDPC) was calculated for each plot with the Fortran IV subroutine AREA (14) and the associated subroutine INTEG (2).

Yield data were collected from the three rows of each plot by cutting, weighing, and counting all spears greater than 20 cm in length for 33 days from 12 April to 13 June 1988 and for 28 days from 17 April to 12 June 1989. The days of harvest were consecutive days during warm weather when growth of spears was rapid and two or more days apart when temperatures were cool. Spears were not trimmed to a specific length. Weight per spear was determined for each harvest day by dividing the weight of spears by the number of spears for each plot. Total weight and total number of spears were determined for each harvest year. Data for weight and number of spears were adjusted to that of a complete stand when stands were not complete after transplanting. Yield ratios were calculated by dividing the yield of a plot with rust by the mean yield of the five plots without rust for each cultivar.

Data for weight, number of spears, and weight per spear were analyzed with analysis of variance as a split-plot design. Single degree of freedom contrasts were used to compare means of yield data from rust-infected and rust-free plots. Yield ratios were analyzed as a randomized complete block with five replicates. Single degree of freedom contrasts were used to compare the yield ratio of each susceptible cultivar with the mean ratio of the two resistant cultivars. Duncan's multiple range test was used to compare AUDPC among cultivars.

RESULTS

Severe rust epidemics developed on plants in whole plots not treated with fungicide in 1987 and 1988. The mean disease progress curve for each cultivar in 1987 and 1988 is shown in Figure 1. The mean values for AUDPC for WSU-1, Mary Washington, UC-157, and Jersey Giant, respectively, were 3,157, 1,554, 560, and 342 in 1987 and 1,817, 985, 441, and 347 in 1988. AUDPC varied significantly ($P < 0.05$) in both years. Cultivars were ranked the same by AUDPC both years with Jersey Giant and UC-157 having significantly less rust than Mary Washington. WSU-1 had significantly more rust than the other cultivars ($P < 0.05$). Rust did not develop in plots treated with fungicide (*data not shown*).

Rust significantly reduced total weight of WSU-1 in 1988 ($P < 0.05$) and of WSU-1 and Mary Washington in 1989 ($P < 0.01$), when tested with single degree of freedom contrasts (Table 1). There was not a reduction in total weight attributable to rust for the cultivars Jersey Giant and UC-157 ($P = 0.05$). Yield ratios for total weight were less during the 1989 than the 1988 harvest for all cultivars (Table 1). Yield reductions were 19% for Mary Washington and 23% for WSU-1 after the first year of infection and 50% for Mary Washington and 54% for WSU-1 after the second consecutive year of infection.

Number of spears was reduced by rust for all cultivars combined in the 1988 ($P < 0.05$) and 1989 ($P < 0.01$) harvest

