Crown Rust Tolerance of Avena sativa-type Oats Derived from Wild Avena sterilis

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ABSTRACT

To test the hypothesis that *Avena sterilis* indigenous to Israel has tolerance to crown rust (*Puccinia coronata* var. *avenae*) potentially valuable in commercial production, three strains rated susceptible in reaction type were crossed with the highly susceptible *A. sativa* cultivars Richland and Clinton. Cultivated-type rust-susceptible segregates selected from the resulting populations were evaluated for field tolerance in epiphytotics artificially initiated with a mixture of common crown rust races. Relative tolerance of segregates to infection was estimated by comparison of the average weight of kernels from infected plants with that from rust-free controls. The amount of tolerance transmitted by the different *A. sterilis* parents varied significantly as estimated by the mean tolerance values of the lines derived from each parent. All 23 lines derived from Richland were significantly more tolerant than Richland; 19 of the 23 lines derived from Clinton were significantly more tolerant than Clinton. Heritability of tolerance was estimated to be 76%. Almost all derived lines were lower in yield, under rust-free conditions, than were their respective cultivated parents.

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Additional key words: responses to infection.

The theoretical advantages of tolerance as opposed to resistance in oats (*Avena sativa* L.) to the crown rust fungus (*Puccinia coronata* Cda. var. *avenae* Fraser & Led.) were reviewed recently (3).

The wild oat *A. sterilis* L. is widespread and abundant in Israel. *Rhamnus palaestina* Boiss., an effective aecial host of the crown rust fungus, is a common shrub in the same area (6). Thus, it is not surprising that *A. sterilis* rusts heavily in Israel. This severe infection, however, does not seem to damage "susceptible" plants appreciably, suggesting that they have tolerance to the fungus (5).

The purpose of my study was to test the hypothesis that "susceptible" strains of *A. sterilis* from Israel have tolerance to crown rust, and that it can be transferred to cultivated-type oats in which it may have commercial value.

MATERIALS AND METHODS.—Five strains of *A. sterilis* from Israel that were believed to have no crown rust resistance were furnished by I. Wahl and his associates.

Since tolerant plants show symptoms that are visually similar to those of susceptible plants, it is necessary to evaluate tolerance by a measurement of the effect of infection on quantitative characters such as yield and kernel weight. The direct measurement of such characters of *A. sterilis* is extremely difficult because of practical problems caused by late maturity, shattering, and awnedness and seed pubesence of this species. Therefore, the strains of *A. sterilis* were crossed with the oat cultivars Clinton and Richland, both highly susceptible to injury from crown rust, but otherwise well adapted to Corn Belt conditions.

Segregates were selected for cultivated plant type and date of maturity through the F_5. During this time, two of the five crosses proved to have segregates resistant to certain races of crown rust, and were discarded. The prepotency of the *A. sterilis* parents resulted in a relatively small number of segregates with acceptable plant type and maturity. True-breeding segregates with acceptable type were grown in replicated hill-plot tests (1) in F_6 and F_7, and confirmation testing of some segregates was carried out in F_8. Epiphytotics of crown rust were initiated artificially by hypodermic injection of one plant in each hill with a suspension of spores of several common crown rust races. Data on yield, kernel weight (based on a sample of 200 kernels), and heading date were recorded. Yield and kernel weight data were corrected for heading date (4).

Duplicate plantings were maintained free of rust with a fungicide to provide an estimate of differences among lines in the absence of rust. I expressed responses to infection as ratios obtained by dividing the values from rusted plots by corresponding values from unrusted plots. This eliminated differences attributable to most causes other than infection (2).

RESULTS.—*Performance in unrusted plots.*—Only scattered pustules of crown rust developed in the fungicide-treated plots. Although the derived lines had the general appearance of cultivated oats, the general yield superiority of the Clinton and Richland parents in these plots was striking (Table 1). The yields of all lines derived from Clinton were significantly (0.01 level) lower than Clinton; some yielded less than half as much as Clinton. Richland derivatives were similar, except that one or two lines approached Richland in yield.

Differences in kernel weight were not so striking, although most of the Clinton-derived lines and more than half the Richland-derived lines had smaller kernels than their respective cultivated parents.

Intensity of infection.—Crown rust developed

TABLE 1. Yields of unrusted (*Puccinia coronata*) plots and kernel weight indexes[a] of lines derived from crosses between cultivated oats and strains of *Avena sterilis*

