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Pest and disease management system for supporting winter oilseed rape decisions (PASSWORD) - Validation phase

by

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This is the final report of a forty-eight month project which started in July 2001. The project was sponsored by Defra with £179,568 through the Sustainable Arable LINK programme, (LK 0917 and LK 0944). Industrial funders were HGCA (£148,546, Project No. 2155), DuPont (UK) Ltd (£56,250), The Perry Foundation (£20,000), ProCam Group Ltd (£47,574) and Syngenta Crop Protection UK Ltd, (£40,000), making a total of £491,938.

Contents

Abstract

Pests and particularly diseases cause serious loss of yield and quality in winter oilseed rape estimated to exceed £80 million/annum in some years. These losses have occurred despite an annual expenditure of about £3.5 million for insecticides and £12 million on fungicides. Decision-making is difficult because there is complex spatial and temporal variation in pest and disease problems and improved guidance is required. The main objective of this project was to test new disease models developed in the first phase of this project and deliver a decision support system for both pest and disease control in oilseed rape.

The regional light leaf spot forecast is well-established and reliable and indicates an increased risk of this disease in spring 2006. A new regional forecast for stem canker incidence pre-harvest has been developed and made available on the Internet. It was successful in 2004/05 and offers strategic guidance on risk provided weather factors are within the range used to develop the model. A four-stage crop-specific stem canker risk assessment method was developed that predicts the onset of phoma leaf spotting using post-harvest weather data and thermal time relationships for canker development and canker severity. Yield loss can then be calculated from canker severity and the economic impact of stem canker predicted.

There is some flexibility in the timing of fungicide sprays to control stem canker. Delays of 2 to 3 weeks beyond a 10-20% plants affected threshold did not adversely affect yield. Stem canker severity and yield of different cultivars showed large variation between years and sites and smaller, but significant, variation in responses to fungicide. When phoma leaf spot appears in late autumn, it is only when plants are small that stem canker is likely to cause yield loss. In commercial crops, there were consistent trends for higher yields to be associated with higher fungicide inputs. Light leaf spot was very difficult to control with fungicides in the Aberdeen area where use of resistant cultivars is essential. The most effective disease control was obtained using a combination of resistant cultivars and fungicides. In some years, responses to fungicides were not cost-effective and targeting their use to high-risk situations is necessary to give the best margins over input costs.

Close contact was maintained with potential users during the project and they influenced priorities and design features. The components of PASSWORD decision support system were tested and provide guidance for the management of invertebrate pests, phoma stem canker and light leaf spot. The system will be available to ArableDS for use in autumn 2006.

Summary

Introduction

Pests and diseases in oilseed rape cause serious loss of yield and quality, estimated to exceed £80 million/annum in some years, predominantly from diseases. Fungicides are widely used to control the two most important diseases, stem canker (*Leptosphaeria maculans*) and light leaf spot (*Pyrenopeziza brassicae*), but yield losses continue to occur because treatments have not been optimised. In much of England, stem canker is the most important disease. Guidance is needed to help the industry to react to large seasonal variations in the onset of epidemics. There is also significant regional variation in disease risk, which has implications for cultivar selection and pesticide use. The PASSWORD project developed epidemiological models that predict disease development in real time.

These issues were addressed through the first phase of the LINK-funded PASSWORD Decision Support System (DSS) (LK 0917), which combines decisions on pests and the two major diseases, light leaf spot and stem canker. This DSS project is a delivery system for Defra and industry-funded research to advisers and farmers. Pest models had already been validated by CSL, but new forecasting systems and predictive models for disease development and yield loss had not been tested. Validation of the disease models at the end of the first phase was required to ensure that the system was robust and reliable for dissemination to industry. This project ensured that new components of the DSS were tested prior to operation, which will facilitate acceptance by industry. The project had strong support from industrial partners to bring the DSS into practical operation.

Objectives

The project objective was to produce and test regional and crop-based models for predicting risks of severe light leaf spot and stem canker in 2004 and 2005 and provide a decision support system for use by ArableDS,

Phoma regional forecast

Models for predicting both incidence and severity of phoma canker in July each year were derived through regression analyses of Defra winter oilseed rape disease survey data from the period 1991 to 2001, using possible explanatory variables. The parameters found to give the most accurate regional prediction of disease incidence (mean % plants affected) were region, incidence of stem canker in the previous season, total rainfall in September/October, total rainfall in February/March and temperature in February. Approximately 55% of the deviance within the data could be attributed to regional variation and the regional level variables accounted for 76% of the regional variation.

New regional forecasts were produced for 2004-2006 and all model outputs were displayed on the phoma forecast website at http://phoma.csl.gov.uk The regional forecast was not reliable in 2004 and this was attributed to the low rainfall in autumn 2003, which was much lower than that used to develop the model. Phoma stem canker incidence differed from predictions by up to 25%. The forecast worked well in 2005 (Figure 1) and stem canker incidence was within 10% of predicted values. The forecast became more reliable when observed winter weather data rather than long-term average values were used. The website was used by industry during the project and over 26,000 hits were recorded during 2004 and 2005.

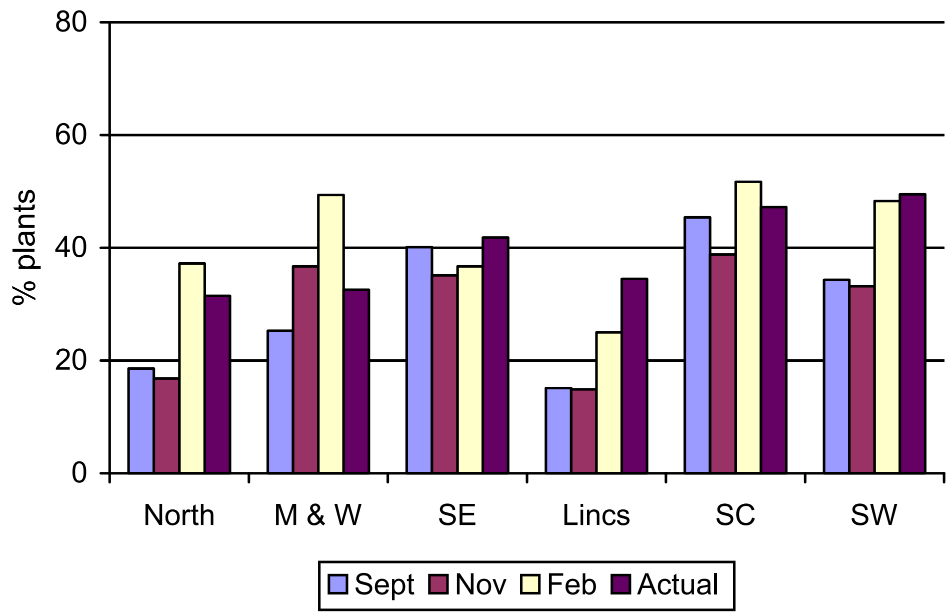


Figure 1. Predicted (Sept, Nov, Feb) percentage plants affected by phoma canker against observed (June/July) percentage plants affected from Defra CropMonitor Winter Oilseed Rape Pest and Disease Survey data for 2005.

The regional forecast provides strategic guidance on changing risk from year to year. It may be used in conjunction with crop-specific models that can predict disease development and estimate yield loss. The regional models could be improved by using recent disease survey records that include more severe disease records than those used to produce the existing models.

Phoma progress model

A four-stage crop-specific phoma stem canker progress model was tested during 2003/05 using cultivars in fungicide experiments and five crops per year from the Defra-funded Crop Monitor project. Quantitative relationships were established in the first phase of PASSWORD for each of the four stages using historic datasets. The first stage model predicts the date when 10% of plants will have phoma leaf spotting (in autumn) using mean maximum temperature and total rainfall between 15 July and 26 September. Stage 2 is a thermal time (as degree-days) model predicting the interval between the onset of phoma leaf spotting and first stem canker symptoms. Symptoms develop more slowly on canker resistant cultivars. The stage 3 model predicts the increase in canker severity with thermal time. This increase is less in cultivars with canker resistance ratings of over 6. From the predicted canker severity at harvest, the stage 4 model can be used to estimate yield loss. The estimates of yield loss provide a framework for defining the number of fungicide applications that can be justified to optimise margins over fungicide costs.

The prediction of the date of 10% phoma leaf spotting was reliable (within 7 days at many sites) in autumn 2004 but gave premature warnings in autumn 2003 when rainfall was well below that used to develop the model. Predictions of stem canker development and its severity pre-harvest were promising. Many of the predictions of yield loss were within 0.2 t/ha of observed values. Yieldresoponses were larger than predicted where plants were very small when phoma leaf spot developed and where light leaf spot and lodging effects influenced yield. The model is sensitive to changes in cultivar resistance rating and predictions should be updated during the course of the season when actual data on disease development, cultivar resistance and weather are available. Further testing of these models is advised.

A mechanistic model for describing dynamics of phoma stem canker epidemics was also produced within the PASSWORD project but was not tested in this project. The model requires temperature data and non-standard inputs of air-borne ascospore concentrations (sampled with Burkard samplers) and leaf wetness duration. The leaf wetness duration may be calculated using a new leaf wetness model.

Light leaf spot regional forecast

The forecast for light leaf spot was developed prior to the PASSWORD project using Defra-funded winter oilseed rape disease survey data from 1987-1999 and monthly weather data. The most important explanatory variables were mean summer temperature (July/August), mean monthly winter rainfall (December-February) and incidence of light leaf spot on pods in the previous season (July). The risk of severe light leaf spot (% crops with >25% plants affected in spring) was predicted in September and updated at the end of February to take account of winter rainfall. The use of Active Server Page (ASP) Internet-based technology allowed interactive input of cultivar resistance rating and sowing date, both of which were used to modify the regional forecast to produce a crop-specific forecast for the situation of a particular grower (see http://www3.res.bbsrc.ac.uk/leafspot/). Validation of the forecast done using regional disease survey data for 2000-2003 showed that 86% of predictions were compatible with the model. New forecasts were produced for 2004, 2005 and 2006. Actual disease levels were lower than forecasted, particularly in spring 2005. This is attributed to the more widespread use of fungicides in autumn, so that most survey crops had received a fungicide spray in autumn/winter. An increased risk of light leaf spot is predicted for spring 2006 compared with 2005 and this information has been made available to industry.

Fungicide x cultivar experiments

Stem canker control

Six experiments to investigate the most effective management strategies for control of phoma stem canker in relation to cultivar resistance were done using three cultivars (Escort, Recital and Royal) (Table 4) and sites at ADAS Boxworth, Cambs, ADAS High Mowthorpe, North Yorkshire and ADAS Rosemaund, Hereford each year during 2003-2005. Similar experiments for light leaf spot using cvs Synergy, Mendel and Winner were done each year at SAC Aberdeen, Scotland. Three fungicide regimes were used in each experiment (Table 1) to determine optimum timing in relation to disease development. Difenoconazole (as Plover), used at stem canker sites in England and flusilazole + carbendazim (as Punch C) followed by tebuconazole (as Folicur) at Aberdeen, were evaluated in relation to an untreated control. Dates of application and treatments in 2004/05 (Table 1) are representative for average disease epidemics. Later timings were used in 2003/04 because below average rainfall delayed the development of phoma leaf spot in England.

A further two experiments investigated the effects of fungicide timing, number of applications and dose on cv. Winner at ADAS Boxworth during 2003/05. Treatments were mainly based on flusilazole + carbendazim (as Punch C) followed by tebuconazole (as Folicur) as a plant growth regulator at mid stem extension.

Table 1. Fungicide treatments used in cultivar x fungicide validation experiments, 2004/2005. (Sites are Boxworth (BX), High Mowthorpe (HM) and Rosemaund (RM)).

Treatment	T1 –based on spore numbers before actual 10% plants with phoma	T2 – phoma well established (2-3 weeks after T1)	T3 Maintain disease control (4-6 weeks after T1)	T4 Maintain disease control (4-6 weeks after T2)	T5 Early stem extn for light leaf spot
ADAS sites 2004/2005	BX – 26 Oct HM – 01 Nov RM – 26 Oct	BX – 11 Nov HM – 25 Nov RM – 11 Nov	BX – 8 Dec HM – 13 Jan RM – 9 Dec	BX – 13 Jan HM – 03 Feb RM – 13 Jan	
1	Untreated	-	-	-	
2 Forecast	Plover (0.25 l/ha)	-	Plover (0.25 l/ha)	-	
3 Onset	-	Plover (0.25 l/ha)	Plover (0.25 l/ha)	-	
4 Managed	-	Plover (0.25 l/ha)	-	Plover (0.25 l/ha)	
SAC Aberdeen 2004/2005	Nov or LLS present 03 Nov GS 1,4-1,5	Dec 02 Dec GS 1,6-1,8			Early stem extn 10 Mar GS 3,1-3,3
1	Untreated	-			-
2	Punch C (0.8 l/ha)	Folicur (1.0 l/ha)			-
3	-	Punch C (0.8 l/ha)			Folicur (1.0 l/ha)
4 Managed	Punch C (0.6 l/ha)	Folicur (1.0 l/ha)			Folicur (1.0 l/ha) if LLS present

The development of phoma leaf spot in the six experiments in 2003/2005 showed large variation between years and smaller variation between sites (Figure 2). Phoma leaf spot developed in December 2003, which was unusually late and followed dry conditions in August and September. The phoma leaf spot epidemic in autumn 2004 was more typical of recent years and developed strongly in October and November. The first fungicide treatments were based on a combination of the number of ascospores of *L. maculans* collected by spore traps and appearance of first symptoms. The second treatment application was made 2-3 weeks later when phoma leaf spot was well established in the crop (Table 1).

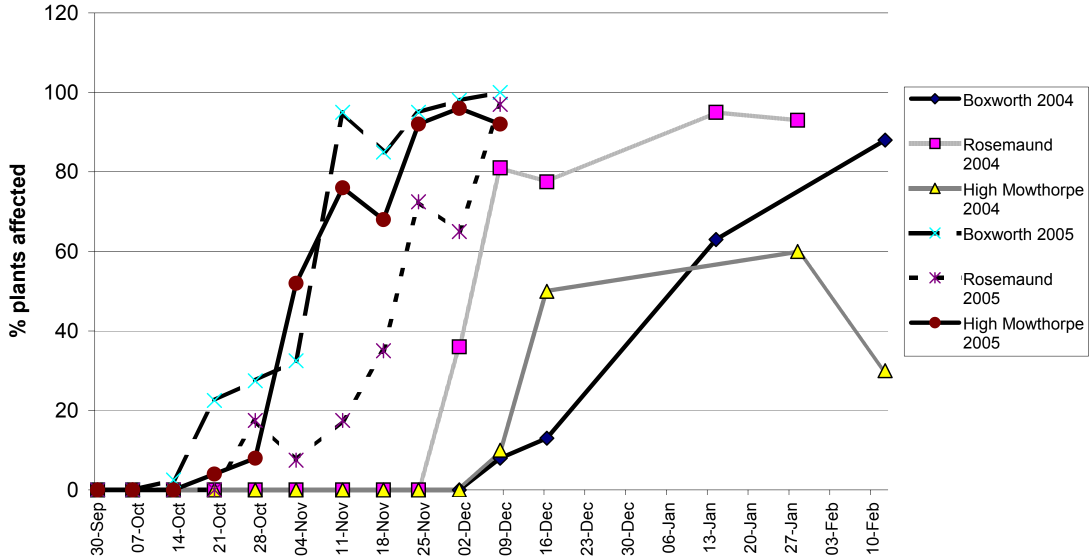


Figure 2. Development of phoma leaf spot in auturevor25mn and early winter on untreated cv. Royal in ADAS cultivar x fungicide experiments, 2003/04 and 2004/05.

The aim of the fungicide strategy was to control moderate and severe stem cankers that are likely to reduce yield. Control of small stem cankers is not worthwhile and the presence of these is acceptable. Fungicides gave good control of phoma leaf spot during the autumn and winter and satisfactory control of stem canker pre-harvest (Table 2).

A cross-site analysis of the phoma stem canker experiments with three cultivars grown at three sites with four fungicide treatments in 2003/04 and 2004/05 provided highly significant differences in disease and yield for all the major factors (Table 3). Year, site, cultivar and fungicide treatment all gave significant effects. Year x site, site x cultivar and year x site x cultivar interactions were also highly significant for yield. The largest differences (effects) on yield came from year (0.82 t/ha) and site (0.81 t/ha) with smaller differences for cultivar (0.44 t/ha) and fungicides (0.37 t/ha). The highest yield was given by the hybrid cultivar Royal, despite its greater susceptibility to stem canker. Cultivar x fungicides interactions were not significant. There were no significant differences in yield between the three fungicide programmes and all the responses (0.29-0.37 t/ha) were cost-effective. The estimated margin over fungicide costs in six experiments was £22/ha from the best programme.

Table 2. Summary of cultivar x fungicide experiments for stem canker control, 2003-2005.

Factor	% plants with stem canker pre-harvest	Stem canker index (0-100) Pre-harvest	Yield (t/ha)
Year			
2004	42.2	17.2	3.66
2005	56.2	19.4	4.48
SED	1.84	0.76	0.056
DF	211	211	202
F test	<0.1%	<0.1%	<0.1%
Site			
Boxworth	48.3	15.7	3.73
High Mowthorpe	31.8	10.1	3.94
Rosemaund	67.5	26.0	4.54
SED	2.25	0.93	0.069
DF	211	211	202
F test	<0.1%	<0.1%	<0.1%
Cultivar			
Escort	49.8	17.5	3.92
Recital	41.9	14.4	3.93
Royal	55.9	20.0	4.36
SED	2.25	0.93	0.069
DF	211	211	202
F test	<0.1%	<0.1%	<0.1%
Fungicide			
Untreated	70.6	26.8	3.82
Onset	44.9	15.1	4.11
Forecast	43.8	14.7	4.19
Managed	37.6	12.5	4.16
SED	2.59	1.07	0.080
DF	211	211	202
F test	<0.1%	<0.1%	<0.1%

Disease control comparisons using pre-harvest stem canker incidence and severity also showed highly significant effects of the major factors. Year x site, year x cultivar, site x cultivar, site x fungicide interactions were also highly significant. The largest effects on stem canker incidence were from site (a difference in incidence of 36% plants affected), fungicide (33%), cultivar (14%) and year (14%). Disease severity comparisons using the stem canker index showed that all two, three and four factor interactions, except year x fungicide, were significant to at least the 5% level. The largest effects were from site (index 16) and fungicide (index 14), followed by cultivar (index 6) and year (index 4). There were small differences in disease control between the three fungicide programmes and the Managed programme gave significantly better control than the Onset programme. The year x fungicide interaction was not significant, which suggests that the timing of sprays to match the phoma leaf spot epidemic gave consistent results.

Light leaf spot control

Control of light leaf spot was poor in the experiments at Aberdeen in 2003/04 and partial control of leaf disease (c. 40%) was achieved only in May and June after the spring spray had been applied. There were no significant effects on yield. In 2004/05, fungicide dose was increased in autumn. Fungicides applied on 3 November significantly reduced the incidence of light leaf spot in early December and in early spring. However, this did not result in a yield response. Clubroot developed at this site and cv. Mendel (partially resistant to clubroot) gave a significantly higher yield (4.03 t/ha) than Synergy (2.92 t/ha) and Winner (2.77 t/ha).

Control of light leaf spot in the Aberdeen area has been poor over several seasons in the PASSWORD experiments and fungicide inputs were often not cost-effective. An experiment in 2001/02 in the Scottish Borders showed that a range of triazole fungicides gave very effective control (>90%) of light leaf spot. This indicates that it should still be possible to control light leaf spot in most areas. Resistance to triazole fungicides is a contributory factor to poor control in the north of Scotland and identification of fungicides with alternative modes of action should be a priority for future research. At present, management of light leaf spot relies heavily on the use of resistant cultivars such as Elan, with fungicide inputs used prior to symptom expression in autumn.

Fungicide timing experiments

Fungicide spray timing experiments at ADAS Boxworth received the first spray on 27 November (5-leaf stage) in 2003/04 and 19 October (6-leaf stage) in 2004/05. In 2003/04 there were significant yield increases (20-30%) from the two-spray programmes initiated in December and the higher rates of Punch C (0.6 and 0.8 l/ha) applied as single sprays in December when phoma leaf spot was well established. This provided new information that higher dose applications were beneficial on small plants. There were no significant effects of fungicides on yield in 2004/05. Some positive yield responses were expected by reducing the canker index from 48 (untreated) to 25-30 and there were positive yield trends (0.03-0.39 t/ha) in all the fungicide treatments. The absence of significant effects on yield was attributed to plants being large in November, when the incidence of phoma leaf spotting increased rapidly.

Evaluation of commercial practice

The use of farm records of crop inputs and yield should allow influential crop inputs to be identified and indicate how the industry has responded to research messages. The ProCam Group 4cast database has collated actual data on yield, costs and profitability of participating farms since 1994. Records are drawn from over 400,000 ha of field walked crops (Figure 3).

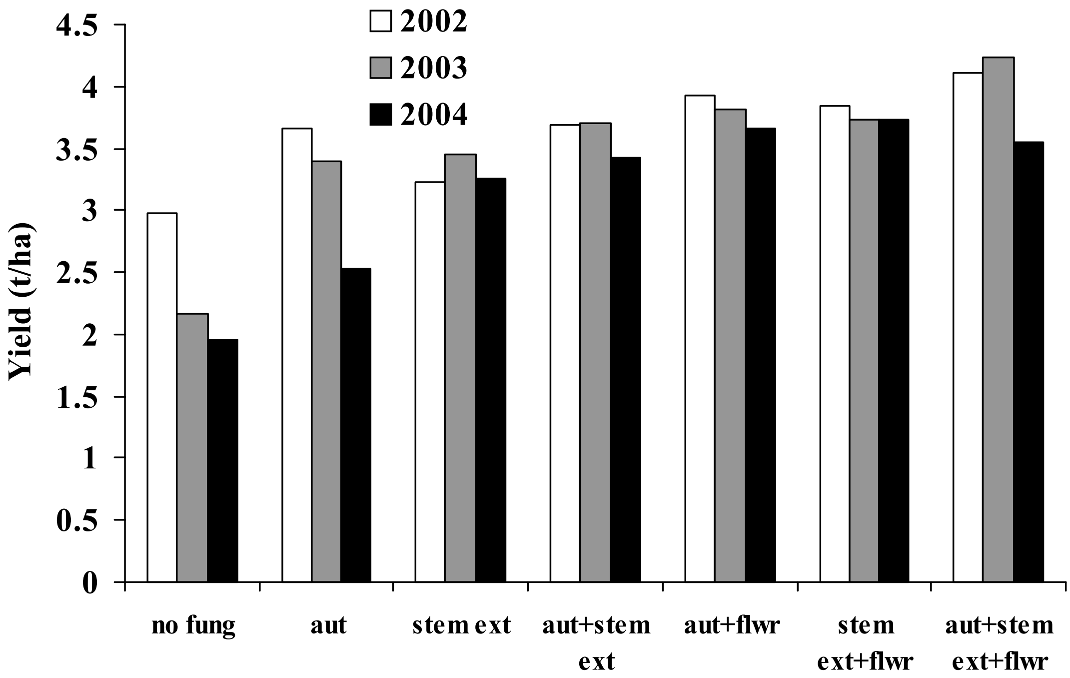


Figure 3. Interaction of winter oilseed rape yield with fungicide timing by year, 2002-2004.

Examination of fungicide effects by year (2002-2004) allows more detailed interpretation of effects and inputs in relation to disease epidemics (that have been quantified at experimental sites). Caution is required when interpreting these effects as decisions may have made to minimise inputs to poor crops. Nevertheless, higher yields are associated with two or three applications of fungicide. In autumn 2003, phoma leaf spot was delayed by the dry conditions, which also affected crop establishment in parts of the east. There were large variations in the yield of untreated (1.95-2.98 t/ha) and autumn treated crops (2.55-3.66 t/ha) during 2002-2004, much less where stem extension sprays (3.23-3.45 t/ha) or programmes were used (3.43-4.23 t/ha) (Figure 3). The trends suggest large responses to autumn sprays (compared with untreated crops) each year (0.68, 1.22 and 0.58 t/ha for 2002, 2003 and 2004, respectively). The highest yields came from a three-spray programme in 2002 and 2003 but two sprays were optimal in 2004. These effects are consistent with levels of variation experienced with replicated experiments. Farm data suggest that seasonal variation and selection of inputs is therefore likely to have significant impact on crop performance.

PASSWORD module (Oilseed Rape Manager) development

The development and design of the Decision Support System utilised experiences from ArableDS and DORIS (Decision support for Oilseed Rape Invertebrate pestS) systems in addition to user consultations. It was an essential requirement to supply useful and accurate information in an easily understandable format and in a timely and cost-effective manner. ArableDS was designed as a PC-based system and is made up of a decision support system (DSS) shell into which multiple DSS can be plugged. It includes databases for weather and pesticide data and a fully functional farm management system. The PASSWORD entity was developed as an ArableDS compliant module, building upon the structure of DORIS. Using the toolkit has ensured that PASSWORD both conforms to the ArableDS requirements and, on release, will be familiar to the users of the DORIS module. The PASSWORD module is a combined pest and disease system that also includes information on beneficial organisms. The user must collect the field data and the system provides the daily meteorological data.

Conclusions

The PASSWORD DSS provides a new system to guide decisions on the major pests and diseases of winter oilseed rape. It is being made available to the Arable DS community for operation in autumn 2006. There is potential to extend the module to make it comprehensive for all diseases of oilseed rape and to include other agronomic inputs. To be successful, the module will need to be maintained, supported and kept up to date. New research projects are underway that could provide new data to enhance the system.

