Detecting Wheat Leaf Rust Resistance Gene *Lr* 13 in Seedlings

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ABSTRACT

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The adult-plant wheat leaf rust resistance gene *Lr* 13 was detected in seedlings of wheat (*Triticum aestivum*) at 25.5 C but not at 18.1 C when inoculated with Cereal Rust Laboratory culture no. 82-BHL-MD of *Puccinia recondita* f. sp. *tritici*. Cultures of *P. recondita* f. sp. *tritici* were separated into two groups on the basis of their virulence to *Lr* 13 at 25.5 C.

The gene *Lr* 13 has been shown to confer resistance to many races of *Puccinia recondita* Rob. ex Desm. f. sp. *tritici* Eriks. & Henn. in adult wheat plants (*Triticum aestivum* L.), but this has not been seen in seedlings until now (3,5). Dyck et al (3) observed it to be effective at the third-leaf stage while the first leaf was susceptible. Although the resistance has not previously been detected in the first leaf of seedlings, it has been used effectively for improvement of cultivars (5). If this gene could be detected in seedlings, it might be used more readily for cultivar improvement. Effects of temperature in modifying expression of genes for leaf rust resistance in wheat have been reported previously (4). Reducing incubation temperature was found to provide the environment for seedling expression of adult-plant resistance to crown rust in oats (2). This research describes the use of high-temperature incubation periods and specific isolates of the pathogen to detect the *Lr* 13 gene in wheat seedlings.

MATERIALS AND METHODS

To detect the gene *Lr* 13, wheat plants were grown at 22.5 C in a growth chamber until 7 days old, then inoculated with fresh urediospores of *P. recondita* f. sp. *tritici* suspended in light mineral oil. After inoculation, plants were held in a dew chamber at 21 C for 16 hr. They were allowed to dry slowly in the chamber for 3 hr and then placed in growth chambers at 25.5 or 18.1 C. These chambers were illuminated at about 15,000 lux for 12 hr each day with light from fluorescent tubes suspended about 15 cm above the plants. Infection types were evaluated when they appeared to be fully developed. At 25.5 C, this was 9–10 days after inoculation; at 18.1 C, it was 12–14 days.

The first test was made to detect possible avirulence in a collection of cultures of *P. recondita* f. sp. *tritici* on wheat seedlings. Twenty-four cultures were selected on the bases of their diverse origins and virulence characteristics. They were used to inoculate seedlings of CT 263 (a Thatcher backcross line near-isogenic for *Lr* 13), with Thatcher as a susceptible check (Table 1). The test was made once at each temperature.

The second test included CT 263; Manitou, Napayo, and Neepawa, three Canadian wheat cultivars that possess *Lr* 13 (5); Chris and Era, two U.S. cultivars that possess *Lr* 13 plus other resistance genes (6,1); and Thatcher (susceptible check cultivar). Plants were inoculated with *P. recondita* f. sp. *tritici* Cereal Rust Laboratory culture no. 82-BHL-MD. This experiment was made three times at each temperature.

The third experiment was made to detect *Lr* 13 in progenies of crosses involving Chris and Era. There were 20 F_3 families of the cross Baart*2/Chris and 24 F_3 families of the cross Baart*2/Era, provided by D. V. McVey. There were seven to 16 plants in each family. The test was made with culture no. 82-BHL-MD at both temperatures.

RESULTS

Three *P. recondita* f. sp. *tritici* cultures, Cereal Rust Laboratory no. 81-LCB-CH from China in 1981, no. 82-BHL-MD from Mexico in 1980, and no. 82-DGB-MX from Chile in 1981, were only slightly virulent to near-isogenic line CT 263 at 25.5 C but fully virulent at 18.1 C (Table 1). They were all fully virulent to Thatcher at both temperatures. The

Table 1. Infection types produced by isolates of *Puccinia recondita* f. sp. *tritici* on seedlings of line CT 263, a line near-isogenic for the resistance gene *Lr* 13

