FORECASTING SCLEROTINIA STEM ROT OF SPRING RAPESEED BY PETAL TESTING

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INTRODUCTION

The need for forecasting sclerotinia stem rot of rapeseed has been recognized in countries such as Denmark, Germany and Canada (Thomas 1985; Buchwaldt 1989; Ahlers 1989). In western Canada, where subsidies are limited and where yields are low because spring rapeseed is grown and moisture is often limiting, systematic fungicide applications to control stem rot are not economically feasible. Disease incidence varies from year to year, from region to region and even from field to field within the same region (Morrall and Dueck 1983). One recent survey over a 6-year period in Saskatchewan (Turkington and Morrall 1991) indicated that fungicide application would have been worthwhile in only 11% of 510 crops; these were where disease incidence exceeded 20%. Thus, methods which allow farmers to identify crops with a high risk of stem rot infection and thereby avoid unnecessary fungicide applications should benefit farmers, the environment and even the chemical industry.

Sclerotinia sclerotiorum (Lib.) deBary is mainly a monocyclic pathogen on rapeseed. It can be controlled by fungicides applied exclusively during flowering because of the unique role of petals in the disease cycle. Dead petals provide a saprophytic food base without which the ascospores cannot germinate and penetrate leaves and stems. Almost 10 years ago Lamarque and co-workers in France (Kapoor et al. 1983; Lamarque 1983) showed that ascospores contaminate and begin to infect rapeseed petals when they are still in the inflorescence. This essentially epiphytic phase in the disease cycle can be exploited not only for chemical control, but also for forecasting stem rot because it starts some time before symptoms appear.

EARLY BLOOM PETAL INFESTATION

The possibility of forecasting stem rot of rapeseed based on petal infestation (PI) with the pathogen was first suggested by Gugel and Morrall (1986). In a study of inoculum-disease relationships in 1983, they showed a strong relationship in three fields between disease incidence and percentage PI at early bloom. The PI values were determined by plating samples of non-surface disinfested petals on an agar medium, incubating and scoring the petals as positive or negative for S. sclerotiorum. Thus, the sampling units were individual petals and a quantal measure of PI was made. Disease incidence was measured by counting the number of diseased individuals in random samples of plants at the end of the season. Much additional work has been done on this subject by our group since 1983, but results as clear as those obtained in 1983 have never been obtained again (Gugel and Morrall 1986; Turkington et al. 1991a). However, where correlations of PI with disease incidence have been weak, questions have arisen that led to ways to make measuring PI a useful method of disease risk assessment.

In 1985 a large-scale project was initiated in Saskatchewan to study the feasibility of forecasting based on measuring PI by agar plating. Many of the petal samples were collected and brought to our lab by farmers according to instructions we distributed. In 1985 and 1986 emphasis was placed on determining PI at early bloom because the application of fungicides was recommended from early to full bloom (Dueck

et al. 1983, Thomson et al. 1984, Morrall et al. 1989). Thus, it was felt that petal testing in a crop would not be of practical use after Growth Stage 4.2 (Harper and Berkenkamp 1975), especially since incubation of the plates for 3-4 days was necessary. However, simple regression analyses of data collected over the last six years have shown that, even when regressions are significant, only 18-30% of the variation in disease incidence in commercial crops is accounted for by PI at early bloom (Turkington et al. 1991a).

The data for six years were simplified by classifying the crops sampled into low, moderate and high categories according to both forecast disease risk and actual disease incidence. These categories were derived by averaging some of the relationships demonstrated by Gugel and Morrall (1986) and they are somewhat arbitrary. However, cross-tabulation of the data from 510 fields over six years showed that the highest success rate in forecasting the incidence of stem rot was achieved when disease risk was low (Turkington et al. 1991a). This means that petal testing at early bloom might be most useful to help farmers decide when fungicide application is unnecessary.

SAMPLE SIZES

Early in our program on petal testing an important question relative to practical forecasting was how extensive petal sampling should be in commercial fields to provide reliable estimates of PI. Turkington et al. (1988) conducted experiments in five rapeseed crops in which samples were collected from up to 100 sites per crop. To determine percentage PI, up to 100 petals were plated per site, with four petals to a petri dish, as in all other work reported in this paper. An analysis of variance on a single dish basis was used to show the effect of various sample sizes on the accuracy of PI values. Sampling at 5-6 sites per crop and plating 40 petals per site was enough to estimate percentage PI with a standard error of about 5% in most fields. This was considered acceptable for commercial forecasting, given the fact that other variables affect the accuracy of forecasting by petal testing. In our experimental work we now routinely sample at five sites per field (Turkington et al. 1991a); however, to reduce inconvenience we suggest farmers sample at four sites, recognizing the slightly greater inaccuracy of estimation this causes.

