EFFECTS OF CROP ROTATION AND FALLOW ON LEAF SPOTTING DISEASES OF WHEAT IN A BROWN SOIL

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INTRODUCTION

In recent years, there has been a steady increase in the incidence of leaf spotting diseases of wheat in western Canada. The main causal agents in Saskatchewan are Pvrenonhora tritici-renentis (tan spot), Septoria nodorum and S. tritici (septoria blotch) (e.g. Bailey et al., 1994).

There has been very little research done on the effect of crop rotations on leaf spotting diseases of wheat in western Canada (e.g. Bailey et al., 1992). No work has been done in the Brown soil zone. to address the effect of crop rotations or fallow on the severity of this disease complex in spring wheat.

The objective of this study was to determine the effects of fallow and crop rotations on the severity of leaf spotting diseases, and relative prevalence of causal agents, for spring wheat in a Brown soil in southwestern Saskatchewan.

MATERIALS AND METHODS

Study I. This crop rotation study was established in 1967 on a Swinton silt loam soil (Ayres et al., 1985), an Orthic Brown Chemozem (Haploboroll) (Canada Soil Survey Committee, Subcommittee on Soil Classification, 1978) at the Agriculture and Agri-Food Canada Research Centre in Swift Current, Saskatchewan. There were 10 crop rotations, only 7 systems are evaluated here (Table 1). All phases of the rotations were represented every year in a randomized complete-block design with three replicates. Plots were 10.5 m by 40 m.

Plots were managed using conventional tillage practices, but frequency and type of tillage were designed to conserve surface crop residues and minimize the risk of soil erosion. Fallow received an average of three tillage operations during the summer season, while seedbeds were prepared with one tillage operation performed just prior to planting. There was no fall tillage, as winter annual weeds were controlled with 2,4-D ester. Herbicides were used as required for in-crop weed control. N (ammonium nitrate) and P (monoammonium phosphate) fertilizer were applied based on fall soil tests and regional soil test recommendations.

Study II. This tillage study was established in 198 1, adjacent to Study I. Only the conventional tillage treatments are presented here. Wheat was grown in sequence with wheat or after fallow (Table 1). Plots were 15 m by 76 m. The management of conventional tillage plots, and experimental design, were the same as described for Study I.

Table 1. Crop sequences of Study I and II conducted at Swift Current, from 1993 to 1995.

Crop sequence	Abbreviation
Study I	
fallow-wheat-wheat	F-W-W
fallow-flax-wheat	F-FIx-W
continuous wheat	ContW
fallow-wheat	F-W
fallow-wheat-wheat-wheat-wheat-wheat	F-W-W-W-W-W
wheat-lentils	W-Lent
Studv II	
fallow-wheat	F-W
wheat-wheat	ContW

Leaf spots. The severity of leaf spots was assessed on randomly selected plants using McFadden's scale from 0 to 11 (McFadden, 199 1). Scores ranged from 7 to 11, 7 being trace to 1% of flag leaf area covered with spots, 6- 10% of middle leaves; 8=2-5% on upper, 1 1-25% on middle; 9=6- **10%** on upper, 26-50% on middle; 1 0=1 1-25% on upper, >50% on middle; and 11=26-50% on upper and >50% on middle leaves. Severity of leaf spots on lower leaves was in all cases >50%.

Percent isolation of each of the fungi was based on the total leaf area colonized, assessed by plating 1 cm^2 leaf sections, from 25 randomly selected flag leaves, onto water agar (Fernandez et al., 1994).

Fungal structures on crop residue. Percent ground cover of crop residues was determined. To determine the formation of infective structures of the leaf spotting fungi on crop residues, all straw in a 0.5 m^2 area was collected immediately after seeding in 1995 (three subsamples per plot). Straw pieces were washed in tap water to remove soil, dried at room temperature and weighted. The straw was separated according to a visual assessment of the degree of decomposition. Forty, 2 cm long fragments, were randomly taken from each of these categories, and observed under the microscope. The number of pseudothecia of P. tritici-repentis, and perithecia and pycnidia of S. nodorum, in each of the straw pieces was recorded. Based on size and presence of matures ascospores, pseudothecia of P. tritici-reuentis and perithecia of S. nodorum were differentiated into mature and immature ones (no ascospores yet formed).