Key results

- Regional disease forecasts are now available on the Internet for both phoma stem canker and light leaf spot and may be used interactively by users.

- The light leaf spot forecast was validated and predictions during 2000-2003 were reliable in 86% of cases.

- New crop-specific forecasts were produced that allow early estimation of fungicide threshold (10% plants with phoma leaf spot) for stem canker development and yield loss from stem canker.

- The combined use of spore trapping and weekly crop monitoring identified progress of phoma leaf spot reliably and provides 2-3 weeks advance warning of disease onset. There is some flexibility in timing of the first fungicide spray as delays of 2-3 weeks after the 10-20% plants affected threshold was reached rarely affected disease control or yield.

- Control of light leaf spot continues to be difficult in the north of Scotland. In high risk situations, it is important to use resistant cultivars and to apply fungicides in early autumn before symptoms of light leaf spot appear.

- Where clubroot is present, use of the partially resistant cultivar Mendel is suggested. Responses to light leaf spot control may be poor if plants are affected by clubroot.

- Late phoma leaf spot starting in December can still produce damaging stem canker if plants are small. Combining the use of late August sowing, cultivars with good stem canker resistance and autumn fungicides provides a robust strategy for stem canker management.

- There are large effects of year, location and cultivar on disease risk and yield. Disease forecasts and regular disease monitoring are required to optimise inputs on individual crops.

- Farm data showed that there are trends for yields of oilseed rape to increase with increasing fungicide inputs. The combinations of treatments that produced the best yields differed between years.

- The PASSWORD decision support system has a user interface with pest and disease activity indicated on a daily basis in relation to weather conditions. The economic impact is indicated on the same screen with further options to calculate cost-benefits of decisions to run various alternative scenarios using historic data. PASSWORD is compatible with ArableDS and being made available to it for use in autumn 2006.

Conclusions and implications for levy payers

- There are large variations between years, locations and cultivars in disease risk and yield. Decision-making and use of crop protection inputs is complex and early assessment of yield loss is required to improve targeting of treatments. The PASSWORD decision support system provides improved guidance on these factors.

- The regional forecasts for light leaf spot and stem canker provide a strategic view on changes in risk from year to year. The predicted risk for light leaf spot is higher in 2006 than in 2005.

- Control of light leaf spot requires use of both resistant cultivars and fungicides in high-risk situations. The use of resistant cultivars is essential in northern Scotland where triazole resistant strains of light leaf spot fungus have been found and fungicide efficacy is poor. In Scotland, northern England and other high-risk situations, the first fungicide spray should be applied in late autumn prior to the appearance of first symptoms.

- August and September rainfall is the key determinant of variation in stem canker risk. New models are available to predict when 10% plants will have phoma leaf spot and predict yield loss.

- Larger plants and resistant cultivars contribute to stem canker control, but fungicides are still required in areas where phoma leaf spot incidence is usually high. Small plants are still at risk if phoma leaf spot appears in December and may justify fungicide treatments at more than half dose.

- The use of fungicides where disease pressure is low is not cost-effective and new predictive models should be used to improve the targeting of fungicides, thereby improving margins over fungicide costs.

- Infection periods for phoma leaf spot and light leaf spot can be identified using weather data and the PASSWORD system also indicates when new symptoms are likely to appear. This provides new guidance on when to inspect crops.

- Clubroot is common in Scotland and increasing in England. Use of the partially resistant cultivar Mendel is favoured where there is risk of clubroot. Other measures such as liming and improving drainage should also be used to manage this disease.

- Where both pest and disease risks are identified, PASSWORD will indicate the optimum date for combining treatments. The economic consequences of delaying a treatment can be estimated, thus guiding decisions on whether a sub-optimal timing is worthwhile.

- The PASSWORD module is being made available to ArableDS and will provide guidance for pest and disease management for the first time in a single system from autumn 2006.

Technical report

Chapter 1

Introduction

Pests and diseases in oilseed rape cause serious loss of yield and quality, estimated to exceed £80 million/annum from diseases in some years (Fitt *et al*., 1997; Turner *et al*., 2002). Fungicides are widely used to control the two most important diseases, stem canker (*Leptosphaeria maculans*) and light leaf spot (*Pyrenopeziza brassicae*), but yield losses continue to occur because treatments have not been optimised. In much of England, stem canker is the most important disease and the industry needs guidance on how to react to large seasonal variations in the onset of epidemics. There is also significant regionalvariation in disease risk, which has implications for cultivar selection and pesticide use. These issues have been addressed through the first phase of the LINK-funded PASSWORDDecision Support System (DSS) (LK 0917) which combines decisions on pests and the two major diseases, light leaf spot and stem canker (Gladders *et al*., 2004). This DSS project is adelivery system for Defra and industry-funded research to advisers and farmers. Pest models have already been validated by CSL, but new forecasting systems and predictive models fordisease development and yield loss have not been tested. Validation of the disease models at the end of the first phase is required to ensure that the system is robust and reliable for dissemination to industry.

Recent and current Defra and HGCA-funded research has provided understanding of the factors which affect the occurrence and distribution of pests and diseases and developing control strategies. This project will allow testing and evaluation of the new disease models over a wider range of locations and against current commercial cultivars. There is complex spatial and temporal variation in pest and disease problems, and decisions for their control are frequently made in relation to calendar date or on a routine prophylactic basis. Disease forecasts allow a regional appraisal of risk and first decisions to apply fungicide in autumn will be guided by a model for predicting 10% plants affected by phoma leaf spot. Linked to this prediction are models that estimate stem canker severity at harvest and hence potential yield loss. Yield loss estimations provide an economic framework for fungicide inputs. Fungicide spray decisions must be made at disease onset (despite the fact that damaging stem symptoms do not appear until about 6 months after the phoma leaf spots are seen) as available products have limited curative activity. Phoma leaf spot epidemics develop very rapidly from onset to maximum incidence and early warnings will enable farmers to prioritise their decisions more effectively. Many farmers have been spraying too late and not achieving disease control. Fungicide sprays applied too early or too late are ineffective. Only a small proportion of winter oilseed rape crops suffer economic damage from pests, yet insecticides are still used on 80% of crops; thus most of this usage is unnecessary.

Scientific challenges have been faced by dealing with contrasting monocyclic (canker) and polycyclic (light leaf spot) pathosystems during the autumn and winter. The PASSWORD project has epidemiological models that predict disease development in real time. Further data to support the operation of these models in real time is required to substantiate predicted development of light leaf spot.

This project brings together data from both Defra disease surveys and new industry funded projects to test and validate disease models developed in PASSWORD. Improved decision making could contribute up to 0.5 t/ha of yield from improved disease control. This project ensures that new components of the DSS are tested prior to operation, which will facilitate acceptance by industry. The project has strong support from industrial partners to bring the DSS into practical operation.

Objectives

- To validate regional disease forecast models for phoma stem canker incidence and severity.
- To produce new regional disease forecasts for light leaf spot and stem canker for 2004 and 2005.
- To test the predictive model for onset of phoma leaf spot in autumn.
- To validate and refine crop specific models for stem canker severity and yield loss.
- To ensure the validated DSS is made available for exploitation by the industry.

Chapter 2

Forecasting risks of phoma stem canker on winter oilseed rape

2.1 Introduction

Data from the Defra CropMonitor surveys of England and Wales show that phoma canker continues to be the most important disease of oilseed rape. Previous studies (Gladders & Symonds, 1995) indicated that there was potential at the regional scale to use forecasts in the autumn and winter to predict the occurrence of stem canker pre-harvest.

2.2 Methods

Empirical risk prediction models, which were developed in the PASSWORD project using the historical data from these surveys (Gladders *et al*., 2004), were used to predict risks from phoma canker in 2004 and 2005. The model produced a regional prediction of stem canker incidence (mean % plants affected) based on information on regional location of the crop, incidence of stem canker in the previous season, total rainfall in September/October, total rainfall in February/March and temperature in February. Initial predictions were made for the six 'phoma risk' regions (Table 2.1) in September of each cropping year, and then updated in November and March as more in-season weather data became available. A second model incorporating additional parameters such as cultivar, autumn disease levels and autumn spray use was used to generate crop specific risk predictions.

Table 2.1. Phoma risk regions

Phoma risk region	Counties included
South-central	Hampshire, Berkshire, Oxfordshire, Buckinghamshire, Surrey & West Sussex
North	Cleveland, Cumbria, Gr. Manchester, Northumberland, N. Yorkshire, W. Yorkshire, Durham, Humberside, Lancashire, Merseyside and Tyne & Wear
East/South-east	Norfolk, Suffolk, Northamptonshire, Cambridgeshire, Essex, Hertfordshire, Bedfordshire, Kent & E. Sussex.
Lincolnshire	Lincolnshire
Midlands and N & W Wales	Cheshire, Clwyd, Derbyshire, Dyfed, Gwynedd, Hereford & Worcestershire, Leicestershire, Nottinghamshire, Powys, Shropshire, S. Yorkshire, Staffordshire & Warwickshire.
S West & S Wales	Avon, Cornwall, Devon, Dorset, Somerset, West Midlands, Gloucestershire, Wiltshire, S. Glamorgan, W. Glamorgan, Mid Glamorgan & Gwent.

2.3 Results

All model outputs were displayed on the phoma forecast website at http://phoma.csl.gov.uk (Figures 2.1& 2.2).

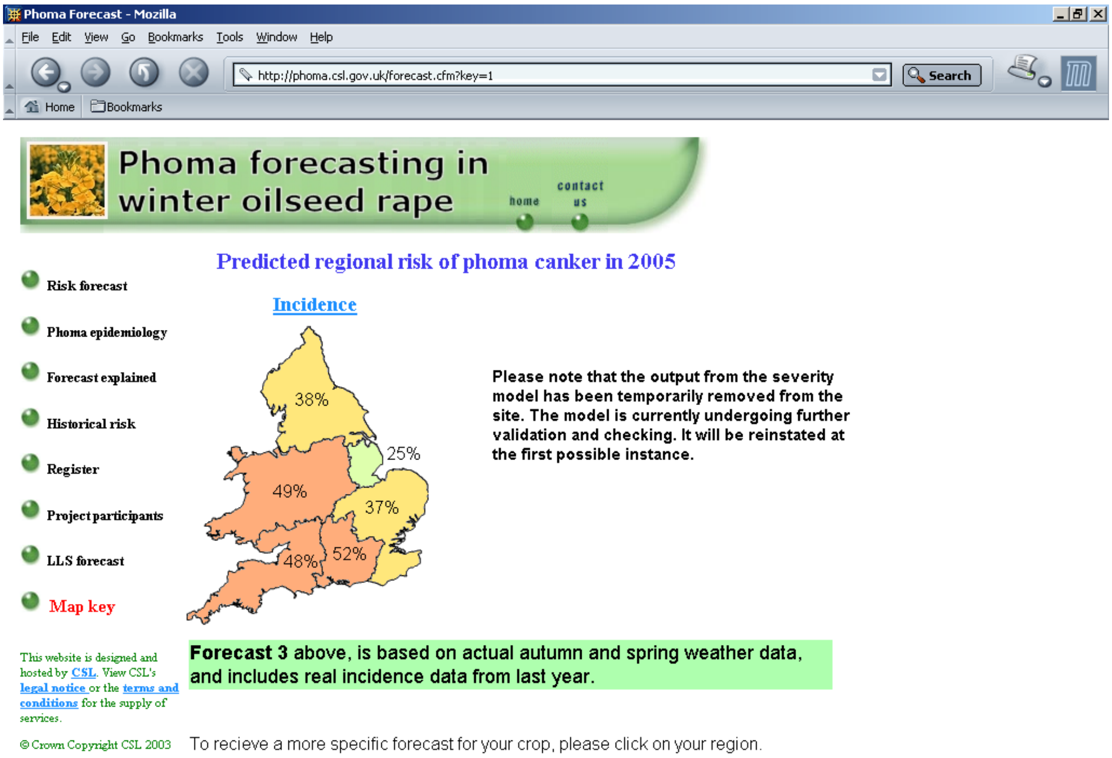
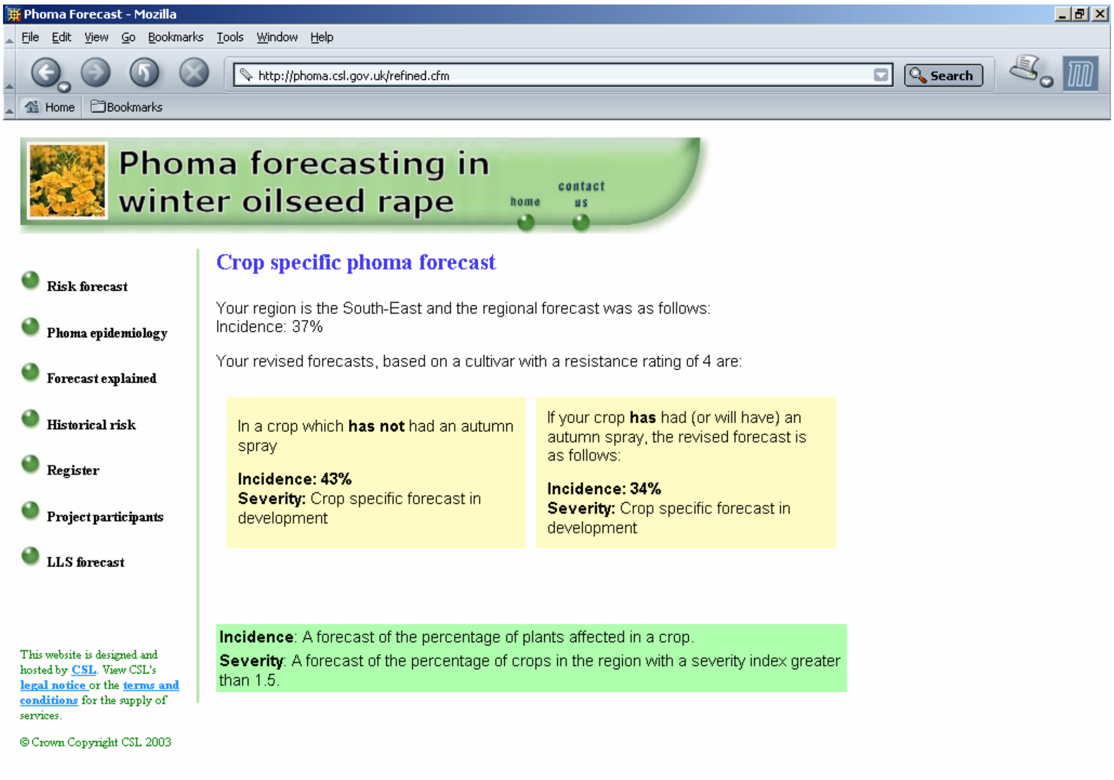


Figure 2.1 Phoma website screens showing regional forecasts for 2005.



Figures 2.2. Phoma website screens showing crop specific forecasts in 2005.

The website has received an average of 115 unique visitors per month with peaks in visits occurring in October at the key time for spray decisions (Figure 2.3).

Phoma risk prediction - 2004

Predictions of disease incidence for 2004 indicated an overall reduction in risk of disease compared to actual phoma canker levels in summer 2003. Update forecasts issued in November 2003 and February 2004 further reduced the predicted risks made in September 2003. A comparison between predicted and observed disease levels shows a poor correlation in most regions with a mean error of nearly 25% (Figure 2.4).

Phoma risk prediction - 2005

In contrast to the previous year, predictions of disease incidence for 2005 indicated an overall increase in risk of disease compared to observed phoma canker levels in summer 2004. Updates to the forecast made during the season indicated increases in risk for some regions whilst decreases were predicted for others. Comparison of predicted versus observed summer 2005 disease levels showed a far better correlation than in 2004 with a mean error of less than 10% (Figure 2.5).

Month	Unique visitors	Number of visits	Pages	Hits
Jan 2004	85	108	364	1931
Feb 2004	126	148	470	2554
Mar 2004	116	133	486	2677
Apr 2004	86	104	239	1498
May 2004	85	94	228	1471
Jun 2004	105	125	297	1672
Jul 2004	106	117	302	1806
Aug 2004	82	94	234	1638
Sep 2004	96	116	540	2646
Oct 2004	170	224	817	4814
Nov 2004	123	164	825	3951
Dec 2004	91	118	369	2322
Total	1271	1545	5171	28980

Month	Unique visitors	Number of visits	Pages	Hits
Jan 2005	123	157	527	2807
Feb 2005	108	133	550	2399
Mar 2005	111	131	403	2054
Apr 2005	148	201	501	2913
May 2005	133	166	335	1911
Jun 2005	123	148	325	1730
Jul 2005	113	147	326	1916
Aug 2005	125	196	497	2163
Sep 2005	144	185	422	2185
Oct 2005	166	233	691	3484
Nov 2005	130	182	413	2131
Dec 2005	56	73	180	962
Total	1480	1952	5170	26655

Figure 2.3. Statistics of the phoma forecast website 2004-2005.

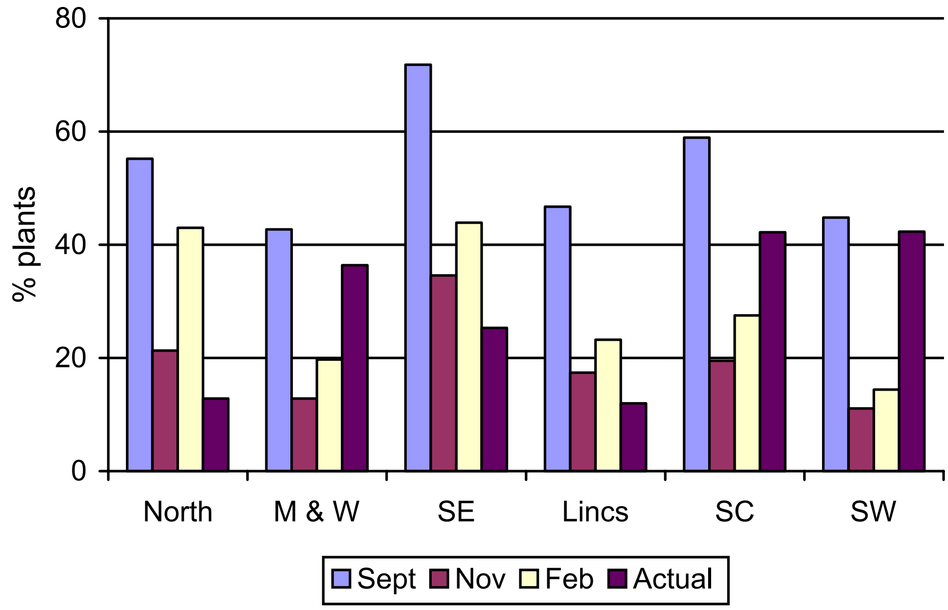


Figure 2.4. Predicted (Sept, Nov, Feb) percentage plants affected by phoma canker against observed (June/July) percentage plants affected from Defra CropMonitor Winter Oilseed Rape Pest and Disease Survey data for 2004.

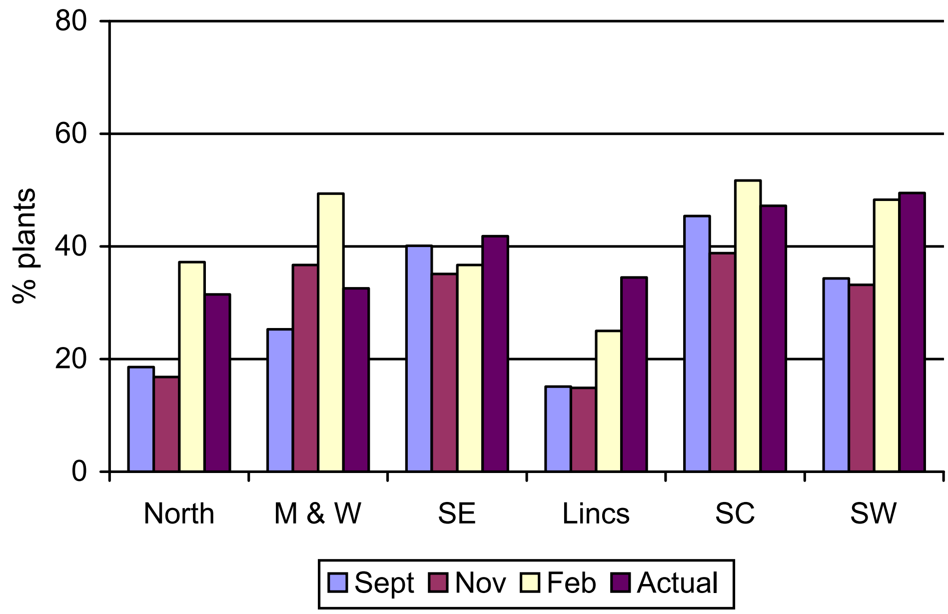


Figure 2.5. Predicted (Sept, Nov, Feb) percentage plants affected by phoma canker against observed (June/July) percentage plants affected from Defra CropMonitor Winter Oilseed Rape Pest and Disease Survey data for 2005.

Predictions for 2006 indicate a similar slightly reduced level of risk compared to actual canker levels recorded in 2005 (Table 2.2). The highest incidence of stem canker is expected in the East, South east and South central regions.

Table 2.2 Predictions for regional incidence of phoma canker 2006

	Predicted percentage plants affected by phoma canker (summer 2006)
Prediction date	September
North	27.5
M & W	23.4
East/South east	51.1
Lincolnshire	24.5
South central	48.8
South west	38.8

2.4 Conclusions

Predictions from the model for the 2003/04 season were very poor, mainly due to the exceptionally low rainfall in some areas during September and October. These weather conditions were outside the experience of the model, which uses average weather parameters to make predictions. Furthermore, the model was developed using an historical dataset within which phoma levels were on average much lower than they have been in recent years. Results of the validation done in 2005 indicate that the model will give more accurate predictions when weather conditions are more in line with long-term averages. Inaccuracies in prediction from forecasting models will be more likely under climate change scenarios and it is recommended that the model be updated with the latest average weather and annual disease data to improve the predictive capability for the future.

The regional models for predicting stem canker severity (Gladders *et al*., 2004) were not evaluated in this phase of the PASSWORD project. Further modelling is required using additional survey data (that have more severe stem canker records) to develop satisfactory predictions of stem canker severity. Crop level predictions of stem canker based on disease survey data have been examined in the first phase of PASSWORD. Cultivar stem canker resistance rating and fungicide use were important factors. Further work is required to improve existing models as indicated for the regional severity index models. At present, the 4-stage canker prediction model is available for predicting stem canker severity in specific crops (see Chapter 4).

Chapter 3

Light leaf spot forecasting and validation

3.1 Introduction

The forecast for light leaf spot was developed prior to the PASSWORD project using Defra-funded winter oilseed rape disease survey data from 1987-1999 and monthly weather data (Welham *et al*., 2004). The most important explanatory variables were mean summer temperature (July/August), mean monthly winter rainfall (December-February) and incidence of light leaf spot on pods in the previous season. The risk of severe light leaf spot (LLS) (% crops with >25% plants affected in spring) was predicted in September and updated at the end of February to take account of winter rainfall. The use of Active Server Page (ASP) Internet-based technology allowed interactive input of cultivar resistance rating and sowing date, both of which were used to modify the regional forecast to produce a crop-specific forecast for the situation of a particular grower (see http://www3.res.bbsrc.ac.uk/leafspot/). Running the forecast model using north of England pod disease data with Scottish meteorological data produced a Scottish forecast. Validation of the forecast done using regional disease survey data for 2000-2003 showed that 86% of predictions were compatible with the model.

3.2 Methods

To validate the 2004/05 forecast, 2005 spring OSR survey data (% plants affected) were provided by CSL and the mean percentage of crops with > 25% plants affected was calculated for each light leaf spot forecast region. However, in recent years, the number of untreated crops sampled in the survey has reduced to zero. This makes validation of the forecast very difficult. To produce the 2005/06 forecast, the 2005 summer (July) survey regional means for the % of pods affected were calculated and used with deviation in summer temperature (July and August 2005) from the 30 year mean of each region and predicted winter rainfall for December 2005 – February 2006 (using the regional mean 30 year mean winter rainfall for each region). These data were combined to produce the preliminary light leaf spot forecast for the 2005/06 winter oilseed rape growing season (in September 2005).

3.3 Results and discussion

The general pattern observed over a number of seasons was observed again this season. Prediction of light leaf spot risk and observed light leaf spot severity were greatest in the northern region (Table 3.1). Although the forecast overestimated the severity of the light leaf spot that could be expected in spring 2005, the survey data suggest that on a local scale the forecast was more precise. For example one crop (cv. Royal) in Northumberland had 40% plants affected with LLS and a crop specific forecast for this region, cultivar and sowing date gave a prediction of 37% plants affected. The field data also suggested that light leaf spot severity in the spring was much lower than expected for the past two seasons (mainly due to dry, warm summers), so that severity of the light leaf spot epidemics in England and Wales has decreased in contrast to the situation of the late 1990s/early 2000s. The survey data also suggest that the switch from spring fungicide applications to predominantly autumn applications for the control of both phoma stem canker and light leaf spot has been very successful in controlling light leaf spot in England and Wales. Oilseed rape survey data for summer 2005, supplied by CSL, suggested that light leaf spot severity on pods was low but that there were some severely affected crops on a local scale.

