How Rotation and Tillage System Affect *Fusarium* Populations in Wheat and Barley in Eastern Saskatchewan

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Introduction

Root rot, caused by *Cochliobolus sativus* and *Fusarium* spp., is a widespread disease of cereal crops in western Canada (Fernandez and Jefferson, 2004). Many of the *Fusarium* spp. isolated from discolored subcrown internodes (SI) of wheat and barley have also been associated with fusarium head blight (FHB) in Saskatchewan (Fernandez et al., 2002).

Given the potential role of fungal colonization of plant tissue in the future development of root and head diseases, it is of interest to determine the impact of crop sequence and tillage system on fungal populations in underground tissue of cereal crops in Saskatchewan.

The objective of this study was to identify *Fusarium* spp. present in discolored SI of spring wheat and barley crops grown in eastern Saskatchewan, and to compare *Fusarium* populations among cereals grown after different crop species or summerfallow, or under different tillage systems.

Materials and Methods

A total of 137 barley and 400 wheat crops, selected randomly in eastern Saskatchewan from 1999 to 2001, were sampled for severity of SI discoloration and percent isolation of fungi. In late July to early August when the crop was at the milk stage, 30-50 plants were carefully pulled at random, and their SI rated for extent of brown to black discoloration on a 0 to 4 severity scale. The proportion of SI within each severity class was computed for each field.

Discolored SI samples (1 to 2 cm) were taken from each affected plant, surface-sterilized, and plated on modified PDA for fungal identification. The percent isolation of each fungal species was calculated based on the total number of isolates in each field.

From each sampled field, we obtained agronomic information directly from producers. Based on this information, fields were classified according to previous cropping practice (cereal, oilseed, pulse or summerfallow) and tillage system (conventional-till: 7 or more tillage operations in the past 3 years, minimum-till: 1 to 6 operations, or zero-till: no tillage). The average number of glyphosate applications in each field in the previous 18 months was 0.5 for conventional-till, 1.2 for minimum-till and 2.0 for zero-till fields.

The effect of previous crop or summerfallow on SI discoloration and fungal populations was assessed on wheat and barley crops grown under minimum-till only, whereas the effect of tillage system was assessed on crops grown after an oilseed crop only. Arcsine-transformed percent SI with severe, or moderate or severe, ratings were analyzed by GLM. Percent isolation of each fungus among crop sequence or tillage categories was analyzed by chi-square tests performed on the actual number of isolations. Simple correlations among the percentages of isolation of the most common fungi were also performed.

Results and Discussion

The fungus most commonly isolated from SI was *C. sativus*, followed by *Fusarium* spp. (Tables 1 and 2). The most common *Fusarium* spp. were *F. avenaceum*, *F. acuminatum*, *F. culmorum*, *F. equiseti* and *F. graminearum*. For all three years combined, the percent isolation of *C. sativus* was negatively correlated with that of *Fusarium* spp. ($r=-0.41$, $P\leq0.01$, for wheat; $r=-0.46$, $P\leq0.01$, for barley). The *Fusarium* spp. isolated, and the negative correlation between percent isolation of *C. sativus* and *Fusarium* spp., agree with findings from a province-wide root rot survey (Fernandez and Jefferson, 2004).

<u>Effect of previously-grown crop for fields under minimum-till management</u>

Growing a noncereal crop or summerfallowing the previous year did not affect the severity of SI discoloration in wheat or barley grown under minimum-till, but it affected the percent isolation of fungi (Table 1). Summerfallow increased the percent isolation of *C. sativus* in the subsequently-grown crop. Wheat and barley grown after a pulse or oilseed crop had either similar or higher levels of total *Fusarium* spp., including the cereal pathogens *F. culmorum* and *F. graminearum*, than when they were grown after another cereal crop.

Similar to our findings, the severity of root rot was found not to differ when wheat or barley were grown after another cereal crop than when grown after canola or summerfallow (Chinn, 1976; Wildermuth and McNamara, 1991), or after one year of flax (Conner et al., 1996). However, Pienning and Orr (1988) found higher root rot levels in stubble barley than in barley following canola or fallow. Bailey et al. (2001) found that increased crop diversity with the use of broad-leaved crops reduced *C. sativus* levels in wheat, but that growing wheat after flax increased the incidence of *Fusarium* spp. in roots.

Effect of tillage system for fields preceded by an oilseed crop

Comparison among tillage systems for wheat and barley preceded by an oilseed crop showed no significant difference in SI discoloration (Table 2). However, there were higher levels of *C. sativus*, and lower levels of some of the *Fusarium* spp., especially *F. avenaceum*, with an increase in the intensity of tillage and a decrease in the use of glyphosate formulations.

