Wheat Leaf Rust in North Dakota During 1979–1981

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ABSTRACT

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Rust nurseries were established at five North Dakota locations to evaluate resistance of wheat (*Triticum aestivum*) cultivars to naturally occurring *Puccinia recondita* f. sp. *tritici* populations. Reactions of commonly grown spring wheats to leaf rust range from resistant to susceptible, with the best protection against the present *P. recondita* f. sp. *tritici* population provided by Olaf, Butte, Coteau, Wared, Len, Era, Kitt, and Alex. Most spring wheat cultivars grown in North Dakota have susceptible reactions with low severities. Increased severities could result in yield losses. Most durum cultivars have low coefficient of infection values and are probably not damaged by leaf rust. Most winter wheat cultivars grown in North Dakota are susceptible to *P. recondita* f. sp. *tritici*. Virulence of the natural population was evaluated on near-isogenic lines and supplemental differentials. Annual changes in virulence were demonstrated. Lines with leaf rust resistant genes *Lr9, Lr16, Lr19, Lr24*, and *Lr25* showed resistance as seedlings to the greatest percentage of field collections of *P. recondita* f. sp. *tritici*.

Leaf rust of wheat (*Triticum aestivum* L.), incited by the fungus *Puccinia recondita* Rob. ex Desm. f. sp. *tritici*, is a disease that is potentially dangerous in North Dakota wheat production. The commercial cultivars available to North Dakota growers range from resistant to susceptible to leaf rust (9). Fortunately, most commercial spring wheat cultivars grown in the state are resistant to the pathogen and are not damaged by leaf rust. However, some cultivars show a susceptible reaction with low severities (9). Increased severity could result from an increase of the *P. recondita* f. sp. *tritici* population virulent on these cultivars. Should severities increase, losses could be enormous because losses of only 3% could amount to 2.1 million hectoliters if production were 70.4 million hectoliters per year. Losses of 6.8% were reported for North Dakota in 1965 (6). Therefore, leaf rust is a potential threat to a North Dakota wheat crop.

The 1977 rust epidemic in Mexico was a recent example of a severe rust epidemic that was responsible for the loss of production from thousands of hectares (2,5). Conditions that favor an epidemic are the seeding of large acreages to cultivars with the same genes for resistance, followed by a mutation or a buildup of the population virulent on the cultivars containing the genes used. If a large percentage of the population is virulent on the genes in the commonly grown cultivars, as occurred in Mexico in 1977 (1), and environmental conditions favor rust development, the stage is set for an epidemic. Because the natural *P. recondita* population has the ability to change rapidly, providing resistant cultivars for growers is a continuing problem.

This study was conducted to evaluate leaf rust on commercial cultivars in North Dakota, evaluate the virulence within the natural *P. recondita* f. sp. *tritici* population, and determine the most useful genes for resistance in North Dakota.

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MATERIALS AND METHODS

Nurseries were planted each of 3 yr at five locations within North Dakota to evaluate the resistance of hard red spring and durum (*T. turgidum* L.) wheat cultivars to the natural *P. recondita* f. sp. *tritici* population. Fields were surveyed to determine rust severity on commercially grown cultivars.

Adult wheat plants in the nursery were evaluated for leaf rust severity and reaction. Severity was estimated according to the modified Cobb scale (4). Host reaction was determined by the modified system described by Mains and Jackson (3). The coefficient of infection (CI) was calculated by multiplying the severity by the numerical value of the resistant or susceptible rust reactions (R = 0.2, MR = 0.4, MS = 0.8, and S = 1.0) times 100. Data from five locations in all years were combined to obtain the average coefficient of infection.

Collections of *P. recondita* f. sp. *tritici* were obtained from hard red spring, durum, and winter wheats throughout North Dakota during the summers of 1979–1981. Urediniospores of each collection were suspended in a nonphytotoxic oil and sprayed on the first leaf of monogenic lines and cultivars listed in Tables 1 and 2. Inoculated plants were maintained at 100% relative humidity at 20 C for 18–20 hr, after which they were placed on greenhouse benches at 21–25 C. Infection types (3) were recorded 10–12 days following inoculation. The recorded infection types were used to classify collections. Thus, infection types 0, 1, and 2 indicated avirulent collections and types 3 and 4 indicated virulent collections.