Table 3.1. Light leaf spot forecast regions of England and Wales, untreated and treated predicted (in the autumn 2004) % of crops to have >25% plants affected and the observed % of crops with >25% plants affected for spring 2005.

Light leaf spot region	% crops with >25 % plants affected			
	No. crops sampled	Predicted		Observed, spring 2005
		Untreated	Treated	
South	10	15	4	0
East Anglia	19	9	2	0
South east	12	12	3	0
North east	25	22	6	0
North	14	46	19	7.1
South west	8	12	3	0
West and Wales	10	19	5	0

The light leaf spot forecast website (http://www3.res.bbsrc.ac.uk/leafspot/) was updated on 10 October 2005 and the regional forecast map (Figure 3.1) was released. The interactive, crop-specific forecast was also updated to provide growers with a forecast for a specific cultivar and sowing date. There is a predicted increased risk of light leaf spot in most regions for spring 2006 compared with spring 2005. This has been widely promoted to industry in autumn 2005. The Rothamsted website had 1897 visitors between October 2004 and March 2006 and 4223 page views. There were peaks of visits in October 2004, April 2005 and October 2005 that co-incided with updates to the forecast. Visitors were mainly from the UK (62%), but visitors from 69 other countries were recorded.

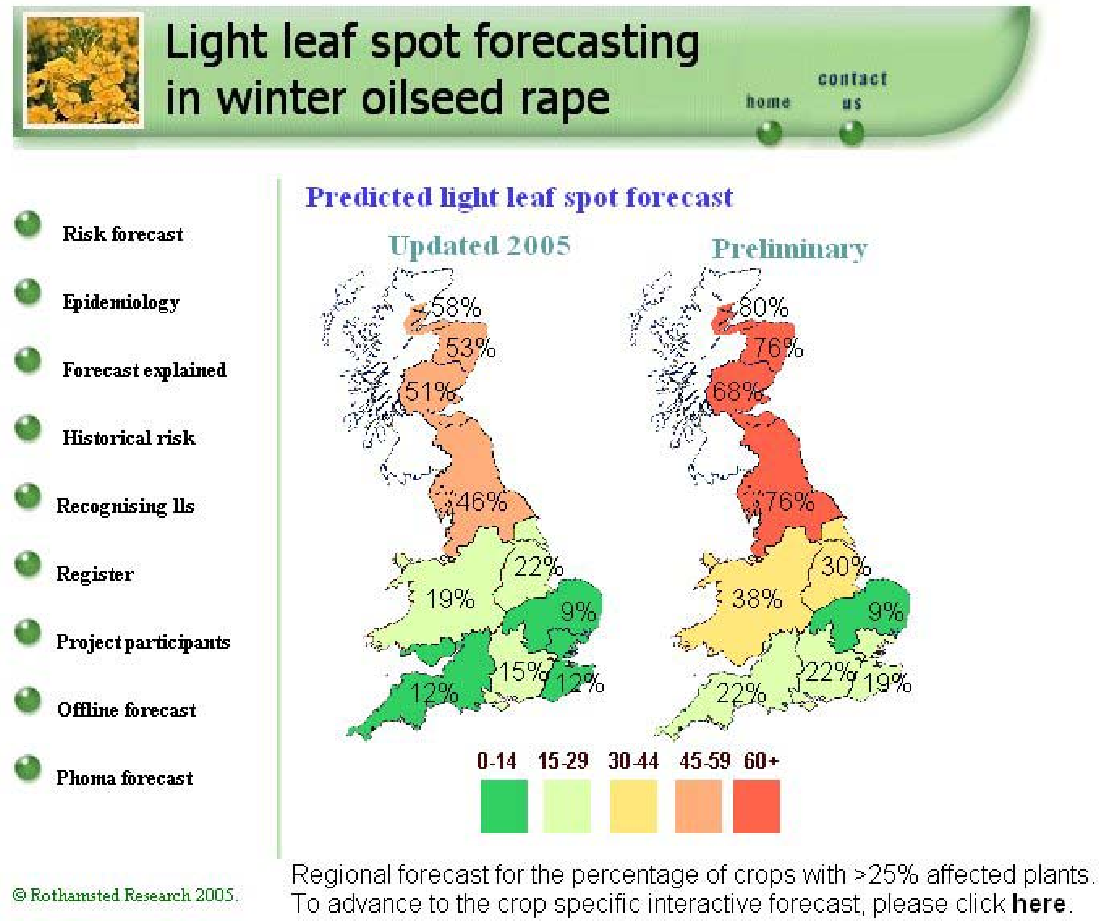


Figure 3.1. Image of the light leaf spot forecast regional map showing the predicted increase in light leaf spot risk for the 2005/06 oilseed rape growing season in comparison to the updated forecast released in March 2005 during the 2004/05 growing season.

Chapter 4

Testing of Phoma onset and progress models

4.1 Introduction

A four-stage crop-specific phoma stem canker progress model has been tested during 2003/05 using cultivars in fungicide experiments and five crops per year from the Defra-funded Crop Monitor project. Quantitative relationships were established in the first phase of PASSWORD for each of the four stages using historic datasets. The first stage model predicts the date when 10% of plants will have phoma leaf spotting (in autumn) using mean maximum temperature and total rainfall between 15 July and 26 September. Stage 2 is a thermal time (as degree-days) model predicting the interval between the onset of phoma leaf spotting and first stem canker symptoms. Symptoms develop more slowly on canker resistant cultivars. The stage 3 model predicts the increase in canker severity with thermal time (degree-days). This increase is slower in cultivars with canker resistance ratings >6. From the predicted canker severity at harvest, the stage 4 model can be used to estimate yield loss. Cultivar resistance rating did not affect the canker severity/yield loss relationship. These interlinked models can be used to predict yield loss when phoma leaf spot first appears and can be updated during the growing season with actual weather data. The estimates of yield loss provide a framework for defining the number of fungicide applications that can be justified to optimise margins over fungicide costs.

4.2 Methods

Meteorological data (15 July – 27 September) from sites across the UK were used to produce a prediction of when 10% phoma leaf spotting could be expected at a range of locations across the UK each season. Detailed records for the 2004/05 season indicated the variation (range 46 days) that can be expected (Table 4.1).

Table 4.1. Predicted dates when 10% phoma leaf spotting could be expected at a range of locations across the UK in autumn 2003 and 2004. (2004/05 seasons).

Meteorological site	Date predicted for 10% phoma		Meteorological site	Date predicted for 10% phoma	
	2003	2004		2003	2004
Aberporth	30 Oct	2 Oct	Linton on Ouse	30 Oct	10 Oct
Andrewsfield	27 Oct	10 Oct	Lyneham	28 Oct	12 Oct
Bedford	27 Oct	24 Sept	Manston	29 Oct	20 Oct
Benson	23 Oct	16 Oct	Marham	14 Nov	4 Oct
Boscombe Down	26 Oct	25 Oct	Milford Haven	16 Oct	5 Oct
Bournemouth	26 Oct	18 Oct	Mumbles	24 Oct	16 Oct
Brize Norton	23 Oct	26 Sept	Newcastle	11 Nov	16 Oct
Carlisle	5 Nov	10 Sept	Pershore	20 Oct	20 Sept
Chivenor	22 Oct	8 Oct	Plymouth	19 Oct	14 Oct
Church Lawford	25 Oct	28 Sept	Redesdale	17 Nov	11 Oct
Coleshill	28 Oct	27 Sept	Redhill	30 Oct	20 Oct
Coltishall	31 Oct	16 Oct	Rothamsted	28 Oct	15 Oct
Cranwell	31 Oct	3 Oct	Saint Athan	16 Oct	13 Oct
Dyce	18 Nov	4 Nov	Shawbury	16 Oct	14 Oct
Emley Moor	12 Nov	3 Oct	Shoeburyness	1 Nov	18 Oct
Fylingdales	3 Nov	7 Oct	St Mawgan	24 Oct	16 Oct
Gogarbank	12 Nov	23 Oct	Thorney Island	28 Oct	12 Oct
Hawarden	18 Oct	23 Oct	Trawscoed	17 Oct	13 Sept
Heathrow	26 Oct	10 Oct	Wainfleet	5 Nov	14 Oct
Herstmonceux	26 Oct	14 Oct	Walney Island	2 Nov	29 Aug
Holyhead Valley	3 Nov	18 Oct	Watnall	2 Nov	30 Sept
Kinloss	14 Nov	19 Oct	Wattisham	30 Oct	8 Oct
Leconfield	30 Oct	9 Oct	Wittering	27 Oct	28 Sept
Leeming	25 Oct	11 Oct	Yeovilton	24 Oct	18 Oct
Leuchars	12 Nov	4 Oct			

Table 4.2. Comparison of predicted date with observed date when plants were expected to have 10% plants affected with phoma leaf spot (*L. maculans*) and epidemic progress for eighteen oilseed rape crops at nine sites across the UK in 2003/04.

Site	Variety[1]	Sowing date	Date 10% phoma leaf spot		Date of canker onset/ first observed		Canker index (0-4 scale)		Yield response (t/ha)	
			Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed
Boxworth, Cambs.	Escort (7)	03 Sep 03	27 Oct 03	8 Dec 03	8 May 04	11 June 2004[4]	0.51	1.53	0	0.04
	Royal (4)	03 Sep 03	27 Oct 03	16 Dec 03	12 Apr 04	11 June 2004[4]	1.26	1.82	0.19	0.62
	Recital (7)	03 Sep 03	27 Oct 03	8 Dec 03[3]	8 May 04	11 June 2004[4]	0.51	1.21	0	0.56
	Winner (6)	21 Aug 03	27 Oct 03	1 Dec 03	8 May 04	2 June 2004[4]	0.51	1.50	0	0.54
High Mowthorpe, N. Yorks.	Escort (7)	27 Aug 03	29 Oct 03	16 Dec 03	7 June 04	01 July 2004	0.21	0.15	0	0.21
	Royal (4)	27 Aug 03	29 Oct 03	8 Dec 03	13 May 04	01 July 2004	0.70	0.47	0.02	0.18
	Recital (7)	27 Aug 03	29 Oct 03	16 Dec 03	7 June 04	01 July 2004	0.21	0.12	0	0.50
Wharram, N. Yorks	Winner (6)	18 Aug 03	29 Oct 03	13 Jan 04	7 June 04	22 June 2004	0.21	0.04	0	-
Rosemaund, Herefordshire	Escort (7)	02 Sep 03	4 Nov 03	11 Dec 03[5]	17 May 04	25 July 2004	0.62	0.82	0	0.21
	Royal (4)	02 Sep 03	4 Nov 03	01 Dec 03[5]	23 Apr 04	25 July 2004	1.45	1.63	0.25	0.02
	Recital (7)	02 Sep 03	4 Nov 03	11 Dec 03[5]	17 May 04	25 July 2004	0.62	1.00	0	0.30
Rothamsted, Herts.	Canberra (7)	03 Sep 03	30 Oct 03	21 Oct 03	20 May 04	22 April 04	0.36	1.1	0	
	Escort (7)	03 Sep 03	30 Oct 03	21 Oct 03	20 May 04	05 May 04	0.36	1.2	0	
	Escort (5)[6]	03 Sep 03	30 Oct 03	21 Oct 03	24 April 04	05 May 04	0.98	1.2	0.11	
	Recital (7)	03 Sep 03	30 Oct 03	21 Oct 03	20 May 04	05 May 04	0.36	0.9	0	
Ashford, Kent	Caracas (7)	27 Aug 03	29 Oct 03	20 Oct 03	7 May 04	21 June 04	0.468	2.00	0	
Kenton, Devon	Tequila (6)	01 Sept 03	25 Oct 03	14 Jan 04	20 May 04	25 June 04	0.31	0.08	0	
Wolverhampton, W. Midlands	Canberra (7)	01 Sep 03	27 Oct 03	20 Oct 03	15 May 04	19 May 04	0.40	0.40	0	
Terrington (Whaplode), Norfolk	Royal (4)	28 Aug 03	29 Oct 03	28 Oct 03	11 April 04	17 May 04	1.06	1.68	0.13	

[1] Figure in parenthesis indicate cultivar resistance rating from the HGCA CEL 2004 Recommended list for winter oilseed rape
[2] Predicted canker severity ratings at this site were 1.55 (susceptible cv.), 0.66 (resistant cv.) and 1.07 for a cultivar with moderate resistance.
[3] Incidence recorded as 8% on 8 December 2003 and 33% on 14 January 2004. [4] Incidence high on first record, mid to late May is estimated onset . [5] Incidence very high at first record but zero the previous week. [6] Escort data when canker resistance rating is adjusted from 7 to 5

Crop and weather data for 13 crops across the UK were used to investigate phoma epidemic progress. A comparison of predicted date when 10% plants would be affected with phoma leaf spot with the observed date when this incidence of phoma leaf spotting occurred (or in some cases the date when phoma leaf spotting was first recorded) showed that the prediction was good (within 1 week) for the majority of sites or at least within 2 weeks at all sites (Table 4.3). As for the 2003/04 season, the predictions were only reliable at a few sites and many were 4-6 weeks too early (Table 4.2). The 10% prediction model appears to work well from the limited data available to test the model. However,it should onlybe consideed reliable when working within the range of weather data used to construct the model.

To validate the phoma stem canker progress model records from fungicide experiments and CropMonitor sites were used. In 2003/04, stem cankers were found several weeks later than predicted initially and this reflected the poor prediction of phoma leaf spot development (Table 4.2). Stem canker severity was higher than predicted except at High Mowthorpe (where observed severity indices were within 0.1-0.2 of predicted values. Plants were smaller than usual at phoma onset at some sites in autumn 2003 and this is likely to have influenced canker severity. In the 2004/05 season, the difference between the predicted date of canker onset and the date when canker was first observed in spring 2005 ranged from 9 days (Rosemaund, cv. Royal) to 49 days (High Mowthorpe, cvs Escort and Recital). Observed dates for the appearance of stem canker were always later than the predicted date except at Rothamsted. The predicted canker severities also tended to be lower than observed severities except at Rothamsted (Table 4.3). At Rosemaund, the model appeared to account for canker development more precisely in the case of the susceptible cultivar Royal, as the predicted and observed canker severity ratings at this site were consistent at 1.49 and 1.60, respectively. Predictions at Rosemaund and High Mowthorpe would have been much closer to observed values if all cultivars had been given the canker susceptible ratings assignedto Escort (now 5), Recital (now 6) and Winner (now 5) in the 2006/07 Recommended list. Actual observations could be used to re-align future predictions during the growing season so that the forecast is more precise.

There is a strong influence of cultivar resistance on the predicted stem canker severity. During the course of the project, the canker resistance rating for Escort decreased from 7 to 5. Adjusting the predicted values for Escort to index 5 for 2004/05 would have improved the prediction of stem canker severity at Boxworth, Rosemaund and High Mowthorpe but not at Rothamsted. The observed stem canker severity at High Mowthorpe and Rothamsted was much higher than predicted. Both these sites were affected by light leaf spot and this may have affected stem canker development.

The reliability of the prediction of canker severity also affects the predicted yield response to fungicides (Tables 4.2, 4.3). In 2003/04, yield losses were expected to be low. This was generally the case and many observed values were within 0.2 t/ha of predictions. There were only significant yield effects at Boxworth and this was obtained from a late phoma epidemic on very small plants (outside datasets used to construct the model). In 2004/05, predictions of yield response were also within 0.2 t/ha observed values with the exception of Rosemaund where responses were 0.9 t/ha. The Rosemaund responses are unlikely to be due to phoma stem canker control and involve light leaf spot control and effects on crop lodging. As with stem canker predictions, the updating of models for decreases in stem canker resistance ratings would have given higher and more reliable values for predicted yield loss. Any expected loss of yield from light leaf spot should be added to the predicted loss from stem canker to improve the estimated yield loss.

The models will require further testing as only 3-4 sites per variety were used in this test. It is not clear whether the models can be used generically for all cultivars with the same resistance rating or whether individual cultivars should be treated separately. There are concerns that changes in cultivar susceptibility will lead to underestimates of yield loss and models should be re-run when changes have been made. A plant size factor may be required as small plants showed more severe canker than predicted and large plants showed less severe canker. There are insuficient historic data on plant size to make adjustments to the model at this stage.

Table 4.3. Comparison of predicted date with observed date when plants were expected to have 10% plants affected with phoma leaf spot (*L. maculans*) and epidemic progress for sixteen oilseed rape crops at seven sites across the UK in 2004/05.

Site	Cultivar[1]	Sowing date	Date 10% phoma leaf spot		Date of canker onset/ first observed		Canker index (0-4 scale)		Yield response (t/ha)	
			Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed
Boxworth, Cambs.	Escort (7)	03 Sep 04	04 Oct 04	11 Oct 04	08 Apr 05	24 Apr 05	0.66	0.82	0.01	0.20
	Royal (4)	03 Sep 04	04 Oct 04	11 Oct 04	08 Mar 05	25 Apr 05	1.55	1.07[2]	0.29	0.38
	Recital (7)	03 Sep 04	04 Oct 04	11 Oct 04	08 Apr 05	26 Apr 05	0.66	0.70	0.01	0.05
	Winner (6)	28 Aug 04	04 Oct 04	19 Oct 04[3]	08 Mar 05	15 Apr 05	0.66	1.92	0.01	0.26
High Mowthorpe, N. Yorks.	Escort (7)	03 Sep 04	08 Oct 04	18 Oct 04	24 May 05	07 Jun 05	0.49	1.34	0	-0.07
	Royal (4)	03 Sep 04	08 Oct 04	25 Oct 04	19 Apr 05	07 Jun 05	1.23	1.84	0.19	0.10
	Recital (7)	03 Sep 04	08 Oct 04	25 Oct 04	24 May 05	07 Jun 05	0.49	1.80	0	0.24
Rosemaund, Herefordshire	Escort (7)	09 Sep 04	22 Oct 04	25 Oct 04[4]	07 May 05	13 Apr 05	0.63	1.52	0	0.89
	Royal (4)	09 Sep 04	22 Oct 04	25 Oct 04[4]	05 Apr 05	14 Apr 05	1.49	1.60	0.27	0.97
	Recital (7)	09 Sep 04	22 Oct 04	25 Oct 04[4]	07 May 05	15 Apr 05	0.63	1.72	0	-0.08
Rothamsted, Herts.	Canberra (7)	03 Sep 04	15 Oct 04	21 Oct 04	13 May 05	22 Apr 05	2.3	1.10	0.52	
	Escort (7)	03 Sep 04	15 Oct 04	21 Oct 04	13 May 05	05 May 05	2.3	1.20	0.52	
	Recital (7)	03 Sep 04	15 Oct 04	21 Oct 04	13 May 05	05 May 05	2.3	0.90	0.52	
Ashford, Kent	Caracas (7)	28 Aug 04	15 Oct 04	13 Oct 04[5]	29 May 05	23 Jun 05	0.4	1.16	0	
Wolverhampton, W. Midlands	Winner (6)	01 Sep 04	26 Sep 04	28 Sep 04[6]	14 Apr 04	10 May 05	0.51	0.52	0	
Terrington, Norfolk	Winner (6)	15 Aug 04	07 Oct 04	05 Oct 04	22 Apr 05	12 May 05	0.5	2.08	0	

[1] Figure in parenthesis indicate cultivar resistance rating from the HGCA CEL 2004 Recommended list for winter oilseed rape
[2] Predicted canker severity ratings at this site were 1.55 (susceptible cv.), 0.66 (resistant cv.) and 1.07 for a cultivar with moderate resistance.
[3] Incidence recorded as nil on 10 October 2004 and 24% on 19 Oct 2004.
[4] Incidence recorded as nil on 18 October 2004 (2.5% for cv. Recital) and 20% on 25 October 2004.
[5] Incidence recorded as nil on 06 October 2004 and 68% on 13 Oct 2004.
[6] Incidence 8% on 28 September 2004, which increased to 20% by 05 October 2004.

More recently, the phoma canker epidemic progress model has also been used to answer an interesting epidemiological question and is currently being used to model the possible effects of climate change on future epidemics. Phoma leaf spotting has been reported to occur in Scotland but damaging stem cankers never develop. Data from Aberdeen indicate that cankers do not develop there because average temperatures are lower, and there is insufficient thermal time for severe stem canker development by comparison to south-east England (Figure 4.1).

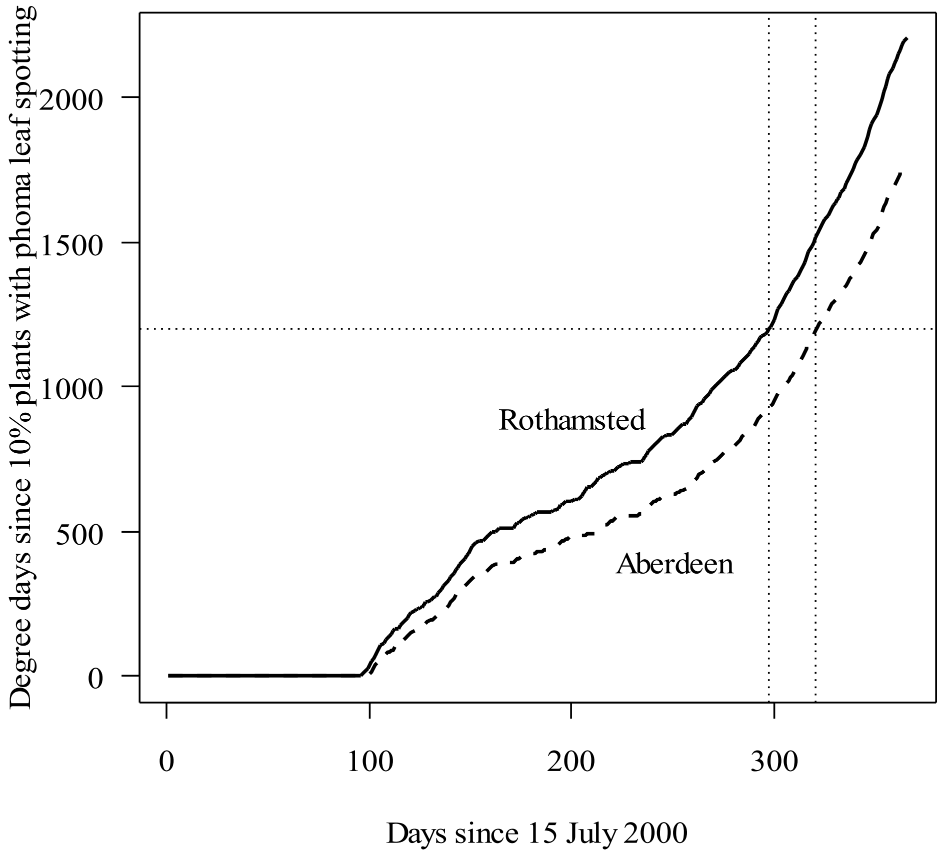


Figure 4.1. Predicted phoma stem canker development at Rothamsted and Aberdeen based on meteorological data for 2000/2001. The dotted line (1200 degree-days) indicates the predicted date for onset of canker development and suggests that, at Aberdeen, onset is too late for damaging cankers to develop before harvest (320 degree days; 31 May 2000) in contrast to the earlier onset at Rothamsted (297 degree days; 8 May 2001).

Manipulation of meteorological data to simulate scenarios of different climatic conditions that may occur due to climate change also allows us to investigate the possible effect that climate change may have on the severity of phoma stem canker epidemics. Most climate change models suggest a 2-3°C increase in the UK mean temperatures in the short-term (e.g. by 2050) with further increases by as much as 4°C by 2080 (Beniston, 2004). Climate change scenarios suggest that even a 1.5°C increase in average temperature would result in an increase in severity of the phoma stem canker epidemic (Figure 4.2). In an average season at Rothamsted (e.g. 2004 meteorological data, Figure 4.2), the date of canker onset was predicted to be 290 days after 15 July which is 1 May. Early canker symptoms were first observed at Rothamsted in early May 2005 and cankers became moderately severe by harvest. However, with a 1.5°C increase in temperature, the model suggests that canker onset would be shifted earlier with onset predicted on day 210 after 15 July, which is 10 February, 18 weeks prior to onset under current climatic conditions (Figure 4.2). With such an early onset date and with higher average temperatures favouring subsequent canker development within stem tissues, the model suggests that phoma stem canker epidemics may become extremely severe if conditions change as current climate change models predict.

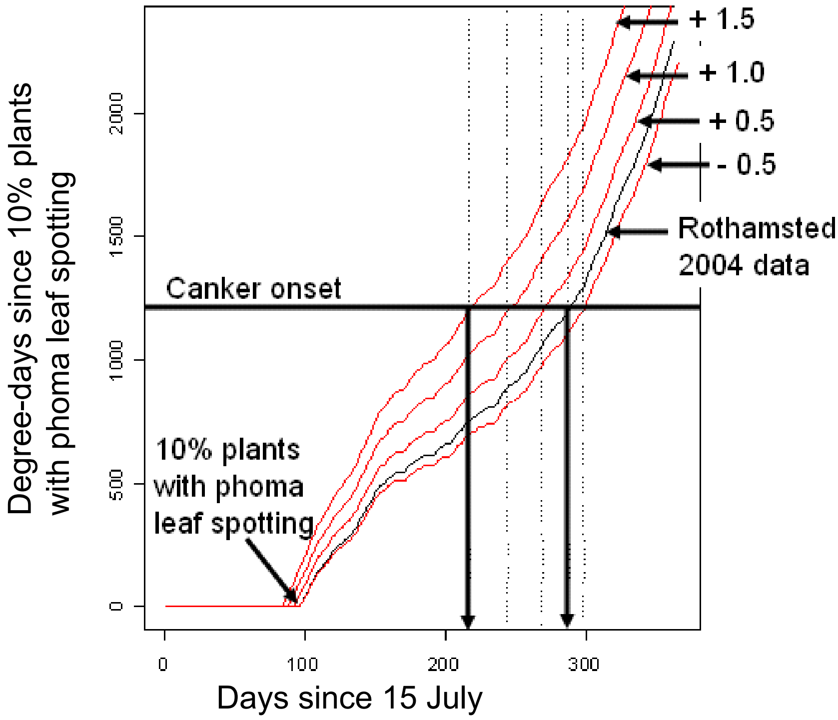


Figure 4.2. Predicted date in spring 2005 of onset of phoma stem canker at Rothamsted made in autumn 2004 and predictions produced for climate change scenarios of a -0.5°C, +0.5°C, +1°C and +1.5°C change in average temperature during the growing season showing an increase in the severity of the phoma stem canker epidemic with increasing temperature (as onset of canker development is earlier).

