Blackleg Sporacle: An aid to understanding and managing blackleg in canola (*Brassica napus*)

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ABSTRACT
A model has been developed to simulate, based on weather conditions, the onset of pseudothecia maturity and seasonal ascospore showers in relation to blackleg stem canker disease (*Leptosphaeria maculans*) in canola (oilseed rape, *Brassica napus*). The model has been satisfactorily tested with field observations at different regions of Western Australia, which characteristically has a Mediterranean type climate. In this paper we have applied the model as an aid to explaining a field experiment that measured the incidence of blackleg and the consequent yield loss in canola planted at three times at three locations.

Key words: Ascospore discharge – blackleg – canola – oilseed rape – *Leptosphaeria maculans* –pseudothecia maturity – *Phoma lingam* – quantitative epidemiology – stem canker – yield loss

INTRODUCTION

Blackleg stem canker, caused by *Leptosphaeria maculans* (Desm.) Ces. & de Not. (anamorph *Phoma lingam* (Tode:Fr) Desm.), is a common disease of canola (*Brassica napus* L.) and oilseed rape (rape-seed, *B*. *rapa* L.). West *et al*. (2001) has highlighted the economic importance of this disease in major canola growing regions of the world especially in Australia, Canada and Europe. Blackleg epidemics in canola are primarily initiated by airborne ascospores of *L*. *maculans* (Hersham and Perkins, 1995, McGee, 1977). After harvest of the crop, the fungus survives as a saprophyte (Williams, 1992) on infected stubble. Pseudothecia (ascocarps) of the fungus form readily on the woody remains of the infected plants (McGee, 1977) and the timing of pseudothecia maturity and subsequent ascospore release appears to be related to weather conditions after harvest (Khangura *et al*., 2002). Once pseudothecia are matured, rainfall (Hall, 1992) and/or heavy dews and high humidity (McGee, 1977) trigger ascospore release. Wind blows the aerosol ascospores to distances as great as 5 km from the infested stubble (Hall, 1992). After maturity, pseudothecia on the stubble release a succession of ascospore showers. Depending on environment, the release of ascospores continues for a period of three to four months or longer with a peak usually occurring one or two months after its onset (Khangura *et al*., 2001, McGee, 1977, Thürwächter *et al*., 1999).

Investigations in controlled environment and in the field have been carried out in a wide range of conditions to measure ascospore concentration and the seasonal discharge pattern of ascospores (Hersham and Perkins, 1995, Khangura *et al*., 2001, McGee, 1977, McGee and Petrie, 1979, Petrie, 1995, Rempel and Hall, 1993, Thürwächter *et al*., 1999). This information is crucial both for understanding the epidemiology of blackleg and for formulating strategies for disease management. Results indicate that the temporal pattern of ascospore discharge varies between locations within a season (Khangura *et al*., 2002, Rempel and Hall, 1993, Thürwächter *et al*., 1999) and between seasons within a location (Khangura *et al*., 2002, Petrie, 1995, Thürwächter et al., 1999). The predominant cause of variation in the initiation of ascospore release is difference in the timing of pseudothecia maturity (Khangura *et al*., 2002, Thürwächter *et al*., 1999, West *et al*., 1999). This variability makes it difficult to formulate both strategic and tactical decisions to manage blackleg at both regional and farm scales (West *et al*., 2001). This difficulty would be overcome if a reliable system for forecasting ascospore release could be developed. Accordingly, we have developed a simple model, Blackleg Sporacle, to predict the onset of pseudothecia maturity of the blackleg fungus in relation to temperature and rainfall in the pre-seasonal summer and/or autumn period (Salam *et al*., 2003). The model also predicts the dynamics of ascospore showers based on the proportion of mature pseudothecia, with release triggered by rainfall.

Blackleg Sporacle satisfactorily predicted the timing of onset of pseudothecia maturity when tested with three years field observation at four locations in Western Australia. The model also agreed reasonably well with the daily pattern of ascospore release observed in two of these locations. In this paper we attempt to explore whether the model's prediction of discharge of ascospores can explain yield loss induced by blackleg in canola.