Cultivated parent	*A. sterilis* parent					
	P.I. 296255		P.I. 296264		6-76-4	
	Yield (g)	Kernel wt index	Yield (g)	Kernel wt index	Yield (g)	Kernel wt index
Clinton	18.8**[b]	.786**	15.6**	.788**	28.7**	.811**
Clinton	27.4**	.780**	18.6**	.762**	20.9**	.740*
Clinton	25.1**	.740*	18.3**	.806**	17.0**	.766**
Clinton	23.1**	.718	14.6**	.782**	20.2**	.728
Clinton	13.2**	.720	19.2**	.760	20.3**	.763**
Clinton	17.6**	.754**	25.6**	.834**	20.6**	.788**
Clinton	22.4**	.722			27.8**	.791**
Clinton	21.1**	.755**			22.4**	.740*
Clinton					18.3**	.758*
Mean	21.1**	.749*	18.6**	.789**	21.8**	.765**
Clinton check	33.0	.702	33.0	.702	33.0	.702
Richland	20.9**	.814**	14.4**	.770**	21.1**	.782**
Richland	18.9**	.821**	21.3**	.770**	22.9**	.770**
Richland	23.3**	.825**	14.9**	.770**	26.2**	.751**
Richland	20.1**	.810**			20.8**	.812**
Richland	22.3**	.829**			19.2**	.771**
Richland	27.5	.788**			8.8**	.779**
Richland	20.9**	.762**			22.1**	.824**
Richland	20.9**	.762**			14.6**	.758**
Richland					27.2*	.769**
Mean	22.3**	.799**	18.0**	.772**	20.0**	.778**
Richland check	30.0	.682	30.0	.682	30.0	.682

[a] See text for explanation of index.
[b] *,** Indicate a difference from the cultivated parent significant at the .05 and .01 levels of probability, respectively.

uniformly and heavily in the rusted plots in all 3 years the material was in replicated tests. Infected Richland plants yielded only about half as much as those which were rust-free; infected Clinton yielded about 60% of the rust-free control. Both cultivars produced kernel weights under rusted conditions that were about 70% of the weights produced in the unrusted plots.

Comparison of A. sterilis parents.—Strains of *A. sterilis* might be expected to transmit different degrees of tolerance. However, the absolute mean differences for both yield and kernel weight responses were small (Table 1). In the case of kernel weight response, the error was small and a large number of replicates was available. These differences were statistically significant for the three possible comparisons of means between Richland crosses. The error for yield response was much larger than for kernel weight response, and there were no significant differences among means for this character.

Performance of individual lines.—The kernel weight of Richland in the rusted plots was only 68% of its value in the unrusted plots. Seven of the derived lines, in rusted plots, produced kernels that weighed more than 80% as much as kernels from corresponding unrusted plots, and all 23 lines derived from Richland had significantly smaller reductions in kernel weight because of rust infection than did Richland (Table 1). In yield response, the differences between Richland and the lines derived from it were not as striking as with kernel weight response, but 15 of the 23 lines were significantly more tolerant on this basis than Richland. Some of these were more than 20% more tolerant than Richland.

Most lines derived from the three Clinton crosses were significantly superior to Clinton in kernel weight response, but only one of the 23 was significantly better in yield response.

Confirmatory testing was carried out in 1971 with seven of the most promising lines from the Richland crosses and six from the Clinton crosses. Six of the seven lines from Richland and five of the six from Clinton were significantly superior in tolerance to their respective cultivated parents in these tests.

Crown rust tolerance and yield.—Correlations between kernel weight response (the best single measure of rust tolerance) and yields of unrusted plants are of great practical importance. Any tendency toward a negative relationship of rust tolerance and yield would complicate the use of the tolerance in developing improved cultivars. As noted, almost all derived lines yielded less than did their respective cultivated parents. Among themselves, however, the derived lines differed greatly, with the best ones yielding over twice as much grain as the poorest. The simple coefficients of correlation between kernel weight response and yield of unrusted plants actually were positive for both the lines derived from Richland and those from Clinton. The values ($r = 0.122$ for Richland lines; $r = 0.251$ for Clinton lines) of these coefficients, however, were

low, and neither reached significance at the .05 probability level.

Heritability of tolerance.—Estimates of heritability of rust tolerance served both to verify that measurable tolerance existed in the wild parents and to furnish an estimate of the relative ease with which this tolerance might be selected from segregating populations. Heritability of tolerance, as indicated by response of kernel weight to infection, was estimated to be 76% when computed by the use of components of variance from an analysis of variance of data obtained in 2 years. Similarly, heritability as reflected by yield response was estimated to be 52%. Details of the method of calculation were presented earlier (3). These heritability values suggest that rust tolerance is not unduly influenced by environmental factors and that tolerant segregates could be identified in a breeding program.

DISCUSSION.—In absolute magnitude, the tolerance obtained from *A. sterilis* was not impressive. Even so, some of the derived lines were as much as 15% higher than the cultivated parent in kernel weight response and 20% higher in yield response. In view of the severity of the rust test and the small number of lines tested from each cross, these results are encouraging. Also, only three strains of *A. sterilis* were evaluated. The positive results with these three suggest that a better sampling of the wild population of *A. sterilis* would almost certainly reveal strains that carried and could transmit a higher degree of tolerance.

A disturbing aspect of the study was the low average yield of the derived lines. These lines varied greatly in yield, however, and a few approached their respective cultivated parents. Here again, a small number of lines was involved, and a larger sample of lines might well have revealed some with greater yielding ability. Since there was no relationship between yield and tolerance, there would be no reason why such high-yielding lines, when found, should not have just as good a chance of being tolerant as would low-yielding lines.

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