RESULTS AND DISCUSSION

The most widely grown hard red spring wheat cultivars by acreage in North Dakota in 1980 were Olaf, Butte, Waldron, Solar, Coteau, Era, Prodax, Ellar, Wared, Len, and Kitt (1) (Table 1). Olaf, Butte, Coteau, Wared, Len, Kitt, and Alex are highly resistant and provided the best protection against the naturally occurring races of *P. recondita* f. sp. *tritici* as indicated by the low CI values (Table 1). Cultivar Solar showed a relatively low CI value, but it had a susceptible reaction and 20% severity in drill strips at Langdon, ND, indicating that there is a potential for rust to develop on Solar and cause yield loss. Most other commercially grown cultivars have susceptible reactions but low severities. Higher severities on these cultivars could cause yield losses.

The CI value of Waldron was 13.8 in 1979 but lower in 1980 and 1981. Ellar had a similar pattern. This virulence pattern indicated that leaf rust could cause economic losses if conditions were favorable for rust development on these cultivars. The CI value of Prodax reached 38.0 in 1981. Prodax had a susceptible reaction and a range of 30 to 60% severity in drill strips at several North Dakota branch stations. Therefore, economic losses probably occurred on this cultivar.

The leading durum wheat cultivars by acreage in North Dakota in 1980 were Ward, Rugby, Crosby, Cando, and Rolette (1) (Table 1). The CI values of Rolette, Rugby, Coulter, and Vic ranged

from 1.8 to 6.3. We previously reported (10) that *P. recondita* f. sp. *tritici* developed more slowly on Rolette than on susceptible cultivars of hard red spring wheat, and yields were not reduced. Thus, leaf rust is probably not reducing yields of the durum cultivars grown in North Dakota. Most durum cultivars, however, display a MS-MR reaction, and higher severities could result in yield loss.

Changes in virulence in the natural leaf rust populations were found (Table 2). The greatest increase in isolates virulent on a single gene line was on *Lr1*. This percentage of isolates virulent on *Lr1* is the highest we have reported in North Dakota (8,9). The number of cultures virulent on cultivars with genes *Lr3ka, Lr17*, and *Lr24* also increased in 1981 over 1979 and 1980. The number of cultures virulent on the cultivar with *Lr11* was lower in 1980 and 1981 than in 1979.

Monogenic lines possessing *Lr9, Lr16, Lr17, Lr19, Lr24* (Agent), and *Lr25* (Transec) genes showed resistances to a high percentage of field collections of *P. recondita* f. sp. *tritici* and probably provided the best protection against leaf rust. Lines possessing *Lr16* produced infection type (IT) 2s on its seedling leaves and may not be the best choice for breeders. In addition, monogenic lines with *LrT, Lr3ka, Lr11*, and *Lr21* genes show an intermediate reaction (IT 2 to 2–3) and are probably not the best sources of resistance.

The percentage of *P. recondita* f. sp. *tritici* isolates virulent on single gene lines in the seedling stage does not appropriately evaluate other genes that condition adult plant resistance. Cultivars that provide the best protection against the natural population and may possess genes for adult plant resistance include Olaf, Butte, Coteau, Wared, Len, Era, Kitt, and Alex.

The average CI values for leaf rust on hard red spring cultivars have changed annually but not greatly from our previous report (9). The most significant change was in Prodax, in which the CI value increased from 5 in 1975 to 38 in 1981 (9). This change indicated a significant increase in that part of the natural *P. recondita* f. sp. *tritici* population virulent on Prodax.

Observations of growers' fields indicated that most hard red spring wheat cultivars planted in North Dakota were resistant to *P. recondita* f. sp. *tritici*. However, severity on 10 of the 69 fields surveyed during the 3-yr period ranged from 10 to 30%, and plants had susceptible reactions (Table 3).

The winter wheat cultivars grown in North Dakota are, in order of decreasing acreage, Roughrider, Winoka, Froid, Winalta, Minter, and Norstar (1). Most of these cultivars are susceptible to leaf rust.

Several hard red winter wheat cultivars were rated for leaf rust at Casselton, ND, in 1981 and had susceptible reactions and severities ranging from 60 to 80% (Table 4). A fungicide spray program may be needed for any susceptible cultivar grown in eastern North Dakota because leaf rust develops in most years on susceptible cultivars (7).