Isolate no.[a]	Origin	Year collected	Infection types[b]	
			18.1 C	25.5 C
82-CGB-OV	Washington	1982	4	4
82-CBC-OQ	Minnesota	1982	4	4
82-MGC-OQ	Minnesota	1982	4	4
82-FBN-LX	Minnesota	1982	4	4
82-FLN-IX	Minnesota	1982	4	4
82-PHB-IY	Minnesota	1982	4	4
82-JCL-FG	North Dakota	1981	4	4
82-MJD-KS	Kansas	1980	4	4
82-CGC-JC	Illinois	1982	4	4
82-CGD-FQ	Ohio	1978	4	4
82-SCB-JA	Pennsylvania	1982	4	4
82-PHD-IV	Virginia	1982	4	4
82-DBL-JU	New York	1982	4	4
82-FLD-DZ	Alabama	1982	4	4
82-NGB-AZ	Alabama	1982	4	4
82-CBB-CE	Louisiana	1982	4	4
82-CLD-O	Louisiana	1981	4	4
82-TBL-IW	Arizona	1982	4	4
79-TCL-BA	Mexico	1979	4	4
79-TBL-AN	Mexico	1979	4	4
82-BHL-MD	Mexico	1980	4	;12
82-SCL-2	Peru	1981	4	4
82-DGB-MX	Chile	1981	4	;12
81-LCB-CH	China	1981	4	;12

[a] Cereal Rust Laboratory isolate number.

[b] Infection types adapted from Stakman et al (7) for *Puccinia graminis* f. sp. *tritici*. Infection type 4 was produced on Thatcher by all isolates at both temperatures.

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Table 2. Infection types in wheats that possess gene *Lr* 13 that were infected with culture no. 82-BHL-MD of *Puccinia recondita* f. sp. *tritici* at two temperatures

Wheats	Possess *Lr* 13	Infection types[a] 25.5 C	18.1 C
CI 263	+	;12	4
Manitou	+	;12 cn	4
Napayo	+	;12 cn	3
Neepawa	+	;12 cn	3
Chris	+[b]	;1	0;
Era	+[b]	;1 cn	;
Thatcher	−	4	4

[a] Infection types adapted from Stakman et al (7) for *Puccinia graminis* f. sp. *tritici*.
[b] Chris and Era possess resistance genes in addition to *Lr* 13 (1,6).

remaining 21 isolates were fully virulent to both CT 263 and Thatcher at both temperatures. These included 18 from the United States, two from Mexico, and one from Peru.

In the second test, Thatcher, the cultivar without *Lr* 13, was again susceptible at 25.5 C, but all the other cultivars were resistant (Table 2). At 18.1 C, all the wheats were susceptible except Chris and Era, which possess other seedling-effective resistance genes. The genes for resistance that these latter wheats possess in addition to gene *Lr* 13 apparently protected them.

Individual plants in three of the F_3 families of Baart*2/Chris and in seven of those of Baart*2/Era were resistant at 25.5 C but susceptible at 18.1 C. All other families of both crosses were susceptible at both temperatures.

DISCUSSION

Through appropriate choice of cultures of *P. recondita* f. sp. *tritici* and high incubation temperature (25.5 C), *Lr* 13 can be identified in wheat seedlings (Table 1). The effect of the cultures was not determined on adult plants.

All cultivars believed to possess only *Lr* 13 showed intermediate high-temperature seedling resistance to the selected culture of *P. recondita* f. sp. *tritici*, whereas they were susceptible at low temperature (Table 2). This is the opposite of the effect of temperature on maturity-related resistance to crown rust in oats reported by Clifford and Schafer (2). Chris and Era, possessing additional resistance, were actually more resistant at 18.1 C than at 25.5 C. Thus, in contrast to *Lr* 13, the additional resistances of Chris and Era were more effective at lower temperature when tested in the seedling stage, as were the temperature-sensitive seedling resistance types previously reported by Johnson and Schafer (4).

Individual plants in F_3 families of both Baart*2/Era and Baart*2/Chris were identified by this technique as possessing *Lr* 13 but not the additional seedling resistance of these two parental resistant cultivars. This technique appears reliable for identifying such a combination of resistance, when occurring, on the basis of the parental reactions at both temperatures presented in Table 2.

It should be possible by this technique to exploit more easily the use of *Lr* 13 to develop leaf rust-resistant cultivars. The gene is valuable because it conditions resistance against many races in adult plants and is particularly effective in combinations (6).

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