MATERIALS AND METHODS

Blackleg Sporacle as described by Salam *et al*. (2003) was used. The model considers that the pseudothecia maturation process progresses when cool temperatures occur in combination with wet conditions. After pseudothecia maturity, mature ascospores are discharged from pseudothecia when a threshold level of wetness is exceeded. Daily average temperature and rainfall are the driving variables of the model.

The model's prediction was compared with field observation of percentage disease index (PDI) and yield loss derived from an experiment that included three times of planting at three locations, Mt. Barker (34.38°S and 117.32°E), Merredin (31.31°S and 118.10°E) and Wongan Hills (30.51°S and 116.44°E), of Western Australia. These experiments were conducted in 2000, with the cultivar Karoo planted directly on 2-year-old blackleg-infected stubble. Yield loss was estimated as the difference between untreated plots and plots that were repeatedly treated with fungicides. Khangura and Barbetti (2001) have described the experimental design in detail.

All model runs were started on 1 January 2000 using weather data for the respective locations. The three times of planting were 12 May, 27 June and 11 July at Mt. Barker, 17 May, 9 June and 30 July at Merredin, and 17 May, 16 June and 6 July at Wongan Hills. The model was used to estimate the proportion of the total annual number of ascospores produced that was discharged during the 6 week-period after the estimated emergence time of the seedlings for each planting date. This 6 week-period is considered to be the susceptible period for seedling infection that would lead to development of severe cankers, causing major yield loss. The model does not predict absolute numbers of spores produced, and the absolute number typically varies between different sites and seasons. For this reason modelled values are not expected to agree in absolute magnitude with the observed values but trends through time should be similar for modelled and measured values within each site.

RESULTS

Trends through time in the model's prediction of spore load, expressed as a proportion of the annual total blackleg ascospores that were released during the susceptible stage of canola, agreed reasonably well with trends in the measured yield loss at three locations (Fig. 1). While trends in measured PDI did not relate with trends in simulated spore load, some qualitative similarity was still evident.

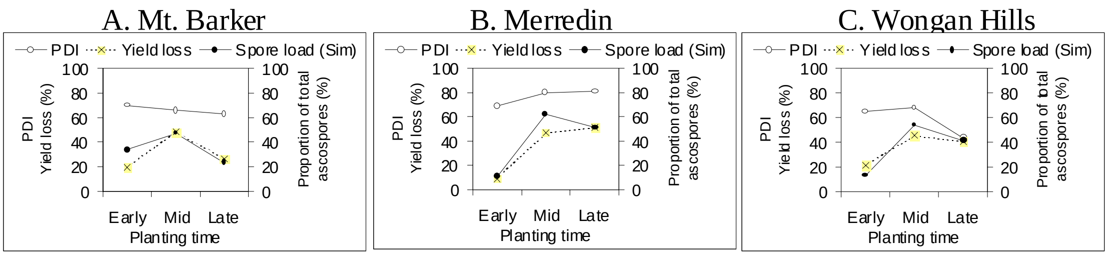

Fig.1. Observed yield loss, PDI (Percentage Disease Index) and proportion of total spores in the 6 weeks after emergence for three sowing times at three locations in Western Australia.

DISCUSSION

The trends through time in the pattern of balckleg-induced yield loss in canola agreed quite well with trends in simulated spore-load during the stage of seedling susceptibility. The similarity in these trends supports the hypothesis that blackleg-induced yield loss in canola could be related to the number of ascospores that reach the seedlings from infected stubble during the susceptible stage. As the absolute number of ascospores produced during the season was often different between the locations, the relationship between the fraction of total ascospores released during the calculated susceptible period and yield loss is expected to differ from site to site. Therefore, the hypothesis should be tested within locations rather than in general. We need further information and model testing to test this hypothesis.

ACKNOWLEDGEMENTS

The Australian Grains Research and Development Corporation funds for this research.

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