Chapter 5

Evaluation of cultivar resistance and fungicide strategies

5.1 Introduction

The overall aim of this component of project was to quantify the contribution of cultivar resistance and fungicides for disease control and to establish guiding principles to optimise disease management. The experiments tested spray timing for control of phoma stem canker in relation to spore trap catches and disease thresholds using Escort as a standard cultivar (linking to previous work) and introducing Royal and Recital as new cultivars. Light leaf spot control was investigated using cultivars relevant to Scotland and higher fungicide applications in autumn. Additional experimemts on timing of fungicides for stem canker control were done on cv. Winner and additional data on light leaf spot control was made available by an industry partner. Data from field experiments have been also been used to test new disease models so that PASSWORD can provide information on the risk of yield loss in current cultivars.

There were five main objectives in this part of the study:

1. To monitor the development of light leaf spot and phoma stem canker epidemics.
2. To appraise the contribution and value of genetic resistance for the control of light leaf spot and phoma stem canker.
3. To examine disease development in relation to weather factors.
4. To determine the optimum strategy for disease control using cultivar resistance and fungicides.
5. To test disease forecasts.

5.2 Materials and methods

The work was done at four locations, each with a specific disease target:

1. ADAS Boxworth, Cambridge – high risk site for phoma leaf spot and stem canker.
Cultivar x fungicide experiments, 2003-2005
Fungicide spray timing experiments, 2003-2005

2. ADAS High Mowthorpe, Malton, North Yorkshire - moderate risk site for phoma leaf spot and stem canker and moderate risk of light leaf spot.

Cultivar x fungicide experiments, 2003-2005

3. ADAS Rosemaund, Hereford - moderate risk site for phoma leaf spot and stem canker and low to moderate risk of light leaf spot.

Cultivar x fungicide experiments, 2003-2005

4. SAC Aberdeen, Aberdeen, Scotland – high risk site for light leaf spot.

Cultivar x fungicide experiments, 2003-2005

5.2.1 Cultivar x fungicide experiments

Single replicated field experiments with three cultivars and four fungicide treatments were done at ADAS Boxworth, ADAS High Mowthorpe, ADAS Rosemaund and SAC Aberdeen in harvest years 2004 and 2005. Disease development and control were monitored throughout the year and related to seed yield.

ADAS cultivar x fungicide experiments

These experiments were laid out as a randomised block design with four replicate blocks. Three cultivars with differing resistance to stem canker (Escort, Recital and Royal) (Table 5.1**)** were sown in late August or early September each year (see Appendix 1, Tables 1.2, 1.4, 1.8, 1.11, 1.13 and 1.17 for crop details). Target plant populations were 40 plants/m^2 for the hybrid cultivar Royal and 80 plants/m^2 for Escort and Recital. Plot size was 48 m^2. Fungicide programmes were applied to manipulate the disease epidemics and were first applied to all cultivars when there were significant ascospore catches or the phoma leaf spot threshold (c.10% plants affected) was reached for at least one cultivar (Table 5.2). Fungicide treatments, timings and rates used are shown in Tables 5.2 a & 5.2b. The main fungicide was difenoconazole (as Plover) at 0.25 l/ha with provision to add carbendazim (as Bavistin DF) 0.5 kg/ha where light leaf spot was active.

Table 5.1. Cultivars and UK disease resistance ratings (1-9 scale for stem canker and light leaf spot respectively in 2004/05) used in cultivar x fungicide experiments 2003-2005.

Reference code	ADAS Cultivar	SAC Aberdeen Cultivar
1	Escort (7,7)	Synergy* (4,5)
2	Royal (4,6)*	Mendel (6, 6)**
3	Recital (7, 6)	Winner (6, 7)

* Hybrid population target was 40-50 plants/m^2, other cultivars require 80-100 plants/m^2

** Mendel included as clubroot resistance is important in Scotland

The incidence and severity of all diseases were assessed. Foliar and pod disease severities were recorded as the % leaf or % pod area affected. Stem diseases were assessed on individual plants using a 0-4 Index (0 = healthy, 4 = dead) that was converted to a 0-100 index for disease severity comparisons. After an initial field sample of 10 plants from each control plot to monitor disease development, all plots were sampled (10 plants/plot) at the second spray date and close to each spray application date and then at approximately 6 weekly intervals until crop maturity (see Appendix 1, Table 3). The plants were generally assessed on the same day as they were sampled in autumn but were incubated in winter/spring for a short period to encourage sporulation of light leaf spot. The final assessment for stem and pod diseases was made in the field on 25 plants/plot. Growth stages were designated using the codes of Sylvester-Bradley (1985). Plant numbers/m^2 were assessed after harvest in all plots in $0.25m^2$ quadrats (5 quadrats/plot).

Table 5.2a. Fungicide treatments used in cultivar x fungicide validation experiments, 2003/2004 (ADAS sites are Boxworth (BX), High Mowthorpe (HM) and Rosemaund (RM)).

Treatment	T1 – based on spore numbers before actual 10% plants with phoma	T2 – phoma well established (2-3 weeks after T1)	T3 Maintain disease control (4-6 weeks after T1)	T4 Maintain disease control (4-6 weeks after T2)	T5 Early stem extn for light leaf spot
ADAS sites 2003/2004	BX – 24 Nov HM – 02 Dec RM – 10 Nov	BX – 18 Dec HM – 16 Dec RM – 16 Dec	BX – 23 Jan HM – 9 Mar RM – 28 Jan	BX – 12 Feb HM – 02 Apr RM – 02 Mar	
1	Untreated	-	-	-	
2 Forecast	Plover (0.25 l/ha)	-	Plover (0.25 l/ha)	-	
3 Onset	-	Plover (0.25 l/ha)	Plover (0.25 l/ha)	-	
4 Managed	-	Plover (0.25 l/ha)	-	Plover (0.25 l/ha)	
SAC Aberdeen 2003/2004	Nov, or LLS present 20 Nov	Dec 11 Dec			Early stem extn 29 Mar
	GS 1,4-1,5	GS 1,6-1,8			GS 3,1-3,3
1	Untreated	-			-
2	Punch C (0.4 l/ha)	-			Folicur (0.5 l/ha)
3	-	Punch C (0.4 l/ha)			Folicur (0.5 l/ha)
4 Managed	Punch C (0.6 l/ha)	-			Folicur (0.5 l/ha) if LLS present

Table 5.2b. Fungicide treatments used in cultivar x fungicide validation experiments, 2004/2005 (sites are Boxworth (BX), High Mowthorpe (HM) and Rosemaund (RM)).

Treatment	T1 –based on spore numbers before actual 10% plants with phoma	T2 – phoma well established (2-3 weeks after T1)	T3 Maintain disease control (4-6 weeks after T1)	T4 Maintain disease control (4-6 weeks after T2)	T5 Early stem extn for light leaf spot
ADAS sites 2004/2005	BX – 26 Oct HM – 01 Nov RM – 26 Oct	BX – 11 Nov HM – 25 Nov RM – 11 Nov	BX – 8 Dec HM – 13 Jan RM – 9 Dec	BX – 13 Jan HM – 03 Feb RM – 13 Jan	
1	Untreated	-	-	-	
2 Forecast	Plover (0.25 l/ha)	-	Plover (0.25 l/ha)	-	
3 Onset	-	Plover (0.25 l/ha)	Plover (0.25 l/ha)	-	
4 Managed	-	Plover (0.25 l/ha)	-	Plover (0.25 l/ha)	
SAC Aberdeen 2004/2005	Nov, or LLS present 03 Nov	Dec 02 Dec			Early stem extn 10 Mar
	GS 1,4-1,5	GS 1,6-1,8			GS 3,1-3,3
1	Untreated	-			-
2 Forecast	Punch C (0.8 l/ha)	Folicur (1.0 l/ha)			-
3 Onset	-	Punch C (0.8 l/ha)			Folicur (1.0 l/ha)
4 Managed	Punch C (0.6 l/ha)	Folicur (1.0 l/ha)			Folicur (1.0 l/ha) if LLS present

Plots were harvested using a Sampo 2025 plot combine and harvested plot lengths were recorded individually. Moisture content was assessed by a Dickey-John GS2000 and final yield expressed at 90% dry matter. Data were analysed by analysis of variance using GENSTAT (Payne *et al.*, 1993), with use of appropriate transformations of data when data showed a skewed distribution. Weather records were available from an automatic weather station at each site.

<u>SAC Aberdeen cultivar x fungicide experiments</u>

Two field experiments were done in Aberdeenshire, during the seasons 2003/2004 and 2004/2005. Three winter oilseed rape cultivars (Synergy, Winner and Mendel) with differing resistance to light leaf spot were used throughout (Table 5.1). Cultivar Mendel was used because of its clubroot resistance and consequent popularity in Scotland. Experiments were sown at standard timings (late August/early September) and seed rates for Aberdeenshire (6 kg/ha Apex and Escort, 3.6 kg/ha Synergy). The fungicides used were Punch C (carbendazim + flusilazole, 125:250 g a.i/l., standard full dose application rate of 0.8 l/ha) and Folicur (tebuconazole, 250 g a.i./l, standard full dose application rate of 1.0 l/ha) (Tables 5.2a & 5.2b). The dose of fungicides was increased after the first year because of poor control of light leaf spot in 2004.

Four fungicide programmes were used to manipulate disease epidemics; the actual timings of these programmes depending on the disease levels and season (Tables 5.2a & 5.2b). All programmes were designed to test the timing, dose and number of sprays applied in autumn. A standard spray was applied at early stem extension (March), although this could be omitted from the Managed regime if no light leaf spot was observed. Experiments were done as a split plot design, with cultivar as main plot and fungicide as sub-plot treatments, with four replicates. Plots were sown using an Oyjord plot drill, with plot size 40 m^2. Fungicides were applied using an AZO hand held sprayer. Fertiliser and other crop protection applications were done according to local practice (see Appendix 2, Tables 2.7 and 2.14 for site details).

Disease assessments were carried out at regular intervals during the season. Prior to stem extension, 10 plants/plot were incubated in a damp chamber at room temperature for 24 – 48 hours before assessing light leaf spot and other diseases. Plants were assessed for % leaves, % plants and % leaf area affected with light leaf spot, phoma leaf spot and stem canker (and alternaria and downy mildew). At the end of the season, disease assessments were done on stems and pods. Plant counts were done in December and after harvest. Plots were harvested using a Sampo plot combine. Moisture content of seeds was calculated by drying 100g of freshly harvested seed in an oven at 80^{o}C for 48 h then weighing. Final yields were adjusted to 90% dry matter. Data were analysed by analysis of variance using the general linear model of the GENSTAT for Windows package. Selected data are shown in the results. Full details can be found in the Appendix.

5.2.2 Fungicide spray timing experiments at ADAS Boxworth 2003/2004 and 2004/2005

One experiment to investigate the effects of spray timing, dose and number of applications of flusilazole products was done at Boxworth each year on a farm crop (cv. Winner, Table 5.3). Replicated plots, located in a commercial crop of cv. Winner, were sown on 21 August 2003 at ADAS Boxworth. Treatments, replicated four times, were applied by OPS sprayer in 200 l/ha through Lurmark LD02F110 nozzles operated at 2 bars. Plot size was 3 x 24 m.

Fungicide treatment applications were adjusted during the season to ensure synchrony with a late phoma leaf spot epidemic (Table 5.4). The late phoma epidemic on small plants provided a test-bed for spray timing and economic responses to fungicide treatment. The crop was grown with farm inputs and combine harvested on 27 July 2004. Seed was cleaned to remove weed seeds and the moisture content then determined using a Dickie John moisture meter. Final yields were adjusted to 90% dry matter. Assessment methods followed standard protocol guidelines, with 10 plants per plot examined for foliar diseases and 25 plants/plot assessed for stem diseases pre-harvest. Treatments were generally made under good conditions (see Appendix 3 Table 3.2 for details) in 2003/2004. There were frosty periods at the time of the December application. There were breezy conditions at the time of the 23 January application with some spray drift.

Table 5.3. Fungicide timing experment treatments, application rates (l/ha product), dates and growth stages, Boxworth 2003/2004.

Treatment	T1 Phoma onset – forecast date or 10% plants (late October) 27 November GS 1,5	T2 Phoma established – 90% incidence (mid November) 18 December GS 1,5-1,7	T3 4-6 weeks after T1/T2 23 January GS 1,4 – 1,9	T4 Early stem extension (late Feb.) 16 February GS 1,13; 3,1
1	Untreated			
2	Punch C 0.4	-	Punch C 0.4	-
3	Punch C 0.4	-	-	-
4	Punch C 0.6	-	-	-
5	Punch C 0.8	-	-	-
6	-	Punch C 0.4	Punch C 0.4	-
7	-	Punch C 0.4	-	-
8	-	Punch C 0.6	-	-
9	-	Punch C 0.8	-	-
10	-	Punch C 0.4	-	Punch C 0.4

In 2004/2005, the spray timing experiment was repeated with extension of treatments to include flusilazole (as Sanction) so that carbendazim applications did not exceed two per crop. Metconazole (as Caramaba) was included at reduced dose as a potential mixture partner with both fungicidal and plant growth regulatory properties (Table 5.4). Replicated plots, located in a direct drilled, commercial crop of cv. Winner, were sown on 28 August 2004 at ADAS Boxworth, grown with farm inputs and combine harvested on 23 July 2005. Assessment, spraying and harvesting methods were as described for the experiment in 2004.

Treatments were made under good conditions (see Appendix 3 Table 3.4 for details). There was little spray drift and foliage was dry at application.

Table 5.4. Fungicide timing experment treatments, application rates (l/ha product) dates and growth stages, Boxworth 2004/2005.

Treat-ment	T1 Phoma onset – first spots (early October) 19 October GS 1,6	T2 T1 + 4 weeks 17 November GS 1,12	T3 T2 +4 weeks 9 December GS 1,14	T4 Late Feb 7 March GS 3,1	T5* Green bud/mid stem extn 25 March GS 3,5-3,7
1	Untreated			-	
2	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	-
3	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	Folicur 0.5
4	Punch C 0.4	-	Punch C 0.4	-	Folicur 0.5
5	Punch C 0.4	-	Punch C 0.4	Sanction 0.4	Folicur 0.5
6	-	Punch C 0.4	-	Punch C 0.4	Folicur 0.5
7	-	Punch C 0.8	-	-	Folicur 0.5
8	Punch C 0.4	Punch C 0.4	-	-	Folicur 0.5
9	Punch C 0.4	Punch C 0.4	-	Sanction 0.4	Folicur 0.5
10	Punch C 0.4	-	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5
11	-	Punch C 0.4	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5

5.2.3 Fungicide evaluation for light leaf spot control

Data were provided by Syngenta on fungicide product comparisons for light leaf spot control.

5.3 Results

5.3.1 ADAS Cultivar x fungicide experiments

2003/2004

Phoma leaf spot was particularly late in appearing in autumn 2003 after dry conditions in August and September and first symptoms only appeared in early December at Boxworth, High Mowthorpe and Rosemaund (Figure 5.1). Air-borne spores of *L. maculans* were first detected in late October (Table 5.5). At Boxworth, phoma incidence reached 33-85% of plants affected by 14 January and this increased further to 83-90% of plants affected by mid February. Phoma leaf spot was more common than usual later in the season because of the short autumn epidemic. Stem canker symptoms were detected at the late flowering stage and final incidence was 78-100% plants affected. Canker severity was moderate (indices 30-46) despite the late phoma leaf spot development. This may be attributed to the small leaf size of plants when they first became infected in late autumn as dry weather had delayed crop emergence, particularly at Boxworth. Phoma upper stem lesions were common and the incidence increased sharply in June (Table 5.7). Light leaf spot did not reach assessable levels.

Table 5.5. Dates of threshold numbers of ascospores of *Leptosphaeria maculans* on spore traps at ADAS sites, 2003/04

Site	Boxworth	High Mowthorpe	Rosemaund
First ascospores	24 Oct	21 Oct	21 Oct
>10 spores/m^3/day	12 Nov	28 Oct	20 Nov
>100 spores/ m^3/day	10 Dec	25 Nov	Not reached

The main effects of fungicide treatments at Boxworth were to reduce the incidence of phoma leaf spotting in January and the severity of phoma spotting up to the end of April (Table 5.6). Fungicides reduced the severity of stem canker and there was a small, but significant benefit from delaying the first spray from spore release until phoma leaf spot had appeared in the crop (Table 5.7). The later timing also provided slightly better control of phoma stem lesions in early June but no control was evident in late June (Table 5.7).

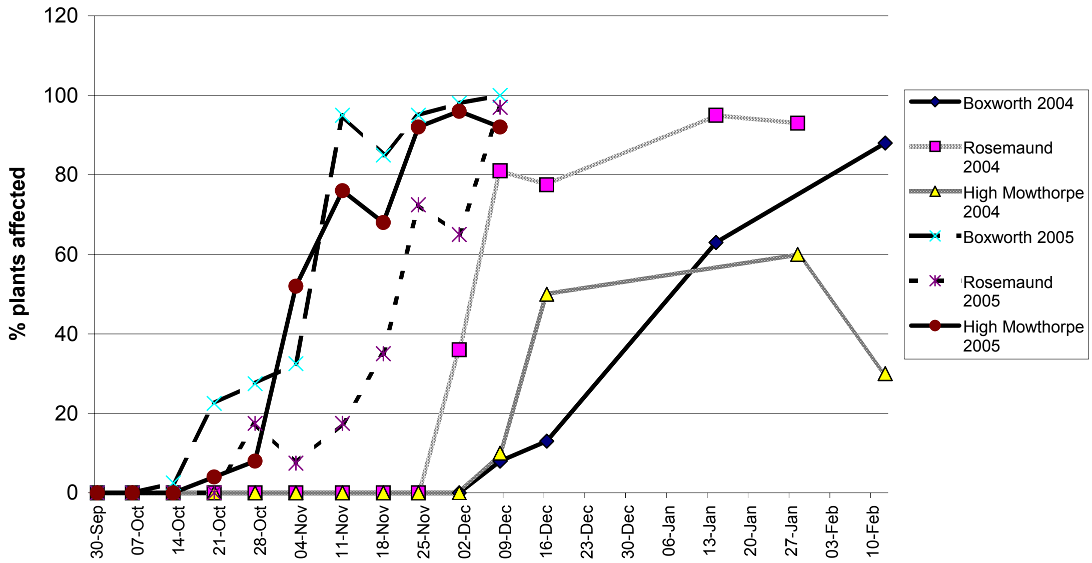


Figure 5.1. Development of phoma leaf spot in autumn and early winter on untreated cv. Royal in ADAS cultivar x fungicide experiments, 2003/04 and 2004/05.

At High Mowthorpe, phoma leaf spot incidence and severity were less than at Boxworth and significantly decreased by fungicides only at the 2 April assessment (Table 5.8). The stem canker index at High Mowthorpe was low and control was achieved with all programmes, with the Forecast regime being better than Onset and Managed programmes (Table 5.9). All fungicide treatments also gave partial control of phoma stem lesions (Table 5.9).

Control of phoma leaf spot was achieved from mid December onwards at Rosemaund in 2003/04. There was a marked effect of fungicide timing by 28 January when the Onset and Managed programmes sprayed on 16 December gave good control whilst the Forecast treatment sprayed on 10 November had only a small effect on disease severity (Table 5.10). Cultivar effects were somewhat variable at this site during the course of the winter. Phoma B spotting was present but no treatment effects were detected. Stem canker was assessed later than at the other two sites. There was most stem canker on cv. Royal. Fungicide significantly reduced stem canker but control was poor (Table 5.11), whilst control of phoma stem lesions approached 50%.

There was sclerotinia stem rot in the experiment at Boxworth, particularly where plants had multiple stems after pigeon grazing. The difference between Royal (18.6% plants affected) and other cultivars (10.0-12.1%) (see Table 5.7) was significant, but fungicide effects were not.

There were significant differences in yield between cultivars at all three sites in 2004 (Table 5.12a). Recital gave the highest yield at Boxworth and the lowest yield at Rosemaund. Royal gave the highest yield overall and performed well at High Mowthorpe. Boxworth was the lowest yielding site as it had been worst affected by the dry conditions in autumn 2003. Yield responses to fungicides were significantly only at Boxworth (Table 5.12b) and these gave a margin over fungicide cost of £25/ha. Plants were smaller in autumn at Boxworth and had only reached the 4-7 leaf stage by early December when phoma leaf spot appeared. At Rosemaund and High Mowthorpe, plants were larger (8-10 leaf stage) and stem cankers were mainly small. These responses at Boxworth may be partially explained by higher plant populations in treated plots compared with the untreated controls pre-harvest (see Appendix 1, Table 1.1). There were no differences between fungicide treatments in the December plant counts at Boxworth.

Table 5.6. Incidence and severity of phoma leaf spot, Boxworth 2003/2004.

	% plants with phoma				% leaf area affected by phoma leaf spot			
Treatment	14/01	12/02	16/03	29/04	14/01	12/02	16/03	29/04
Cultivar								
Escort	29.6	53.7	55.6	64.4	0.53	0.77	0.26	0.20
Royal	28.8	75.0	66.3	62.5	0.23	0.99	0.47	0.35
Recital	13.1	62.5	55.6	73.7	0.11	0.76	0.31	0.34
SED 33df	4.90	8.64	6.73	5.28	0.110	0.156	0.097	0.062
F test	1%	Ns	Ns	Ns	1%	Ns	Ns	5%
Fungicide								
Nil	60.0	86.7	74.2	71.7	0.66	1.38	0.88	0.53
Forecast	6.7	-	55.0	65.0	0.06	-	0.19	0.25
Onset	12.5	-	51.7	64.2	0.31	-	0.15	0.22
Managed	16.2	40.8	55.8	66.7	0.12	0.30	0.18	0.19
SED 33df	5.66	7.05	7.77	6.10	0.127	0.128	0.112	0.072
F test	<0.1%	<0.1 %	5%	Ns	<0.1%	<0.1%	<0.1%	<0.1%
Interaction	<0.1%	Ns	5%	5%	Ns (5.1%)	Ns	Ns	Ns

Table 5.7. Incidence and severity of phoma canker and phoma stem lesions, Boxworth 2003/2004.

	% plants with phoma canker		Phoma stem canker index (0-100)		% plants with phoma stem lesions		Phoma stem lesion index (0-100)		% plants with sclerotinia
	11/06	29/06	11/06	29/06	11/06	29/06	11/06	29/06	29/06
Treatment									
Cultivar									
Escort	16.3	51.9	7.2	19.3	11.2	70.1	2.8	18.2	12.1
Royal	24.4	61.9	10.0	22.6	10.0	83.0	2.7	20.6	18.6
Recital	9.4	34.2	4.1	11.6	15.6	85.0	4.1	21.8	10.0
SED 33df	3.85	5.06	1.97	1.87	3.46	4.45	0.98	1.38	2.68
F test	1% skew	<0.1%	5% skew	<0.1%	Ns	1%	Ns	5%	1%
Fungicide									
Nil	48.3	86.4	21.3	38.0	19.2	83.5	5.0	21.2	15.2
Forecast	10.8	50.3	4.8	16.0	13.3	74.3	3.3	19.1	8.7
Onset	4.2	35.7	1.3	9.8	10.0	84.0	2.7	21.1	15.3
Managed	3.3	25.0	1.0	7.3	6.7	75.7	1.7	19.3	15.0
SED 33df	4.45	5.84	2.28	2.15	4.00	5.14	1.13	1.60	3.09
F test	<0.1% skew	<0.1%	<0.1% skew	<0.1%	5%	ns	5%	Ns	Ns
Interaction	1%	Ns	Ns	Ns	Ns(6%)	Ns	Ns (8%)	Ns	Ns

Table 5.8. Incidence and severity of phoma leaf spot, High Mowthorpe 2003/2004.

	% plants with phoma leaf spot			% leaf area affected by phoma leaf spot		
Treatment	12/03	2/04	20/04	12/03	02/04	20/04
Cultivar						
Escort	16.9	17.5	10.0	0.02	0.09	0.01
Royal	23.8	22.5	28.7	0.04	0.11	0.04
Recital	8.1	18.1	20.0	0.01	0.08	0.02
SED 33df	5.03	5.28	5.54	0.008	0.020	0.010
F test	5%	Ns	Ns	1%*	Ns	Ns
Fungicide						
Nil	20.0	34.2	16.7	0.03	0.13	0.03
Forecast	15.0	10.8	18.3	0.02	0.08	0.02
Onset	15.8	15.8	20.8	0.02	0.08	0.02
Managed	14.2	16.7	22.5	0.02	0.08	0.02
SED 33df	5.81	6.09	6.40	0.009	0.023	0.011
F test	Ns	1%	Ns	Ns*	5%	Ns
Interaction	Ns	Ns	Ns	Ns	Ns	Ns

*Skewed data, angular transformed data analysed satisfactorily but actual percentage data presented

Table 5.9. Incidence and severity of phoma canker and phoma stem lesions, High Mowthorpe 2003/2004.