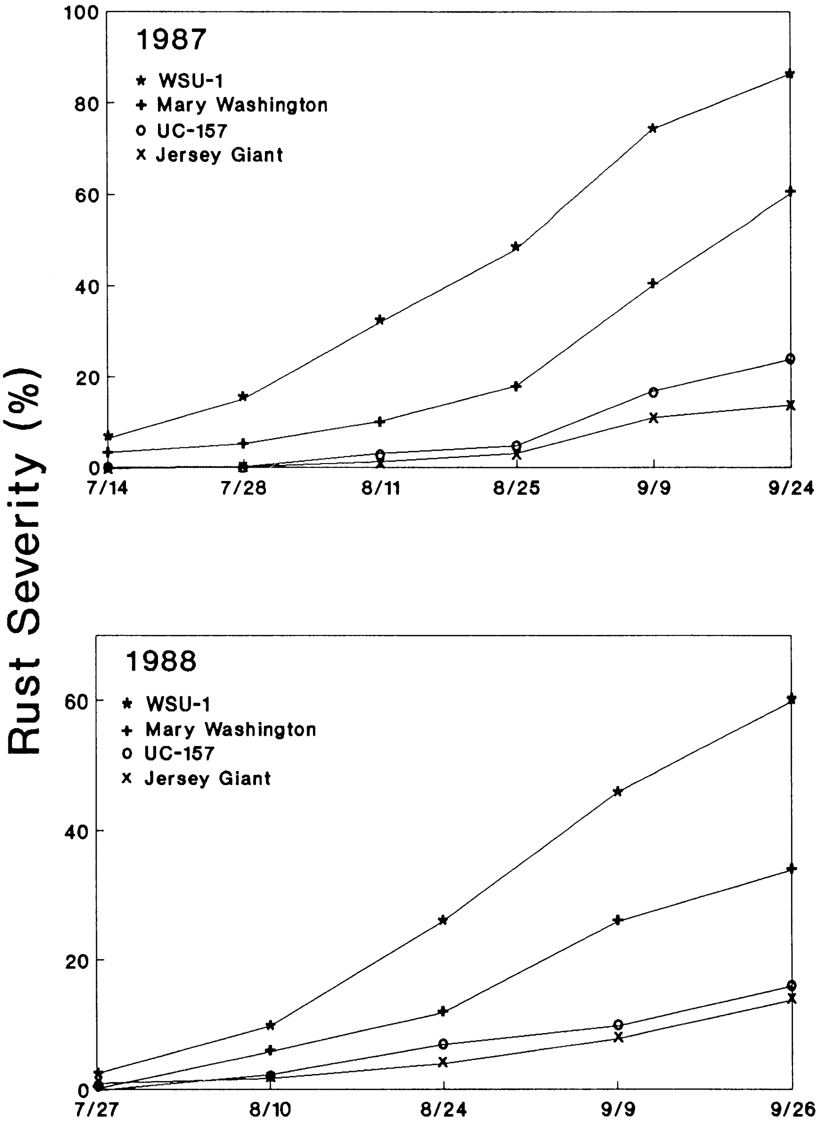

Fig. 1. Disease progress curves of asparagus cultivars infected with *Puccinia asparagi* in the field in 1987 and 1988. Curves are means of five replicates.

Table 1. Yield components of asparagus cultivars either infected or not infected with *Puccinia asparagi* 2 yr in the field[z]

Year and cultivar	Total weight (kg)			No. of spears			Weight/spear (g)		
	Rust	Rust-free	Ratio	Rust	Rust-free	Ratio	Rust	Rust-free	Ratio
1988									
Jersey Giant	54.5	57.3	0.95	2,466	2,654	0.93	22.1	21.6	1.04
UC-157	40.0	40.7	0.98	2,094	2,005	0.95	19.4	18.9	1.03
Mary Washington	36.4*	44.7	0.81	1,770*	2,087	0.85	21.3	21.4	1.00
WSU-1	36.4*	47.4	0.77***	1,877**	2,535	0.74****	19.9	18.5	1.07
1989									
Jersey Giant	12.3	13.9	0.89	1,018	1,009	1.01	12.4	12.7	0.97
UC-157	12.7	14.9	0.85	1,129	1,186	0.95	11.6	12.6	0.92
Mary Washington	6.8**	13.7	0.50****	737*	1,032	0.71****	9.5**	13.2	0.72***
WSU-1	6.6**	14.4	0.46****	695**	1,126	0.54****	9.2	11.0	0.83

[z] Mean of five replicates (yield/plot) in 1988 and 1989. Single degree of freedom contrast. * And ** are significantly different from rust-free at $P < 0.05$ and 0.01, respectively; *** and **** are significantly different from the combined mean of Jersey Giant and UC-157 at $P < 0.05$ and 0.01, respectively.

seasons. Single degree of freedom contrasts showed that spear numbers of Jersey Giant and UC-157 were not significantly ($P = 0.05$) reduced by rust either year, whereas the number of spears was reduced for Mary Washington ($P < 0.05$) and WSU-1 ($P < 0.01$) in 1988 and 1989 (Table 1). Yield ratios for number of spears were less after the second year of infection than after the first year for the two susceptible cultivars but not for the resistant cultivars (Table 1).

In both years and for all yield measurements, the cultivar × disease interaction was nonsignificant ($P = 0.05$). Weight per spear was not significantly ($P = 0.05$) affected by rust in the 1988 harvest. Only the weight per spear of Mary Washington was reduced in the 1989 harvest (Table 1).

DISCUSSION

Rust reduced total weight and number of spears of the susceptible cultivars but not of the cultivars with slow-rusting resistance. Weight per spear was affected by rust only in the cultivar Mary Washington after the second consecutive year of infection. A cumulative effect of rust infection on yield of the susceptible cultivars was seen in that yield reductions were greater after the second year of infection. Even though significant differences attributable to rust were not detected for the resistant cultivars, it appeared that two consecutive years of infection reduced total weight of the resistant cultivars because lower yield ratios were measured the second year.

Quantitative types of resistance have been used previously to maintain yields in small grains infected with rust (9,11,15). Severity of rust on the slow-rusting asparagus cultivars Jersey Giant and UC-157 has been consistently low when compared with susceptible cultivars in several studies (3,5,7). In the commercial asparagus growing area of south central Washington, rust can be managed with slow-rusting resistance, coupled with sanitation practices that eliminate development of aecia (10,12). Rust was much more severe in the plots of resistant cultivars in this study than what we have observed in commercial fields of slow-rusting cultivars in Washington over a 12-yr period. This possibly is because plots of resistant cultivars were showered with inoculum from susceptible plants growing nearby. Hence, slow-rusting asparagus cultivars should maintain yields in commercial production in Washington when conditions favor rust on susceptible cultivars.

