

Inheritance of Resistance to Leaf Rust in Waldron Wheat

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ABSTRACT

Inheritance of resistance to wheat leaf rust incited by *Puccinia recondita* f. sp. *tritici* was investigated in Waldron, a hard red spring wheat. Waldron is highly resistant to leaf rust in the field and to numerous cultures representing a wide range of virulence in greenhouse tests. Little Club was used as the susceptible parent in

reciprocal crosses to Waldron. Genetic analysis revealed that two genes, one dominant and one recessive, in Waldron, conditioned resistance to culture 70-1, a widely avirulent culture of *P. recondita*. The two genes have been assigned the temporary symbols *LrW-1* and *LrW-2*.

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Additional key words: *Triticum aestivum*, isogenic lines, host genes, digenic ratio, widely avirulent.

The use of resistant cultivars has been a highly successful method for control of leaf rust and reduction of yield losses (3, 4). However, if resistant parents with unknown genotypes are used in a breeding program, a narrow base of resistance may result (1). Therefore, studies of the inheritance of resistance to *Puccinia recondita* Rob. ex Desm. f. sp. *tritici* are useful in determining the genetic nature of unknown host genotypes so that the best combination of host genes can be incorporated into new varieties for the most effective long term resistance.

The inheritance of resistance to leaf rust (*P. recondita*) was studied in crosses of *Triticum aestivum* L. em. Thell. Waldron (C.I. 13958) to the leaf rust-susceptible cultivar Little Club (C.I. 4066). Waldron has been used extensively in breeding programs because of its excellent agronomic and acceptable milling and baking qualities and its resistance to prevalent races of *P. recondita* in North Dakota (7).

MATERIALS AND METHODS.—Waldron, C.I. 13958, was used as the resistant parent in reciprocal crosses to Little Club, C.I. 4066, which is susceptible to *P. recondita*. A single pustuled uredial culture of race 1 (culture 70-1) was used to test all progeny, as previous work indicated that more genes could be differentiated with a widely avirulent culture (6). Culture 70-1 was avirulent (0 to 0; infection type) on Waldron and virulent on Little Club (4 infection type). Since F_1 plants of the cross Waldron \times Little Club and its reciprocal were resistant to culture 70-1, they were backcrossed to Little Club, the susceptible parent. The F_2 plants and F_3 families from the crosses as well as backcross- F_1 plants and backcross- F_2 families were inoculated with culture 70-1 and evaluated for seedling reaction. F_2 and backcross- F_1 plants were also inoculated and evaluated in the adult stages.

Plants were inoculated by being dusted with a mixture of urediospores of culture 70-1 and talcum powder on the first leaf for seedling reaction and on the flag leaf for adult reaction. Inoculated plants were held at approximately 100% relative humidity and 20

C for 20-22 hr. Plants were then incubated for 12 days at 21-25 C in the greenhouse. Parent cultivars were included in all tests.

The rust reaction of each plant was scored after 12 days by the method proposed by Stakman et al. (5). The inoculated leaves were removed after the 12-day incubation period and placed in groups that differed in reaction types according to the method of Gough & Williams (2). The chi-square test for goodness of fit was used to analyze the segregating populations.

Waldron and host lines containing host genes *Lr1*, *Lr2*, *Lr2D*, *Lr3*, *Lr9*, *Lr10*, *Lr16*, *Lr17*, *Lr18*, or *Lr19* were inoculated with several leaf rust cultures representing a wide range of pathogenicity. Reaction patterns on the isogenic lines were compared with those on Waldron.

RESULTS AND DISCUSSION.—The infection types on F_1 plants from reciprocal Waldron \times Little Club crosses were similar to the infection types on Waldron (0 to 0;) in all cases. The 273 F_2 plants derived from six F_1 plants segregated into two reaction types 0 to 0; and 3 to 4. The numbers of

TABLE 1. Reactions of F_2 plants and F_3 families from reciprocal Waldron \times Little Club crosses to culture 70-1 of *Puccinia recondita*

F ₂ plants	No. plants	
	Expected (13:3)	Observed
Resistant	221.8125	217
Susceptible	51.1875	56
	<i>P</i> > .25	
F ₃ families	No. families	
	Expected (7:6:2:1)	Observed
Homozygous resistant	104.125	120
Segregating 3R:1S or 13R:3S	89.250	79
Segregating 1S:3R	29.750	26
Homozygous susceptible	14.875	13
	<i>P</i> > .10	

TABLE 2. Reactions of backcross-F₁ plants and backcross-F₂ families from reciprocal Waldron × Little Club crosses to culture 70-1 of *Puccinia recondita*

Backcross-F ₁ plants	No. plants	
	Expected (1:1)	Observed
Resistant	69.5	67
Susceptible	69.5	72
	<i>P</i> > .75	
Backcross-F ₂ families	No. families	
	Expected (2:1:1)	Observed
Segregating 3R:1S	59.50	63
Segregating 3S:1R	29.75	23
Homozygous susceptible (S)	29.75	33
	<i>P</i> > .10	

plants gave a satisfactory fit to a three resistant:one susceptible (or a 13 resistant:three susceptible *P* > .25) ratio when the moderately susceptible (infection type 3) were combined with the susceptible types (infection type 4) (Table 1). The chi-square test for heterogeneity indicated that the families were homogeneous (*P* > .75) and that there was no maternal influence. F₂ data indicated that a single dominant gene conditioned resistance to culture 70-1 in Waldron.