TIME OF SAMPLING

In 1986 several rapeseed crops with low PI at early bloom were severely infested with stem rot by the end of the season (Turkington et al. 1991a). Thus, the initial disease risk was a substantial underestimation of disease incidence. Most of the petal samples from these crops had been collected during moderate rainfall and the possibility was considered that rain could cause unrealistically low PI values. Hence, we conducted a study of diurnal and weather-related fluctuations in PI by repeated sampling over several days (Turkington et al. 1991b). A general pattern of slightly increasing percentage PI from morning to afternoon was demonstrated, but there was no evidence that rain-scrubbing removed ascospores from petals and reduced PI significantly. The diurnal pattern could be attributed to a periodicity of ascospore release that has been demonstrated in *S. sclerotiorum* (Ben-Yephet and Bitton 1985). However, the fluctuations would be greatly dampened by the fact that most petals in randomly collected samples have been exposed to ascospores in the air for several days. Thus, time of day and weather conditions have limited effects on PI and do not explain the underestimation of disease incidence in 1986. Nevertheless, we now advocate collecting petals after noon and waiting several hours after rainfall as precautions against slight underestimation of PI values.

EFFECTS OF LONG-TERM FLUCTUATIONS IN PETAL INFESTATION AND OF CANOPY DENSITY

Whereas the errors in forecasting disease incidence from PI values at early bloom were mostly underestimates in 1986, overestimates occurred in 1985 (Turkington et al. 1991a). In 1986 dry weather in June before flowering was followed by wetter weather after early bloom, but in 1985 moist conditions until early bloom gave way to hot dry weather at late bloom and during ripening. Thus, some of the discrepancies between disease risk and disease incidence may have been due to weather-related changes in PI during flowering. Since 1987 we have monitored PI in commercial crops in Saskatchewan throughout the flowering period and have shown that major fluctuations may occur (T.K. Turkington unpublished; Rude 1989). For example, in 1987 and 1988 PI levels, and therefore disease risk, increased considerably from early to late bloom, but the opposite tended to occur in 1989.

Canopy density affects stem rot. By altering the microclimate in the crop, the relationship between inoculum and disease incidence is also affected. We have shown that more disease occurs per unit of PI in dense crops (Turkington et al. 1991a). In attempts to quantify this relationship, we have used analyses of covariance with data from plots seeded at different rates and multiple regression analyses with data from commercial fields of different densities. In contrast with the simple linear regressions described above, multiple regression models which include PI values at early, full and late bloom and measurements of canopy density as independent variables have accounted for up to 78% of the variation in disease incidence (T.K. Turkington unpublished). Of course, when PI does not reach a high level until late bloom or when it declines from early to late bloom, or when canopy density is unusually light, we would expect disease incidence to be less than if PI remained high throughout flowering in a crop of average density. As explained further below, such variations may be accounted for by adjustment of fungicide applications.

DEVELOPMENT OF PETAL TEST KITS

Since 1987 we have addressed the question of whether petal testing to forecast stem rot can be used directly by growers without the aid of a technical specialist. Kaminski (1987) developed and tested a kit which included agar plates, forceps, disinfectant and written and videotaped instructions for sampling petals and setting up a test. Working with about 30 grower volunteers in E. central Saskatchewan, he compared plates prepared at home by growers with plates prepared by technicians in the lab from duplicate petal samples collected at the same sampling sites. There was no significant difference in percentage PI values, nor in contamination of plates with *Rhizopus*. In 1990 J.R. Thomson and R.A.A. Morrall (unpublished) prepared a manual containing color photographs illustrating the difference between *S. sclerotiorum* and common saprophytes which develop from rapeseed petals. Using these photographs and a key in the manual, about 45 growers from across western Canada successfully used a modified kit to set up petal tests and read the results. The percentage PI values recorded by the growers were checked later by Thomson; a major difference occurred in only one case, where the grower had not followed the instructions properly. In both Kaminski's and Thomson and Morrall's studies the growers involved were obviously a well-motivated group; however, they represented a broad range of ages and educational backgrounds (Fig.1).

DISCUSSION AND CONCLUSIONS

Petal testing throughout the bloom period can be integrated with chemical control of stem rot. Recent work has indicated that adequate