Asparagus cultivars resistant to rust are available (5,7). Considerable heterogeneity for rust resistance exists within open-pollinated and clonal hybrid asparagus cultivars, and progress in developing more highly resistant cultivars is possible using selected germ plasm from commercial asparagus cultivars (6). Because of the availability of resistance and its effectiveness in limiting yield reductions, rust-resistant asparagus cultivars with satisfactory yield and quality traits should be grown in areas where rust may develop. In the semiarid environment of south central Washington where rust epidemics are infrequent, rust-resistant cultivars are beneficial in that yields are maintained when rust is present and yields are usually at least equal to the yield of rust-susceptible cultivars when rust is absent. Furthermore, fields of rust-resistant cultivars do not require thorough monitoring for rust development to schedule fungicide applications as do fields of rust-susceptible cultivars.

The reason why the yields of all plots were lower in 1989 than in 1988 is not known. Less fertilizer was applied before the 1989 than the 1988 harvest, but this did not account for the yield reductions. Plots may have been harvested excessively in 1988, which would have weakened the crowns for the 1989 harvest; however, the fern growth of plants in our plots after the 1988 harvest was vigorous, indicating that plants were not harvested excessively. Commercial fields of asparagus from transplants in our area are generally cut for 2 wk their second year and for at least 30 days the third year. We did not cut the second year and harvested for 33 days over a 9-wk period the third year.

LITERATURE CITED

1. Bailey, B. A., Schuh, W., Frederiksen, R. A., Bockholt, A. J., and Smith, J. D. 1987. Identification of slow-rusting resistance to *Puccinia polysora* in maize inbreds and single crosses. Plant Dis. 71:518-521.
2. Bevington, P. R. 1969. Data reduction and error analysis for the physical sciences. McGraw-Hill, New York. 336 pp.
3. Blanchette, B. L., Groth, J. V., and Waters, L., Jr. 1982. Evaluation of asparagus for resistance to *Puccinia asparagi*. Plant Dis. 66:904-906.
4. Hepler, P. R., Thompson, A. E., and McCollum, J. P. 1957. Inheritance of resistance to asparagus rust. Ill. Agric. Exp. Stn. Bull. 607. 47 pp.
5. Johnson, D. A. 1986. Two components of slow-rusting in asparagus infected with *Puccinia asparagi*. Phytopathology 76:208-211.
6. Johnson, D. A. 1989. Variation for rust resistance within asparagus cultivars. Plant Dis. 73:309-312.
7. Johnson, D. A. 1990. Development of rust on asparagus cultivars after inoculation with basidiospores, aeciospores, and urediniospores of *Puccinia asparagi*. Phytopathology 80:321-325.
8. Johnson, D. A., and Wilcoxson, R. D. 1978. Components of slow-rusting in barley infected with *Puccinia hordei*. Phytopathology 68:1470-1474.
9. Johnson, D. A., and Wilcoxson, R. D. 1979. Yield losses of fast and slow rusting barleys infected with *Puccinia hordei*. Plant Dis. Rep. 63:764-768.
10. Kahn, R. P., Anderson, H. W., Hepler, P. R., and Linn, M. B. 1952. An investigation of asparagus rust in Illinois, its causal agent and its control. Ill. Agric. Exp. Stn. Bull. 559. 56 pp.
11. Krull, C. F., Reyes, R., Orjuela, J., and Bustamante, E. 1965. Importance of the "small uredia" reaction as an index of partial resistance to oat stem rust in Colombia. Crop Sci. 5:494-497.
12. Norton, J. B. 1913. Methods used in breeding asparagus for rust resistance. U.S. Bur. Plant Ind. Bull. 263. 60 pp.
13. Peterson, R. E., Campbell, A. B., and Hannah, A. E. 1948. A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Can. J. Res. 26:496-500.
14. Skovmand, B., Wilcoxson, R. D., Shearer, B. L., and Stucker, R. E. 1978. Inheritance of slow rusting to stem rust in wheat. Euphytica 27:95-107.
15. Statler, G. D., Watkins, J. E., and Nordgaard, J. 1977. General resistance displayed by three hard red spring wheats (*Triticum aestivum*) cultivars to leaf rust. Phytopathology 67:759-762.
16. Subrahmanyam, P., McDonald, D., Gibbons, R. W., and Subba Rao, P. V. 1983. Components of resistance to *Puccinia arachidis* in peanuts. Phytopathology 73:253-256.
17. Thompson, A. E., and Hepler, P. R. 1956. A summary of resistance and susceptibility to *Puccinia asparagi* DC within the genus *Asparagus*. Plant Dis. Rep. 40:133-137.