The overall lack of an effect of tillage system on the severity of root rot agrees with observations by Bailey et al. (2001) and Windels and Wiersma (1992). Our observation that discoloration caused by *C. sativus* was less severe under zero-till agree with previous findings by Bailey et al. (2000, 2001), Mathieson et al. (1990) and Tinline and Spurr (1991), whereas the observation that zero-till had increased levels of some Fusarium spp. compared to conventional-till also agree with those of Bailey et al. (2000, 2001) and Windels and Wiersma (1992). The lower percent isolation of *C. sativus* from crops under zero-till could be attributed to lower total spore populations and cooler and moister conditions observed in this system than in conventional-till (Mathieson et al., 1990). These conditions may also explain the higher frequency under zero-till of *F. avenaceum*, which is known to be favoured by cooler temperatures (Wiese, 1987). Differences in fungal populations among tillage systems might also be due to direct or indirect effects of previous glyphosate application (Fernandez et al., 2005; Levesque and Rahe, 1992).

Conclusions

- *Fusarium* populations in underground tissue of wheat and barley were not affected much by the preceding crop, but the percent isolation of some of these species increased as soil disturbance decreased and glyphosate use increased.

- Whether the increase in *Fusarium* populations in reduced tillage systems is due to reduced competition from *C. sativus* or a direct growth stimulation is not known and requires further investigation as an increasing number of producers adopts conservation-tillage practices.

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Table 1. Mean severity of subcrown internode (SI) discoloration, and mean percent isolation of *Cochliobolus sativus* and *Fusarium* spp. from discolored subcrown internodes of wheat and barley grown under minimum-till management after an oilseed, pulse or cereal crop, or summerfallow, in eastern Saskatchewan in 1999-2001.

		SI Discoloration			***Fusarium***					
Crop sampled/ preceding crop	**# of fields**	**MS/S**[1]	**S**	***C. sativus***	***avenaceum***	***acuminatum***	***culmorum***	***equiseti***	***graminearum***	**total**
		%								
Wheat:										
cereal	52	29	14	37	5	1	3	6	1	17
oilseed	95	28	12	38	6	1	2	6	<1	17
pulse	42	28	11	35	9	1	1	4	<1	17
summerfallow	14	24	11	58	3	<1	0	7	0	12
Chi-square:				44.69***	16.51***	3.82ns	15.40***	5.69ns	6.58*	4.32ns
Barley:										
cereal	30	48	24	52	4	1	4	6	1	16
oilseed	38	47	23	46	5	2	5	9	1	23
pulse	4	51	28	49	2	0	3	15	20	39
summerfallow	9	53	26	64	6	0	4	14	0	24
Chi-square:				26.83***	3.67ns	8.50**	2.06ns	19.42***	6.67*	27.67***

[1] MS/S: moderate or severe (>25%) discoloration; S: severe (>50%) discoloration.
*, ** and ***, significant at P≤0.10, P≤0.05 and P≤0.01, respectively; ns: not significant.

Table 2. Mean severity of subcrown internode (SI) discoloration, and mean percent isolation of *Cochliobolus sativus* and *Fusarium* spp. from discolored subcrown internodes of wheat and barley grown following an oilseed crop under conventional-till, minimum-till or zero-till, in eastern Saskatchewan in 1999-2001.

		SI Discoloration			***Fusarium***					
Crop sampled/ tillage system	**# of fields**	**MS/S**[1]	**S**	***C. sativus***	***avenaceum***	***acuminatum***	***culmorum***	***equiseti***	***graminearum***	**total**
		%								
Wheat:										
conventional	29	33	13	52	2	1	2	7	1	14
minimum	95	28	12	38	6	1	2	6	<1	17
zero	58	28	11	31	8	1	1	5	1	18
Chi-square:				65.36***	19.20***	1.10ns	2.43ns	1.45ns	1.43ns	3.82ns
Barley:										
conventional	11	51	17	64	3	1	5	9	0	19
minimum	38	46	23	46	5	2	5	9	1	23
zero	10	46	19	40	10	0	1	14	2	29
Chi-square:				24.27***	9.6***	4.86*	8.01**	4.63*	3.53ns	6.11**

[1]MS/S: moderate or severe (>25%) discoloration; S: severe (>50%) discoloration.
*, ** and ***, significant at P≤0.10, P≤0.05 and P≤0.01, respectively; ns: not significant.

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