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## Rotation and Fertility Effects on Root Rot of Spring Wheat in Southwest Saskatchewan

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### Abstract

Spring wheat grown in a replicated trial for one or two years after summerfallow, lentil, flax, or continuously (with and without fertilizer N) was examined for subcrown internode discoloration from 2000 to 2002 in southwest Saskatchewan. Discolored tissue was plated on nutrient agar for fungal identification. Root rot was in general present at highest levels in wheat grown after lentil, and at lowest levels in wheat grown continuously with low N fertility. The most common species were *Cochliobolus sativus* and *Fusarium* spp. Among the latter, *F. avenaceum*, *F. equiseti* and *F. pseudograminearum* were the most commonly isolated. *F. avenaceum* is the most important fusarium head blight (FHB) pathogen in western Saskatchewan. The percent isolation of *Fusarium* species was lowest in continuously-grown wheat with low N. Wheat after lentil had one of the highest levels of *F. avenaceum*. Among the crop rotations examined, it appears that the most favourable to the development of root rot in spring wheat was a wheat-lentil rotation. This rotation may also contribute to the build-up of *F. avenaceum* inoculum for the development of FHB, which is an important emerging disease of wheat and barley in western Saskatchewan.

### Introduction

Common root rot is a widespread disease of wheat in western Canada. (Tinline and Ledingham, 1979). Agronomic practices such as fertilizer application, summerfallow, and crop rotation have been shown to influence the severity of root rot in cereals. Root rot in wheat was reported to decrease (Smith et al., 1962), increase (Ledingham, 1970), or not change with fertilizer levels (Broscious and Frank, 1986). In most cases, rotations with noncereal crops reduced root rot severity in cereals (Bailey et al., 1992; Sturz and Bernier, 1989). Common root rot severity in wheat grown after summerfallow was similar (Chinn, 1976), or lower (Bailey et al., 1992) than after another wheat crop.

The objective of this study was to determine the effects of summerfallow, crop sequence, and N fertilizer on root rot in spring wheat grown under the semiarid conditions of southwest Saskatchewan.

## Materials and Methods

The experiment was established in 1966 at the Semiarid Prairie Agricultural Research Centre, in Swift Current, Saskatchewan. The crop rotations examined were: one year of AC Eatonia wheat after summerfallow (SF-W), two years of wheat after summerfallow (SF-W-W), wheat grown continuously (ContW), wheat grown continuously with no N fertilizer (ContW(noN)), wheat grown after flax preceded by summerfallow (SF-Flax-W), and wheat grown after lentil (W-Lentil). All phases of the rotations were present each year, with each crop fertilized with recommended rates of N and P, except as indicated above. Treatments were arranged in a randomized complete block design, with three replicates. Plots were 10.5 m wide and 40 m long. Plot management was done as described by Fernandez et al. (1998).

Plants (30-40) were randomly pulled at late milk-early dough from each plot, and washed thoroughly in tap water. Subcrown internodes were rated on a 0-3 scale based on the total surface area discolored: 0=no discoloration, 1=1-25% (slight), 2= 26-50% (moderate) and 3=>50% (severe). A common root rot (CRR) index, based on the incidence and severity of subcrown internode discoloration, was calculated for each plot. A 1-2 cm of each discolored subcrown internode was surface-disinfested in 10% Javex for 60 s, rinsed, and plated on modified potato dextrose agar (Burgess et al., 1988). After incubation for about 7 d, fungi were identified and percent isolation of each fungus was calculated based on the total number of isolates in each plot. The data were analyzed using ANOVA. When F values were significant ( $P<0.05$ ), LSDs were calculated.

## Results

Because fertilizer N was applied to plots, total available N was generally similar among rotations (overall mean of 83-106 kg ha<sup>-1</sup>) except for ContN(noN) where no fertilizer N was applied (overall mean of 23 kg ha<sup>-1</sup>). As expected for this semiarid region, soil water content at seeding was higher for wheat grown on summerfallow (mean of 251 mm) than for wheat grown on stubble (mean of 209 mm). Mean temperature for the growing season (May to August) was higher, and precipitation lower, in 2001 (17°C, 121 mm) and 2003 (16.8°C, 150 mm) than in 2000 (15.5°C, 259 mm) or 2002 (14.8°C, 341 mm).

