Tillage and Rotation have Minimal Effect on Diseases of Lentil and Wheat in Diverse Rotations

B.D. Gossen[1], K.L. Bailey[1], D.A. Derksen[2] , P.R. Watson[2]

[1]Agriculture & Agri-Food Canada Research Centre, 107 Science Place, Saskatoon, SK, S7N 0X2, [2]AAFC Research Centre, P.O. Box 100A, RR#3, Brandon, MB, R7A 5Y3

Abstract

The current trend towards reduced tillage practices was expected to increase losses due to plant disease relative to conventional tillage; increased diversity in crop rotation was expected to reduce these losses. To test these widely-accepted hypotheses, diseases (incidence and severity) were monitored on spring wheat, lentil, and field pea grown in diverse crop rotations under zero and conventional tillage at Indian Head, SK from 1992-1995. Crop rotation and tillage practice had little effect on lentil diseases, but epidemics of ascochyta blight [*Ascochyta lentis*] and botrytis blight [*Botrytis cinerea*] were most severe in the treatments with the densest plant stands. Leaf disease severity on wheat grown under zero tillage did not differ from wheat under conventional tillage, but root disease severity was lower. The importance of individual root pathogens of wheat changed under zero tillage, with *Fusarium* spp. increasing while *Bipolaris sorokiniana* decreased. Rotation did not affect disease severity or the incidence of pathogens causing root disease. However, leaf disease severity on spring wheat was slightly higher in the most diverse rotation than in two other diverse rotations. Regardless of the tillage or crop rotation practices used, the annual environment was the most important factor limiting the severity of disease and the losses incurred.

Introduction

Agronomic practices on the Canadian prairies are rapidly moving away from a reliance on cultivation as the principal management tool in simple cereal-fallow rotations. This system is being replaced with reduced cultivation systems, together with a diversity of crops under continuous cropping. As part of this trend towards greater crop diversity, there have been large increases in the acreage of lentil (*Lens culinaris*) and other pulse crops. The area grown to lentil has gone from a few hundred hectares in the early 1970's to nearly 400,000 ha in the 1990's, and total pulse crop area has increased to nearly 1.5 million ha. The rapid pace of this change has stimulated interest and concern about crop losses caused by plant diseases such as foliar diseases of wheat and lentil. The objectives of this study were to monitor changes in pathogen populations and disease severity on wheat, lentil and field pea grown in diverse crop rotations with zero and conventional tillage management systems.

Materials and Methods

The study was conducted from 1992-95 at Indian Head, SK. Tillage treatments (zero vs. conventional tillage) were the main plots, the crop-types grown in rotation (phases: cereal, oilseed, cereal, pulse) were subplots, and the specific crops grown in six rotations were the sub-subplots. All phases of the rotations were present in every year. Each experimental unit (sub-subplot) was 6 x 18 m^2. Zero tillage plots were seeded directly into standing stubble. Conventional tillage plots were cultivated in fall and again prior to seeding in spring. Details of plot design, maintenance and yield have been published previously (Derksen et al. 1998).

In 1994, three of the six rotations seeded to lentil required reseeding. The initial seeding was made on April 28 (cv. Laird) and the plots were reseeded at 45 kg ha^{-1} on June 22 to cv. Eston (small seeded, early maturing). The Eston seed was infected (5% incidence) with *Ascochyta lentis*, which had not previously been present at this site.

Twenty-five spring wheat plants in Rotations 3, 4, and 5 were collected shortly before harvest each year for evaluation of root and leaf spot diseases. Disease severity was assessed on roots using a 0-3 scale and on leaves using 0-11 scale. Species prevalence was assessed (% incidence and frequency of isolation) based on isolation onto several semi-selective media. Lentil assessments (and the single rotation with field pea) were also made at the vegetative and flowering stage each year. The pathogen complex on lentil and pea were quite simple at this site, so visual assessments of symptoms were used to identify species prevalence. No ratings were taken in 1992. In 1993 and 1994, 50 lentil seeds per plot were surface sterilized, plated onto PDA and assessed for the incidence of *A. lentis* and *Botrytis cinerea*.

