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FORECASTING LIGHT LEAF SPOT ON WINTER OILSEED RAPE

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by

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This is the final report of a four year project which started in January 1996. The work was led by IACR Rothamsted and carried out in collaboration with ADAS Boxworth, SAC Aberdeen and CSL York. The work was funded by a grant of £163,219 from HGCA (Project no. 1531).

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ABSTRACT

The aim of this four year project was to improve strategies for control of light leaf spot by developing accurate systems for forecasting the severity of the disease and by optimising the efficacy of fungicide applications.

Seven 'light leaf spot regions' were identified (using existing disease survey and weather data), and now form the basis of a regional light leaf spot risk forecast. A model was developed to identify which crops were most at risk in any season, by assessing the influence of cultural and weather factors on light leaf spot epidemiology. This model is used to forecast, in the autumn, the risk of severe light leaf spot occurring in the spring. The forecast has been issued each autumn since 1996 (with updates in the spring), and so growers have been aware of impending, high risk seasons in their regions. Each year, predicted disease severity has been compared with actual disease severity, and the model modified in the light of new information (including results from controlled environment, epidemiology studies). As a result, the forecast has become progressively more accurate. In 1998, the forecast was made available on a web-site, which also contains other relevant information on the disease. The web-site is now interactive, and growers can in-put information on sowing date, cultivar and use of autumn fungicides, in order to customise the risk forecast for their own crops.

A series of nine field experiments showed that large yield increases can result from well-timed use of fungicides in the autumn. Growers have been advised of these findings and there has been a shift from spring to autumn spraying in recent years. Cultivar susceptibility to light leaf spot was shown to be very important in determining yield loss and yield benefit from use of fungicides and this information has been incorporated into the forecast of crop risk.

A molecular diagnostic technique for *Pyrenopeziza brassicae*, for use as a research tool, has been successfully developed, and work has begun on an immunodiagnostic technique, which could be used by growers to help them detect light leaf spot in winter oilseed rape crops.

SUMMARY

Despite the annual application of fungicides costing c. £7.5M to winter oilseed rape crops in the UK, losses in excess of £30M are estimated to occur. One of the most economically important diseases on this crop is light leaf spot (*Pyrenopeziza brassicae*) which is known to cause yield losses of up to 3 t/ha. The disease is favoured by cool, wet conditions and, although the disease severity is usually greater in the north, severity varies considerably between seasons and regions. In its 1991 review of oilseed rape diseases, HGCA recognised the need to improve existing strategies for control of this disease. The aims of this project were to:

- develop an accurate system for forecasting severe epidemics of light leaf spot at a time when growers need to make spray decisions (i.e. in the autumn), both on a regional basis and for individual crops.
- develop a methodology for sampling and assessing light leaf spot in individual winter oilseed crops.
- develop a molecular method for detecting *P brassicae* in infected plants.
- investigate the epidemiology of light leaf spot in controlled environment experiments.
- study optimum timing of fungicides for light leaf spot control in field experiments.

<u>Forecasting scheme</u>

Light leaf spot is favoured by cool, wet conditions but, although the disease is usually more severe in the north, severity varies considerably between seasons and regions. A forecasting scheme, able to accurately predict in the autumn (when growers need to make spray decisions) the risk of severe epidemics of the disease occurring in particular seasons and regions, would therefore be of great value to growers.

Methods

Using the MAFF Winter Oilseed Rape Pest and Disease Survey data from 1987 onwards, patterns of light leaf spot incidence across years in different counties were used to identify regions with differing light leaf spot risk. Met. Office regions and ADAS regions were used initially, but both proved unsatisfactory, accounting for little of the variance in light leaf spot incidence. Multivariate techniques were then used to generate seven new regions in the UK (‘light leaf

spot regions') within which surveys showed that light leaf spot followed a similar pattern and which accounted for 48% of the variance in light leaf spot incidence. (Scotland could not be included in the regional forecast because disease survey data for light leaf spot incidence was not available).