Because we have demonstrated losses up to 30% or 9.4 q/ha on susceptible cultivars with severe leaf rust (7), the value of resistance in the presently grown wheat cultivars is probably worth several million dollars each year to North

Table 1. Average coefficient of infection of *Puccinia recondita* f. sp. *tritici* on adult spring wheat cultivars at five North Dakota locations[a] and acreage by percentage

Cultivars	North Dakota hectares 1980[b] (%)	Average coefficient of infection[c] 1979	1980	1981
Hard red spring wheat				
Olaf	26.9	1.6	2.5	2.8
Butte	22.1	0.9	1.5	3.2
Waldron	18.5	13.8	6.3	2.0
Solar	7.4	3.2	1.5	3.0
Coteau	5.9	0.5	1.5	0.8
Era	3.7	2.4	2.8	3.8
Prodax	3.5	12.1	18.8	38.0
Ellar	2.4	10.0[d]	12.0[d]	4.0[d]
Wared	2.1	1.2	1.5	1.5
Len	1.7	0.6	1.3	0.9
Kitt	0.8	1.0	1.0	1.5
Profit 75	<1	...	4.0[d]	...
Chris	<1	2.6	2.5	4.8
Alex	...	1.4	2.3	1.7
Thatcher	...	72.0	70.0	70.0
Durum				
Ward	37.7	3.8	1.4	1.6
Rugby	18.7	5.6	1.8	2.0
Crosby	11.8	3.0	2.0	1.2
Cando	11.2	4.8	4.6	2.1
Rolette	6.2	5.4	3.3	5.2
Calvin	3.1	2.4	2.8	2.5[d]
Wells	2.8	...	...	...
Vic	2.3	2.0[d]	...	5.2
Botno	1.8	4.6	3.0	4.0[d]
Edmore	1.5	4.4	1.5	5.0[d]
Coulter	<1	6.3	2.8	4.3

[a] Oakes, Carrington, Minot, Langdon, Fargo.
[b] About 2.9 million ha of hard spring wheat and 1.8 million hectares of spring durum wheat were grown in 1980.
[c] Coefficient of infection is based on the following values for resistant or susceptible reaction types multiplied by percentage of severity: R = 0.2, MR = 0.4, MS = 0.8, S = 1.0.
[d] Data collected from one location only; cultivar not in nursery.

Table 2. Percentage of *Puccinia recondita* f. sp. *tritici* isolates collected in North Dakota virulent on wheat seedlings containing single genes for resistance to leaf rust[a]

Monogenic line or cultivar[b]	1979	1980	1981
Lr1	6.9	43.7	88.8
Lr2	60.4	87.5	77.7
Lr2c	60.4	...	77.7
Lr3	97.6	100.0	97.7
Lr3ka	4.6	6.2	20.0
Lr9	0.0	0.0	4.4
Lr10	93.0	100.0	97.7
Lr11	58.1	6.2	11.1
Lr16	0.0	0.0	2.2
Lr17	2.3	0.0	8.8
Lr19	0.0	0.0	0.0
Lr21	18.6	8.3	20.0
Lr23	81.3	100.0	100.0
Lr24 (Agent)	2.3	2.1	8.8
Lr25 (Transec)	0.0	2.1	0.0
LrT	25.6	14.6	33.3
D6733[c]	...	14.6	13.3

[a] Values based on about 45 collections each year.
[b] Monogenic lines in Thatcher background.
[c] Experimental *Triticum turgidum*.

Table 3. Number of hard red spring wheat fields surveyed in North Dakota[a]

Year	Leaf rust severity (%) 0	>1	5	10	20	30
1981	19	7	3	4	2	1
1980	9	3	0	1	1	0
1979	9	2	7	0	1	0

[a] Anthesis to dough stage of development.

Table 4. Percentage of severity and reaction of *Puccinia recondita* f. sp. *tritici* on winter wheat cultivars at Casselton, ND, in 1981

Winter wheat cultivar	Percentage severity and reaction
Roughrider	70 S[a]
Froid	70 S
Norstar	80 S
Winoka	70 S
Centurk	60 S

[a] S = susceptible reaction type to naturally occurring population of *Puccinia recondita* f. sp. *tritici* in North Dakota.

Dakota growers. Several sources of resistance are being used in North Dakota to guard against a rust epidemic. In addition, information on virulence of the natural population and data from rust nurseries combined with greenhouse testing are useful when we decide which genes are most effective in conditioning resistance to the natural *P. recondita* f. sp. *tritici* population.

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