Effects of tillage methods and crop rotations on the incidence and severity of soil-borne and foliar diseases of wheat, flax, and peas.

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Cultural practices can alter the relationship between a plant pathogen and its host. For example, monoculture or continuous cropping often increase the severity of a disease within the field whereas breaks in the cropping sequence with non-host crops can decrease disease (Ledingham 1961; Chinn 1976; Sturtz and Bernier 1987 1989; Piening and Orr 1988; Conner and Atkinson 1989). Zero-till systems have been introduced in an attempt to reduce soil erosion, salinization, and water loss. Residue on the soil surface from the previous crop could harbour the pathogens and provide a source of inoculum in the spring. However in other cropping systems, varying results have been observed in studies on the relationship between tillage and plant disease (Anon. 1984; Dodman and Wildermuth 1989; Mathieson et al. 1989). It appears that specific crop/disease combinations must be analyzed to determine the effects of crop rotation and tillage systems on the incidence and severity of plant disease. The objectives of this study were to examine the dynamics of naturally occurring soil-borne and foliar diseases in three rotation sequences involving spring wheat, winter wheat, peas, and flax grown under zero-till, minimum-till, and conventional-till management systems from 1987 to 1990.

METHODS AND MATERIALS:

Three management systems and three crop rotations were used in this study. The management systems were i) conventional-till (CT) including both fall and spring pre-seeding tillage, ii) minimum-till (MT) using only spring pre-seeding tillage, and iii) zero-till (ZT) with no fall or spring tillage. In the latter case, soil disturbance only occurred during the seeding operation. The three crop rotation sequences were as follows:

i) S1 = fallow, spring wheat, spring wheat, winter wheat,
ii) S2 = spring wheat, spring wheat, flax, winter wheat, and
iii) S3 = peas, spring wheat, flax, winter wheat.

Treatment of the summerfallow period in S1 depended on the management system. Under CT, only tillage was used for weed control whereas both tillage and herbicides were used under MT. Only herbicides were used under ZT. The experiment was a split plot design with four replications per treatment, located at Indian Head, Saskatchewan. It was conducted from 1987 to 1990.

Naturally occurring foliar and soil-borne diseases were visually evaluated on 30 randomly selected plants from each plot in late July or early August, respectively. Foliar diseases were rated using a 0-9 scale where a rating of zero refers to no symptoms and a rating of nine refers to greater than 90% of the leaf area covered in lesions. Ratings for soil-borne diseases were calculated on the basis of the number of plants in different severity classes. Frequency data on soil-borne diseases were arcsine and square root transformed (Little and Hill 1978). The data in tables are reported as untransformed means. Data were analyzed using analysis of variance procedures and least significant difference multiple comparison tests.

Results and Discussion:

The average disease rating of the prevalent foliar and soil-borne diseases observed from 1987 to 1990 are listed in Table 1. No diseases were observed on flax in any year.

Peas

Analysis of variance indicated no differences in the effects of the tillage management systems on the diseases found on peas. The mycosphaerella blight/ascochyta foot rot complex was least severe in 1987, whereas bacterial leaf spot was least severe in 1988. There was a significant decrease in disease severity of foot rot in 1990 under CT. In 1989 and 1990, leaf spot significantly increased under CT . The environment was a major factor in the disease severity attained. Environment x management system interactions may have masked any effects that tillage might have had on disease control.

Wheat

Common root rot of spring wheat was significantly lower in crop rotations with S1 (19%) and S3 (22%) than S2 (25%). The severity of common root rot on spring wheat was lowest following summerfallow (15.4%) and peas (21.6%) than following either spring (23.5%) or winter wheat (25.2%) in the rotation (Table 2). Others have observed similar results. Ledingham (1961) found that the longer the interval between susceptible hosts, the lower the disease rating. He concluded that common root rot may be lessened by using long rotations.

Analysis of variance indicated no differences among management systems. Significant year x management system interactions indicated higher levels of disease under CT in two years (1988 and 1990) than under MT and ZT (Table 3). Similarly, in a one year study, Mathieson et al. (1989) found more disease on plants and more spores in the soil under CT as compared to ZT plots. However, in 1989, the results of the current study showed that CT decreased disease severity and in 1987, there were no effects. The benefits of management systems to provide disease control of common root rot are sometimes masked by environmental factors. It appears that in years when the disease is at low to moderate levels, ZT may provide additional control. But, in years that are highly conducive to severe disease development, ZT and MT serve to enhance disease severity.

