Evaluation of Oat Crown Rust Disease Parameters and Yield in Moderately Resistant Cultivars

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ABSTRACT

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Twelve oat cultivars that differed in susceptibility to crown rust caused by *Puccinia coronata* f. sp. *avenae* were evaluated during severe, moderate, and light epidemics in 1971 and 1972 at St. Paul and Rosemount, MN. A multiline (ML) cultivar and cultivars with the following crown rust reactions were evaluated: S = susceptible, M = moderate, ET = early telia, SR = slow ruster, and HR = highly resistant. The differences in both disease and yield parameters between the moderately resistant types (M, ML, ET, and SR) and the R and S cultivars were more distinct with increased epidemic severity. Correlations between disease severity and the ratios of yield or kernel weight in rusted and nonrusted subplots were negative and highly significant. Thus, crown rust reduced yields in direct proportion to disease severity; however, the yields of some moderately resistant types (66B1269, Minhafer, Iowa M70, and Portage) equaled or exceeded the yield of the HR types under severe epidemic conditions, even though rust development on them was greater.

Additional key words: *Avena sativa*, race diversity, nonspecific resistance.

Historically, race-specific resistance has been utilized to control crown rust of oats (*Avena sativa* L.) caused by *Puccinia coronata* Cde. f. sp. *avenae* Fr. & Led. (1,2,10), but this type of resistance too frequently has been overcome by new races of the pathogen. As a result, research efforts have been directed toward identifying more stable moderate resistance (2,3,5,9,11). To be useful, this resistance must provide an acceptable degree of protection against rust even if not equivalent to that provided by race specific resistance. Such a degree of protection has been suggested by work with wheat (13,16), and oats (4).

In the present study, we evaluated the resistance of oat cultivars to crown rust and measured the effects of those resistances on yields.

MATERIALS AND METHODS

In 1971 and 1972, 12 oat cultivars (Table 1) were planted at St. Paul and Rosemount, MN, in a randomized complete block with a split-plot arrangement of treatments replicated four times. Cultivars were assigned to whole-plots that were isolated with 2.4-m-wide drill strips of a wheat-barley mixture (3:1, v/v). Each whole-plot was subdivided into two subplots (each 1.8 × 1.8 m) separated by a single row of the wheat-barley mixture. Each subplot included 13 rows (15-cm row spacing) and was seeded at 72–90 kg/ha.

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For inoculations with *P. coronata* f. sp. *avenae*, a spreader hill of the cultivar Coachman (15 seeds per hill) was planted in the center of each subplot. Treatments with and without rust were assigned randomly to each of the subplot pairs. Each subplot without rust was sprayed with maneb (4.5 kg/ha) at 7- to 10-day intervals beginning at the time of inoculation. Rusted subplots were treated as follows: the Coachman spreader hill was inoculated before full boot growth stage with an oil/spore mixture (0.10–0.15 ml per hill) of aeciospores or urediospores of *P. coronata* f. sp. *avenae*. After 8–10 days, plants in the inoculated spreader hills were thinned to leave 50–150 pustules per hill.

Rust severity (percentage of the flag leaf area infected) was recorded periodically. Areas under the disease progress curve (AUDPC) were calculated for each cultivar to quantify rust severity differences over time. To calculate AUDPC, the rust severity data were plotted (Y-axis) versus days after planting (X-axis), by replication for each cultivar. The areas of graph paper included between each curve and its X-axis were cut out and weighed to the nearest 0.01 g. Individual curve weights were divided by the weight of a unit area of paper to obtain replicated AUDPC values for each cultivar.

The effect of crown rust on the yield of each cultivar was indicated by the yield ratio; ie, the yield of rusted subplot divided by the yield of nonrusted subplot. Yield determinations were based on the threshed grams of grain per plot and 250-kernel weights (nearest 0.01 g). Standard analysis of variance procedures were followed for analyzing all the data (14).