Differences in the pathogen populations and disease severity in each year were compared using analysis of variance. Stepwise linear regression on treatment means was used to evaluate the associations between yield and disease in wheat. Two multivariate statistical methods were used; Principal Components Analysis (PCA), to summarize underlying trends and Canonical Discriminant Analysis (CDA), for hypothesis testing.

Results and Discussion

Spring Wheat

Zero tillage did not affect leaf spot severity relative to conventional tillage, but root severity was less under zero tillage in 3 of 4 years (Table 1). Tillage system did not affect wheat yield, except in 1993 when yield was greater under zero tillage than conventional tillage.

Leaf spot diseases were more severe in Rotation 5 than in either R3 (3/4 years) or R4 (2/4 years) (Table 2). Foliar disease severity in R3 and R4 were similar, except in 1992 when severity was greater in R4. Root disease severity did not differ among the rotations in any year. There was no consistent effect of rotation on yield; in 1992, yield was lower in R4 than in R3 and R5, but in 1994, yield was higher in R3 than in R4 and R5. A tillage x rotation interaction for leaf spot severity occurred in only 1 of 4 years, and there was no T x R interaction for root disease severity.

The most prevalent foliar pathogens were *S. tritici* at 47% of all isolations, followed by *P. tritici-repentis* at 20%, but the relative abundance of the various pathogens on leaves shifted substantially from year to year (data not shown). From roots, *Bipolaris sorokiniana* and *Fusarium* spp. were each isolated from more than 50% of the plants sampled. Tillage practice and rotation influenced the prevalence of several pathogens. The relative abundance of *P. tritici-repentis* from leaves and *Fusarium* spp. from roots was higher with zero-tillage, but the relative abundance of *B. sorokiniana*

was lower (data not shown).
Differences in weather among years had an important impact on foliar disease severity. Lower leaf spot severities in 1992-93 were associated with cooler, drier conditions than in 1994-95. There were significant negative relationships between disease severity (foliar and root) and wheat yield, based on stepwise regression analysis, but these relationships varied considerably from year to year.

In 1995, a sample of *32 Fusarium* isolates were identified to species; 17 isolates were *F. equiseti*, 6 were *F. acuminatum*, 4 were *F. culmorum*, 3 were *F. graminum*, and 2 were *F. graminearum*. Most of these species, e.g. *F. equiseti* and *F. acuminatum*, are common saprophytes or weak pathogens that survive primarily on crop residue (Burgess 1981). The high proportion of saprophytic Fusarium isolates relative to pathogens may explain why root disease severity was low.

Multivariate analysis demonstrated that differences among years was much more important than differences among treatments in this study (not shown). This supported the conclusions from conventional univariate analysis of variance.

Lentil

No ratings were taken on lentil in 1992. In 1993, botrytis stem and leaf blight developed in the plots just before harvest. Rotation and tillage treatments had no effect on the incidence or severity of *B. cinerea* (Table 3). There were no differences among treatments for root rot incidence or severity at any date in 1993 (Table 1 - only the final root ratings are presented). Red *Fusarium* spp. were consistently isolated from root lesions. A random sample of 34 *Fusarium* isolates were identified to species; 15 (44%) of the isolates were *F. acuminatum*, 9 (26%) *F. avenaceum*, and 11 (32%) divided among five other *Fusarium* spp.

In 1994, differences in seeding date, coupled with intrinsic differences in plant architecture between cvs. Laird and Eston, resulted in a large difference in growth stage and canopy density between the early (Laird) and late (Eston) groups of treatments. By August 10, ascochyta blight severity was higher in Laird than in Eston (data not shown). Both cultivars are susceptible to ascochyta blight, so this difference was probably due to a denser canopy in plots of Laird. Just before harvest, botrytis blight was severe in Laird (R2, R3, R4), but low in Eston (R1, R5, R6, see Table 3). Ascochyta blight severity was low, but levels were slightly higher in Laird than Eston (1.3 vs 0.9, see Table 2). Root rot severity was slightly lower (*P* £ 0.001) in Eston than Laird (0.2 vs 0.4), but there was no effect of tillage on root rot incidence or severity. In harvested seed, the incidence of *B. cinerea* was lower in zero- (18%) than conventional-tillage (25%) (Table 3) and *A. lentis* was higher in Laird (16%) than in Eston (6%). These results indicate that ascochyta and botrytis blight develop more quickly where the crop canopy is dense than in more open canopies

In 1995, foliar and root disease severity was low. The main effect of tillage on ascochyta blight severity was significant, but differences between tillage treatments were small (Table 1).