Models for predicting spring light leaf spot incidence were derived from possible explanatory variables. The variables found to give the most accurate predictions were: incidence of light leaf spot on pods in the previous summer, the number of winter rain days and the autumn temperatures (expressed as deviations about a 30-year regional mean). The forecasts issued since 1998 have been based on these three measurements. The % crops with > 25% plants affected in each region and the probability that an individual crop would have >25% plants affected were forecast, to give estimated risk of severe light leaf spot epidemics occurring. The degree of fit for observed vs predicted incidence was found to differ between regions. For example, in East Anglia there was a strong correlation with pod disease in the previous season, but a low correlation with weather factors, suggesting the amount of inoculum was the limiting factor in this region. However, in the north, autumn temperature and winter rain days were more important, while pod disease incidence was less important. This suggests the amount of inoculum was not limiting in the north. The model was therefore modified for each region. The model was expanded to take account of individual crop factors (cultivar, sowing date and autumn fungicide application). Predictions of regional risk were generated using the summary regional model and predictions of individual crop risk were generated from the expanded model. These predictions were generated in early autumn (from July survey data for pod disease incidence) and updated in the winter and spring to take account of actual autumn temperatures and winter rain days.

In 1998, a web-site was developed with the aim of disseminating the forecast and providing other relevant information to help growers make decisions about light leaf spot control. The regional disease risk was displayed as a map of the light leaf spot regions. An initial forecast was displayed at the beginning of autumn and updated in late winter. Since the actual incidence of light leaf spot in individual crops varied greatly about the predicted regional mean, growers were advised to assess disease incidence in their own crops. Information on crop sampling and pictures to aid disease diagnosis were therefore provided to help growers sample and assess their own crops. Information on the light leaf spot disease cycle and estimated yield losses in previous seasons was also given. In 1999 an interactive component was added to the forecast which allows a customised prediction of risk for individual crops in response to user input. At present, users can input information on cultivar, sowing date and whether autumn fungicide has been used. The web-site address is www.iacr.bbsrc.ac.uk/lightleafspot

Key results

- Seven light leaf spot regions identified accounting for 48% of the variance in light leaf spot incidence.
- Three factors identified as predictors of severe light leaf spot occurring in the spring: light leaf spot incidence on pods in the previous summer, number of winter rain days and autumn temperatures.
- Initial forecast issued in autumn using actual pod disease incidence data from MAFF disease surveys and predicted weather data. Updated forecast issued in late winter to take account of actual weather data
- Forecasts disseminated by conventional means (Press Releases etc) and also by development of a web-site.

Methodology for sampling and assessing light leaf spot

The main diagnostic symptoms for identifying light leaf spot in the autumn are the white spore masses that erupt through the leaf surface. These are not generally apparent in winter oilseed rape crops because they are washed off by rain. The disease also has a patchy distribution in the field at the start of the season. Diagnosis and estimation of light leaf spot incidence and severity are therefore difficult in the autumn, just at the time when growers need to make spray decisions. As a result, many fungicide applications are made at the wrong time or unnecessarily (as prophylactic sprays). More accurate sampling and assessment methods are therefore needed.

Methods

Plants were sampled from six positions within plots of oilseed rape and assessed for incidence and severity of light leaf spot. Visual assessments of disease in crops were compared with assessments made on samples taken from the same crops and placed in polyethylene bags at different temperatures for up to 5 days.

