The Effect of Management Systems on Leaf Spot Diseases of Wheat in the Brown Soil Zone

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Introduction

Leaf spots have been shown to have a negative effect on grain yield. kernel weight, test weight, and grain protein of wheat (Femandez et al., 1992; Rees and Platz, 1983). They continue to be the most common diseases of wheat in Saskatchewan (Femandez et al., 1997; 1998).

The epidemiology of leaf spot pathogens is not well known in western Canada (Bailey et al.. 1992), particularly in the Brown soil zone. The objective of this research was to determine the effect of summerfallow crop rotation with a noncereal crop, and tillage management on the severity of leaf spot diseases of wheat. Data were collected from two long-term experiments conducted in the Brown soil zone of southern Saskatchewan from 1993 to 1996, and of a survey of producers' fields completed in 1995 and 1996.

Materials and Methods

The crop rotation experiment was established in 1967 on a Swinton silt loam soil, an Orthic Brown Chemozem (Haploboroli), at the Agriculture and Agri-Food Canada Research Centre in Swift Current, SK. Ten crop rotations were established with various sequences of spring wheat (cv. Lancer), fall rye (cv. Prima), flax (cv. Vimy), lentil (cv. Laird). and summerfallow. All phases of the rotations were represented each year and the rotations were cycled on their assigned plots, in a RCB design, with three replicates. Plots were 10.5 m wide and 40 m long. Soil tillage was kept to a minimum so as to conserve surface crop residues and maximize soil water conservation. Fallow areas received an average of three tillage operations during the summer using a heavy-duty cultivator and/or rodweeder.

The tillage experiment, established in 198 1, was located in an area adjacent to the crop rotation experiment. Spring wheat (cv. Lancer) was grown in a continuous wheat system or after summerfallow. Three tillage methods were used: conventional. minimum and zero-till. Conventional fallow areas received three to four tiilage operations, performed during the summer with a heavy-duty cultivator. Weed control on minimum- and zero-till fallow plots was achieved with broad-spectrum herbicide tank-mixes which included glyphosate After the first application, all subsequent weed control on minimum-till fallow was accomplished with tillage alone, whereas one or two further applications of broad-spectrum herbicide were performed on the zero-till fallow areas. When in a crop phase, the seedbed for minimum- and conventional-till

was prepared with one operation of a heavy-duty cultivator. Glyphosate was applied to zero-till treatments. continuous wheat and the crop phase of wheat after fallow. before seeding each year.

A survey of producers' fields was conducted throughout southwestern Saskatchewan in 1995 and 1996. Two to four durum wheat (cv. Kyle) fields in close proximity to each other, where at least two were under a wheat monoculture system, one in rotation with fallow and the other continuously cropped. and the other one or two fields in a noncereal rotation, were selected from each producer surveyed.

The severity of leaf spots in both studies was assessed at milk stage, using a 0 to 11 severity scale (McFadden. 199 1). lesioned leaf tissue collected from each plot was plated on water agar. as indicated by Femandez et al. *(1994)* to identify leaf spot pathogens.

Results

Only selected of the results obtained from both studies are presented here. In all four years of testing. leaf spot severity at the milk stage for individual plots ranged from 7 to 11, 7 being trace to 1% of flag leaf area covered with spots, and 6 to 10% of penultimate leaves; 8=2 to 5% of flag, and 11 to 25% of penultimate; 9=6 to 10% of flag, 26 to 50% of penultimate; 1 0=1 1 to 35% of flag, >50% of penultimate; and 1 1=26 to 50% of flag, >50% of penultimate. Severity of leaf spots on lower leaves was >50% in all cases. The most predominant leaf spot disease was tan spot. Septoria leaf blotch was less commonly observed in both studies.

Table 1. Leaf spot scores (0- 11 scale) of wheat in a crop rotation experiment at Swift Current, Saskatchewan (1993 to 1996) (adapted from Femandez et al., 1998).

