Grower Summary

Modelling Light Leaf Spot (*Pyrenopeziza brassicae*) on Oilseed Rape (*Brassica napus*) and Vegetable Brassica (*Brassica oleracea*).

CP 179

Final report 2023

Project title:	Modelling Light Leaf Spot (*Pyrenopeziza brassicae*) on Oilseed Rape (*Brassica napus*) and Vegetable Brassica (*Brassica oleracea*).
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Project leader:	Thomas Crocker, Newcastle University
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Location of project:	Fera Science Ltd
Industry Representative:	Femke van den Berg, Fera Science Ltd Judith Turner, Fera Science Ltd
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DISCLAIMER

The results and conclusions in this report are based on an investigation conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headline

A new infection model for light leaf spot on winter oilseed rape (WOSR) and vegetable brassica (VB) was developed to improve disease forecasting efforts in both host types. The model was developed from a mixture of laboratory, glasshouse and field survey experiments to simulate key components of the pathogen lifecycle.

Background

Light leaf spot (*Pyrenopeziza brassicae*) is an important fungal pathogen that affects all commercially cultivated *Brassica* crops. WOSR and specific varieties of VB with long growing seasons such as Brussel sprouts (*B. oleracea* var. *gemmifera*) and storage cabbage (*B. oleracea* var. *capita*) are particularly vulnerable. The pathogen is regarded as one of the most damaging diseases of WOSR – resulting in up to 30% yield losses in badly affected crops, and in VB yield losses have been reported to be as high as 10% per annum.

P. brassicae is capable of multiple cycles of infection and sporulation each year. Primary infections are caused by windborne ascospore released from contaminated necrotic tissue such as dropped leaves and debris left over from harvested crops. Ascospore infections are thought to occur at low frequency, producing a random distribution of infected plants early in the growing season. From these initial foci the disease spreads to neighbouring plants via splash-dispersed conidia which are released from living host tissue; causing the distribution of infections to become patchy as the growing season progresses. Initially, infections caused by ascospore or conidia are asymptomatic, the disease cannot usually be detected during this latent period by visual assessment before conidia production begins. Both ascospore and conidia are released throughout the growing season allowing the disease to build up rapidly in response to favourable environmental conditions. Together these characteristics make it difficult to visually assess disease severity in WOSR or VB crops which hinders effective disease control.

Light leaf spot is characterised by white masses of conidia that form on latently infected tissue. Conidia production occurs during high humidity and are splashed off the leaf by rain. As the disease develops more permanent necrotic damage becomes visible, taking the form of ‘thumb-print’ lesions in VB and mealy regions of chlorosis and necrosis in WOSR. The latent period of the pathogen has been determined by laboratory experiments to be between 10 and 30 days. In WOSR visible symptoms are rarely seen before spring leading early researchers to conclude that primary infection by ascospore must occur on WOSR around November and that the pathogen must build up within a crop by production of conidia over winter to reach detectable levels by spring. However, more recent research has shown that *P. brassicae* ascospore are present above WOSR crops throughout summer and autumn thus infection could theoretically occur earlier in the WOSR growing season. The environmental factors that affect light leaf spot infection and the length of the latent period are unclear. VB are typically planted between late spring and early summer and disease symptoms can become visible from August onwards.

As the growing seasons between WOSR and VB overlap there is the potential for a 'green bridge' to occur, allowing disease epidemics from one crop to move into the other, and between growing seasons. WOSR is the most widely cultivated brassica in the UK, being the third most widely grown arable crop after wheat and barley. It is combinable and tolerant to a wide range of soil types and environmental conditions making it useful as a break crop in cereal rotations. VB are high value horticultural crops with intense manual labour requirements and production is concentrated around small regions with fertile soils plus the infrastructure to support crop establishment from seedlings, through to harvesting, and onwards to supermarket supply chains. Their relatively high value means that routine fungicide applications in VB are almost always economically viable whereas in WOSR growers are more likely to adjust inputs in response to perceived risks. Given the larger areas cultivated for WOSR, it is likely that the main risks are transmission from WOSR to VB, potentially exacerbated as the mechanical harvest of WOSR can send large amounts of potentially infected debris into the air where it can be carried long distances by the wind

Suppression of light leaf spot is achieved by applying fungicides, planting resistant varieties and implementing cultural controls such as crop rotation, later sowing dates and cultivation after harvest to bury contaminated debris. These control measures may conflict with efforts to curb fungicide usage and no-tillage regimes designed to improve soil structure. Given the increased prevalence of severe light leaf spot epidemics in the past 20 years they are widely held to be insufficient by growers. To help growers manage the disease, AHDB releases a light leaf spot forecast that predicts the proportion of WOSR fields likely to experience 'severe' epidemics (i.e. > 20% of plants infected) by spring based on regional summer temperatures, winter rainfall and some field-level variables e.g. sowing date and the crop AHDB resistance rating. The forecasting system can help WOSR growers decide whether to apply fungicides in autumn and spring but provides only limited field level information because its predictions are averaged over large regions and released only twice yearly. In recent years field-level weather data has become more accessible and remote sensing technologies can now provide detailed maps of the annual distribution of WOSR fields. There is a need for improved disease modelling that can make use of these new field-level data inputs to better inform WOSR and

VB growers so that they can use fungicides more effectively and achieve acceptable light leaf spot control.