RESULTS AND DISCUSSION

Leaf spots.

Study I. Leaf spot severity at the milk stage was greater in 1995 (mean score 9.5) than in 1993 (8.6), with 1994 having the lowest severity (7.3). Based on an analysis of variance, there was a rotation effect in all three years (Table 2). One degree of freedom contrasts also showed that there was a significant difference in leaf spot severity among rotation sequences (all phases grouped together). Wheat after fallow had a significantly higher severity of leaf spots than continuous wheat ($P<0.10$ to $P<0.01$), or wheat after flax or lentils ($P<0.01$) (Tables 2 and 3). Severity of leaf spots in continuous wheat did not differ from that in wheat after flax or lentils in 1993 or 1994, but did differ in 1995 ($P<0.10$ to $P<0.01$), where wheat in the mixed rotations had a lower severity of leaf spots than continuous wheat. Higher levels of leaf spots in wheat after wheat in 1995 than in previous years is attributed to environmental conditions, which were more conducive to disease development than in previous years.

Table 2. Analysis of variance, and one degree of freedom contrasts, of leaf spot ratings in Study I at Swift Current, from 1993 to 1995.

Treatment	1993	1994	1995
Rotation	3.35***	**4.24*** **	7.53***
Rep	NS	**NS**	NS
CONTRASTS:			
among rotations	3.93***	4.65***	12.89***
F-W vs. ContW	10.26***	13.71***	3.48*
ContW vs. F-Flx-W	NS	NS	3.48*
ContW vs. W-Lent	NS	NS	18.93***
F-W vs. W-Flx-W	16.04***	13.71***	13.91***
F-W vs. W-Lent	16.04***	13.71***	38.64***

*, ** and ***, significant at :<0. 10, P<0.05 and P<0.01, respectively.

Table 3. Leaf spot ratings of wheat in Study I and II at Swift Current, from1993 to1995.

	Leaf spots'			
Crop sequence	**1993**	**1994**	**1995**	**Mean**
STUDY I				
Wheat grown on fallow				
F-W	9.7	8.0	10.0	9.2
F-W-W	8.7	7.8	10.0	8.8
	9.2	7.9	10.0	9.0
Wheat grown on wheat stubble				
F-W-W	8.3	7.2	9.7	8.4
Wheat grown on continuous wheat stubble				
ContW	8.3	7.2	9.5	8.3
Wheat grown on noncereal stubble				
F-Flx-W	8.0	7.2	9.0	8.1
W-Lent	8.0	7.2	8.3	7.8
	8.0	7.2	8.7	8.0
LSD:	0.8**	0.5**	0.5**	
STUDY II				
Wheat grown on fallow				
F-W	10.2	10.0	10.7	10.3
Wheat grown on continuous wheat stubble				
ContW	9.5	8.3	10.0	9.3
LSD:	0.5*	0.6**	0.4**	

[1] Leaf spot scores based on a scale of 0 to 11.
* and **, at P<0. 10 and P<0.05, respectively.

Study II. There was a significant treatment effect (P<0.10 to 0.01) in all three study years. Continuous wheat had lower leaf spot severity levels than wheat after fallow (Table 3).

Identification of leaf spotting fungi

In both studies, P. tritici-reuentis was in most cases the most commonly isolated fungus from leaf spot lesions. In Study I, average percent isolation for the whole test was 22% in 1993, 49% in 1994 and 67% in 1995; whereas in Study II average percent isolation was 64% in 1993, 7 1% in 1994 and 9 1% in 1995. In both studies, percent isolation of this fungus from wheat after fallow was similar than from wheat after wheat. In Study I in 1994 and 1995, percent isolation of P. tritici-repentis was lower (P<0. 10 to P<0.05) in wheat after flax or lentils (15% in 1994, 60% in 1995) than in continuous wheat (53% in 1994, 78% in 1995). The second most common fungus in both studies was S. nodorum.