	% plants with no phoma canker		Phoma canker index (0-100)		% plants with no phoma stem lesions	Phoma stem lesion index (0-100)
	29/06	29/06 ang* trans	29/06	29/06 ang*. trans	29/06	29/06
Treatment						
Cultivar						
Escort	93.0	77.7	1.8*	6.2	74.5	6.4
Royal	81.0	66.2	5.2	12.0	36.7	16.3
Recital	94.5	79.8	1.4	5.0	40.2	15.4
SED 33df		1.99	0.46	0.98	5.47	1.48
F test		<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
			skew			
Fungicide						
Nil	77.0	62.7	6.2	13.5	24.3	19.7
Forecast	97.7	84.4	0.6	2.8	63.3	9.2
Onset	93.7	78.4	1.7	5.9	61.7	9.8
Managed	89.7	72.7	2.8	8.8	52.7	12.0
SED 33df		2.29	0.54	1.13	6.32	1.71
F test		<0.1%	<0.1%	<0.1%	<0.1%	<0.1%
			skew			
Interaction		Ns	<0.1%	Ns	Ns	Ns

Table 5.10. Incidence and severity of phoma leaf spot, Rosemaund 2003/2004.

	% plants with phoma A (B)				% leaf area affected by phoma A (B)			
Treatment	16/12	07/01	28/01	02/03	16/12	07/01	28/01	02/03
Cultivar								
Escort	30.0	45.0	51.5 (5.0)	87.5 (22.5)	0.174	0.356	0.595 (0.0164)	0.87 (0.065)
Royal	61.2	66.2	57.5 (6.3)	92.5 (17.5)	0.411	0.526	0.793 (0.0194)	1.67 (0.047)
Recital	75.0	48.7	38.7 (6.9)	90.0 (32.5)	0.530	0.337	0.380 (0.0381)	0.87 (0.079)
SED 33df	6.66	5.94	5.14 (3.00)	7.55 (11.06)	0.077	0.0768	0.0604 (0.0214)	0.336 (0.0377)
F test	<0.1%	1%	1% (Ns)	Ns (Ns)	0.1%	5%	<0.1% (Ns)	Ns (Ns)
Fungicide								
Nil	72.5	75.0	82.5 (6.7)	90.0 (24.2)	0.497	0.653	1.275 (0.0452)	1.14 (0.063)
Forecast	38.3	31.7	75.8 (6.7)	-	0.247	0.160	0.863 (0.0214)	-
Onset	-	-	22.5 (3.3)	-	-	-	0.128 (0.0137)	-
Managed	-	-	15.8 (7.5)	-	-	-	0.091 (0.0183)	-
SED 33df	5.44	4.85	5.94 (3.46)	-	0.0628	0.0627	0.0697 (0.02477)	-
F test	<0.1%	<0.1%	<0.1% (Ns)		0.1%	<0.1%	<0.1% (Ns)	
Interaction	Ns	1%	Ns (Ns)		Ns	1%	0.1% (Ns)	

Table 5.11. Incidence and severity of phoma canker and phoma stem lesions, sclerotinia and light leaf spot at harvest, Rosemaund 2003/2004.

	% plants with phoma canker	Phoma canker index (0-100)	% plants with phoma stem lesions	Phoma stem lesion index (0-100)	% main stems with sclerotinia	Sclerotinia main stem index (0-100)	% plants sclerotinia	Light leaf spot % stems	Light leaf spot % stem area
	25/07	25/07	25/07	25/07	25/07	25/07	25/07	25/07	25/07
Treatment									
Cultivar									
Escort	58.0	21.25	58.2	15.94	4.7	4.37	7.5	2.5	0.36
Royal	85.7	31.31	59.0	17.19	6.5	5.31	8.5	15.8	1.06
Recital	54.5	18.75	81.0	23.12	11.8	11.31	14.0	2.5	0.08
SED 33df	4.09	1.918	6.69	2.158	2.54	2.275	3.38	5.32	0.373
F test	<0.1%	<0.1%	1%	1%	5%	1%	Ns	5%	5%
Fungicide									
Nil	75.0	28.75	89.0	27.67	5.3	5.08	8.3	20.3	1.42
Forecast	66.3	24.58	61.7	17.00	8.0	7.58	11.0	1.7	0.25
Onset	66.0	26.08	59.0	15.83	11.3	9.75	13.3	3.3	0.06
Managed	57.0	19.67	54.7	14.50	6.0	5.58	7.3	2.3	0.26
SED 33df	4.72	2.215	7.72	2.492	2.94	2.627	3.90	6.14	0.431
F test	1%	1%	<0.1%	<0.1%	Ns	Ns	Ns	5%	5%
Interaction	Ns	Ns	Ns	Ns	Ns	Ns	Ns	1%	<0.1%

Table 5.12. Yield in cultivar x fungicide experiments at 3 ADAS sites, 2003/2004:

a) cultivar mean yield

Treatment	Yield at 90% DM (t/ha)			
	Boxworth	High Mowthorpe	Rosemaund	Mean
Cultivar				
Escort	2.46	3.71	4.36	3.48
Royal	2.70	4.54	4.51	3.93
Recital	3.07	4.05	3.68	3.61
SED 33df	0.120	0.088	0.1421	
F test	<0.1%	1%	<0.1%	
cv	10.7%	6.1%	9.6	

b) fungicide mean yield

Treatment	Yield (t/ha)											
	Boxworth				High Mowthorpe				Rosemaund			
Fungicide	Escort	Royal	Recital	Mean	Escort	Royal	Recital	Mean	Escort	Royal	Recital	Mean
Nil	2.42	2.30	2.57	2.43	3.64	4.44	3.76	3.95	4.38	4.39	3.52	4.10
Forecast	2.44	2.73	3.25	2.80	3.69	4.61	4.20	4.17	4.53	4.43	3.59	4.18
Onset	2.46	2.92	3.13	2.84	3.85	4.62	4.26	4.24	4.59	4.41	3.82	4.27
Managed	2.55	2.87	3.33	2.92	3.67	4.52	3.97	4.05	3.94	4.80	3.77	4.17
SED 33df	0.240			0.138	0.101			0.175	0.164			0.231
F test	Ns			1%	5%			Ns	Ns			Ns
Interaction	Ns				Ns				Ns			

ADAS Cultivar x fungicide experiments 2004/2005

Ascospores were detected particularly early in autumn 2004, following above average rainfall in August. Spores were collected as soon the spore trap was operated at High Mowthorpe on 24 August and at other sites the spore concentration thresholds (Table 5.13) were reached 4-8 weeks earlier than in 2003. September had below average rainfall and the potential September epidemic did not materialise. This is a warning that very early phoma leaf spot epidemics can occur in the UK.

Table 5.13. Threshold numbers of phoma spores on spore traps 2004/05.

Site	Boxworth	High Mowthorpe	Rosemaund
First ascospores	08 Sept	24 Aug	13 Sept
>10 spores/m^3/day	15 Oct	24 Aug	15 Sept
>100 spores/ m^3/day	04 Nov	14 Sept	19 Oct

At Boxworth, phoma leaf spot was first detected on 11 October and thresholds were reached by 18 October (Figure 5.1). High levels of phoma were present by 8 November, though there was less on Escort than the other two cultivars. Plots which received a fungicide on 26 October were quite heavily re-infected by 9 December and T3 sprays were applied at this stage (Table 5.14). At Rosemaund, phoma leaf spot appeared on 18 October and reached the threshold by 25 October. Thereafter, phoma incidence increased steadily and re-infection of plots sprayed on 26 October was obvious on 9 December (Table 5.14). At High Mowthorpe, phoma leaf spot was first recorded on 18 October and thresholds were reached by 1 November (Figure 5.1).

Foliar sprays gave prolonged control of phoma leaf spotting in 2004/05. The control of phoma leaf spot achieved by T1 sprays became apparent quite slowly during November. Fungicide treatments gave large reductions (c. 80%) in the severity of phoma leaf spot and there were some small but significant differences between cultivars in early December (Table 5.15). Spray programmes completed on 8 December were still giving good control of phoma leaf spot in February at Rosemaund and in March at Boxworth (Table 5.16). In January at High Mowthorpe, all the spray programmes gave good control of phoma leaf spot; untreated severity was 1.84% leaf area affected and treatments averaged 0.14-0.42% area affected (Table 5.18).

The Managed programme, which had the latest treatment application (13 January), maintained good control of phoma leaf spot until 24 April at Boxworth (Table 5.17). All fungicide programmes were effective under lower disease pressure at Rosemaund on 13 April (Table 5.17). At High Mowthorpe, disease assessments in January at the time of the T3 application showed that all fungicide treatments had reduced the incidence and severity of phoma leaf spot, by about 50% and 70%, respectively. In mid - late April, 50-78% untreated cultivars were affected by phoma leaf spot and levels of control were still about 50% (based on incidence) and 70% (based on severity assessments) (Tables 5.18 & 5.19).

Table 5. 14. Disease assessments at T3 timing at Boxworth and Rosemaund, 9 December 2004.

Cultivar	Fungicide	Boxworth 9 December 2004		Rosemaund 9 December 2004	
		% plants with phoma leaf spot	% leaf area with phoma leaf spot	% plants with phoma leaf spot	% leaf area with phoma leaf spot
Escort	Untreated	100	1.77	93	2.06
	Forecast	45	0.20	48	0.39
	Onset	68	0.17	58	1.06
	Managed	70	0.20	53	0.48
Recital	Untreated	100	2.23	93	1.76
	Forecast	23	0.04	30	0.16
	Onset	75	0.25	18	0.06
	Managed	68	0.24	45	0.43
Royal	Untreated	100	2.38	95	2.12
	Forecast	60	0.11	35	0.34
	Onset	95	0.78	28	0.14
	Managed	63	0.18	35	0.22
	SED (33 df)	10.09	0.239	14.29	0.291
		5.05 cultivar 5.83 fungicide	0.120 cultivar 0.138 fungicide	7.14 cultivar 8.25 fungicide	0.145 cultivar 0.168 fungicide
	F test	<0.1% fungicide 5% cultivar 5% interaction	<0.1% fungicide Ns cultivar & interaction	<0.1% fungicide 5.8%cultivar Ns interaction	<0.1% fungicide 5% cultivar Ns interaction

Table 5.15. Fungicide treatment data from disease assessments at T3 timing at Boxworth and Rosemaund 9 December 2004.

Cultivar	Fungicide	Boxworth 9 December 2005		Rosemaund 9 December 2005	
		% plants with phoma leaf spot	% leaf area with phoma leaf spot	% plants with phoma leaf spot	% leaf area with phoma leaf spot
Mean of	Untreated	100	2.13	93	1.98
3 varieties	Forecast	43	0.12	38	0.30
	Onset	79	0.40	34	0.42
	Managed	67	0.21	44	0.36
	SED (33 df)	5.83	0.138	8.25	0.168
	F test	<0.1%	<0.1%	<0.1%	<0.1%

Table 5.16. Disease assessments at early stem extension at Boxworth and Rosemaund Feb/March 2005.

Cultivar	Fungicide	Boxworth 11 March 2005		Rosemaund 17 February 2005	
		% plants with phoma leaf spot	% leaf area with phoma leaf spot	% plants with phoma leaf spot	% leaf area with phoma leaf spot
Escort	Untreated	98	0.44	78	0.95
	Forecast	70	0.15	28	0.18
	Onset	55	0.12	23	0.12
	Managed	45	0.07	25	0.19
Recital	Untreated	100	0.66	70	0.68
	Forecast	75	0.13	18	0.08
	Onset	68	0.12	25	0.22
	Managed	60	0.10	23	0.13
Royal	Untreated	100	0.64	68	0.69
	Forecast	80	0.15	15	0.09
	Onset	88	0.21	25	0.11
	Managed	85	0.18	20	0.09
	SED (33 df)	9.67	0.040	10.7	0.116
		4.83 cultivar 5.58 fungicide	0.020 cultivar 0.023 fungicide	5.35 cultivar 6.18 fungicide	0.058 cultivar 0.067 fungicide
	F test	<0.1% cultivar and fungicide	<0.1% cultivar and fungicide 1% interaction	<0.1% fungicide	<0.1% fungicide

Table 5.17. Disease assessments at early flowering at Boxworth and Rosemaund, April 2005.

Cultivar	Fungicide	Boxworth 24 April 2005		Rosemaund 13 April 2005*	
		% plants with phoma leaf spot	% leaf area with phoma leaf spot	% plants with phoma leaf spot	% leaf area with phoma leaf spot
Escort	Untreated	95	0.30	15	0.08
	Forecast	80	0.30	10	0.01
	Onset	95	0.24	23	0.05
	Managed	63	0.13	15	0.02
Recital	Untreated	100	0.80	33	0.16
	Forecast	95	0.50	5	0.01
	Onset	98	0.48	10	0.03
	Managed	85	0.24	5	0.01
Royal	Untreated	98	0.77	28	0.08
	Forecast	93	0.59	5	0.02
	Onset	95	0.69	3	0.01
	Managed	98	0.26	0	0
	SED (33df)	5.73	0.131	0.79	0.034
		5.83 cultivar 6.73fungicide	0.066 cultivar 0.076fungicide	0.393 cultivar 0.454 fungicide	0.017 cultivar 0.020 fungicide
	F test	<0.1% cultivar; fungicide 1% interaction	<0.1% cultivar; fungicide Ns interaction	<0.1% fungicide Ns interaction	<0.1% fungicide

*Very first stem cankers recorded 7.5% untreated Royal and 2.5% untreated Escort

Table 5.18. Disease assessments at T3 timing (January) and green bud stage (April) at High Mowthorpe, 2005.

cultivar	Fungicide	13 January 2005		12 April 2005		12 April 2005	
		% plants with phoma leaf spot	% leaf area with phoma leaf spot	% plants with phoma leaf spot	% leaf area with phoma leaf spot	% plants with light leaf spot	% leaf area with light leaf spot
Escort	Untreated	63	1.55	50	1.20	0	0
	Forecast	30	0.04	15	0.23	0	0
	Onset	23	0.26	18	0.28	0	0
	Managed	25	0.16	13	0.18	0	0
Recital	Untreated	75	1.67	70	1.60	17.5	0.30
	Forecast	48	0.50	28	0.55	10.0	0.35
	Onset	33	0.10	28	0.43	2.5	0.03
	Managed	23	0.16	28	0.58	10.0	0.40
Royal	Untreated	68	2.31	78	2.28	0	0
	Forecast	53	0.73	40	0.73	0	0
	Onset	33	0.41	40	1.13	0	0
	Managed	35	0.11	45	0.65	0	0
	SED (33 df)	11.85	0.409	9.85	0.295	5.55	0.179
		6.84 fungicide 5.93 cultivar	0.236 fungicide 0.204 cultivar	4.92 cultivar 5.69 fungicide	0.148 cultivar 0.170 fungicide	2.78 cultivar 3.20 fungicide	0.090 cultivar 0.104 fungicide
	F test	<0.1% fungicide Ns cultivar Ns interaction	<0.1% fungicide Ns cultivar Ns interaction	<0.1% cultivar and fungicide Ns interaction	<0.1% cultivar and fungicide Ns interaction	<0.1% cultivar Ns fungicide Ns interaction	1% cultivar Ns fungicide Ns interaction

Table 5.19. Phoma and light leaf spot disease assessments at early flowering at High Mowthorpe, April 2005.

Cultivar	Fungicide	26 April 2005		26 April 2005	
		% plants with phoma leaf spot	% leaf area with phoma leaf spot	% plants with light leaf spot	% leaf area with light leaf spot
Escort	Untreated	83	2.24	0	0
	Forecast	43	0.39	0	0
	Onset	35	0.33	0	0
	Managed	43	0.27	0	0
Recital	Untreated	70	1.51	45	7.2
	Forecast	43	0.29	20	0.8
	Onset	50	0.44	8	0.2
	Managed	35	0.37	0	0
Royal	Untreated	83	1.73	5	0.1
	Forecast	58	0.55	0	0
	Onset	60	0.46	0	0
	Managed	40	0.20	0	0
	SED (33 df)	15.14	0.332	11.46	1.75
		7.57 cultivar 8.74 fungicide	0.166 cultivar 0.192 fungicide	5.73 cultivar 6.62 fungicide	0.87 cultivar 1.01 fungicide
	F test	Ns cultivar <0.1% fungicide Ns interaction	Ns cultivar <0.1% fungicide Ns interaction	1% cultivar Ns fungicide Ns interaction	5% cultivar Ns fungicide 5% interaction

Table 5.20. Disease assessments on stem canker at early flowering (24 April) and end of flowering (2 June) at Boxworth 2005.

Cultivar	Fungicide	4 April 2005		2 June 2005		
		% plants with phoma canker	Canker index (0-4)	% plants with phoma canker	Canker index (0-4)	% plants with phoma stem lesions
Escort	Untreated	20	0.23	38	0.58	18
	Forecast	0	0.00	15	0.15	18
	Onset	20	0.23	12	0.13	23
	Managed	8	0.08	8	0.08	13
Recital	Untreated	20	0.25	65	0.85	45
	Forecast	10	0.13	15	0.20	43
	Onset	8	0.10	18	0.23	45
	Managed	8	0.10	8	0.08	20
Royal	Untreated	25	0.28	53	0.78	20
	Forecast	5	0.05	23	0.25	20
	Onset	13	0.13	23	0.25	15
	Managed	23	0.28	3	0.08	23
	SED (32 df)	8.24	0.109	7.66	0.126	8.89
		4.12 cultivar 4.76 fungicide	0.055 cultivar 0.063 fungicide	3.83 cultivar 4.42 fungicide	0.063 cultivar 0.073 fungicide	4.45 cultivar 5.13 fungicide
	F test	5% fungicide	5% fungicide	<0.1% fungicide	<0.1% fungicide	<0.1% cultivar

Table 5.21. Disease assessments on stem canker at end of flowering (3 June) at Rosemaund 2005.

Cultivar	Fungicide	3 June 2005		3 June 2005	
		% plants with phoma canker	Phoma canker index (0-4)	% plants with phoma stem lesions	Phoma stem lesion index (0-4)
Escort	Untreated	38	0.73	2.5	0.10
	Forecast	20	0.20	5.0	0.15
	Onset	35	0.50	5.0	0.05
	Managed	18	0.23	2.5	0.03
Recital	Untreated	80	0.88	0.0	0.00
	Forecast	20	0.23	7.5	0.08
	Onset	25	0.25	0.0	0.00
	Managed	28	0.30	2.5	0.05
Royal	Untreated	70	0.83	7.5	0.08
	Forecast	23	0.33	2.5	0.05
	Onset	18	0.30	5.0	0.10
	Managed	15	0.15	7.5	0.08
	SED (32 df)	1.68	0.079	0.089	0.034
		0.837 cultivar 0.967 fungicide	0.039 cultivar 0.045 fungicide	0.044 cultivar 0.051fungicide	0.017 cultivar 0.020 fungicide
	F test	<0.1% fungicide	<0.1% fungicide	Ns	<0.1% fungicide

Table 5.22. Disease assessments on stem canker at end of flowering at High Mowthorpe 2005.

Cultivar	Fungicide	7 June 2005		7 June 2005	
		% plants with phoma canker	Phoma canker index (0-4)	% plants with phoma stem lesions	Phoma stem lesion index (0-4)
Escort	Untreated	58	0.98	48	0.48
	Forecast	50	0.68	18	0.20
	Onset	50	0.70	12	0.23
	Managed	23	0.28	18	0.18
Recital	Untreated	60	0.80	73	1.03
	Forecast	45	0.50	35	0.48
	Onset	55	0.58	38	0.45
	Managed	65	0.88	35	0.40
Royal	Untreated	95	1.30	45	0.58
	Forecast	32	0.40	30	0.30
	Onset	48	0.50	28	0.28
	Managed	53	0.78	8	0.08
	SED (33 df)	16.52	0.222	10.79	0.139
		8.26 cultivar 9.54 fungicide	0.111 cultivar 0.128 fungicide	5.40 cultivar 6.23 fungicide	0.070 cultivar 0.080 fungicide
	F test	Ns cultivar 5% fungicide Ns interaction	Ns cultivar 1% fungicide 5% interaction	1%cultivar <0.1% fungicide Ns interaction	<0.1% cultivar and fungicide Ns interaction

Escort continued to show the lowest phoma leaf spot severity at Boxworth, but this was not the case at other sites where cultivar differences were more variable. Light leaf spot was most active on Recital at High Mowthorpe and was first recorded in mid April. It was well controlled by Plover programmes as severity was reduced from 7.2% to 0-0.8% leaf area affected. (Table 5.19). Given the disease distribution on the three cultivars (all with light leafspot resistance ratings of 6 or 7), the emergence of a new race able to overcome the resistance of Recital is suspected.

Stem cankers appeared early in 2005 and the first cankers were observed at the start of flowering or during flowering. Early stem cankers were expected to cause yield loss in 2005. Control of stem canker with the fungicide treatments was evident from early flowering (April) and at the end of flowering. All fungicide treatments gave control of canker at all three sites in early June, but there was no significant difference between cultivars (Table 5.20, 5.21 & 5.22). Phoma stem canker incidence was rather lower than usual at Boxworth in 2005 and this reflected lower inoculum after a reduced area of winter oilseed rape in the locality survived to harvest in 2004. The phoma canker index was below 25 in all treatments except untreated Royal (Table 5.23). The untreated canker indices followed the current canker resistance ratings (Royal 4, Escort 5 and Recital 6) at the pre-harvest assessments. At Boxworth, however, averaged across all treatments, Escort had the lowest canker severity. The incidence of moderate or severe canker ranged from 7% in Recital to 19% in Royal and was decreased by fungicides on Royal and Escort but not Recital. The Managed treatment was significantly more effective than the Onset programme. Usually yield responses are small or absent at this level of severity.

There were numerous small phoma stem lesions pre-harvest with significantly lower incidence on Escort (72% plants affected) than on other cultivars (88% plants affected) at Boxworth (Table 5.23). Fungicide treatments had no effect on these stem lesions. Powdery mildew affected stems and pods throughout the experiment, (average 14.6% stem area and 7.1% pod area affected). Sclerotinia affected only 1% of plants overall. Fungicide treated plots did not show lodging at Boxworth apart from the Forecast treatment on Escort (16% lodged); untreated cultivars had some lodging: Royal (28%), Recital (13%) and Escort (40%).

At Rosemaund, stem canker control was achieved with all fungicide treatments at the end of flowering and pre-harvest (Tables 5.21 & 5.24). The efficacy of control was about 50% in the more effective treatments. Light leaf spot and alternaria were not controlled by fungicides, a not unexpected effect given the late occurrence of these diseases. Both stem cankers and phoma stem lesions were present at high levels at High Mowthorpe and both were fungicides significantly decreased by (Tables 5.22 & 5.25). Phoma stem lesions were most prevalent on Recital as at Boxworth.

Table 5.23. Disease assessments on stem canker pre-harvest (28 June) at Boxworth 2005.

Cultivar	Fungicide	28 June 2005		28 June 2005	
		% plants with phoma canker	Canker index (0-100)	% plants with phoma stem lesions	Phoma stem lesion index (0-100)
Escort	Untreated	63	21	67	21
	Forecast	28	7	76	20
	Onset	37	11	72	20
	Managed	19	5	74	19
Recital	Untreated	62	18	97	32
	Forecast	41	14	86	26
	Onset	42	13	93	26
	Managed	24	7	79	22
Royal	Untreated	88	27	95	29
	Forecast	58	15	83	23
	Onset	63	18	88	26
	Managed	34	9	88	26
	SED (33 df)	7.56	2.53	7.84	6.27
		3.78 cultivar 4.36 fungicide	1.26 cultivar 1.46 fungicide	3.92 cultivar 4.53 fungicide	3.14 cultivar 3.62 fungicide
	F test	<0.1% cultivar + fungicide	<0.1% cultivar + fungicide	<0.1% cultivar	<0.1% cultivar

Table 5.24. Disease assessments on stem canker and light leaf spot pre-harvest (20 July) at Rosemaund 2005.

Cultivar	Fungicide	20 July 2005		20 July 2005	
		% plants with phoma canker	Canker index (0-100)	% stem area with light leaf spot lesions	% stem area with alternaria
Escort	Untreated	96	39.8	2.0	1.8
	Forecast	60	23.8	3.0	1.5
	Onset	77	32.8	0.0	0.5
	Managed	63	23.8	0.0	1.5
Recital	Untreated	95	43.0	3.8	2.3
	Forecast	51	17.0	1.8	1.8
	Onset	46	18.8	1.8	1.5
	Managed	64	28.5	1.0	1.3
Royal	Untreated	93	38.0	1.3	1.8
	Forecast	65	25.8	1.3	0.9
	Onset	61	22.3	0.8	1.0
	Managed	56	19.0	3.3	1.3
	SED (32 df)	11.05	6.62	1.75	0.86
		5.53 cultivar 6.38 fungicide	3.31 cultivar 3.82 fungicide	0.875 cultivar 1.011 fungicide	0.429 cultivar 0.496 fungicide
	F test	<0.1% fungicide	<0.1% fungicide	Ns	Ns

Table 5.25. Disease assessments on stem canker pre-harvest at High Mowthorpe July 2005.