Over all years, the severity of crown rot of winter wheat was not affected by the previous crop in the rotations (Table 2). Environment may have had more influence on disease severity. However, Sturtz and Bernier (1989) found that a one-year rotation with flax could reduce the frequency of occurrence and severity of Cochliobolus sativus and Fusarium culmorum in crown and roots of winter wheat. They isolated C. sativus more frequently than F. avenaceum from winter wheat following flax in rotation. Since no isolations were performed in the current study, it is unknown whether C. sativus or Fusarium spp. were the causal agent or which one was more important.

Take-all of spring and winter wheat was observed only in 1990. It was more severe on winter wheat than spring wheat (Table 4). The management system had no effect on the incidence of take-all on spring wheat but in winter wheat, ZT significantly decreased the amount of take-all. More take-all was observed in winter wheat plots under MT and CT, respectively. Crop rotation sequence did not significantly affect the incidence of take-all, although there was a tendency for those treatments with two or more years of consecutive wheat (S1 and S2) to have slightly greater take-all (4.0% and 3.9%) than alternating wheat with peas and flax as in S3 (2.9%).

Tan spot and septoria leaf blotch (leaf spots) occurred in all four years. The lowest ratings occurred in 1988 when the weather was hot and dry. Data were similar for both diseases, so only the results for tan spot are shown. Small differences in the occurrence of disease was observed on spring and winter wheat but the results did not indicate any clear trends. In 1990, when leaf spots were evaluated in June instead of July, the ratings were significantly lower under CT as compared to ZT or MT and the ratings were lower in S3, which alternated wheat crops with peas or flax, as compared to S1 and S2 which grew three years of continuous wheat (Table 5). There was an indication that disease ratings were higher for spring wheat grown on spring wheat or winter wheat stubble than when grown on pea stubble or fallow (Table 2). The results indicate that under moist conditions, leaf spot diseases could become more serious under continuous wheat cropping. However, under Saskatchewan conditions, disease levels were so low that it was difficult to determine the effect of management systems and crop rotations on leaf spots. Rotations with wheat on wheat or one year between wheat crops, did not result in severe increases of leaf spot diseases. In some years, but not all, conventional-till may help to control disease severity.

Crop rotations and tillage systems had a greater influence on the level of disease caused by soil-borne organisms. Disease severity of common root rot, and take-all were greater in continuous wheat rotations and under conventional-till. However, year to year variation caused by fluctuations in weather had a greater effect than any cultural practice tested.

LITERATURE CITED

Anon. 1984. New disease found in no-tilled wheat, barley. Crops and Soils magazine 37:26.
Anon. 1984. Diseases not building up in no-till corn, soybeans. Crops and Soils magazine 37:30.
Chinn, S.H.F. 1976. Influence of rape in a rotation on prevalence of Cochliobolus sativus conidia and common root rot of wheat. Can. J. Plant Sci. 56:199-201.
Conner, R.L. and T.G. Atkinson. 1989. Influence of continuous cropping on severity of common root rot in wheat and barley. Can. J. Pl. Pathol. 11:127-132.
Dodman, R.L. and G.B. Wildermuth. 1989. The effect of stubble retention and tillage practices in wheat and barley on crown rot caused by Fusarium graminearum Group 1. Plant Protection Quarterly 4:98-99.
Ledingham, R.J. 1961. Crop rotations and common root rot in wheat. Can. J. Plant Sci. 41:479-486.
Little, T.M. and F.J. Hills. 1978. Agricultural Experimentation Design and Analysis. John Wiley and Sons Inc. Canada. pp 350.
Mathieson, J.T., C.M. Rush, O.R. Jones. 1989. Influence of tillage and crop rotation on common root rot of wheat and spore distribution, 1988. Biological and Cultural Tests for Control of Plant Diseases. 4:52.
Piening, L.J. and D. Orr. 1988. Effects of crop rotation on common root rot of barley. Can J. Pl. Pathol. 10:61-65.
Sturtz, A.V. and C.C. Bernier. 1987. Survival of cereal root pathogens in the stubble and soil of cereal versus noncereal crops. Can. J. Pl. Pathol. 9:205-213.
Sturtz, A.V. and C.C. Bernier. 1989. Influence of crop rotations on winter wheat growth and yield in relation to the dynamics of pathogenic crown and root rot fungal complexes. Can. J. Pl. Pathol. 11:114-121.