Fungal structures on crop residues

In both studies, the amount of crop residues per unit area which would have served as source of primary inoculum for the most prevalent fungi, was greater in continuous wheat than in wheat after fallow (Table 4).

Table 4. Percent ground cover of residue m^{-2} in Study I and II at Swift Current, in 1994 and 1995.

Crop sequence	Percent ground cover of residues 1994	1995
	%	
STUDY I:		
Wheat mown on fallow		
F-W	25.6bc[1]	25.6d
F-W-W	24.4c	26.7d
Wheat grown on wheat stubble		
F-W-W	35.0a-c	53.9a
Wheat grown on continuous wheat stubble		
ContW	42.8a	64.4a
STUDY II:		
Wheat grown on fallow		
F-W	14.0c	26.0c
Wheat grown on continuous wheat stubble		
ContW	34.8b	52.0b

[1] Values followed by the same letter are not significantly different (P<0.05) according to an LSD test.

In 1995, examination of fungal structures on straw from previous seasons indicated that new and unweathered straw (i.e. from the 1994 crop) had very few mature (or immature) infective structures, whereas older straw (i.e. mostly from the 1993 crop) had a greater density of structures, both per unit area and per gram of residue tissue (Table 5). For both studies, older straw in the continuous wheat treatment was found to constitute an average of only 17% of the straw collected per unit area, so that the majority of the straw in the continuous wheat treatment was from the 1994 season (69% on the ground, 3 1% standing). The amount of straw from the 1993 season was three to four times greater in the wheat after fallow than in the wheat after wheat treatment.

The lower disease severity in wheat after wheat than in wheat after fallow, observed in both studies, could thus be explained by the lower amount of initial inoculum available in the former than the latter treatment. The sparsity of fungal structures on new straw might be explained by environmental conditions, in particular temperature, not having been adequate for fungal growth and production of reproductive structures throughout the winter in southwestern Saskatchewan (Harrower, 1974; Odvody et al., 1982). In addition, fungitoxic substances released from wheat straw in its initial stages of decomposition (Cook et al., 1978) might have alse played a role.

Finally, similar levels of leaf spots in rotations with flax or lentils, than in continuous wheat, in two out of three years, might be explained by the survival of wheat pathogens in crop residues of nonhost species (Femandez et al., 1993), and/or to wheat residues being carried over from previously grown wheat crops.

CONCLUSIONS

The two studies examined in the Brown soil zone in southwestern Saskatchewan indicated that, under conventional tillage management systems designed to conserve crop residue, growing wheat after fallow resulted in a greater severity of leaf spots than growing wheat after wheat. Furthermore, in most cases, a rotation with flax or lentils did not result in lower disease levels than in continuous wheat.

Table 5. Number of reproductive structures of P. tritici-repentis and S. nodorum on wheat straw collected in May 1995, from Study I and II at Swift Current.

Study/ Crop sequence	Year	Straw position	Straw g m^{-2}	P. tritici-repentis pseudothecia mature	P. tritici-repentis pseudothecia immature	S. nodorum perithecia mature	S. nodorum perithecia immature	S. nodorum pycnidia
Study I								
fallow-wheat	1993	ground	20.6	230[12][1]	310[15]	88[5	614[40]	34958[1727
wheat-wheat	994	standing	10.0	9[1]	16[2]	0[0]	57[7	57[9
	1994	ground	21.7	51[2]	32[1	0[0]	10[0	444[20]
	1993	ground	5.8	690[20]	310[48	158[2	608[105]	4669[83
Study II								
fallow-wheat	1993	ground	29.1	1496[5	3859[139	66[3]	572[24	51094[1715
wheat-wheat	1994	standing	9.3	0[0]	0[0]	0[0]	0[0]	279[23
	1994	ground	21.5	0[0]	22[1	0[0]	0[0]	495[21]
	1993	ground	7.0	332[40]	546[69]	124[10]	1167[101	5223[725

[1] number of fungal structures per half a square meter; per gram of straw tissue in brackets.

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