Cultivar	Fungicide	20 July 2005		20 July 2005	
		% plants with phoma canker	Canker index (0-100)	% plants with phoma stem lesions	Phoma stem lesion index (0-100)
Escort	Untreated	67	32	76	20
	Forecast	28	10	58	15
	Onset	43	22	54	14
	Managed	45	20	45	12
Recital	Untreated	84	45	97	53
	Forecast	47	16	89	31
	Onset	58	22	87	28
	Managed	58	21	79	23
Royal	Untreated	90	46	95	30
	Forecast	54	18	64	16
	Onset	56	22	65	17
	Managed	68	28	70	19
	SED (33 df)	7.0	4.6	7.8	1.3
		3.5 cultivar 4.1 fungicide	2.3 cultivar 2.6 fungicide	3.9 cultivar 4.5 fungicide	2.6 cultivar 3.0 fungicide
	F test	<0.1% cultivar and fungicide Ns interaction	5% cultivar <0.1% fungicide Ns interaction	<0.1% cultivar and fungicide Ns interaction	<0.1% cultivar and fungicide Ns interaction

Table 5.26. Yield (90% dry matter) and yield responses at Boxworth, High Mowthorpe and Rosemaund 2005.

Cultivar	Fungicide	Boxworth		Rosemaund		High Mowthorpe		Mean
		Yield (t/ha)	Yield response (t/ha)	Yield (t/ha)	Yield response (t/ha)	Yield (t/ha)	Yield response (t/ha)	Yield response (t/ha)
Escort	Untreated	4.56		4.15		3.41		
	Forecast	4.65	0.09	4.90	0.75	3.59	0.18	0.34
	Onset	4.76	0.20	5.04	0.89	3.34	-0.07	0.34
	Managed	4.89	0.33	5.13	0.98	3.67	0.26	0.52
Recital	Untreated	4.61		4.40		3.17		
	Forecast	4.72	0.11	5.19	0.79	3.57	0.40	0.43
	Onset	4.66	0.05	4.32	-0.08	3.41	0.24	0.07
	Managed	4.92	0.31	4.73	0.33	3.41	0.24	0.29
Royal	Untreated	4.44		4.27		4.30		
	Forecast	5.09	0.65	5.82	1.55	4.66	0.36	0.85
	Onset	4.82	0.38	5.24	0.97	4.40	0.10	0.48
	Managed	5.00	0.56	5.55	1.28	4.42	0.12	0.65
	SED (32 df)	0.123 interaction		0.824 interaction		0.170 interaction		
		0.071 fungicide 0.061 cultivar		0.476 fungicide 0.412 cultivar		0.085 cultivar 0.098 fungicide		
	CV(%)	3.6		17.4		6.4		
	F test	<0.1% fungicide Ns Cultivar 5% interaction		0.029 fungicide Ns Cultivar Ns interaction		<0.1% cultivar 5% fungicide Ns interaction		

Yield

Yields were above average at Boxworth in 2005. There were significant responses to fungicide but not to cultivar at Boxworth. All the fungicide programmes gave a significant response (LSD = 0.14 t/ha) and the best programme was the Managed programme where sprays were applied on 11 November and 19 January (Table 5.26). The fungicide x cultivar interaction showed that there were larger responses on Royal and indicated that earlier timings may be required on susceptible cultivars. There was a better response from the stretched interval between sprays. Optimising the timing gave an extra 0.20 t/ha and illustrates the potential benefits of improved guidance on spray timing.

There were high yields and some large responses to fungicide at Rosemaund. Phoma canker severity was moderate and treatments reduced this to an index of about 25 (see Table 5.24) across all cultivars There were large responses on Royal and Escort across all three fungicide treatments (0.75-1.55 t/ha). The responses on Recital were variable and only the Forecast treatment resulted in a large yield response (Table 5.26). The yield benefits were larger than might be expect from phoma canker control alone. Control of light leaf spot and alternaria probably added to the yield response (Table 5.26) and fungicides also appeared to have effects on lodging. There was variation in lodging severity and no significant treatment effects were identified. Optimising the programmes by cultivar gave benefits of about 0.5 t/ha.

At High Mowthorpe, there were significant differences between cultivars and fungicide treatments. Royal gave the highest yield and the Forecast treatment (October + December) gave the greatest yield response (Table 5.26). Stem canker lesions were small pre-harvest and responses of about 0.2 t/ha were indicative of low disease pressure. Responses were rather higher on Recital and this reflected the control of light leaf spot on this cultivar.

Margins over fungicide costs were very variable between sites, treatments and varieties. All treatments on Royal at Boxworth and Rosemaund, Escort at Rosemaund and the Forecast treatment on Recital at Rosemaund gave large margins over fungicide costs. Mean data showed only the Forecast treatment on Recital was not cost effective, contrasting with a mean margin of £85/ha for the Forecast treatment on Royal.

Over the two years of this project, there appears to be some flexibility in timing of the first spray application with Plover, which is known to have curative activity. Thus short delays of 1-2 weeks may not adversely affect disease control and yield response.

5.3.2 SAC culitivar x fungicide experiments for light leaf spot

2003/2004

Weather and general crop growth

The experiment was sown slightly later than the ideal timing for the area but at a similar time to commercial crops. The weather was very dry after sowing and the crop was very slow to emerge, particularly in replicates 1 & 2 that were in the drier part of the field at the top of the slope. There was concern that the crop would not survive if the winter was severe. Fortunately, from mid-October the weather was wet but mild (Figure 5.2) and the crop survived the winter. Although there was ample rain during the autumn, conditions were much drier than in 2002/2003.

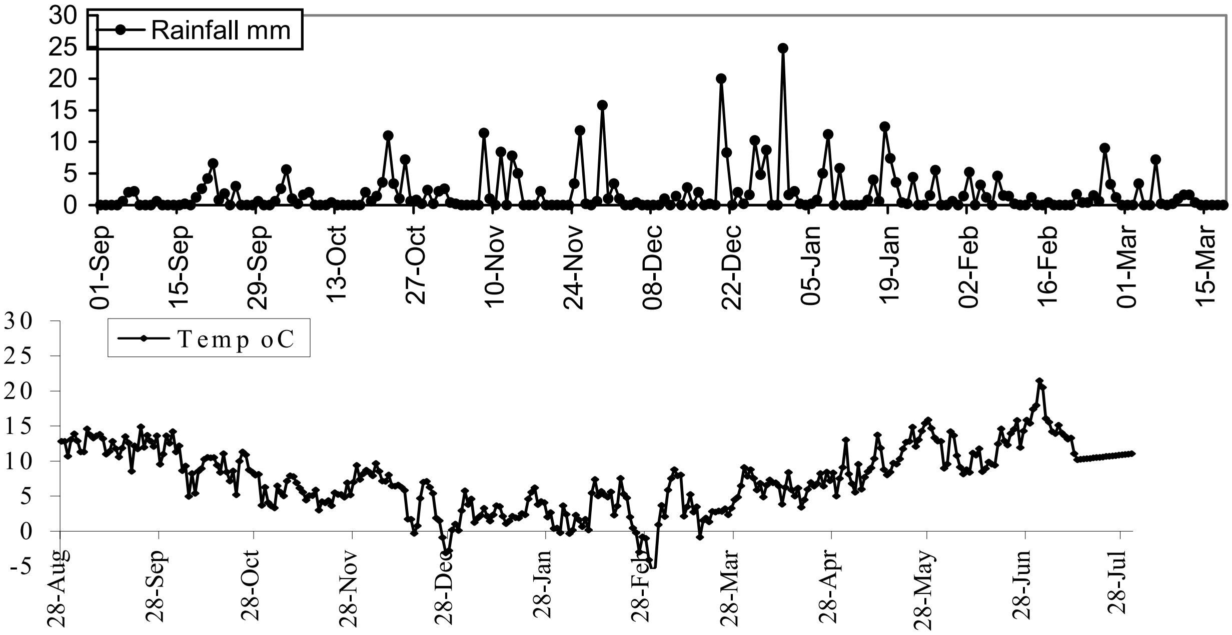


Figure 5.2. Rainfall and temperature in Aberdeen, 2003-2004.

During the autumn and winter the plots were quite thin. The cultivar Synergy was especially sparse, short and suffered from 'Bienvenu syndrome, particulary in replicates 1 & 2 (Table 5.27). Bienvenu syndrome was first detected in the cultivar Bienvenu during the 1990s. The first true leaf is often enlarged and the second leaf is fused into a 'trumpet'. Production of subsequent leaves is encouraged with the result these leaves are often greatly reduced in size. By mid-December, Synergy had started to recover and plant counts were within the range required for this cultivar (see Appendix 2 Table 2.2). Conditions were drier and warmer during spring and summer but turned wet again near harvest and the crop was not harvested until mid-August.

Table 5.27. Physical properties of oilseed rape cultivars, Abnerdeen 2003/04.

Cultivar	Plants with Bienvenu syndrome (%)	Height of plants (cm)
Synergy	15.0	3.87
Mendel	0	5.00
Winner	0	5.48
SED	7.07	0.81
df	6	6
LSD	17.30	1.98
significance	ns	ns

Development of light leaf spot in untreated plots, 2003 – 2004.

The first light leaf spot was found in untreated plots of all cultivars in mid December (Table 5.28). Disease levels in untreated plots increased during the winter and spring months, reaching a maximum in May/June. The disease development curves for all three cultivars were similar. Calculation of AUDPC for the whole season showed that the levels of light leaf spot in the susceptible cultivars Synergy and Mendel were similar, but were higher in the less susceptible cv. Winner. The incidence of stem light leaf spot lesions in all cultivars was high at the end of the season but the severity of stem lesions was low. There were few differences between the cultivars. Pod disease was very low, but the cultivar Winner showed the highest pod infection.

Efficacy of fungicide programmes for control of light leaf spot, 2003 – 2004.

Fungicide programmes did not reduce the incidence (% plants affected) of light leaf spot in any cultivar at any time during the season (Table 5.28). Application of an autumn spray in November or December failed to reduce the % leaves affected during the autumn or early spring. After application of 0.5 l/ha Folicur at stem extension there were little or no interactions between cultivar and fungicide programme on the % leaves affected during late spring/summer. In general, Winner had significantly greater % leaves affected compared with Synergy and Mendel. All ungicide programmes reduced incidence (% leaves affected) and severity (% leaf area infected) of light leaf spot compared with the untreated but there were no differences between the fungicide programmes. Fungicide had no effect on incidence or severity of stem and pod disease (Table 5.28)

Phoma leaf spot, 2003 – 2004.

Very little phoma leaf spot developed in the trial this season (Table 6). The disease first appeared on the cultivar Winner in mid-January, but did not appear on Synergy or Mendel until the end of March 2004. Maximum incidence was 2.5% plants affected. There were no effects of fungicide.

Plant counts, 2003 – 2004.

Cultivars were sown at rates of 6 kg/ha (Winner) and 3.6 kg/ha (Synergy & Mendel), rates typical for Aberdeenshire, to give plant establishments of 60 – 70 plants/m^2 and 40 plants/m^2. The actual plant establishment in untreated plots in December 2003 were 97 plants/m^2 (Winner), 47 plants/m^2 (Synergy) and 48 plants/m^2 (Mendel) (see Appendix 2 Table 2.2). Average plant losses over-winter were 17.2% in Synergy and 22.3% in Winner. There were no winter plant losses in Mendel; this was significantly different to the other two cultivars. Fungicide treatments did not reduce plant losses during the season.

Yield and yield components, 2003 – 2004.

Cultivars Mendel and Winner gave the highest average yield, 3.30 t/ha and 3.27 t/ha respectively, (Table 5.29). This was significantly higher than Synergy, which yielded 2.57 t/ha. Mendel gave the highest average yield benefit from fungicide treatment, (9.0%), compared with Synergy (7.4%). Despite producing high yields, the average yield response to fungicide treatment in Winner was only 6.6%. Application of fungicide did not significantly improve the yield or yield response in any of the three cultivars. Mendel and Winner both gave significantly higher MOFC (£407.2/ha & £404.4/ha) compared with Synergy (£313.5/ha). Fungicide application did not improve the MOFC compared with the untreated in any of the cultivars. Calculation of the economic benefits of the fungicide programmes showed that on average £1.30/ha - £1.50/ha was lost if fungicide was applied to Synergy or Winner rather than leaving the crop untreated. There was an average benefit of £11.80/ha to growers who applied fungicide to the cultivar Mendel. These differences, however, were not significant. There were no differences between the fungicide programmes on any of the cultivars.

General comments

Application of fungicide in the autumn failed to reduce levels of light leaf spot in any of the cultivars grown. This was reflected in little or no yield benefit from the use of fungicide. As a result growers would have lost money from using fungicide this season, particularly on the light leaf spot susceptible cultivar Synergy and the less susceptible cultivar Winner. Even on the light leaf spot susceptible but clubroot resistant cultivar Mendel, economic returns from the use of fungicide would have been low. These results may in part reflect the influence of light leaf spot on very small plants early in the season and the poor initial establishment of cultivar Synergy. However, results support the findings of the previous three years from PASSWORD.

Table 5.28a. Effect of fungicide on levels of light leaf spot, Aberdeen, 2003 – 2004.

Cultivar	Treatment	% plants affected								% Leaves affected							
Date		24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun	AUDPC	24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun	AUDPC
GS		1,03-1,05	1,06-1,08	1,07-1,09	3,1	3,1-3,3	4,0/4,1	5,1		1,03-1,05	1,06-1,08	1,07-1,09	3,1	3,1-3,3	4,0/4,1	5,1	
Synergy																	
	Untreated	0	7.8	7.5	95.0	92.5	100.0	100	10849	0	1.6	1.00	74.4	29.7	76.1	84.6	5786
	Full	-	-	15.0	-	95.0	100.0	100	11462	-	-	3.8	-	35.8	57.3	64.6	5322
	Autumn	-	-	10.0	-	92.5	100.0	100	11006	-	-	3.1	-	32.9	64.6	86.4	5704
	Managed	-	-	15.0	-	100.0	97.5	100	11654	-	-	3.5	-	32.9	66.4	73.5	5609
Mendel																	
	Untreated	0	22.5	20.0	97.5	87.5	100.0	100	11354	0	4.3	4.9	75.9	31.4	62.3	83.1	5598
	Full	-	-	20.0	-	95.0	100.0	100	11778	-	-	5.8	-	32.5	52.7	64.8	5098
	Autumn	-	-	40.0	-	100.0	100.0	100	13320	-	-	11.7	-	42.2	54.5	66.0	6099
	Managed	-	-	22.5	-	97.5	100.0	100	12076	-	-	5.1	-	40.2	49.7	73.3	5504
Winner																	
	Untreated	0	22.5	27.5	100.0	95.0	100.0	100	12250	0	6.7	9.6	81.8	34.9	80.9	86.8	6832
	Full	-	-	15.0	-	95.0	100.0	100	11462	-	-	3.4	-	37.6	72.3	86.3	6273
	Autumn	-	-	17.5	-	95.0	100.0	100	11620	-	-	3.1	-	29.6	65.9	85.4	5553
	Managed	-	-	25.0	-	100.0	100.0	100	12375	-	-	8.0	-	32.7	64.2	87.4	6006
SED		-	10.75	11.82	3.54	6.35	1.02	-	913	-	2.68	3.90	8.05	6.96	5.81	5.28	575.3
df		-	6	33	6	33	33	-	33	-	6	33	6	33	33	33	33
LSD		-	26.30	24.05	8.65	12.91	2.08	-	1858	-	6.56	7.93	19.7	14.16	11.82	10.75	1170.4
Signif. Cv x Treat		-	-	ns	-	ns	ns	-	ns	-	-	ns	-	ns	ns	*	ns
Signif. Cv			ns	ns	ns	ns	ns	-	ns		ns	ns	ns	ns	***	***	ns
Signif. Treat			-	ns	-	ns	ns	-	ns		-	ns	-	ns	***	**	ns

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at p≤0.001

Table 5.28b (cont). Effect of fungicide on levels of light leaf spot, Aberdeen , 2003 – 2004.

Cultivar	Treatment	% leaf area infected								% plants with stems affected	% stem area affected	% plants with pods affected	% pod area affected
Date		24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun	AUDPC	08 Jul	08 Jul	08 Jul	08 Jul
GS		1,03-1,05	1,06-1,08	1,07-1,09	3,1	3,1-3,3	4,0/4,1	5,1		6,3	6,3	6,3	6,3
Untreated	Synergy	0	0.23	0.09	17.7	11.9	13.8	14.5	1397	100.0	4.4	4.0	0.12
Full		-	-	0.05	-	15.4	7.4	8.8	1275	97.0	5.0	6.0	0.06
Autumn		-	-	0.23	-	7.5	9.4	7.5	896	96.0	3.6	0	0
Managed		-	-	0.07	-	12.5	9.3	10.2	1204	98.0	4.2	4.0	0.08
	Mendel												
Untreated		0	0.12	0.31	17.9	12.5	9.3	10.1	1213	96.0	4.9	5.0	0.09
Full		-	-	0.23	-	14.4	6.2	6.0	1139	100.0	5.4	5.0	0.06
Autumn		-	-	1.24	-	14.9	5.7	6.2	1220	100.0	4.6	3.0	0.04
Managed		-	-	0.99	-	14.7	6.2	7.7	1234	99.0	4.8	5.0	0.09
Untreated	Winner	0	0.28	1.43	18.8	10.9	17.9	15.4	1589	99.0	5.8	12.0	0.38
Full		-	-	0.26	-	16.7	9.8	12.7	1510	98.0	6.4	11.0	0.14
Autumn		-	-	0.07	-	10.4	9.4	12.4	1123	99.0	5.5	3.0	0.03
Managed		-	-	1.03	-	10.5	13.7	11.1	1326	98.0	5.1	5.0	0.06
SED		-	0.16	0.635	4.82	5.59	2.43	1.90	357.3	1.88	1.29	4.63	0.116
df		-	6	33	6	33	33	33	33	33	33	33	33
LSD		-	0.38	1.292	11.79	11.37	4.98	3.88	726.9	3.81	2.62	9.42	0.235
Signif. Cv x Treat		-	-	ns	-	ns	ns	ns	ns	ns	Ns	ns	ns
Signif. Cv			ns	ns	ns	ns	***	***	ns	ns	Ns	ns	ns
Signif. Treat			-	ns	-	ns	***	***	ns	ns	Ns	ns	ns

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at p≤0.001

Table 5.29. Yield and yield components, Aberdeen, 2004.

Cultivar	Treatment	Yield@ 90% DM (t/ha)	Yield benefit (t/ha)	Yield response %	MOFC £/ha	Economic Benefit £/ha
Synergy	Untreated	2.42	-	-	314.8	-
	Full	2.50	0.078	4.2	298.9	-15.9
	Autumn	2.53	0.105	7.4	302.4	-12.3
	Managed	2.85	0.427	17.9	337.8	23.0
Mendel	Untreated	3.04	-	-	395.5	-
	Full	3.27	0.229	8.4	399.2	3.8
	Autumn	3.43	0.391	13.8	420.2	24.8
	Managed	3.43	0.392	13.9	413.9	18.5
Winner	Untreated	3.12	-	-	405.9	-
	Full	3.28	0.160	6.9	400.7	-5.2
	Autumn	3.43	0.305	12.8	419.5	13.6
	Managed	3.26	0.141	6.9	391.7	-14.2
SED		0.247	0.237	8.11	32.14	30.75
df		33	33	33	33	33
LSD		0.503	0.481	16.51	65.40	62.56
Signif. CV x Treat		ns	ns	ns	ns	ns
Signif. Treat		ns	ns	ns	ns	ns
Synergy		2.57	0.152	7.4	313.5	-1.3
Mendel		3.30	0.253	9.0	407.2	11.8
Winner		3.27	0.151	6.6	404.4	-1.5
SED		0.124	0.1193	4.06	16.07	15.38
df		33	33	33	33	33
LSD		0.252	0.2407	8.25	32.70	31.28
Signif. CV		***	ns	ns	***	ns

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at $p \leq 0.001$
MOFC based on fungicide costs of £26.00/ha (SAC Farm Management Handbook); price of oilseed rape seed @ £130/t (Farmers Weekly 05 September 2004).

SAC site 2004/2005

Weather and general crop growth

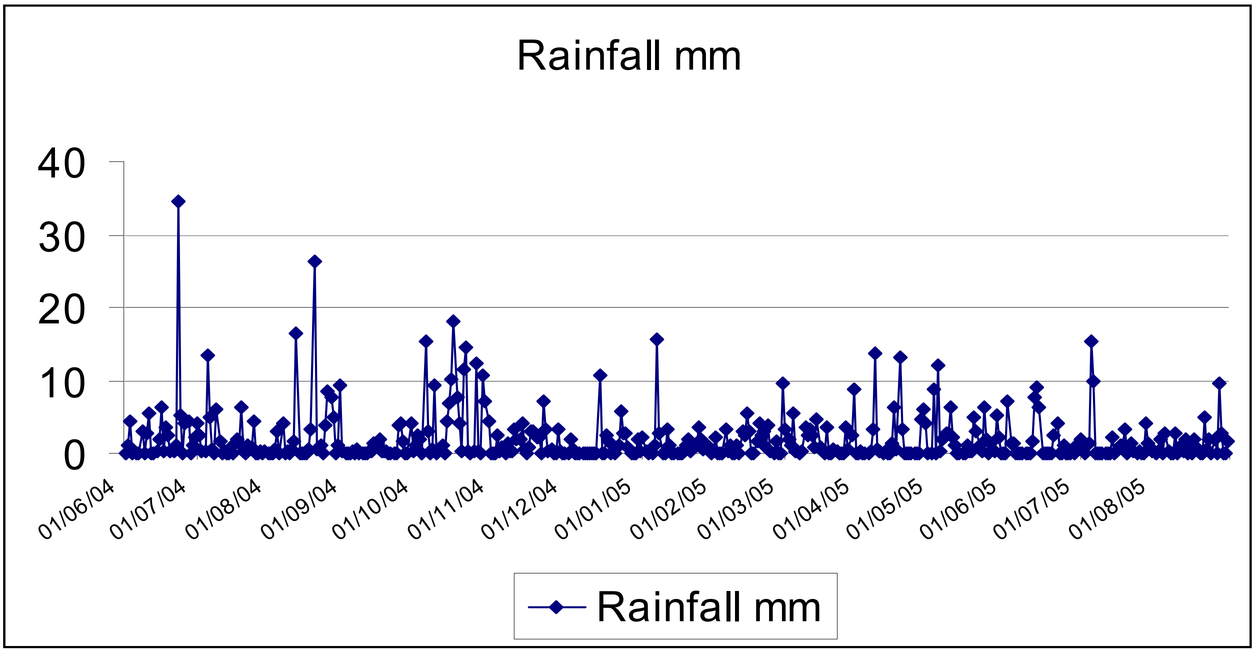
The experiment was sown slightly later (1 September 2004) than the ideal timing for the area (17 August) but it was sown at a similar time to commercial crops. The mild autumn and early winter meant the crop was well established despite the late sow date. Following a mild and wet autumn and winter, the weather in February, March and April 2005 turned cold, with periods of snow cover in late February (Figure 5.3). Rainfall levels during this period were generally below average. Weather conditions improved in May and were followed by a relatively warm but dry summer. The impact the weather had on crops was to provide good conditions for good establishment in the winter, but the wet soil conditions and high levels of clubroot in the soil did lead to the development of extensive clubroot in the experiment. The cold spring (or late winter) led to a period of very slow crop development at the stem extension stage. This was ideal for the development of light leaf spot, which affected crop growth during the stem extension and flowering growth stages. Warmer conditions in the summer eventually provided good conditions for growth, but the impact of clubroot and drying soils over this period led to further crop stress.

Development of light leaf spot in untreated plots, 2004 - 2005

The first light leaf spot was observed in untreated plots of all cultivars in late November (Table 5.31a and Figure 5.4). By December, levels of disease were high in all cultivars. By March, disease levels in the untreated had reduced, with lowest levels seen in Winner and the highest in Mendel. These differences between the cultivars remained into July. Levels on the stems in August were similar in the three cultivars. Although light leaf spot levels on the pods were low, Synergy had significantly lower levels than Winner.

Efficacy of fungicide programmes on control of light leaf spot, 2004– 2005.

On 13 December, all three fungicide programmes had significantly reduced the incidence (% plants affected) of light leaf spot (Table 5.31a). Treatments were more successful on cv. Synergy than cvs Mendel or Winner. The least effective treatment in all three cultivars was the Onset treatment. This is due to the treatment being applied later (on 2 December) compared to the Forecast and Managed treatments, which received a treatment on 3 November 2004 and a second spray on 2 December 2004. Application of an autumn spray in November reduced the % leaves affected during the autumn and early spring. The Onset treatment was less effective, but it also resulted in a reduction in the % leaves affected. Fungicides had no significant effect on stem or pod disease (Table 5.31c).