The CRR index was significantly higher ( $P<0.05$ ) in 2001 (1.7) than in 2000, 2002 or 2003 (1.3 for all three years). For all four years, the most common fungal species isolated from discolored subcrown internodes were *Cochliobolus sativus* and *Fusarium* spp. (Table 1). Among the *Fusarium* spp., the most commonly isolated were *F. pseudograminearum* (previously known as *F. graminearum* Group 1), *F. avenaceum* and *F. equiseti*. There was a difference ( $P<0.05$ ) among years in the percent isolation of fungal isolates (Table 1). *Fusarium avenaceum* was most commonly isolated in 2000 and 2001, whereas *F. pseudograminearum* and *C. sativus* were least common in 2001.

Differences in the CRR index, and percent fungal isolation, among rotations were also significant ( $P < 0.05$ ) (Table 2). Wheat in the W-Lentil rotation had the highest mean CRR index, whereas wheat grown continuously at low N levels (ContW(noN)) had the lowest. The CRR index for the other rotation with a noncereal crop (SF-Flax-W) was lower than in W-Lentil, but similar than in SF-W-W.

**Table 1.** Percent Isolation of Fungal Species from Discoloured Subcrown Internodes of AC Eatonia Wheat Grown in Crop Rotations at Swift Current, Saskatchewan (2000-2003).

Fungal species	Year				Mean
	2000	2001	2002	2003	
	----- % -----				
<i>Fusarium</i> spp.	32 ab <sup>1</sup>	33 a	28 b	35 a	32
<i>F. acuminatum</i>	2 bc	2 ab	1 c	4 a	2
<i>F. avenaceum</i>	10 b	14 a	5 c	3 d	8
<i>F. culmorum</i>	0 b	1 a	<1 ab	<1 ab	<1
<i>F. equiseti</i>	7 b	9 ab	4 c	13 a	8
<i>F. pseudograminearum</i>	14 ab	6 c	17 a	11 b	12
<i>Cochliobolus sativus</i>	34 b	19 c	40 ab	42 a	34
<i>Microdochium bolleyi</i>	4 a	1 b	6 a	4 a	4
<i>Rhizoctonia</i> spp.	5 a	1 b	8 a	2 b	4

<sup>1</sup> Values across rows followed by the same letter are not significantly different at  $P < 0.05$  using LSD.

The lowest percent isolation of *C. sativus* was observed in the ContW rotation, whereas the lowest percent isolation of *Fusarium* spp. was in ContW(noN) (Table 2). Among the *Fusarium* spp., the percent isolation of *F. avenaceum* was higher in W-Lentil and ContW than in the other rotations, except for SF-Flax-W, whereas the percent isolation of *F. pseudograminearum* was lowest in ContW(noN) and SF-Flax-W. The highest levels of *F. equiseti* were found in SF-Flax-W; however, these were not different from the first year of SF-W-W or ContW(noN).

## Discussion

Despite very marked differences in environmental conditions among the four study years, differences among years in levels of root rot and in the percent isolation of fungi from discolored subcrown internodes of spring wheat, although significant, were not very pronounced. These findings agree with those reported by Bailey et al. (2000) for the more humid southeastern region of Saskatchewan.

Our results indicate that the main factors that affected root rot of spring wheat were fertilizer N and rotation with a noncereal crop. The lower root rot levels observed at low N (ContN(noN)) agree with the findings of Tinline et al. (1993), Smiley et al. (1996), and Johnston and Holm

(1992) for wheat infected primarily by *C. sativus*, *F. pseudograminearum* and *F. avenaceum*, respectively. In our study, the reduction in disease levels at low N fertility appeared to be associated with lower levels of *Fusarium* spp., particularly *F. pseudograminearum*. This is similar to findings by Warren and Kommedahl (1973) that the latter pathogen was more abundant in the presence of fertilizer. Further, the observation that *C. sativus* was isolated at relative higher levels at low N (ContW(noN)) than at recommended N fertility (ContW) agrees with Butler (1959) who reported that this fungus was better able to survive at a lower level of fertility than *F. culmorum*.

**Table 2.** Common Root Rot Index and Percent Isolation of *Fusarium* spp. and *Cochliobolus sativus* from Discolored Subcrown Internodes of AC Eatonia Wheat Grown in Crop Rotations at Swift Current, Saskatchewan (2000 to 2003).