Testing the F₃ families indicated a second gene for resistance in Waldron that was recessive. The F₃ families segregated into four reaction classes. One hundred and twenty F₃ families from resistant F₂ plants were homozygous resistant, and 79 segregated three resistant to one susceptible or 13 resistant to three susceptible (Table 1). Monogenic 3:1 ratios and

digenic 13:3 ratios could not be differentiated in all cases with the family size used (30-40 plants). Twenty-six F₃ families from susceptible F₂ plants segregated one susceptible to three resistant, and 13 were homozygous susceptible. Chi-square tests indicated that the F₃ families satisfactorily fit a 7:6:2:1 digenic ratio for one dominant and one recessive gene (Table 1).

The backcross-F₁ [Little Club × (Waldron × Little Club) and Little Club × (Little Club × Waldron)] segregated 67 resistant to 72 susceptible. Chi-square tests indicated that the combined data from the backcrosses fit a 1:1 ratio (*P* > .90) (Table 2). The chi-square test for heterogeneity indicated that the families were homogeneous (*P* > .50).

The backcross-F₂ families derived from 119 backcross-F₁ plants segregated into three phenotypic groups. Sixty-three backcross-F₂ families from resistant backcross-F₁ plants segregated three resistant to one susceptible. Twenty-three backcross-F₂ families from susceptible backcross-F₁ plants segregated three susceptible to one resistant, and 33 families from susceptible backcross-F₁ plants were homozygous susceptible. The number of families in the three groups satisfactorily fit a 2:1:1 ratio (*P* > .10), and thus support the hypothesis that a single dominant gene and a single recessive gene condition resistance to culture 70-1 of *P. recondita* in Waldron.

Backcross-F₁ plants and F₂ plants were also inoculated with culture 70-15 (race 15) *P. recondita*. The 126 backcross-F₁ plants derived from Waldron × Little Club crosses inoculated with culture 70-15 segregated approximately one resistant to one susceptible (*P* > .75). The 270 F₂ plants inoculated with culture 70-15 satisfactorily fit a three resistant to one susceptible ratio, indicating that a single dominant gene conditioned resistance to culture 70-15 of *P. recondita*. Backcross-F₂ and F₃ families were not tested with culture 70-15, and therefore the

TABLE 3. Seedling reactions of 10 isogenic wheat lines and Waldron inoculated with 10 cultures of *Puccinia recondita*

Isogenic line or variety	Culture number									
	70-1	70-15	68-5	70-13	70-142	70-147	70-159	70-110	70-96	70-197
	<i>Host reaction types^a</i>									
Lr1	R	R	S	S	R	R	S	R	S	R
Lr2	R	R	MS	S	R	R	R ⁺	R	MR	S
Lr2D	R	MR	S	S	MR	S	MR	MR	S	MR
Lr3	R	S	S	S	S	S	S	S	S	S
Lr9	R	R	R	R	R	R	R	R	R	R
Lr10	R	S	MS	R	S	MR	S	R	S	S
Lr16	MR	MR	MR	MR	MR	S	MR	MR	MR	R
Lr17	R	R	MS	MR	R	S	R	R	R ⁺	S
Lr18	R	R	MS	MR	S	S	MR	S	S	S
Lr19	R	R	R	R	R	R	R	R	R	R
Waldron	R	R	R	R	R	R	R	R	R	S

^a R = resistant. R⁺ = a few susceptible type pustules. MR = moderately resistant. MS = moderately susceptible. S = susceptible.

recessive gene detected with culture 70-1 was not differentiated.

The leaf rust reaction types on Waldron did not resemble those of the isogenic host lines when tested with 10 leaf rust cultures representing a wide range of pathogenicity (Table 3). When tested with several other cultures, Waldron was susceptible only to culture 70-197 and only in the seedling stage. This indicates that the two genes in Waldron condition resistance to leaf rust cultures representing a wide range of pathogenicity, and that Waldron may have an additional gene which conditions resistance to culture 70-197 in the adult stage. Waldron has shown excellent field resistance when grown in leaf rust nurseries at six North Dakota locations in 1970 and 1971. This indicates that the two genes in Waldron condition resistance to the prevalent rust races comprising the natural leaf rust population which compositely form a rather wide range of virulence (7). The two genes in Waldron have been assigned the temporary symbols *LrW-1* and *LrW-2* in accordance with the North American Leaf Rust Workers Committee.

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