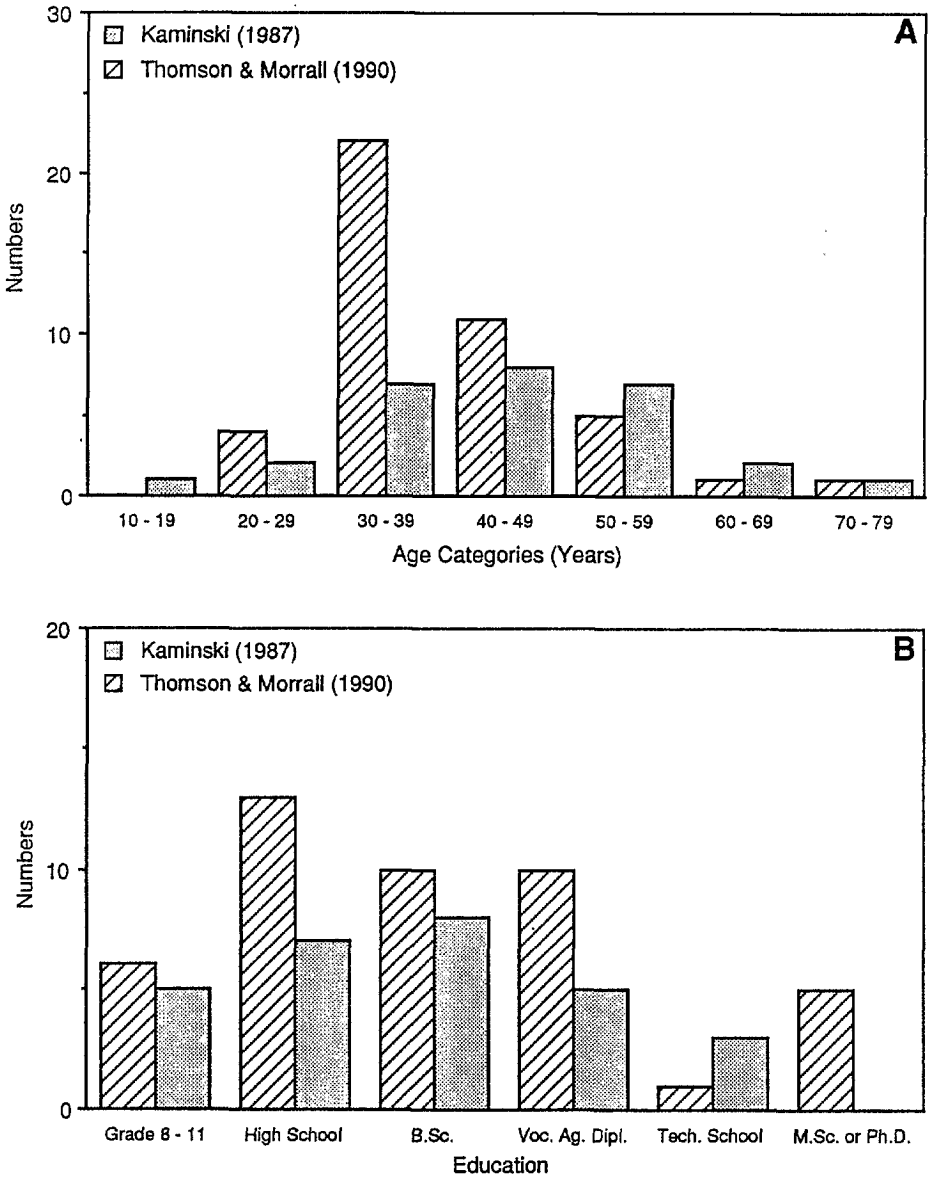

Figure 1. Distribution according to age category (1A) and educational background (1B) of grower co-operators in studies by Kaminski (1987) and by Thomson and Morrall (unpublished).

control can be achieved with low fungicide doses, especially when disease pressure is limited, and applications at late bloom are effective when inoculum is not abundant until full bloom or later (Rude 1989, Morrall et al. 1989). Thus, fungicide application can be delayed until the petal test shows at least a moderate disease risk and the dose of fungicide can be adjusted according to the PI value. Frequently, the most economic option for growers in western Canada is application at considerably below the recommended fungicide dose (R.A.A. Morrall unpublished).

The manual used by growers in 1990 has been modified to correct minor problems that occurred in its use, but it is clear that growers can successfully use a kit to conduct their own petal tests (J.R. Thomson and R.A.A. Morrall unpublished). Kits are being sold on a limited basis in western Canada in 1991. We recommend that growers consider up to three successive petal tests during flowering to account for fluctuations in PI, but unless PI remains low, only two are usually necessary.

Petal testing has several advantages over other methods of forecasting stem rot of rapeseed. It is applied on an individual crop basis, which is important in areas like western Canada where major variations in disease incidence occur among fields. It is superior to searching for apothecia in accounting for sources of inoculum that are aggregated or extrinsic to the crop. Finally, in the disease cycle infested petals are a few steps closer than apothecia to the forecast target, namely diseased plants; thus, there is less potential for environmental intervention between forecast and reality. However, petal testing will never prevent unnecessary fungicide applications when a high disease risk is not translated into high disease incidence because of dry weather after flowering. This deficiency applies to all forecasting systems for sclerotinia stem rot.

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