EPIDEMIOLOGICAL ASPECTS OF RESISTANCE IN RAPESEED TO BLACKLEG

C.B. Rempel(1), Z. Lisieczko(2), and R. Hall(1)

(1) University of Guelph, Department of Environmental Biology, Guelph, Ontario, Canada N1G 2W1
(2) King Agro, Listowel, Ontario, Canada N4W 3G7

INTRODUCTION

The relationship between two plant disease measurements, disease incidence (proportion of diseased entities within a sampling unit) and disease severity (quantity of disease affecting entities within a sampling unit) has been investigated in a number of pathosystems (James and Shih, 1973; Reddy et al., 1979; Seem and Gilpatrick, 1980; Xi et al., 1990). The incidence-severity (I-S) relationship may play an important role in disease and loss assessment models (Seem, 1984) as well as assessing the impact of host resistance and various disease management practices, such as the assessment of fungicide efficacy.

This study was conducted to investigate the relationship between incidence and severity of blackleg disease of rapeseed (*Brassica napus* L.) caused by *Leptosphaeria maculans* (Desm.) Ces. & de Not. The effect of rapeseed genotypes on the I-S relationship was determined at various times over the course of the growing season. The effect of blackleg disease severity on crop yield loss was also investigated.

MATERIALS AND METHODS

The data in this study were obtained from field experiments grown at four locations (3 sites in Ontario, 1 site in Manitoba). Twenty-one 8 x 10 m plots (7 plots x 3 replications) were planted at each location in an RCB design. Seven rapeseed genotypes were used in each experiment.

The pathogen incites both leaf and stem lesions in the host. The stem lesions contribute most to yield loss (McGee, 1973). Therefore, blackleg disease was assessed on basal stem lesions at 3 different sampling dates starting at midflower through to maturity. Disease incidence was determined as the percentage of infected plants. Disease severity was rated on a 0-4 disease category scale (Xi et al., 1990). Forty plants from each plot were sampled for severity.

To determine yield loss due to blackleg disease, 50 plants were sampled from each of the five disease categories for each genotype at each of the four locations. The plants were threshed and seed weights were determined. Yield loss in each disease severity category was compared to the seed weight of healthy plants.

The statistical analysis of all data included linear regression and appropriate tests for significance. An arcsine transformation was applied to incidence data to make the variance more uniform.

RESULTS

Table 1 shows the disease incidence vs severity relationship of blackleg at three sampling dates grouped over all genotypes and locations. The relationship between disease incidence and disease severity was linear for each sampling date. The relationship between average disease incidence and disease severity was strongest on the final sampling date as shown by the coefficient of determination. There was a very poor correlation between disease incidence and severity at the second sampling date. For the final sampling date, 63 percent of the observed variability over genotypes and locations was explained by linear regression.

Table 1. Comparison of coefficients from regression lines of severity verses arcsine transformed incidence of blackleg disease at three successive sampling dates.

Sample time	a	b	R^2
First	-0.25	0.02	0.39
Second	0.87	0.01	0.03
Final	-2.39	0.08	0.63

a = Y intercept, b = slope

Figure 1 shows the I-S relationship for the final sampling date at each of the four locations. When all of the genotypes were grouped over each location, the coefficients of determination indicate that 39 - 62 percent of the observed variability of the disease severity was accounted for by disease incidence (data not shown). The b values (regression slopes) in the regression equation

Disease Severity = a + b ((arcsine) Disease Incidence)

characterize the relationship between incidence and severity and serve as an estimate for the rate of increase of disease incidence. The lower slope coefficient for location 1 indicates that blackleg disease severity over all seven genotypes increased at a slower rate for each increase in disease incidence when compared to the other three locations. The b values were identical for three of the locations, indicating the stability of the I-S relationship over locations.

Table 2 shows the I-S relationship of blackleg disease for each of the seven rapeseed genotypes, grouped over all locations, at all three sampling dates.

Table 2. Comparison of coefficients representing the relationship between disease severity and arcsine transformed incidence of blackleg separated according to genotypes at three sampling dates.

Genotype	First sample		Second sample		Final sample	
	b	R^2	b	R^2	b	R^2
Global	0.01	0.61	0.06	0.49	0.06	0.68
Hybrid 1	0.03	0.91	0.09	0.29	0.07	0.72
Hybrid 2	0.01	0.11	0.04	0.11	0.08	0.74
Westar	0.03	0.37	0.00	0.01	0.07	0.87
Hybrid 3	0.03	0.55	0.05	0.25	0.08	0.75
Regent	0.02	0.49	0.06	0.12	0.06	0.60
Hybrid 4	0.01	0.09	0.04	0.17	0.04	0.37

b = slope

The I-S relationship for all seven genotypes showed considerable heterogeneity at the first two sampling dates. The large differences in the slope coefficients, especially at the second sampling date, shows that disease severity in certain genotypes increases more rapidly for each increase in disease incidence. The pathogen grows systemically through the plant, via the leaf and petiole, to the stem (Hammond et al., 1985). Lower initial disease incidence levels at the first sampling date may reflect increased resistance to leaf infection by the pathogen. The slope coefficients at the early sampling period may provide the most information on the I-S relationship as it applies to genotype resistance, for a rapid increase in severity may reflect increased susceptibility of the host to the pathogen once it has reached the stem.

Figure 2 shows the relationship between blackleg disease severity and rapeseed yield loss, expressed as percent yield loss compared to healthy plants. This relationship was determined over all genotypes at all locations. The data shows a significant correlation between crop yield loss and final disease severity. When disease severity was high, major yield losses occurred in all genotypes. When disease severity was low, some of the genotypes showed significant yield losses while other genotypes showed very little loss (data not shown).