Rotation phase	CRR Index <sup>1</sup>	Fungal species				
		<i>F. pseudo-graminearum</i>	<i>F. avenaceum</i>	<i>F. equiseti</i>	Total <i>Fusarium</i> spp.	<i>C. sativus</i>
		----- % -----				
SF- <u>W</u>	1.5 b <sup>2</sup>	12 b	5 b	8 bc	28 b	45 a
SF- <u>W</u> -W	1.4 bc	12 b	6 b	9 ab	32 ab	39 ab
SF-W- <u>W</u>	1.4 bc	17 ab	6 b	5 c	32 ab	29 c
Cont <u>W</u>	1.5 b	19 a	11 a	6 c	41 a	16 d
Cont <u>W</u> (noN)	0.8 d	3 c	7 b	10 a-c	21 c	37 a-c
SF-Flax- <u>W</u>	1.3 c	4 c	8 ab	13 a	32 ab	37 a-c
<u>W</u> -Lentil	1.8 a	14 ab	13 a	7 bc	38 a	34 bc
Mean:	1.4	12	8	8	32	34

<sup>1</sup> CRR=common root rot.

<sup>2</sup> Values in columns followed by the same letter are not significantly different at P<0.05 using LSD.

The observation that growing wheat in rotation with flax (SF-Flax-W) resulted in most cases in similar levels of root rot than when wheat was grown continuously at recommended N levels (ContW) or alternated with summerfallow (SF-W and SF-W-W) agrees with Bailey et al. (2001) who did not find major differences in root rot levels of spring wheat between a rotation with flax and continuously cropped wheat, and with Conner et al. (1996) who found that growing flax for one year in a rotation that also included summerfallow was not enough to reduce the development of root rot in subsequent wheat crops. On the other hand, the lower root rot level in wheat grown after flax (SF-Flax-W) compared to ContW under the hot and dry conditions of 2001 is similar to what was previously reported (Sturz and Bernier 1989, 1991). The observation that overall wheat in the SF-Flax-W rotation had lower levels of the wheat pathogen *F. pseudograminearum*, and higher levels of the weak pathogen *F. equiseti*, than most other rotations examined in this study also partially agrees with previous reports. For example, Bailey

et al. (2001) reported that in spring wheat levels of *Fusarium* spp., identified as being mostly *F. equiseti*, appeared to be in some cases higher in a rotation that included flax, or flax and pea, than in a rotation that included only wheat.

The consistently high levels of root rot in wheat grown in rotation with lentil (W-Lentil) could be attributed partly to higher levels of *F. avenaceum*, which is a root pathogen of lentil (Hwang et al., 1994), and wheat (Kollmorgen, 1974). In a study of fungal populations in underground tissue of cereal and noncereal crops in southeast Saskatchewan, *F. avenaceum* was more commonly isolated from pulse than from oilseed or cereal crops (Fernandez, 2003). In the present study, increased fungal infection of wheat subcrown internodes could not be attributed to higher N levels since all rotations, except for ContW(noN), had similar total N levels. Other factors, such as mineralization of legume residue N throughout the growing season (Zentner et al., 2004), might have affected fungal growth. In any case, the higher root rot levels in wheat grown after a lentil crop did not appear to have affected wheat grain yields in relation to the other rotations where wheat was grown at recommended N levels. The main factor affecting grain yield appeared to be available soil water, which agrees with other reports for this region (Zentner et al., 2004).

The observation that none of the rotations with a noncereal crop appeared to have had an impact on the levels of *C. sativus*, the most important common root rot pathogen of wheat in Saskatchewan (Tinline 1994; unpublished), could be attributed to the fact that these noncereal crops were only grown for one year in between wheat crops, and/or to the ability of the pathogen to survive and grow on residues and living tissue of noncereal crops (Duczek et al., 1996; Fernandez, 1991; Fernandez et al., 1992).

Finally, our results that root rot levels in ContW were in general similar to those in SF-W or SF-W-W agree with those of Ledingham (1961), Sturz and Johnston (1985), and Wildermuth and McNamara (1991). However, wheat grown continuously (ContW) had a different relative fungal frequency than when grown alternated with summerfallow (SF-W). The lower levels of *Fusarium* spp. in SF-W than in ContW agree with a previous report by Sturz and Johnston (1985).

## **Conclusion**

Based on our findings, we recommend that producers designing their long-term rotation strategies need to consider the impact of noncereal crops, such as lentil, on the severity of root rot in subsequently-grown wheat, and on the frequency of pathogens with wide host ranges, such as *F. avenaceum*. This pathogen is the most common *Fusarium* species responsible for fusarium head blight in Saskatchewan. An increase in the colonization of plant tissue by *F. avenaceum* might impact the subsequent development of fusarium head blight in cereal crops, provided environmental conditions are favourable.

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