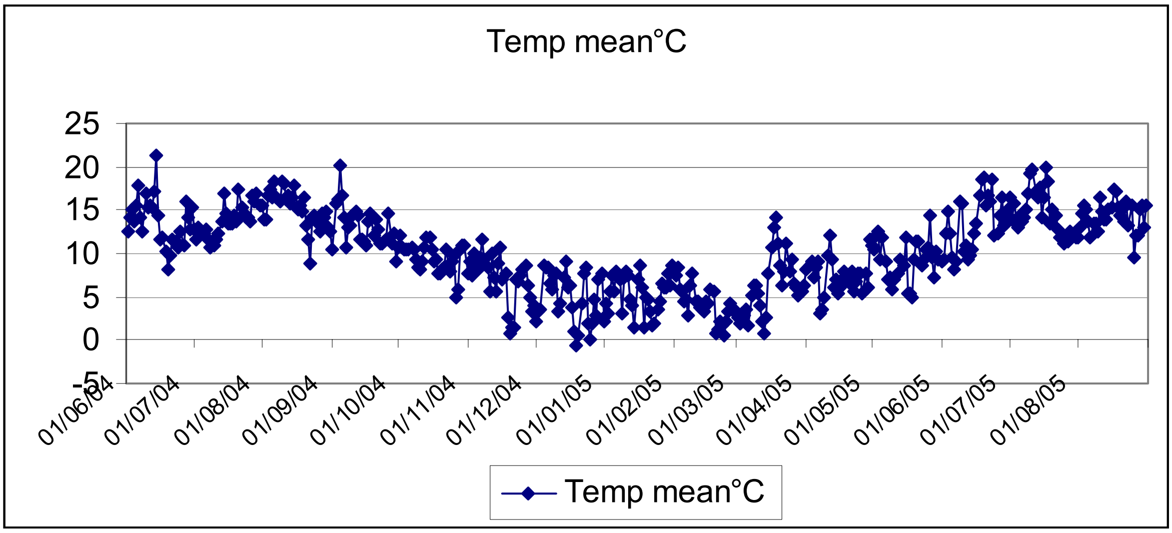


Figure 5.3. Rainfall and temperature in Aberdeen, 2004-05.

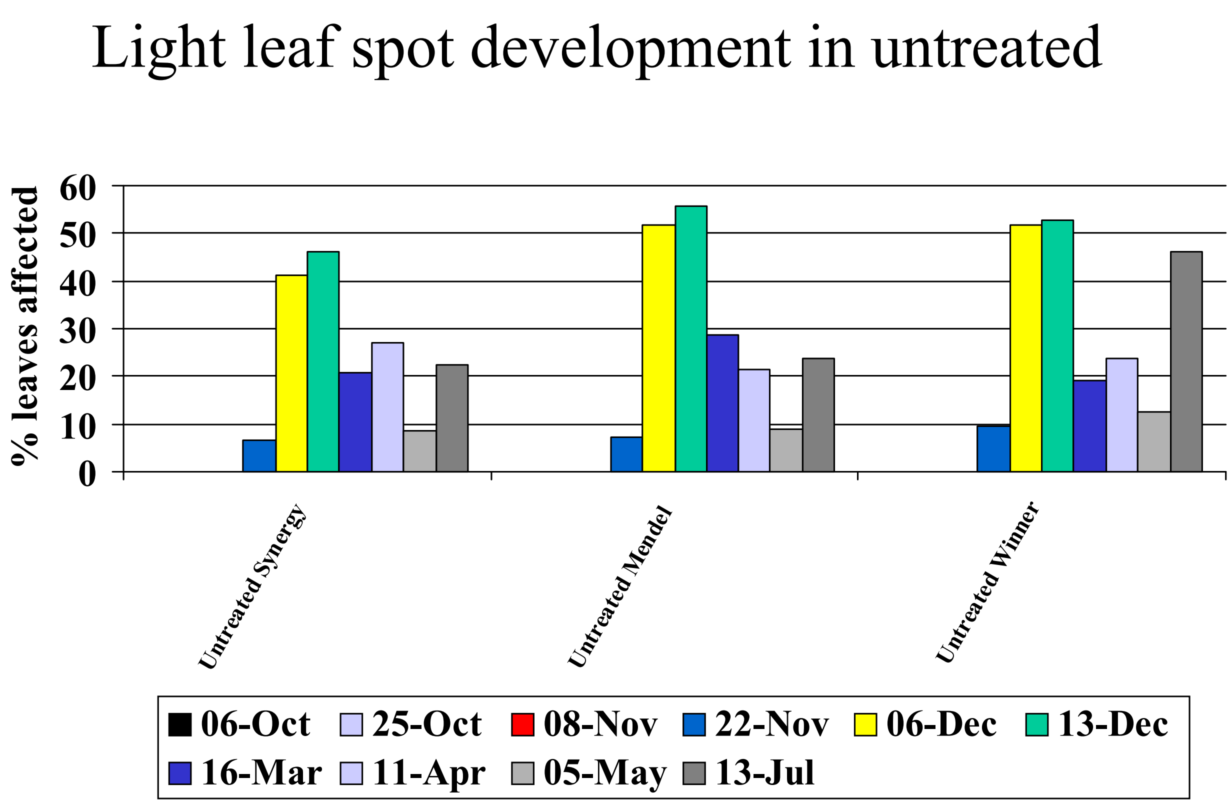


Figure 5.4. Light leaf spot development in untreated plots.

Phoma leaf spot, 2004 – 2005

Very little phoma leaf spot developed in the trial this season (Appendix 2, Table 2.8). The disease first appeared on the cultivars Mendel and Synergy on 6 December and on cv. Winner on 13 December. Maximum incidence was 10% of plants affected in untreated Synergy. Differences between treatments were not significant but on 13 December, the trend was towards a higher number of plants affected in the untreated control.

Plant counts, 2004-2005

Cultivars were sown at rates of 6 kg/ha (Winner) and 3.6 kg/ha (Synergy & Mendel), rates typical for Aberdeenshire, to give plant establishments of 60 – 70 plants/m^2 and 40 plants/m^2. The actual plant establishments in untreated plots in December 2004 were 89.8 plants/m^2 (Winner), 40.6 plants/m^2 (Synergy) and 90 plants/m^2 (Mendel) (see Appendix 2 Table 12.10). Plant losses over the winter were low. This is a reflection of the mild autumn which helped get plants established.

Yield and yield components, 2004 – 2005.

The cultivar Mendel gave the highest average yield, (4.03 t/ha) (Table 5.30). This was significantly higher than Synergy (2.92 t/ha) and Winner (2.77 t/ha). Mean fungicide treatment effects approached significance (P=0.09), but there was no cultivar x fungicide interaction. There was no significant yield response to fungicides or a fungicide x cultivar interaction. The best yield benefits from fungicide were in Synergy from the Managed treatment. This treatment received three fungicide applications, but still achieved the best margin over fungicide cost. The response to fungicide was least for the cultivar Mendel, and all the fungicide treatments resulted in a negative economic benefit. In Winner, the Managed programme achieved the best yield, but the Onset programme gave the best economic benefit.

Table 5.30. Yield, yield components and economic benefits, Aberdeen, 2005.

Cultivar	Treatment	Yield t/ha @ 90% DM	Yield response t/ha	MOFC £/ha	Economic benefit £/ha
Synergy	Untreated	2.60	-	364	-
	Forecast	2.95	0.35	373	+9
	Onset	2.89	0.29	365	+1
	Managed	3.22	0.62	391	+27
Mendel	Untreated	3.99	-	559	-
	Forecast	4.08	0.09	532	-27
	Onset	4.03	0.04	524	-35
	Managed	4.03	0.04	505	-54
Winner	Untreated	2.56	-	358	-
	Forecast	2.70	0.14	338	-20
	Onset	2.89	0.33	365	+7
	Managed	2.91	0.35	348	-10
SED		0.226		31.6	
df		33		33	
LSD		0.459		64.2	
Signif. CV x Treat		ns		ns	
Signif. Treat		0.09		Ns	
Synergy		2.92		373	
Mendel		4.03		530	
Winner		2.77		352	
SED		0.113		15.8	
Df		33		33	
LSD		0.229		32.1	
Signif. CV		<0.001		<0.001	

ns = not significant;
MOFC based on fungicide costs of £40/ha treatment 2,3 £60/ha treatment 4. Price of oilseed rape seed @ £140/t

General comments

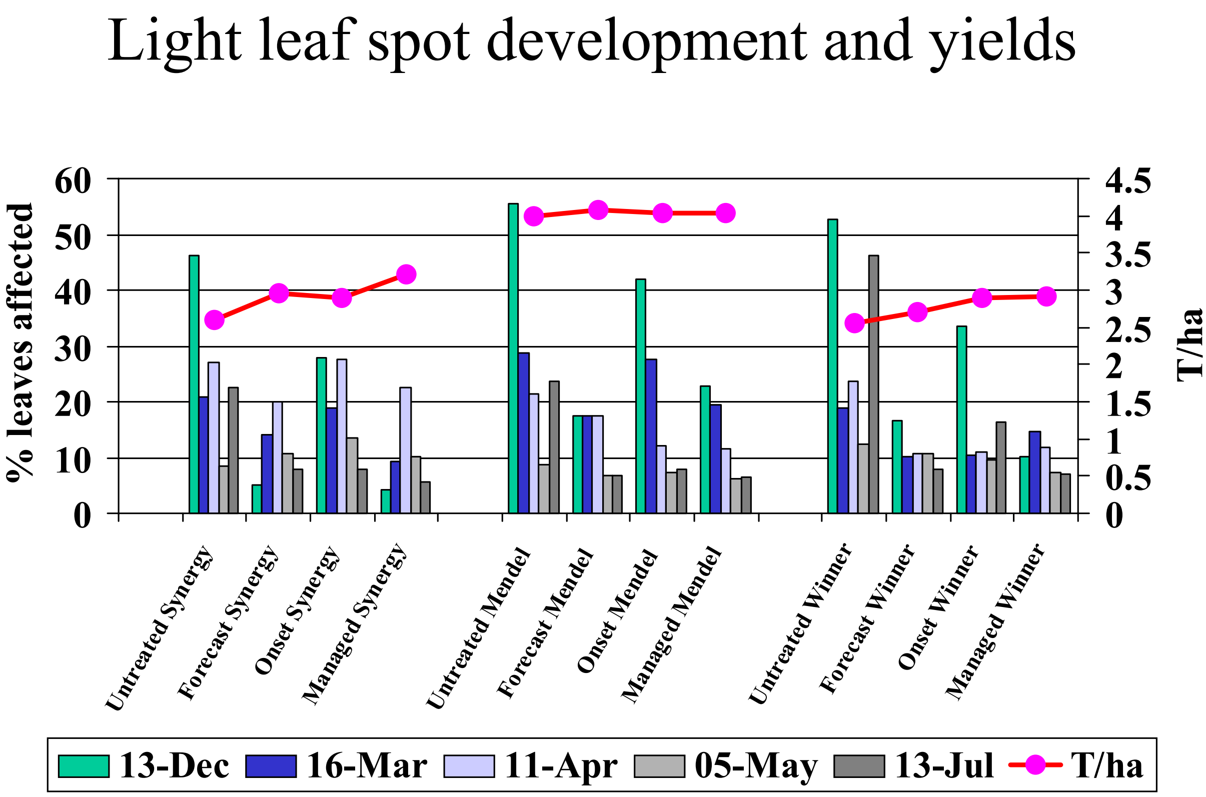


Figure 5.5. Light leaf spot development and yields, Aberdeen 2005.

Figure 5.5 shows the development of light leaf spot and yield in relation to fungicide treatments. Despite high levels of light leaf spot in Mendel, this cultivar achieved the best yield overall, with little response to fungicides. Light leaf spot control was most effective in Winner in the Managed programme, but the yield still did not approach the yield from Mendel. Clubroot was a common problem on the roots in this trial (Appendix 2 Table 2.11). The cultivar Mendel achieved a significant reduction in the disease compared to cvs Winner and Synergy (See Figure 5.6).

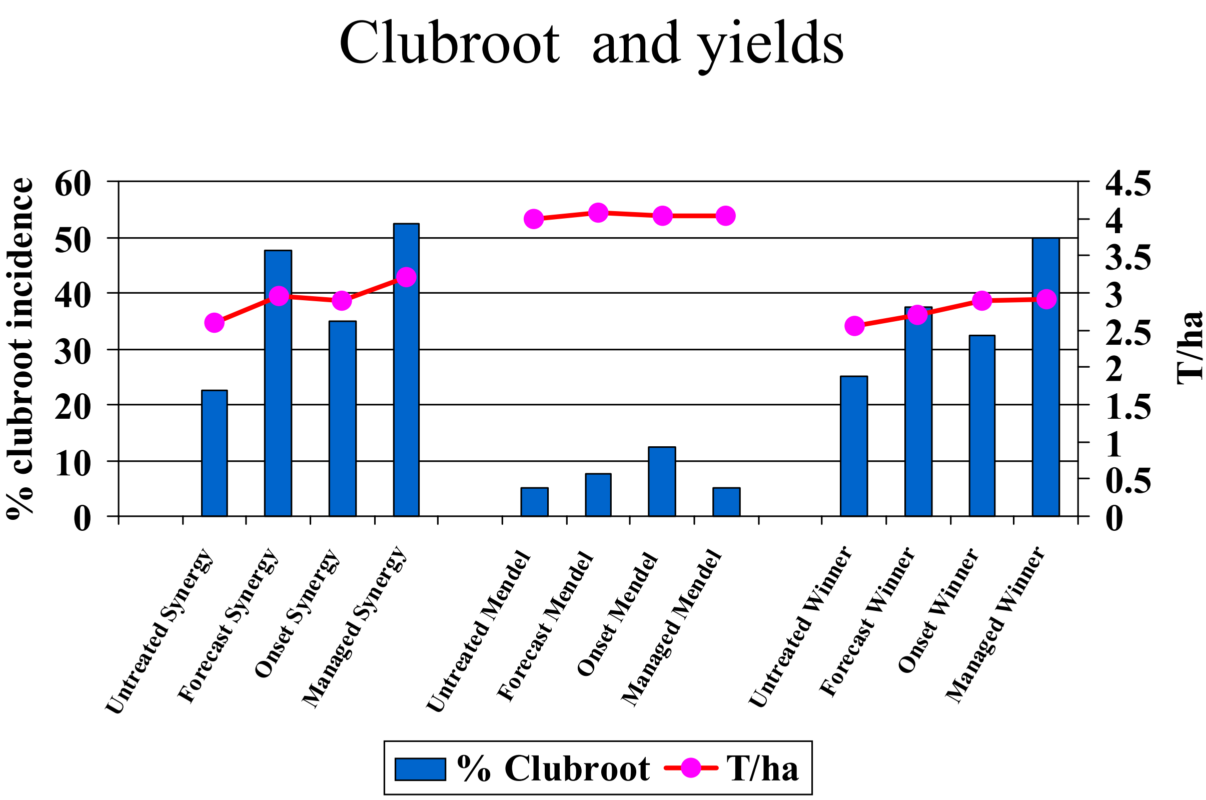


Figure 5.6. Clubroot and yields at Aberdeen 2005.

The lower level of clubroot is a likely factor in the good yields achieved from Mendel. It was surprising,, however, that the Managed programme (which had lowest levels of clubroot and light leaf spot) did not achieve a better yield benefit. In cvs Synergy and Winner, it is likely that any gains from controlling light leaf spot may not have been reflected in the yield because clubroot would have limited the ability of the plant to respond to foliar disease control with fungicide. Autumn treatments were effective at reducing light leaf spot. The Onset treatment was the least effective at controlling the disease, and in a situation where clubroot may not have been a factor, waiting for light leaf spot to appear before starting the fungicide treatment is not likely to be a cost-effective option. Early preventative fungicide treatment is likely to remain the most cost-effective option.

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Table 5.31a. Effect of fungicide on levels of light leaf spot, Aberdeen, 2004 – 2005.

Cultivar	Treatment	% Plants affected					
	Date	6 Oct	25 Oct	8 Nov	22 Nov	6 Dec	13 Dec
	GS	1,3-1,4	1,5-1,6	1,6-1,7	1,9	1,8-1,10	1.10
Synergy	Untreated	0	0	0	28	92	92.5
	Forecast						22.5
	Onset						67.5
	Managed						17.5
Mendel	Untreated	0	0	0	32	92	92.5
	Forecast						62.5
	Onset						87.5
	Managed						55.0
Winner	Untreated	0	0	0	40	96	95.0
	Forecast						42.5
	Onset						72.5
	Managed						30.0
SED (df)							9.55 (33)
LSD							19.43
Signif. Cv x Treat							0.09
Signif. Cv							<.001
Signif. Treat							<.001

Table 5.31b (Cont). Effect of fungicide on % leaves with light leaf spot, Aberdeen, 2004 – 2005

Cultivar	Treatment	% Leaves affected									
	Date	6 Oct	25 Oct	8 Nov	22 Nov	6 Dec	13 Dec	16 Mar	11 Apr	5 May	13 July
	GS	1,3-1,4	1,5-1,6	1,6-1,7	1,9	1,8-1,10	1,10	3,1	3.4	4.0/4.1	6.1
Synergy	Untreated	0	0	0	6.5	41.2	46.2	20.8	27.0	8.45	22.5
	Forecast						5.1	14.1	20.0	10.60	8.0
	Onset						27.9	19.0	27.5	13.60	7.75
	Managed						4.1	9.4	22.5	10.03	5.50
Mendel	Untreated	0	0	0	7.2	51.8	55.6	28.8	21.3	8.75	23.75
	Forecast						17.4	17.6	17.5	6.63	6.75
	Onset						42.1	27.6	12.0	7.35	8.0
	Managed						22.8	19.5	11.5	6.25	6.5
Winner	Untreated	0	0	0	9.4	51.8	52.6	19.0	23.8	12.43	46.25
	Forecast						16.5	10.1	10.8	10.65	8.0
	Onset						33.5	10.5	11.0	9.45	16.25
	Managed						10.2	14.7	11.8	7.28	7.0
SEDdf (33)							5.86	5.73	4.96	1.57	2.52
LSD							11.92	11.67	10.10	3.19	5.13
Signif. Cvx Treat							Ns	Ns	Ns	1%	<.0.1%
Signif. Cv							<.0.1%	1%	<0.1%	<0.1%	<.0.1%
Signif. Treat							<0.1%	Ns	1%	Ns (7%)	<.0.1%

Table 5.31c (cont). Effect of fungicide on levels of light leaf spot pre-harvest, Aberdeen, 2004-05.

Cultivar	Treatment	% plants with stems affected	% plants with pods affected
Date		1 Aug 05	1 Aug 05
GS		9,5	9,5
Synergy	Untreated	12.2	2.0
	Forecast	16.5	3.5
	Onset	13.2	3.5
	Managed	10.8	2.3
Mendel	Untreated	15.3	3.8
	Forecast	23.2	4.0
	Onset	13.5	2.0
	Managed	9.0	2.3
Winner	Untreated	12.0	4.5
	Forecast	9.8	4.8
	Onset	19.8	2.8
	Managed	11.2	6.3
SED df		6.93 (33)	1.14 (33)
LSD		14.10	2.31
Signif. Cv x Treat		ns	0.07
Signif. Cv		ns	0.007
Signif. Treat		ns	ns

5.3.3 Fungicide spray timing experiments

ADAS sites 2003/2004

Disease development

Plants grew relatively slowly after a dry September and phoma leaf spot first appeared on 1 December when plants were at the 5-leaf stage. Plants were relatively small and remained so during December and January with leaves 5-11 cm long. Subsequent development was slower than usual at Boxworth and phoma leaf spot incidence reached 77.5% plants affected in mid January and increased further to reach a maximum in late March. Phoma leaf spot remained common for the remainder of the season, well beyond the flowering period (Table 5.32). At T1 on 27 November, there were no phoma leaf spots, but ascospores of *Leptoshaeria maculans* were being trapped at Boxworth. There was a low incidence of phoma leaf spot in December, but T2 assessments on 15 December showed no phoma leaf spot present although 17.5 % plants had been affected on 1 December. There were further fluctuations in phoma leaf spot incidence in January (55 –77% plants affected) associated with loss of old affected leaves. The incidence of small dark leaf spots caused by Phoma B (now known as *L. biglobosa*) was generally very low.

The late development of phoma epidemics in autumn is usually folowed by strong activity in spring and this was the case in 2003/04. Assessments on 4 May at early flowering showed phoma leaf spot incidence was 93-100% plants affected and severity was 0.6% leaf area affected in the untreated, 0.6% in treatment 2 and 0.4% in treatment 6. Fungicide treatments were not targeted against this late phase of the phoma leaf spot epidemic and, as expected, it was not controlled by winter treatments. Stem canker symptoms were not evident at early flowering but were present on 72.5% plants at the end of flowering and 87.5% plants pre-harvest. Canker severity was moderate, with 3% plants dead and 20% plants with weakened stems (index 3 cankers). Phoma upper stem lesions appeared by early flowering (7.5% untreated plants affected on 4 May, 0% in treatment 2 and 2.5% plants affected in treatment 6) and then increased rapidly in untreated plots (55% plants affected at the end of flowering and 99% plants pre-harvest). Stem lesions were numerous but remained small.

Other diseases were of minor importance. Downy mildew was very common from autumn until late January, but subsequently showed little activity. Sclerotinia stem rot was more prevalent than usual, affecting 11% plants pre-harvest in untreated plots, but was not controlled by fungicides applied in autumn and winter (Table 5.37). Pod diseases were present at very low levels and were not assessed.

Table 5.32. Occurrence and development of diseases on untreated control plants, Boxworth 2003/04.

Date sampled	Growth stage	Downy mildew % plants	Downy mildew % area	Phoma leaf spot % plants	Phoma leaf spot % area	Phoma canker % plants (index)	Phoma stem lesions % plants (index)	Stem rot % plants (index)
27/11/03	1,5	56.0	1.5	0	0			
01/12/03	1,4-1,6	90.0	12.5	17.5	0.04			
08/12/03	1,5-1,6	72.5	3.0	2.5	0.03			
15/12/03	1,6-1,7	85.0	3.5	0	0			
29/12/03	1,6	100.0	5.4	16.0*	0.04			
05/01/04	1,5-1,7	80.0	5.1	12.5	0.19			
19/01/04	1,4-1,9	85.0	4.4	77.5	2.98			
26/01/04	1,4-1,8	75.0	3.7	55.0	1.35			
16/02/04	3,1	0	0	92.5	0.93			
25/03/04	3,3	0	0	100	1.77			
04/05/04	4,1	0	0	92.5	0.64	0	7.5 (0.08)	0
02/06/04	5,9; 6,1	15.0	0.02	90	0.39	72.5 (1.13)	55.0 (0.55)	0
24/06/04	6,3	-	-	-	-	87.0 (1.50)	99.0 (1.01)	11 (0.35)

* 4% plants had phoma B leaf symptoms (trace severity <0.01%)

Disease control

The 27 November sprays performed well and gave good control of phoma leaf spot at 26 January assessments (Table 5.33), and were matched by the higher rates of Punch C (0.6 and 0.8 l/ha) applied on 18 December. Low levels of phoma B also appeared to be controlled by these treatments. By 26 March (Table 5.34), a large effect on phoma leaf spot incidence was only being achieved by the December + February programme, though all the two-spray programmes significantly reduced the severity of phoma leaf spotting. The 18 December treatments were no longer giving control of phoma leaf spot even at the 0.8 l/ha rate, but 23 January sprayed treatments still had less severe phoma spotting 9 weeks after treatment (Table 5.34).

Phoma stem lesions were evident on the untreated plants from early flowering (4 May) and canker lesions appeared at the end of flowering. Pre-harvest, the crop had a mean canker index of 1.5 (23 % plants had severe cankers and 14% had moderate cankers). Canker incidence was reduced from 87% plants affected to 36-41 % plants affected by the three two-spray treatments (Table 5.35). The December timing was marginally more effective against stem canker than the late November timing but these differences were not significant. There were no significant differences between rates of Punch C at either November or December timings. The effect of fungicide treatments on the incidence of cankers by severity index is shown in Fig. 5.7. This clearly illustrates the effectiveness of the two spray programmes in increasing the percentage healthy plants from 13% to c. 60% and almost eliminating severe stem cankers. There were small but significant reductions in phoma stem lesion incidence and severity. The two spray programmes and the high rate of Punch C in November gave the lowest stem phoma values (Table 5.36).

Sclerotinia stem rot was more prevalent than usual and lateral stem infection occurred where the crop had suffered some pigeon damage in the winter. There were significant block differences in sclerotinia incidence (range Block 1 = 14% plants affected to Block 4 3.2% plants affected, but no fungicide treatment differences (Table 5.37). Other diseases remained at very low levels and did not contribute to yield effects.

Yield

The experiment produced significant yield differences from the two spray programmes initiated in December and the higher rates of Punch C (0.6 and 0.8 l/ha) applied as single sprays in December. The other treatments all gave positive effects, but these were not significant (Table 5.38).

Table 5.33. Incidence and severity of phoma leaf spot, ADAS Boxworth 26 January 2004.