The twelve cultivars (Table 1) were selected for study because they represented a broad range in resistance to crown rust. With the exception of the multiline (Iowa M70; Reg. No. 247), the cultivars have been stable in reaction to crown rust when tested under conditions of race diversity in a buckthorn (*Rhamnus cathartica* L.) nursery over a period of years (M. B. Moore, *unpublished*). Tippecanoe (CI 6913) and Coachman (CI 7684) were included as susceptible (S) cultivars along with 680bs8038 (CI 8369) and CI 8235 as highly resistant (HR) cultivars. Cultivar 66B1285 (MN65B1301) was characterized as an early telia (ET) type on which urediospore fructification was rapidly followed by teliospore production. Cultivar 66B1269 (MN65B1286) was slow rusting (SR) (ie, had a slower rate of rust increase than susceptible cultivars). Kota, Kelsey, Ajax, Minhafer, and Portage (CI 8178, 8171, 4147, 7680, and 7170, respectively) were classed as moderately resistant (M).

RESULTS AND DISCUSSION

The mean values for severity of crown rust on flag leaves and AUDPC for all cultivars were 31, 14, and 9% and 1.84, 1.31, and 0.84 in the severe (1971, St. Paul), moderate (1972, St. Paul) and light (1972, Rosemount) rust epidemics, respectively (Table 1). The

TABLE 1. The mean severity of crown rust (*Puccinia coronata* f. sp. *avenae*) on the flag leaves and areas under the disease progress curve (AUDPC) for 12 oat cultivars in years when the disease was severe (1971, St. Paul), moderate (1972, St. Paul) and light (1972, Rosemount)

Maturity classes[x] and cultivars	Crown rust reaction[y]	Severity of rust (%) in epidemics that were[z]			AUDPC in epidemics that were		
		Severe	Moderate	Light	Severe	Moderate	Light
Early							
Tippecanoe	S	85	57	22	4.55	5.20	1.71
Minhafer	M	15	5	3	0.92	0.64	0.91
Iowa M70	ML	8	6	...	0.38	1.19	...
Midseason							
Coachman	S	85	50	24	5.55	4.10	2.20
Kota	M	40	4	18	2.30	0.70	1.73
Kelsey	M	30	18	21	1.81	1.43	1.46
Ajax	M	27	5	2	1.80	0.34	0.64
Portage	M	5	1	2	0.27	0.19	0.29
Late							
66B1285	ET	43	15	2	3.24	1.33	0.20
66B1269	SR	20	3	0-1	1.09	0.45	0.02
CI 8235	HR	5	0-1	0-tr	0.11	0.11	0.02
680bs8038	HR	5	tr	0-tr	0.04	0.09	0.02
Mean		31	14	9	1.84	1.31	0.84

[x]Maturity classes are based on the relative heading date differences between the cultivars.
[y]S = susceptible, M = moderate, ML = multiline, ET = early telia, SR = slow ruster, and HR = highly resistant.
[z]Mean percentage of flag leaf area infected for four replications.

TABLE 2. Mean yield and kernel weight ratios[u] for 12 oat cultivars that differed in susceptibility to *Puccinia coronata* f. sp. *avenae* in years when crown rust was severe (1971, St. Paul), moderate (1972, St. Paul) and light (1972, Rosemount) in Minnesota

Maturity classes[v] and cultivars	Crown rust reaction[w]	Yield ratios in epidemics that were:			Kernel weight ratios in epidemics that were:		
		Severe	Moderate	Light	Severe	Moderate	Light
Early							
Tippecanoe	S	0.54 ab[x] **[y]	0.98 ab[x]	0.84 a[x] *[y]	0.65 ab[x] **[y]	0.88 abc[x] **[y]	0.90 abc[x] **[y]
Minhafer	M	0.72 cde **	1.07 b	0.96 a	0.83 de **	0.94 bc *	0.93 abcd **
Iowa M70	ML	0.84 e **	1.00 ab	0.86 a *	0.87 e **	0.97 c	0.99 d
Midseason							
Coachman	S	0.50 ab **	0.84 ab **[y]	0.83 a *	0.63 a **	0.79 a **	0.85 a **
Kota	M	0.58 abc **	0.83 a **	0.91 a	0.74 abcde **	0.83 ab **	0.91 abcd **
Kelsey	M	0.56 ab **	0.82 a **	0.90 a	0.73 abcd **	0.84 ab **	0.90 abc **
Ajax	M	0.57 abc **	0.91 ab *	0.96 a	0.73 abcd **	0.91 bc **	0.91 abcd **
Portage	M	0.76 de **	1.02 ab	1.03 a	0.80 cde **	0.97 c	0.92 abcd **
Late							
66B1285	ET	0.49 a **	0.90 ab *	0.94 a	0.68 abc **	0.90 abc **	0.88 ab **
66B1269	SR	0.83 e **	0.82 a **	0.96 a	0.77 bcde **	0.87 abc **	0.92 abcd **
CI 8235	HR	0.79 de **	0.95 ab	0.96 a	0.79 cde **	0.93 bc *	0.94 bcd *
680bs8038	HR	0.65 bcd **	0.93 ab	0.95 a	0.79 cde **	0.93 bc *	0.94 bcd *
Mean		0.65	0.92	0.93	0.74 **	0.90	0.92
hsd (P=0.5)[x]		0.15	0.23	0.28	0.13	0.11	0.08
CV[z]		9.7	10.0	12.3	7.2	5.3	3.8