Key results

- Significant variation was found in incidence and severity of light leaf spot between plots, between different ends of the same plot and between plants within the same sampling positions, indicating variability at all levels. To accurately assess the amount of light leaf spot in their crops, growers therefore need to walk transects across their crops regularly (monthly) during autumn/winter, looking for patches of affected plants, or, if possible, collect a sample of at least 100 plants taken at regular intervals along the transects.
- Incubating plants in polyethylene bags induced production of the characteristic white spots (spore masses). Sporulation occurred most rapidly at 15^0C. Growers can therefore confirm the presence of light leaf spot by incubating plants for 4-5 days at around 10-15^0C.
- This guidance is available to growers on the web-site

<u>Molecular diagnosis</u>

In view of the difficulty in identifying light leaf spot in winter oilseed rape crops, a molecular diagnostic technique would be useful, particularly if it was capable of detecting the disease in infected plants before disease symptoms were expressed. *P. brassicae* has two mating types, both of which need to be present for sexual reproduction to occur. Sexual reproduction produces ascospores which are wind-dispersed and therefore capable of spreading the disease over long distances. A technique which could distinguish between the mating types would therefore be useful to detect the presence of both mating types.

Methods

A PCR (polymerase chain reaction) based technique specific for *P. brassicae* was developed with two sets of primers, one of which can detect all isolates of the fungus, and another which can distinguish between the two mating types of *P. brassicae*. The technique can detect *P. brassicae* in the plant, as well as in isolation, and has a very low limit of detection. It is therefore a useful research tool, but, because it requires laboratory facilities, growers will not be able to use it themselves. An immunodiagnostic technique is therefore being developed which could be made available to growers as a diagnostic kit.

Key results

- Successful development of PCR techniques for use in research into *P. brassicae*
- Some progress on development of an immunodiagnostic technique for possible use by growers

Epidemiology

Air-borne ascospores (sexually produced spores from apothecia which develop on senescent plant debris) of *P. brassicae* are believed to be responsible for initial infection of winter oilseed rape crops in the autumn. Thereafter, the disease is thought to be spread by rain-splashed spores (conidia) produced by asexual reproduction in the living plant. There may also be further releases of ascospores from apothecia that have developed on fallen leaves later in the growing season which may contribute to epidemic development in the spring. A greater understanding of the environmental factors affecting the progress of light leaf spot epidemics in winter oilseed rape is needed in order to develop a model which can accurately forecast severe epidemics of the disease.

Methods

Experiments were done on pot-grown winter oilseed rape plants which were artificially inoculated with spore suspensions of *P. brassicae*. The plants were kept in controlled environment cabinets at a range of temperatures and wetness conditions to investigate the effect of these two factors on infection by conidia. A technique was also developed for growing apothecia on senescent plant material from plants which had been artificially inoculated with *P. brassicae* which was used to study the effects of temperature and wetness on development of ascospres.

Key results

- Infection of rape leaves by conidia was found to be affected by an interaction of temperature and leaf wetness duration (LWD). The optimum temperature for infection was 16^{o}C, while at 24^{o}C infection was not successful; at temperatures <16^{o}C, longer LWD were needed (e.g. 6 hours LWD at 16^{o}C, 24 hours LWD at 6^{o}C).
- Temperature was found to have a significant effect on the rate of development of mature apothecia capable of producing ascospores: maturation occurred at 6^{o}C, but not at 22^{o}C. The optimum temperature, at which maturation occurred most rapidly, was 17^{o}C.

- A comparative study of the infectivity of conidia and ascospores showed that ascospores are more infective than conidia: 700 conidia/leaf were needed to cause a lesion, but only 300 ascospores/leaf. Ascospores are probably more important in spreading light leaf spot than was previously thought. Predicting development of mature apothecia from weather factors could therefore provide a useful addition to the forecasting scheme.

Field experiments

Although autumn applications of fungicide were thought to be most effective in controlling light leaf spot, growers were known to be making the majority of applications in the spring. Field experiments were therefore done to investigate the effects of fungicide timing on the development of light leaf spot and consequent yield.

