Modeling Blackleg Disease Progress on Canola under Different Rotation and Tillage Conditions

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ABSTRACT

Leptosphaeria maculans (Desm.) Ces. Et de Not. (anamorph: *Phoma lingam*) causes blackleg disease of canola (*Brassica napus*). The disease progress over time was examined under different rotation and tillage conditions during different growth stages of the canola crop. Crops in the rotation were: canola (C), wheat (W) and flax (F). Rotation was done under conventional (T) or zero-till (Z) conditions. The canola variety was Westar, which is very susceptible to the blackleg pathogen. Plant disease severity was estimated as the percent sum of lesions per leaf per plant. Less disease was prevalent in tilled plots compared to zero-till plots. Under the same tillage regime, less disease was observed when crops were rotated (CWCT < CCCT < CWCZ < CCCZ). The integrated exponential model Y = 0.00014 exp (0.135t), the linear models Y = - 3.514 + 0.069t, Y = - 3.566 + 0.07t and Y = - 3.622 + 0.07t provided the best fit for the disease progress in CCCZ, CWCZ, CCCT and CWCT, respectively. Y = percent sum of lesions per leaf per plant and t = days after seeding. The models described 98.5%-99.8% of the variation in disease severity over the growth stages of canola. Use of these models in conjunction with data of different growth stages would allow the prediction of blackleg disease development in canola.

Keywords: Model - blackleg - disease progress - canola - rotation and tillage

INTRODUCTION

Blackleg, caused by *Leptosphaeria maculans* (Desm.) Ces. Et de Not. (anamorph: *Phoma lingam*), is the most serious disease of canola. With significant acreage expansion of land sown to canola during the past two decades, the concern about blackleg has increased. Crop rotation and tillage have interested most farmers with their low cost, easy operation and low risk of yield loss. In 1999, we investigated the effects of crop rotation and tillage on blackleg disease of canola, and intended to use mathematical models to describe blackleg disease epidemics, quantify and compare effects of different crop rotation and tillage systems on the disease and provide a foundation for the establishment of predicting disease and assessment of crop damage.

MATERIALS AND METHODS

The experiment was conducted in Manitoba, Canada from 1999 to 2002. A split-plot design with three replicates was used with conventional till (T) and zero till (Z) as main plots and canola (C) rotated with wheat (W) and flax (F) as subplots. There were four treatments involved in the establishment of models: CCCZ, CWCZ, CCCT, and CWCT. Canola, wheat and flax cultivars were Westar (susceptible to blackleg pathogen), Barrie and Norlin, respectively. Pathogen was *Leptosphaeria maculans* PG-2 isolate PG-12. Disease was measured on July 17, 20, 24 and 31, 2001. Total area covered by lesions on a plant was measured and expressed as sum of size of all lesions on the plant. The EIPMODEL computer program, applied in this study, involved five models where y = proportion of tissue infected by pathogen; y_0, or b_0 = initial proportion of tissue infected by pathogen; r, or b_1 = rate of change in disease; t = time (Table 1). R^2 (coefficient of determination) and MSE (mean square error) were used for estimating disease progress and analyzing fit of models.

RESULTS

The total area covered by lesions in CWCT was significantly less than CCCT (Table 2). Similar results were obtained with CWCZ < CCCZ, CWCT < CWCZ, and CCCT < CCCZ.

For CCCZ, the exponential model gave the largest R^2, 99.2% among five models (Table 3). It indicated that it best fitted disease progress in CCCZ, and described 99.2% of the variation in disease severity over the growth stage of canola. The linear model was found best fitting disease progress in the other three cropping systems (Table 3). The linear model described 99.8%, 99.1% and 98.5% of variations of disease severity in CWCZ, CCCT and CWCT, respectively (Table 3).

CONCLUSIONS

Under the same tillage regime, less disease was observed when crops were rotated; less disease was prevalent in tilled plots compared with zero-till plots.

The best-fitting models were $y = -3.622 + 0.07t$ in CCCZ, $y = -3.566 + 0.07t$ in CWWZ, $y = -3.514 + 0.069t$ in CCCT, and $y = 0.00014 \exp(0.135t)$ in CWCT.

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REFERENCES

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Table 1. Temporal plant disease progress models

Model	Integrated expression	Linearized equation
Gompertz	$y=\exp\{[\ln(y_0))]\exp(-rt)\}$	$-\ln[-\ln(y)]=-\ln[-\ln(y_0)]+rt$
Exponential	$y=(y_0)\exp(rt)$	$\ln(y)=\ln(y_0)+rt$
Logistic	$y=1/\{1+[(1-y_0)/y_0]\exp(-rt)\}$	$\ln[y/(1-y)]=\ln[y/(1- y_0)]+rt$
Monomolecular	$y=1-(1-y_0)\exp(-rt)$	$\ln[1/(1-y)]=\ln[1/(1- y_0)]+rt$
Linear	$y=b_0+b_1t$	$y=b_0+b_1t$

(Nutter and Parker, 1997)

Table 2. Percent area covered by lesions on plants infected by *L. maculans* under different rotation and tillage systems

Treatment	Date			
	July 17	July 20	July 24	July31
CCCZ	3.87 a	6.11 a	7.92 a	27.00 a
CWCZ	0.78 b	3.64 b	6.68 b	19.43 b
CCCT	0.57 b	1.89 c	5.34 c	11.92 c
CWCT	0.49 b	0.94 d	3.70 d	8.74 c

Different letters within a column indicates significant differences according to the Fisher's least significant difference (LSD) test ($P<0.05$).

Table 3. Transformed data and statistical analyses with the EPIMODEL computer program under different rotation and tillage systems

Model	Intercept	Slope	R^2	MSE
CCCZ				
Gompertz	-16.080	0.314	0.930	0.925
Exponential	-8.874	0.135	0.992	0.090
Logistic	-19.662	0.367	0.951	0.896
Monomolecular	-13.400	0.274	0.912	0.915
Linear	-1.984	0.074	0.969	0.086
CWCZ				
Gompertz	-17.202	0.332	0.967	0.665
Exponential	-9.010	0.138	0.821	0.695
Logistic	-22.671	0.416	0.991	0.428
Monomolecular	-13.660	0.278	0.929	0.831
Linear	-3.514	0.068	0.998	0.020
CCCT				
Gompertz	-17.113	0.331	0.979	0.522
Exponential	-8.779	0.135	0.817	0.689
Logistic	-22.376	0.413	0.971	0.099
Monomolecular	-13.630	0.278	0.943	0.741
Linear	-3.566	0.068	0.991	0.051
CWCT				
Gompertz	-17.266	0.333	0.973	0.604
Exponential	-8.984	0.137	0.865	0.585
Logistic	-22.675	0.416	0.996	0.293
Monomolecular	-13.702	0.279	0.938	0.773
Linear	-3.622	0.069	0.985	0.064

R^2 – coefficient of determination; MSE – mean square error.