Table 1. Prevalent foliar and soil-borne diseases observed on spring and winter wheat, peas, and flax at Indian Head, SK from 1987-1990.

Crop	Common name of disease	Average disease rating *
Flax	No diseases observed	-
Peas	Bacterial leaf spot	2.5
	Mycosphaerella blight and ascochyta foot rot complex	80%
Wheat	Leaf rust	0.7
	Tan spot	2.0
	Septoria leaf blotch	1.9
	Glume blotch	0.1
	Yellow wheat streak mosaic	1.2
	Fusarium root rot	11%
	Take-all	4%
	Common root rot	22%
	Crown rot	95%

* Foliar diseases rated on scale of 0-9; soil-borne diseases rated as percentage; take-all observed in 1990; Fusarium root rot observed in 1987-1989; wheat streak mosaic observed in 1989-1990.

Table 2. Effect of previous crop on the average disease severity of common root rot, crown rot and tan spot on spring and winter wheat.

Previous crop	Planted crop	Disease severity *		
		Common root rot	Crown rot	Tan spot
Winter wheat	Spring wheat	25.2 a**	-	2.1 a
Spring wheat	Spring wheat	23.5 a	-	2.0 ab
Peas	Spring wheat	21.6 ab	-	1.8 b
Fallow	Spring wheat	15.4 b	-	1.7 b
Spring wheat	Winter wheat	-	94.7 a	2.3 c
Flax	Winter wheat	-	96.4 a	2.1 c

* Tan spot rated on 0-9 scale; others rated as percentage.

** Data followed by the same letter within a vertical column are not significantly different (LSD test, P= 0.05).

Table 3. Average disease severity (%) of common root rot on spring wheat grown under zero-till (ZT), minimum-till (MT), and conventional-till (CT) from 1987-1990.

TILLAGE	YEAR				
SYSTEM	1987	1988	1989	1990	Mean
ZT	19 a	14 a	40 b	9 a	21 B
MT	15 a	16 a	39 b	11 a	20 B
CT	19 a	31 b	32 a	19 b	25 B
Mean	17 AB	20 B	37 C	13 A	

* Data followed by the same lower case letter within a vertical column for each disease are not significantly different (LSD test, P=0.05) ** Data followed by the same upper case letter are not significantly different (LSD test, P=0.05).

Table 4. Effect of spring wheat vs winter wheat and management systems on the incidence (%) of take-all in 1990.

Management system	Spring wheat	Winter wheat
Zero-till	2.6 a*	5.8 a
Minimum-till	0.7 a	7.5 ab
Conventional-till	0.0 a	10.8 b
Mean	1.1 A**	8.0 B

* Data within a vertical column followed by the same lower case letter are not significantly different (LSD test, P=0.15). ** Data followed by the same upper case letter are not significantly different (LSD test, P=0.01).

Table 5. Effect of management systems and rotational sequence on the the severity of tan spot (rated on a 0-9 scale) of spring and winter wheat from 1987-1990.

	Management system **			Rotation sequence***		
Year	ZT	MT	CT	S1	S2	S3
1987	2.3 a*	2.3 b	2.2 b	2.3 a	2.2 b	2.3 b
1988	1.0 b	1.0 c	1.1 d	1.0 b	1.1 c	1.0 d
1989	2.5 a	2.6 a	2.6 a	2.6 a	2.6 a	2.6 a
1990	2.3 a A	2.3 b A	1.9 c B	2.4 a A	2.2 b A	1.8 c B

* Data followed by the same lower case letter within a vertical column are not significantly different (LSD test, P=0.05). Data followed by the same upper case letter are not significantly different (LSD test, P=0.05). ** ZT= zero=till; MT= minimum=till;CT= conventional-till. *** S1= fallow, spring wheat, spring wheat, winter wheat; S2= spring wheat, spring wheat, flax, winter wheat; S3= peas, spring wheat, flax, winter wheat