	Leaf spots				
Rotation sequence	1993	1994	1995	1996	Mean
Wheat on fallow	9.7	8.0	10.0	10.2	9.5
Wheat on wheat stubble	8.3	7.2	9.5	8.8	8.5
Wheat on lentil stubble	8.0	7.2	8.3	8.0	8.0
$LSD_{(0.05)}$	0.8	0.5	0.5	0.5	

Crop rotation study: In all years, wheat in the fallow-wheat rotation had a higher severity of leaf spots than continuous wheat (Table 1). Wheat in rotation with lentil had a lower leaf spot severity than in fallow-wheat in all four years. The severity of leaf spots in wheat after lentil did not differ from that in continuous wheat in 1993 or 1994, but it was lower in 1995 and 1996, when the overall disease severity was the greatest.

In 1995 and 1996, surveys of producers' fields in southern Saskatchewan showed similar effects of rotations as the research plots (Table 2). Fields of Kyle grown after fallow were more severely diseased than those grown after wheat or following a noncereal crop. In turn, the latter had in most cases a higher leaf spot severity than wheat grown continuously.

Table 2. Leaf spot scores (0- 11 scale) of Kyle fields under different rotations in close proximity to each other, in 1995 and 1996.

Year/ Location	Previous crops	Leaf spots (O-l 1)
1995		
Morse	fallow/CWRS	10.0
	peas/fallow/CWRS	8.5
	mustard/fallow/CWRS	8.0
Carmichael	fallow/CWAD/fallow	10.0
	CWAD/CWAD/lentil	8.0
	canola/fallow/CWRS	9.0
Allison	fallow/CWAD	9.5
	CWAD	9.0
	lentil	9.0
1996		
Swift Curent	fallow/CWAD/fallow	10.0
	CWAD/lentil	6.0
	lentil/CWAD/fallow	8.0
Tompkins	fallow/CWAD/fallow	8.0
	CWAD/lentil/fallow	8.0
	canola/fallow/CWAD	7.0
	lentil/canola/fallow	7.0
Gull Lake	fallow/CWAD/fallow	8.0
	CWADICWADICWAD	7.0
	lentil/CWRS/lentil	8.0
	canola/fallow/CWAD	8.0
Carmichael	fallow/CWAD/fallow	8.0
	CWAD/CWAD/CWAD	6.0
	peas/CWAD/CWAD	8.0
Elrose	fallow/CWAD/lentil	9.0
	CWAD/fallow/CWAD	8.5
	lentil/CWAD/fallow	11.0

Tillage study: The severity of leaf spots was similar in wheat after fallow in all three tillage systems (conventional-, minimum- and zero-till) (Table 3). In addition, severity levels were

lower in continuous wheat than in wheat after fallow, either under conventional- or zero-till management.

Table 3. Leaf spot scores (0- 11 scale) of wheat in a tillage experiment conducted at Swift Current, SK., from 1993 to 1996.

Treatment	Leaf spots (1993-96)
Wheat on fallow (zero-till)	10.5
Wheat on fallow (minimum-till)	10.3
Wheat on fallow (conventional-till)	10.3
Wheat on wheat stubble (zero-till)	9.5
Wheat on wheat stubble (conventional-till)	9.2
$LSD_{(0.05)}$	0.6

Examination of fungal structures on crop residues showed that new and relatively unweathered residues (i.e. from the immediately previous crop) had fewer ($P<0.01$ to 0.05) reproductive structures (pseudothecia) of *Pyrenophoru tritici-repentis* (the causal agent of tan spot) per gram of residue tissue than older residues (mostly two years old) (Table 4). This resulted in greater numbers of mature pseudothecia per unit area in the fallow-wheat than in the continuous wheat treatment, under conventional-till management. Similar observations were made in the crop rotation study (data not presented). In zero-till treatments, the density of pseudothecia per unit area were similar ($P>0.05$) in wheat after fallow and in continuous wheat. In addition, the density of pseudothecia per gram of residue (and per unit area in 1995) were higher ($P<0.01$ to 0.05) on two-year old residues in the fallow-wheat treatment under conventional-till than under zero-till management.