Summary

A primary aim of this research was to develop mechanistic models of the light leaf spot disease cycle, through understanding processes from spore germination through to the field-scale. Specific objectives were to

a) quantify spore germination and germtube growth in artificial media across a range of temperatures. Two models for germination and germtube extension were developed.

b) quantify spore germination and germtube growth on WOSR and VB leaf disks. This was done on a subset of temperatures identified from the artificial media experiments, and likely to occur in the field. Both susceptible and partially resistant strains of WOSR and VB were investigated, and the two models from a) updated accordingly.

c) determine infection in WOSR and VB plants. Glasshouse-grown plants were infected with *P. brassicae* under different leaf wetness durations and temperatures, to reflect a range of scenarios likely to occur in the field. This allowed the effects of infection severity to be distinguished from the effects of temperature post-infection. The infection model developed from this component of the research can use time-series data, for example derived from meteorological temperature and rainfall, as inputs.

d) model light leaf spot under field conditions. Pathogen development in WOSR field plots was assessed relative to meteorological conditions, aerial spore data and landscape scale distribution of WOSR fields.

The research presented provided a thorough understanding of aspects of these four components, but also highlighted gaps in knowledge where additional studies are required. An outstanding challenge is to integrate across scales, particularly from laboratory and glasshouse experiments to the field conditions.

The initial experiments were designed to understand key environmental factors that affected *P. brassicae* spore germination, and germtube growth rates, first in artificial media, second on detached leaf disks, and finally glasshouse plants. It was assumed that direct observations of the pathogen would be more informative than observations of light leaf spot symptoms, given the pathogen's latent period before symptoms are visible. It was anticipated that spore germination and germtube growth rate might vary between host types because of physical and molecular differences in the leaf surfaces, and potentially differences in disease resistance. The need for a minimum germtube length before infection was also considered. Variation in leaf level resistance mechanisms in *B.*

oleracea and *B. napus* might have important implications for modelling infection in vegetable brassica and WOSR crops in the field.

The research indicated that the characteristics of the leaf surface (as defined by the host type) in practice had little effect on germination and germtube tube extension of *P. brassicae* conidia compared to spores that were allowed to develop in artificial media. Their early development was in all cases principally influenced by the temperature. Furthermore, the threshold germtube length required for infection of *B. napus* was very close to zero, suggesting that infection can occur following germination irrespective of germtube length. Whilst germination is possible at temperatures above 20 °C, this is much higher than optimum infection temperatures (Gilles et al., 2001), and rarely occurs in the UK with periods of sustained leaf wetness under field conditions. Thus, a simpler infection model that predicted infection severity by fitting a restricted exponential equation to the thermal time accumulated during a period of leaf wetness was implemented. This indicated that infection first becomes possible after approximately 90 °C hours and that the by 573 °C hours infection severity reaches 95% of its maximum value. Under field conditions a simple 90 °C hour threshold in combination with a 2 mm per hour rain intensity threshold is enough to distinguish leaf wetness periods that are suitable for infection from those that are too short, too cold or lack sufficient rainfall for splash dispersal of conidia.

These models required relatively simple weather data inputs, therefore in-field weather stations or short-term weather forecasts could be used to make field-level predictions. When the infection model was run at a series of WOSR field sites it was found that the number of infection events detected from September to April was significantly correlated with disease incidence in spring with the number of infection events explaining approximately 50% of the variation in incidence. At all field sites infection events were evenly dispersed throughout the growing season, suggesting that the environment can potentially be suitable for light leaf spot infection throughout the year.

Financial Benefits

A significant relationship was discovered between the number of predicted infection events detected during an WOSR growing season and light leaf spot disease incidence in spring. This will have direct applications to existing disease forecasting systems by providing an additional field-level variable that can be used to predict the severity of the light leaf spot epidemic. The infection models have been developed from a fundamental analysis of the mechanisms behind spore germination in relation to weather and thus it is likely that its predictions will be relatively resilient to short-term future changes to weather patterns or farming practices. Therefore, this model could be integrated into the AHDB light leaf spot forecast on WOSR to enhance its capabilities, or alternatively it could form the basis of a new dynamic forecasting system for light leaf spot on both WOSR and VB.

Action Points

- Further work should focus on the implementation of the models developed during this project into forecasting / decision support systems that can be used by growers to make crop management decisions.
- Given that infection events and ascospore release were predicted to occur throughout the year it is likely that light leaf spot infections occur earlier in the growing season than previously thought. Growers may benefit by switching to earlier fungicide applications if the conditions at the start of the WOSR growing season have been favourable for the pathogen. Further work is however required to investigate how such alterations would impact the existing WOSR spray program targeting all WOSR pathogens, in particular, stem canker and alternaria.
- Additional field research should be conducted with untreated vegetable brassica plots to test if the same relationship between infection events and disease incidence also holds true for *B. oleracea* crops under growing conditions typical of a commercial enterprise.
- New research into the distribution of *P. brassicae* ascospore should be considered using *B. napus* field plots established in more remote locations further from potential sources of infection.