Field pea

Mycosphaerella pinodes was the only foliar pathogen noted at the site. Red *Fusarium* spp. were consistently isolated from infected root lesions. There were no differences in foliar or root disease severity among tillage treatments in any year (Table 1).

Conclusion

In this study, reduced tillage did not increase disease severity on wheat and lentil grown in diversified crop rotations (i.e. cereal-oilseed-cereal-pulse). The effect of annual environment was the strongest factor influencing disease severity and the prevalence of species in the pathogen population structure. We conclude that, regardless of agronomic practices used, weather will have a greater influence on the disease epidemic within the season than rotation or tillage. Although disease severity and population prevalence were occasionally associated with a particular practice (i.e. zero vs. conventional tillage or diversity in crop rotation), differences were not generally associated with differences in yield.

Acknowledgment: The authors thank Sheila Reed, Karyn Sutherland, and Krista Anderson for technical assistance, and the Agriculture Development Fund and the Parkland Agricultural Research Initiative for partial funding of the project.

Table 1. Effect of tillage system on disease severity and yield (000's kg ha^{-1}) of spring wheat, lentil and field pea at Indian Head, SK from 1992-1995.

Tillage practice	1992	1993	1994	1995
		---Spring wheat---		
Leaf spot severity (0-11 scale)				
- Zero-till	3.6 a †	4.1 a	7.1 a	6.2 a
- Conventional-till	3.4 a	3.6 a	7.1 a	6.4 a
Root rot severity (0-3 scale)				
- Zero	1.3 a	0.2 a	0.2 a	0.3 a
- Conventional	1.5 a	0.5 b	0.4 b	0.6 b
Yield (000's kg ha^{-1})				
- Zero	3.2 a	2.3 a	4.8 a	2.7 a
- Conventional	2.9 a	1.8 b	5.0 a	2.8 a
		---Lentil---		
Leaf spot severity				
- Zero	nd	0 a	1.0 a	2.0 b
- Conventional	nd	0 a	1.1 a	1.7 a
Root rot severity				
- Zero	nd	1.3 a	0.2 a	0.5 a
- Conventional	nd	1.2 a	0.2 a	0.6 b
Yield				
- Zero	nd	1.0 a	2.1 a	2.5 a
- Conventional	nd	1.3 b	1.8 a	2.9 a
		---Field Pea---		
Leaf spot severity				
- Zero	nd	1.8 a	3.7 a	1.7 b
- Conventional	nd	1.7 a	3.4 a	2.0 a
Root rot severity				
- Zero	nd	0.5 a	0.8 a	0.7 a
- Conventional	nd	0.5 a	0.7 a	0.6 a
Yield				
- Zero	nd	3.3 a	3.4 a	1.4 a
- Conventional	nd	2.7 b	3.1 b	1.4 a

† For each measured variable, values in columns followed by the same letter are not significantly different at $P = 0.05$ using a LSD test for comparisons between tillage practices; nd = not done.

Table 2. Effect of crop rotation on disease severity and yield (000's kg ha^{-1}) of spring wheat, lentil, and field pea at Indian Head, SK from 1992-1995.