Table 4. Number of pseudothecia of P. *tritici-repentis* on crop residues collected from a tillage study, in 1995 and 1996.

Year of sampling/ treatment	Age of residues	Pseudothecia unit area[1]	Pseudothecia gram
1995			
Wheat on fallow (conventional-till)	2-yr old	1151	40
Wheat on wheat (conventional-till)	1 -yr old	18	1
	2-yr old	409	50
Wheat on fallow (zero-till)	2-yr old	82	3
Wheat on n-heat (zero-till)	2-yr old	38	2
	1 -yr old	366	18
1996			
Wheat on fallow (conventional-till)	2-yr old	765	82
Wheat on n-heat (conventional-till)	1 -yr old	187	6
	2-yr old	65	17
Wheat on fallow (zero-till)	2-yr old	428	21
Wheat on wheat (zero-till)	2-yr old	23	1
	1 -yr old	339	23

[1] number of mature pseudothecia per unit area (0.5 m^2), and per gram of residue tissue.

Discussion

Results from both studies showed that, in the Brown soil zone of southwestern Saskatchewan, growing wheat after fallow resulted in a greater severity of leaf spots (mainly tan spot) than growing wheat after wheat, regardless of the tillage method used. The lower disease severity in wheat grown continuously than in wheat grown after fallow could be explained by the lower amounts ofprimary inoculum found on one- than two-year old residues. This could be attributed to environmental conditions, in particular temperature, from harvest of one crop to seeding of

the next. not being adequate for fungal growth and production of reproductive structures (Summerell and Burgess. 1988). This would explain why when our next spring wheat emerged. the residues from the immediately previous season had a lower level of inoculum than residues from two seasons previous.

Our study also showed that there was no effect of tillage method on leaf spot severity. These observations differ from those reported elsewhere indicating that a decrease in tillage resulted in an increase in leaf spot severity (Sutton and Vyn, 1990). However, in our study the conventional-till treatment was designed to conserve as much surface residue as possible, with the number of tillage operations used being lower than what it would normally be practiced by most area producers. The lack of difference in leaf spot severity between conventional- and zero-till fallow systems. despite the greater amounts of residue in the latter, could again be attributed to the density of infective structures per gram of crop residue, which was greater in fields managed using conventional- versus zero-till practices. This might be related to an inhibitory effect of glyphosate on the formation of these structures (Sharma et al., 1989). However. a favourable microciimate for disease development created by the higher density of residues in a zero-till system. some of which was standing, might have compensated for the overall lower levels of inoculum per unit area in 1995, and would explain disease levels as high as in wheat after conventional-till fallow. In turn, the higher disease severity in wheat after zero-till fallow than in continuous zero-till wheat, despite the fact that there was no difference between these treatments in density of reproductive structures per unit area, could be attributed to the greater degree of layering of residues in the latter treatment, which might have negatively affected the dispersal of inoculum.

Both the research plots and producer fields' surveys showed that a rotation with a noncereal crop for one year did not always result in lower disease levels than in hard red spring or durum wheat grown continuously. Other studies have also suggested that one year of a noncereal crop in between wheat crops did not reduce the amount of leaf spot diseases in the latter (Bailey et al., 1992; Pedersen and Hughes, 1992). The high disease levels in wheat in rotation with a noncereal crop could be attributed to 2-year old wheat residues containing viable infective structures being carried over from previously grown wheat crops, especially under reduced tillage.

Conclusions

Our observations showed that reducing tillage from a conventional system designed to conserve crop residues to zero-till did not result in increased levels of leaf spots in spring wheat. However, the practice of summerfallow increased leaf spot severity compared to continuous wheat, regardless of tillage method. Based on our observations of crop rotations, we conclude that in southwestern Saskatchewan, the best rotation to achieve a low level of leaf spot infection would involve two consecutive years of wheat followed by at least two years of a noncereal crop, or by a noncereal crop and summerfallow, to allow for decomposition of wheat crop residues.

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