Methods

Field experiments were done at three sites: Rothamsted (Herts.), Boxworth (Cambs.) and Aberdeen (Scotland) over three seasons (1996/97, 1997/98 and 1998/99). In all the experiments tebuconazole fungicide was applied, as full-dose treatments in the autumn or spring, as split-dose treatments in the autumn and spring or as monthly half-dose treatments. Two cultivars were included in each of the nine experiments: Bristol (NIAB resistance rating of 2 to light leaf spot), and Capitol (resistance rating 8). Since light leaf spot is not normally a serious disease in southern England, moderate epidemics at Boxworth, and severe epidemics at Rothamsted were induced by inoculating with infected stem debris soon after sowing. Natural epidemics occurred each year at Aberdeen. At Rothamsted and Aberdeen, light leaf spot was the predominant disease in all seasons; at Boxworth, moderate stem canker epidemics also occurred in some seasons.

Key results:

- Yield benefits of up to 2t/ha occurred on the susceptible cv Bristol when a severe epidemic of light leaf spot was controlled by monthly applications of fungicide.
- Large, and often significant, differences in disease severity and yield were found between the two cultivars.

- All fungicide treatments decreased disease severity, especially on cv Bristol, but only routine fungicide applications gave complete control of severe epidemics.
- In most experiments, when disease was severe, autumn fungicide treatments decreased disease incidence and increased yield.
- When light leaf spot occurred late in the season, especially when it reached the pods, spring treatments controlled pod disease and increased yields (although the growth regulatory effect of tebuconazole applied in the spring may also have contributed to the yield increase).
- In most experiments, split-dose autumn/spring treatments produced higher yields than single, full-dose treatments applied in either autumn or spring.

Conclusions and implications for growers

Since 1996, the light leaf spot regional forecast has enabled growers to foresee potential high risk seasons for their region and to plan their spray program accordingly. Growers have also been able to foresee low risk seasons, so as to avoid the unnecessary use of prophylactic fungicides. Each year, the model on which the forecast is based, has been amended and improved in the light of new information. Clearly, the more accurate the forecast, the more confident growers will be, and therefore less likely to apply prophylactic fungicides.

More recently, a web-site has been developed to disseminate the forecast (and other relevant information on light leaf spot) to growers. This is considered to be an effective and efficient method of disseminating a forecast based on centrally collected weather data which is frequently updated, since the updating need only be done once by the site manager and not by individual users. Improvements to the model, resulting from increased understanding of the disease, can also be made by the site manager. User feedback is being used to improve the site. Since 1999, when the light leaf spot forecast web-site became interactive, growers have been able to customise the forecast for their own particular crops by in-putting information on sowing date, cultivar and use of autumn fungicides. Growers are likely to have more confidence in more precise forecasts. Growers can also use the system to assess future risk under different agronomic conditions: prior to sowing, growers can produce forecasts of risk for the full range of recommended varieties, and test the effects of early or late sowing and the effects of using an autumn fungicide application.

Possible future developments to improve the accuracy of the risk forecast are to use crop-based models based on local weather and local inoculum levels. In addition, models for jointly forecasting light leaf spot and other diseases, such as stem canker, could be developed.

The development of a PCR diagnostic kit will be of value as a research tool to improve our understanding of light leaf spot. Its high sensitivity means it could also be used to detect air-borne spores of *P. brassicae*, which may help in predicting epidemic progress at crop level. The immunodiagnostic technique, currently under development, may be suitable as a diagnostic kit for growers to enable them to detect the disease in their crops before symptoms become apparent.

Studies on the epidemiology of light leaf spot have enhanced our understanding of the disease and hence our ability to predict its development and to control it. Modifications to improve the accuracy of the forecasting model were made as a result of such studies.

Field experiments confirmed the value of autumn fungicides, and also showed that spring sprays, or split-dose autumn + spring sprays of tebuconazole, were beneficial when epidemics were prolonged. The experiments also showed that cultivar susceptibility to light leaf spot had a major effect on yield loss. Cultivar susceptibility and use of autumn fungicides are therefore now included in the forecast model for crop risk. Growers are also better informed on the optimum timing of fungicide applications.

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