Variable & Rotation	1992	1993	1994	1995
		----Spring wheat---		
Leaf spot severity (0-11 scale)				
R3	2.9 a †	3.7 a	6.8 a	6.3 a
R4	3.8 b	3.7 a	6.8 a	6.1 a
R5	4.1 b	4.4 b	8.2 b	6.6 a
Root rot severity (0-3 scale)				
R3	1.5 a	0.5 a	0.2 a	0.4 a
R4	1.3 a	0.7 a	0.3 a	0.5 a
R5	1.5 a	0.6 a	0.4 a	0.4 a
Yield (000's kg ha^{-1})				
R3	3.4 a	2.1 a	5.4 a	2.8 a
R4	2.5 b	2.0 a	4.5 b	2.8 a
R5	3.6 a	2.0 a	4.6 b	2.5 a
		------Lentil-------		
Leaf spot severity (0-11 scale)				
R1 (w-c-w-l[1])	nd	0 a	0.9 a	1.6 b
R2 (w-c-w-l[2])	nd	0 a	1.1 a	1.5 a
R3 (w-c-w-l[3])	nd	0 a	1.4 b	2.1 a
R4 (w-p-w-l)	nd	0 a	1.3 b	1.9 ab
R5 (cs-s-w-l)	nd	0 a	0.9 a	2.0 ab
R6 (w-m-cs-l)	nd	0 a	0.8 a	2.1 a
Root rot severity (0-3 scale)				
R1	nd	1.3 a	0.2 a	0.5 a
R2	nd	1.3 a	0.3 b	0.6 b
R3	nd	1.2 a	0.3 b	0.5 a
R4	nd	1.3 a	0.3 b	0.5 a
R5	nd	1.2 a	0.1 a	0.5 a
R6	nd	1.2 a	0.1 a	0.6 a
Yield (000's kg ha^{-1})				
R1	nd	1.2 a	0.9 c	2.9 a
R2	nd	1.1 ab	2.2 b	2.7 ab
R3	nd	1.2 a	2.7 b	2.3 b
R4	nd	1.0 ab	3.3 a	2.5 ab
R5	nd	1.1 ab	1.2 c	3.0 a
R6	nd	0.9 b	1.4 c	2.9 a

† For each variable assessed, values in columns followed by the same letter are not significantly different at $P = 0.05$ based on Duncan's Multiple Range test; nd = not done.
1 = post emergent herbicide, 2 = pre & post emergent herbicide, 3 = low input.
w = wheat; c = canola, l = lentil, p = field pea, cs = canaryseed, s = sunflower, m = mustard.

Table 3. Impact of crop management system on lentil stem infection by *Botrytis cinerea* (*Bc*) and seed infection by *Bc* and *Ascochyta lentis* (*Al*) at Indian Head, SK., 1993-1995.

Management practice	% stems with *Bc* August 10, 1994	% Seed infection 1993 ¶ *Bc*	1993 *Al*	1994 *Bc*	1994 *Al*	1995 *Bc*	1995 *Al*
		-------Tillage-------					
Zero-till	17 b †	10 a	0 a	18 a	14 b	5 a	0 a
Conventional-till	22 b	10 a	0 a	25 b	8 a	3 a	2 a
		-------Rotation-------					
R1 (w-c-w-l[1])	0 a	10 a	0 a	18 a	6 a	6 a	1 a
R2 (w-c-w-l[2])	26 b	10 a	0 a	19 ab	14 b	4 a	2 a
R3 (w-c-w-l[3])	47 b	8 a	0 a	23 ab	17 b	4 a	1 a
R4 (w-p-w-l)	42 b	10 a	0 a	21 ab	18 b	4 a	1 a
R5 (cs-s-w-l)	0 a	12 a	0 a	23 ab	6 a	4 a	1 a
R6 (w-m-cs-l)	2 a	11 a	0 a	27 b	6 a	5 a	1 a

† For each management practice assessed, values in columns followed by the same letter are not significantly different at $P = 0.05$ based on Duncan's Multiple Range test.
1 = post emergent herbicide, 2 = pre & post emergent herbicide, 3 = low input.
w = wheat; c = canola, l = lentil, p = field pea, cs = canaryseed, s = sunflower, m = mustard.

References

Burgess, L.W. 1981. General ecology of the fusaria. Pages 225-235 in Eds. P.E. Nelson, T.A. Toussoun, and R.J. Cook, Fusarium:Diseases, Biology, and Taxonomy. The Pennsylvannia State University Press, University Park, USA.

Derksen, D.A., P.R. Watson, and H. A. Loeppky. 1998. Weed community composition in seedbanks, seedling, and mature plant communities in a multi-year trial in western Canada. Aspects Appl. Biol. 51: 43-50.