[u]Yield and kernel weight ratios were derived by dividing the yield from the rusted subplot by the yield from the adjacent nonrusted subplot.
[v]Maturity classes based on relative heading date differences between the cultivars.
[w]S = susceptible, M = moderate, ML = multiline, ET = early telia, SR = slow ruster, and HR = highly resistant.
[x]Data followed by a common letter are not significantly different as determined by Tukeys hsd test ($P = 0.05$).
[y]Asterisks indicate a signficant effect on yield of a cultivar due to crown rust (*, $P = 0.05$; **, $P = 0.01$).
[z]CV = coefficient of variability.

differences in rust severity and AUDPC between epidemics resulted from different times of initiation of the epidemics relative to cultivar maturity. The 1971 St. Paul epidemic was initiated while the early maturing cultivars (Tippecanoe, Minhafer, and Iowa M70) were heading. The 1972 St. Paul epidemic was initiated when the midseason cultivars (Coachman, Kota, Kelsey, Ajax, and Portage) were heading. The 1972 Rosemount epidemic was initiated as the late-season cultivars were heading.

Regardless of the severity of the epidemic (Table 1), rust severity ratings and AUDPC values of the cultivars with M, SR, ET, ML crown rust reactions were intermediate between those of the HR and S cultivars. Under less severe epidemics, it was more difficult to separate the cultivars with intermediate reactions to crown rust from those that were S or HR. AUDPC was probably more indicative of cultivar differences than was rust severity.

The overall mean yield ratios (0.65, 0.92, and 0.93) and 250-kernel-weight ratios (0.74, 0.90, and 0.92) (Table 2) increased as the severity of the epidemic decreased from severe to light, respectively. This was also true for the individual cultivars. The correlation coefficients (r) between the measures of disease intensity and the yield and kernel weight ratios were negative, highly significant, and ranged between −0.75 and −0.81, as similarly reported in 1940 by Murphy et al (6). Thus, crown rust generally reduced yield in proportion to the severity of the disease. As shown in Table 2, the yield ratios of the cultivars with crown rust reactions of M, ML, ET, and SR, ranged from higher than those of the HR cultivars to as low as those of the S cultivars. Thus, the yield and 250-kernel-weight ratios did not as clearly differentiate the cultivars as did the disease data, because the losses of some moderately resistant cultivars were less than those of resistant HR cultivars in the presence of crown rust. This confirms the findings of Murphy et al (6) that among Bond Hybrids, Markton × Rainbow crosses, and miscellaneous crosses there were lines with rust coefficients ranging 30–70 that yielded as well as cultivars with rust coefficients that ranged 0–10. Therefore, for some cultivars that can support significant amounts of crown rust, the yield loss may be no more than that sustained by resistant cultivars.

As suggested by Vanderplank (15), the value of cultivars with moderate degrees of resistance to crown rust may not be fully realized until they are widely grown. We have no data from these tests on the stability of the moderate types of resistance studied, but the cultivars had been tested and selected for the stability of their crown rust reactions over a period of years in the presence of a diverse mixture of *P. coronata* races (7,8,12).

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