DISCUSSION

In this study, the I-S relationship for blackleg of rapeseed was shown to be stable over diverse locations. There are numerous reports which show that the I-S relationship remains constant over a large geographic area (James and Shih, 1973; Seem and Gilpatrick, 1980; Xi et al., 1990).

A method for estimating disease severity from disease incidence is desirable for selecting genotypes with increased resistance to blackleg because it simplifies assessment and reduces inputs of time and labour (James and Shih, 1973). Seem and Gilpatrick (1980) found that the I-S relationship for powdery mildew remained constant for apple cultivars with different levels of resistance to the disease. Reddy et al. (1979) examined the I-S relationship for bacterial leaf blight of rice and found that the slope coefficients were similar between susceptible rice varieties. However, the slope coefficient was significantly lower for the disease tolerant variety. Xi et al. (1990) found that in rapeseed genotype trials, differences in disease incidence did not explain differences in blackleg disease severity. In this study, the different rapeseed genotypes had a significant effect on the regression coefficients on the I-S regression line. This was true for all sampling periods, especially mid-sampling. Disease severity ratings for determining genotype resistance are typically done prior to harvest. The best I-S relationship for all genotypes at all locations was obtained at the final sampling date prior to harvest. However, this study shows that differences in the I-S relationship for various rapeseed genotypes are intrinsically large. Incidence is a poor indicator of blackleg disease severity, making it difficult to select resistant genotypes based on disease incidence alone.

Mathematical models of the relationship between disease severity and yield loss can be divided into two general groups: critical point models which provide an estimate of loss for any given level of disease at a given time, and multiple point models which estimate the disease loss based on multiple assessments (James, 1974). The goal of yield loss estimates is to measure disease and develop a reliable method of translating this into loss. The disease severity - yield loss relationship determined from this study was similar to that of McGee and Emmett (1977). The general relationship found in our study requires further examination with respect to individual genotype over a number of sampling dates. Rapid increases in severity of stem canker during the early period of pod filling may explain the large yield losses of some rapeseed genotypes. Conversely, a genotype having a high incidence of initial infection but a slow increase in stem canker severity over the pod filling period, may have significantly higher yields and yield losses due to disease may be minimized.

Our critical point model gives a general relationship between disease severity and yield loss. However, a multiple point model may account for some of the variation in loss among genotypes, especially if one considers the high variability in infection rates and the relatively long period for yield accumulation in rapeseed.

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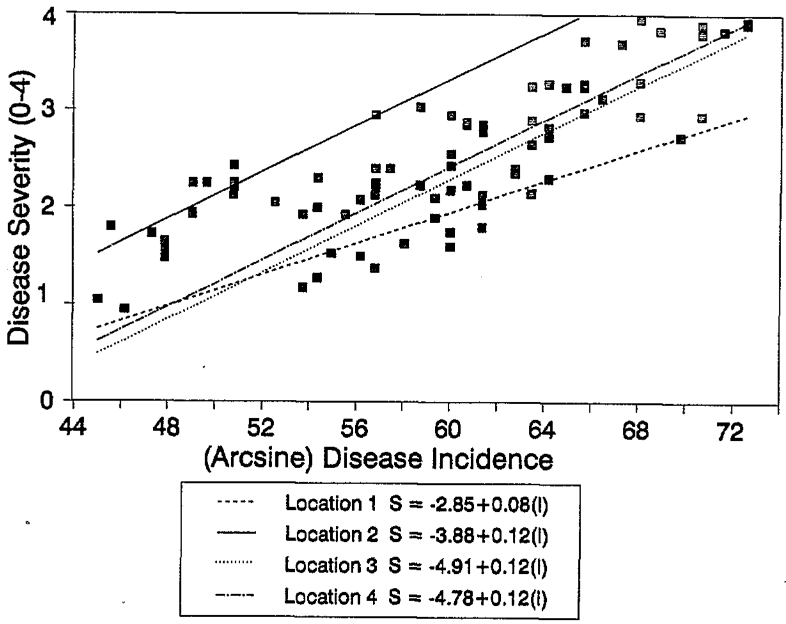

Figure 1. Relationship between final disease severity and arcsine transformed disease incidence of blackleg at four locations.

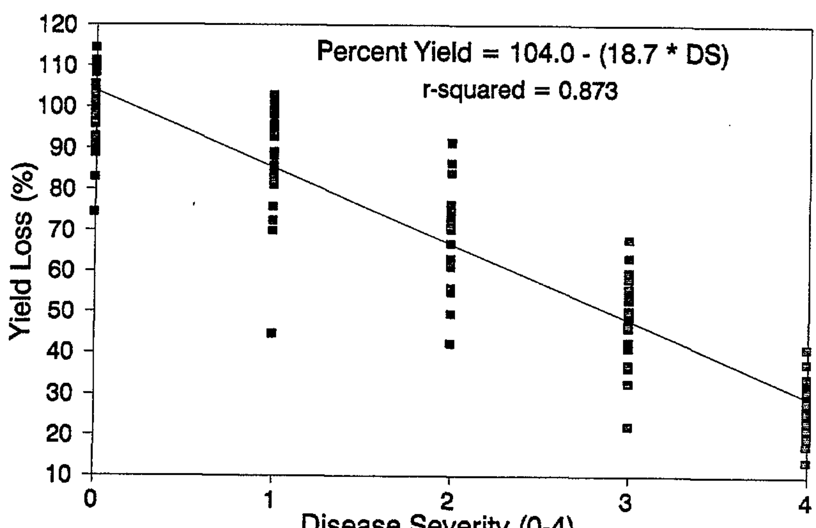

Figure 2. The effect of blackleg disease severity on percent yield loss of seven rapeseed genotypes.