Treatment Date	T1 Phoma onset – forecast date or 10% plants (late October) 27 November	T2 Phoma established – 90% incidence (mid Nov) 18 December	T3 4-6 weeks after T1/T2 23 January	T4 Early stem extension (late Feb) 16 February	Phoma leaf spot incidence (% plants)	Phoma leaf spot severity (% leaf area affected)	Phoma B leaf spot incidence (% plants)	Phoma B leaf spot severity (% leaf area affected)
1	Untreated				55	1.35	13	0.018
2	Punch C 0.4	-	Punch C 0.4	-	0	0.00	3	0.003
3	Punch C 0.4	-	-	-	3	0.01	3	0.003
4	Punch C 0.6	-	-	-	0	0.00	3	0.003
5	Punch C 0.8	-	-	-	0	0.00	10	0.010
6	-	Punch C 0.4	Punch C 0.4	-	13	0.13	3	0.003
7	-	Punch C 0.4	-	-	15	0.05	0	0.000
8	-	Punch C 0.6	-	-	3	0.03	5	0.010
9	-	Punch C 0.8	-	-	0	0.00	5	0.008
10	-	Punch C 0.4	-	Punch C 0.4	35	0.38	3	0.003
	SED (27 df)				8.05	0.291	5.58	0.0074
	F test				<0.1% skew	1% skew	ns, skew	ns, skew

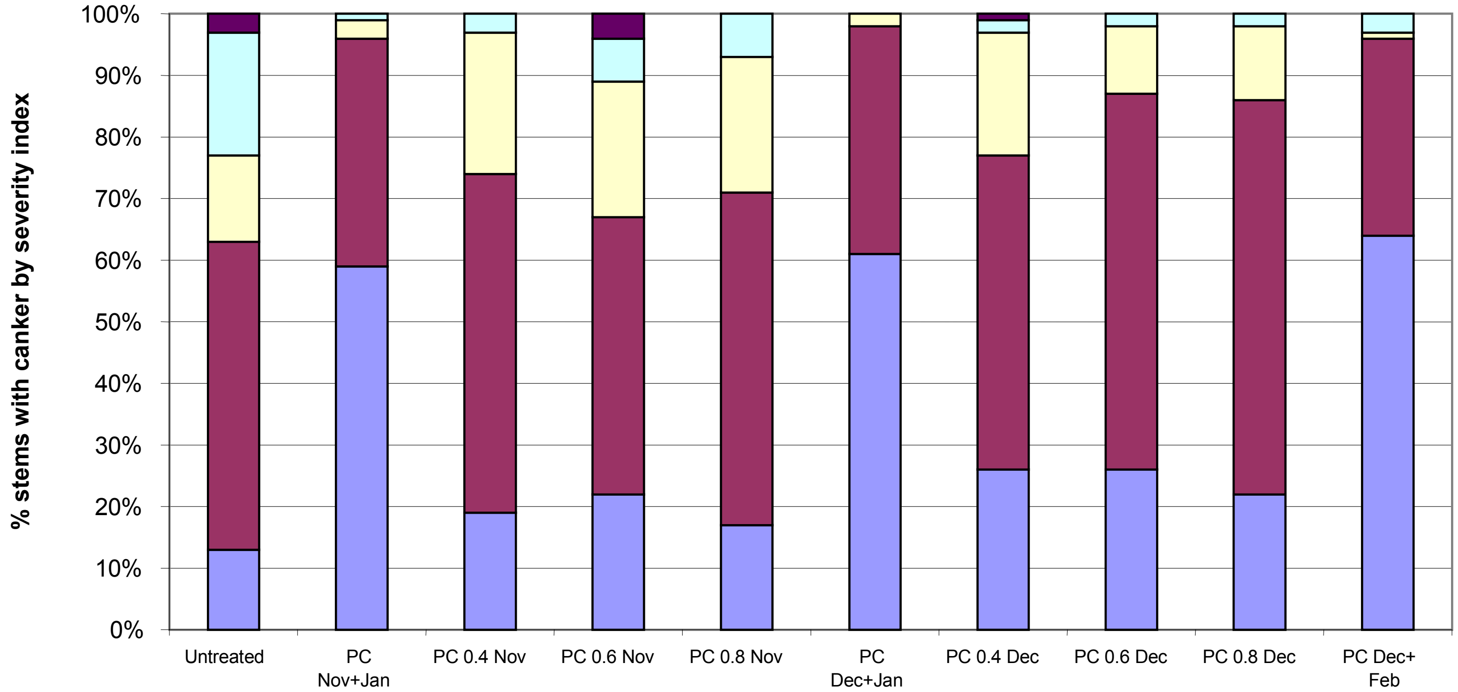

Figure 5.7. Effect of fungicide treatment on phoma stem canker incidence by severity class, Boxworth 2004.

(Stem canker indices 0 – 4 in sequence with index 0 values nearest the x-axis)

Overall crop vigour was similar to 2003 harvest, so the final level of yield was not unexpected. The surrounding crop of winter oilseed rape was abandoned in late winter and replaced by a crop of spring oilseed rape. However, it does show that fungicide responses can be obtained on crops where autumn growth was slow and from late phoma epidemics on small plants. There was no evidence of spray damage following treatment.

Table 5.34. Incidence and severity of phoma leaf spot, ADAS Boxworth, 26 March 2004.

Treatment	T1 Phoma onset – forecast date or 10% plants (late October)	T2 Phoma established – 90% incidence (mid Nov)	T3 4-6 weeks after T1/T2	T4 Early stem extension (late Feb)	Phoma leaf spot incidence (% plants)	Phoma leaf spot severity (% leaf area affected)
1	Untreated				100.0	1.77
2	Punch C 0.4	-	Punch C 0.4	-	77.5	0.41
3	Punch C 0.4	-	-	-	100.0	1.74
4	Punch C 0.6	-	-	-	97.5	1.14
5	Punch C 0.8	-	-	-	97.5	1.75
6	-	Punch C 0.4	Punch C 0.4	-	97.5	0.74
7	-	Punch C 0.4	-	-	97.5	1.62
8	-	Punch C 0.6	-	-	97.5	1.23
9	-	Punch C 0.8	-	-	97.5	1.77
10	-	Punch C 0.4	-	Punch C 0.4	57.5	0.24
	SED (27 df)				8.76	0.394
	F test				<0.1	0.1%

Table 5.35. Pre-harvest phoma stem canker assessments, ADAS Boxworth, 24 June 2004.

Treatment	T1 Phoma onset – forecast date or 10% plants (late October)	T2 Phoma established – 90% incidence (mid Nov)	T3 4-6 weeks after T1/T2	T4 Early stem extension (late Feb)	Phoma stem canker (% plants)	Phoma stem canker index (0-100)
1	Untreated				87	38
2	Punch C 0.4	-	Punch C 0.4	-	41	12
3	Punch C 0.4	-	-	-	81	28
4	Punch C 0.6	-	-	-	78	32
5	Punch C 0.8	-	-	-	83	30
6	-	Punch C 0.4	Punch C 0.4	-	39	10
7	-	Punch C 0.4	-	-	74	25
8	-	Punch C 0.6	-	-	74	22
9	-	Punch C 0.8	-	-	78	24
10	-	Punch C 0.4	-	Punch C 0.4	36	11
	SED (27 df)				9.70	4.09
	F test				<0.1%	<0.1%

Table 5.36. Pre-harvest phoma stem lesion assessments, ADAS Boxworth, 24 June 2004.

Treatment	T1 Phoma onset – forecast date or 10% plants (late October)	T2 Phoma established – 90% incidence (mid Nov)	T3 4-6 weeks after T1/T2	T4 Early stem extension (late Feb)	Phoma stem lesions (% plants)	Phoma stem lesion index (0-100)
1	Untreated				99	25
2	Punch C 0.4	-	Punch C 0.4	-	88	22
3	Punch C 0.4	-	-	-	100	26
4	Punch C 0.6	-	-	-	94	24
5	Punch C 0.8	-	-	-	86	22
6	-	Punch C 0.4	Punch C 0.4	-	89	22
7	-	Punch C 0.4	-	-	97	24
8	-	Punch C 0.6	-	-	95	25
9	-	Punch C 0.8	-	-	98	25
10	-	Punch C 0.4	-	Punch C 0.4	85	21
	SED (27 df)				3.80	1.11
	F test				0.1%	1%

Table 5.37. Pre-harvest sclerotinia stem lesion assessments, ADAS Boxworth, 24 June 2004.

Treatment	T1 Phoma onset – forecast date or 10% plants (late October)	T2 Phoma established – 90% incidence (mid Nov)	T3 4-6 weeks after T1/T2	T4 Early stem extension (late Feb)	Sclerotinia stem lesions (% plants)	Sclerotinia stem lesion index (0-100)
1	Untreated				11	8.8
2	Punch C 0.4	-	Punch C 0.4	-	6	4.3
3	Punch C 0.4	-	-	-	12	9.3
4	Punch C 0.6	-	-	-	4	3.3
5	Punch C 0.8	-	-	-	14	11.8
6	-	Punch C 0.4	Punch C 0.4	-	5	4.3
7	-	Punch C 0.4	-	-	9	5.3
8	-	Punch C 0.6	-	-	8	7.3
9	-	Punch C 0.8	-	-	10	8.8
10	-	Punch C 0.4	-	Punch C 0.4	8	6.0
	SED (27 df)				4.14	3.44
	F test				ns	ns

Table 5.38. Yield and yield response in relation to fungicide treatment,ADAS Boxworth 2004.

Treatment	T1 Phoma onset – forecast date or 10% plants (late October)	T2 Phoma established – 90% incidence (mid Nov)	T3 4-6 weeks after T1/T2	T4 Early stem extension (late Feb)	Yield at 90% dry matter (t/ha)	Yield response (t/ha)
1	Untreated				2.97	-
2	Punch C 0.4	-	Punch C 0.4	-	3.20	0.23
3	Punch C 0.4	-	-	-	3.36	0.39
4	Punch C 0.6	-	-	-	3.12	0.15
5	Punch C 0.8	-	-	-	3.04	0.07
6	-	Punch C 0.4	Punch C 0.4	-	3.43	0.46
7	-	Punch C 0.4	-	-	3.27	0.30
8	-	Punch C 0.6	-	-	3.32	0.35
9	-	Punch C 0.8	-	-	3.45	0.48
10	-	Punch C 0.4	-	Punch C 0.4	3.51	0.54
	SED (27 df)				0.150	
	CV (%)				6.5	
	F test				5%	

Discussion

Phoma developed particularly late in the autumn after dry conditions in August and September 2003. Whilst the dry weather effects on ascospore production could be monitored using spore traps, the economic impact on small plants was less easy to predict. Previous HGCA experiments with late phoma epidemics on large plants at Boxworth indicated that late phoma epidemics did not affect yield. This experiment indicates that fungicides can provide benefits of up to 0.54 t/ha (18%) from December/January phoma epidemics. The yield increase of 0.54 t/ha is worth £81/ha (rapeseed at £150/t), providing a margin of about £50/ha over fungicide and application costs. The single and two spray programmes were highly cost-effective on yield alone and may produce additional benefits through increased oil content.

Two-spray programmes gave good disease control and were more effective than single applications at high dose. Yield benefits were largest with programmes starting when phoma leaf spot had reached 10-20% plants affected or from single higher dose applications at the 10-20% threshold. The timing of the second application in programmes at either 4 or 8 weeks after the first spray was equally effective. The 0.8 l/ha rate applied in December appeared to give a higher yield than lower rates applied on the same date. There was some indication of a trend with dose on the 26 January assessments of phoma leaf spot, but this did not persist in final stem canker indices. If the higher dose treatment had increased plant survival to harvest, this would have contributed to yield improvement whilst not demonstrating improved disease control. The single sprays, even at 0.8 l/ha rate, were less effective against stem canker than the two-spray programmes and left a higher proportion of index 1 cankers (Fig. 1). Whilst these did not affect yield in this case, it suggests that the two-spray approach may be more robust in commercial practice.

The size of the yield response was relatively large, given that only 23% plants had moderate or severe cankers. Crops with stem canker indices of 25-30 in untreated control plots have given small yield responses in previous studies. However, the combination of a late epidemic on small plants has rarely been studied. Small plants should therefore be considered more sensitive to late phoma epidemics than large plants. Indeed, some crops with small plants may require a three-spray programme to achieve satisfactory control of stem canker if epidemics continue from October to February.

2004/05 Fungicide timing experiment

Disease progress

Phoma leaf spot developed from 17 October onwards (Table 5.39) and this fungicide timing experiment showed how the different phases of infection were controlled. The T1 + T2 programmes gave almost complete control of phoma leaf spot by 10 December (3 weeks after the second spray) (Table 5.40). There was re-infection after the T1 only spray by 10 December (7 weeks after treatment), but plants were large and T3 sprays were still expected to control spread of phoma down the petiole. Where the first spray was applied at T2, old phoma leaf spot lesions on the older leaves were still present on 10 December, but the appearance of new lesions was prevented.

On 9 February, untreated plants were showing multiple phoma spotting on the oldest 3-4 leaves. Most plants were quite large and showing signs of stem extension but with no clear internodes. There was variability in phoma severity from plant to plant that was influenced by retention of the old yellow leaves with severe phoma spotting. The early February assessments showed low levels of new phoma spotting in some treatments (e.g. 6, 7, 8 and 9) and residual old phoma leaf spots in others (e.g. 4 and 10) (Table 5.41). This indicated phoma was just starting to re-infect crops after the 17 November treatments. The three-spray programmes and T2 + T3 sprays gave very good control of phoma leaf spot. Comparison of phoma incidence and severity in February with December shows a marked dose effect of the full rate Punch C (in treatment 7) for reducing phoma. This reflected the loss of old infected leaves since the T3 application in December. There was also a contrast between treatments 10 and 11, showing the benefit of the November spray in the programme.

Table 5.39. Development of diseases on untreated control plants cv.Winner in fungicide spray timing experiment, Boxworth 2004/05.

Date sampled	Growth stage	Downy mildew % plants	Downy mildew % area	Phoma leaf spot % plants	Phoma leaf spot % area	Phoma Bleaf spot % plants	Phoma B leaf spot % area	Phoma canker % plants (index)	Phoma stem lesions % plants (index)	Stem rot % plants (index)
11/10/04	1,5-1,6	100	0.66	0	0					
17/10/04	1,6	92	0.37	24 Lvs 7-19cm	0.03					
25/10/04	1,8-1,10	92	0.43	32	0.09	4	0.0004			
01/11/04	1,9	68	0.13	60	0.16	0	0			
08/11/04	1,10	8	0.004	68	0.12	8	0.0003			
11/11/04	1,11	45	0.11	93	0.39	0	0			
17/11/04	1,12	8	0.008	98	0.84	2.5	0.0003			
06/12/04	1,13	0	0	96	0.80	16	0.0003			
10/12/04	1,14	0	0	100	1.16	0	0			
09/02/05	3,1	0	0	100	2.13	2.5	0.003			
07/03/05	2,3, 3,1	0	0	92	0.51	20	0.072	0		
15/04/05	4,2	28	0.05	98	0.57	5	0.0005	42.5 (0.43)	0	0
29/05/05	6,1							82.5 (1.10)	10 (0.10)	0
23/06/05	6,3 *							96 (1.93)	64 (0.67)	0 (trace)

*Powdery mildew affected 11.7% stem area and 5.0 %pod area

- Alternaria was noted at trace levels on leaves on 17 Oct, 27 Oct and 8 Nov

Table 5.40. Treatments and disease assessments at T3 timing, Boxworth 10 December 2004.

Treatment	T1 Phoma onset – first signs (early October) 19 Oct	T2 T1 + 4 weeks 17 Nov	T3 T2 +4 weeks 9 Dec	T4 Late Feb 7 Mar	T5* Green mid /bud stem extn 25 Mar	Phoma leaf spot incidence (% plants affected)	Phoma leaf spot severity (% leaf area affected)
1	Untreated			-		100	1.16
2	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	-	10	0.02
3	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	Folicur 0.5	8	0.01
4	Punch C 0.4	-	Punch C 0.4	-	Folicur 0.5	90	0.51
5	Punch C 0.4	-	Punch C 0.4	Sanction 0.4	Folicur 0.5	90	0.36
6	-	Punch C 0.4	-	Punch C 0.4	Folicur 0.5	85	0.53
7	-	Punch C 0.8	-	-	Folicur 0.5	85	0.39
8	Punch C 0.4	Punch C 0.4	-	-	Folicur 0.5	10	0.02
9	Punch C 0.4	Punch C 0.4	-	Sanction 0.4	Folicur 0.5	15	0.03
10	Punch C 0.4	-	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	90	0.41
11	-	Punch C 0.4	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	93	0.43
	SED (30 df)					6.84	0.114
	F test					<0.1%	<0.1%

Table 5.41. Treatments and disease assessments 9 weeks after T3 timing, Boxworth, 09 February 2005.

Treatment	T1 Phoma onset – first signs (early October) 19 Oct	T2 T1 + 4 weeks 17 Nov	T3 T2 +4 weeks 9 Dec	T4 Late Feb 7 Mar	T5* Green mid/bud stem extn 25 Mar	Phoma leaf spot incidence (% plants affected)	Phoma leaf spot severity (% leaf area affected)
1	Untreated			-		100	2.13
2	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	-	15	0.01
3	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	Folicur 0.5	5	0.01
4	Punch C 0.4	-	Punch C 0.4	-	Folicur 0.5	88	0.28
5	Punch C 0.4	-	Punch C 0.4	Sanction 0.4	Folicur 0.5	80	0.17
6	-	Punch C 0.4	-	Punch C 0.4	Folicur 0.5	68	0.09
7	-	Punch C 0.8	-	-	Folicur 0.5	20	0.03
8	Punch C 0.4	Punch C 0.4	-	-	Folicur 0.5	48	0.08
9	Punch C 0.4	Punch C 0.4	-	Sanction 0.4	Folicur 0.5	63	0.16
10	Punch C 0.4	-	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	95	0.39
11	-	Punch C 0.4	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	10	0.01
	SED (29 df)					10.86	0.102
	F test					<0.1%	<0.1% skew

Table 5.42. Treatments and pre-harvest stem canker assessments, Boxworth 23 June 2005.

Treatment	T1 Phoma onset – first signs (early October) 19 Oct	T2 T1 + 4 weeks 17 Nov	T3 T2 +4 weeks 9 Dec	T4 Late Feb 7 Mar	T5* Green mid/bud stem extn 25 Mar	Phoma canker incidence (% plants affected)	Phoma canker severity (0-100 index)
1	Untreated			-		98	49
2	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	-	44	12
3	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	Folicur 0.5	29	7
4	Punch C 0.4	-	Punch C 0.4	-	Folicur 0.5	55	16
5	Punch C 0.4	-	Punch C 0.4	Sanction 0.4	Folicur 0.5	25	7
6	-	Punch C 0.4	-	Punch C 0.4	Folicur 0.5	39	14
7	-	Punch C 0.8	-	-	Folicur 0.5	60	19
8	Punch C 0.4	Punch C 0.4	-	-	Folicur 0.5	55	16
9	Punch C 0.4	Punch C 0.4	-	Sanction 0.4	Folicur 0.5	44	15
10	Punch C 0.4	-	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	42	12
11	-	Punch C 0.4	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	50	15
	SED (29 df)					10.26	3.68
	F test					<0.1%	<0.1%

Table 5.43. Treatments and pre-harvest phoma stem lesion assessments, Boxworth 23 June 2005.

Treatment	T1 Phoma onset – first signs (early October) 19 Oct	T2 T1 + 4 weeks 17 Nov	T3 T2 +4 weeks 9 Dec	T4 Late Feb 7 Mar	T5* Green mid/bud stem extn 25 Mar	Phoma stem lesion incidence (% plants affected)	Phoma stem lesion severity (0-100 index)
1	Untreated			-		60	16
2	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	-	67	17
3	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	Folicur 0.5	52	13
4	Punch C 0.4	-	Punch C 0.4	-	Folicur 0.5	65	16
5	Punch C 0.4	-	Punch C 0.4	Sanction 0.4	Folicur 0.5	32	8
6	-	Punch C 0.4	-	Punch C 0.4	Folicur 0.5	47	12
7	-	Punch C 0.8	-	-	Folicur 0.5	39	11
8	Punch C 0.4	Punch C 0.4	-	-	Folicur 0.5	47	12
9	Punch C 0.4	Punch C 0.4	-	Sanction 0.4	Folicur 0.5	44	11
10	Punch C 0.4	-	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	52	13
11	-	Punch C 0.4	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	45	12
	SED (29 df)					13.98	3.57
	F test					ns	ns

Table 5.44. Yield and yield response in fungicide spray timing experiment, Boxworth 2005.

Treatment	T1 Phoma onset – first signs (early October) 19 Oct	T2 T1 + 4 weeks 17 Nov	T3 T2 +4 weeks 9 Dec	T4 Late Feb 7 Mar	T5* Green mid.bud stem extn 25 Mar	Yield (t/ha) 90% dry matter	Yield response (t/ha)
1	Untreated			-		4.01	-
2	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	-	4.04	0.03
3	Punch C 0.4	Sanction 0.4	Punch C 0.4	-	Folicur 0.5	4.40	0.39
4	Punch C 0.4	-	Punch C 0.4	-	Folicur 0.5	4.21	0.20
5	Punch C 0.4	-	Punch C 0.4	Sanction 0.4	Folicur 0.5	4.18	0.17
6	-	Punch C 0.4	-	Punch C 0.4	Folicur 0.5	4.27	0.26
7	-	Punch C 0.8	-	-	Folicur 0.5	4.18	0.17
8	Punch C 0.4	Punch C 0.4	-	-	Folicur 0.5	4.28	0.27
9	Punch C 0.4	Punch C 0.4	-	Sanction 0.4	Folicur 0.5	4.28	0.27
10	Punch C 0.4	-	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	4.37	0.36
11	-	Punch C 0.4	Punch C 0.4 + Caramba 0.3	-	Folicur 0.5	4.10	0.09
	SED (30 df)					0.200	
	CV (%)					6.7	
	F test					Ns	

Disease control

Good control of phoma stem canker was achieved by all the fungicide treatments (Table 5.42). Treatments 3 and 5 gave the lowest stem canker indices and both were based on three-spray programmes for stem canker control; the timing of Sanction could be either November or March. The inclusion of Sanction did result in a significant reduction in stem canker incidence (Table 5.42). Canker severity was moderate overall in the untreated with only a few dead plants evident by late June. Control of small cankers does not usually produce a yield response, but does provide evidence of disease control. Small phoma stem lesions were common this season, but are unlikely to have affected yield. There was little to choose between the various treatments against phoma stem lesions and no significant effects were obtained (Table 5.43). There was useful suppression of powdery mildew on stems and pods by the fungicide treatments but this is also unlikely to have affected yield.

There were no significant effects of fungicides on yield (Table 5.44). Some positive yield responses were expected by reducing the canker index from 48 (untreated) to 25-30 and there were positive yield trends in all the fungicide treatments. There appeared to be a response to the spring Folicur treatment of up to 0.35 t/ha (compare treatments 2 and 3) and a positive effect of Caramba (+0.16 t/ha) in December (compare treatments 4 and 10). However, there was no significant lodging in the trial area and plants stood well. In adjacent trials some fungicides were shown to improve rooting and similar effects may have produced small but non-significant effects in this experiment. The yield trends (responses) are within expectations, given that phoma started in October, but the main phoma leaf spot epidemic developed in mid November when plants were large (GS 1,12). Under these conditions a single autumn spray followed by a plant growth regulator treatment would probably have been optimal.

5.4 Fungicide efficacy against light leaf spot

Concerns have been raised about control of light leaf spot in HGCA Topic Sheet No. 25 (light leaf spot control in winter oilseed rape) published in autumn 2003. Results from the PASSWORD project indicate that control may be difficult to achieve in the Aberdeen area. Triazole fungicides remain dominant for control of light leaf spot and in England and the Borders they can still provide good control. Data comparing different fungicides for activity against light leaf spot are limited. Results from an experiment on cv. Synergy in Berwickshire in 2001/02 are shown in Table 5.45 (courtesy of Syngenta). All the fungicides gave very good control of light leaf spot from a programme of two sprays applied on 1 November and 25 March. There were no significant differences between treatments in either February or April assessments. Plot score data are presented and overall plant severity was moderate in late April as 7.5% leaf area of untreated plots was affected. Treatments reduced winter scorch and improved plant vigour but differences were not always significant. All three Plover programmes and the sequence of Punch C followed by Folicur gave significant yield responses. The inclusion of carbendazim with Plover at the 0.25 l/ha rate and use of Plover at the higher rate (0.5l/ha) were cost-effective. Interestingly, the sequence of Punch C followed by Folicur gave a significantly higher yield than two sprays of Punch C. Caramba and Folicur, both triazoles with plant growth regulatory properties, did not give significant yield responses at this site.

Table 5.45. Comparison of fungicide programmes against light leaf spot (LLS) Berwickshire 2001/2002.

No.	Autumn GS 1,6 01 Nov 2001	Spring GS 3,1 25 March 2002	% LLS (plot score) 28 February	% LLS (plot score) 25 April	Yield (t/ha) 91% DM
1	Nil	Nil	33.8	67.5	3.60
2	Punch C 0.4 /ha	Folicur 0.5 l/ha	0.5	1.3	4.47
3	Plover 0.25 l/ha	Plover 0.25 l/ha	3.8	6.3	4.18
4	Plover 0.25 l/ha + MBC 0.25 l/ha	Plover 0.25 l/ha + MBC 0.25 l/ha	3.8	0	4.27
5	Punch C 0.4 /ha	Punch C 0.4 l/ha	1.0	1.3	3.99
6	Folicur 0.5 l/ha	Folicur 0.5 l/ha	0	0	4.03
7	Caramba 0.6 l/ha	Caramba 0.6 l/ha	3.0	0	3.80
8	Plover 0.5 l/ha	Plover 0.5 l/ha	0	0	4.49
SED			4.39	5.18	0.230
F test			<0.1%	<0.1%	<0.1%
% Cv					4.5

Discussion

Limited data comparing fungicide products are available. Historic data show small differences between triazole products and other characteristics such as growth regulatory activity and curative activity against phoma leaf spot are important for product selection (HGCA Project OS28, Gladders *et al.,* 1998). There is evidence of poor control of light leaf spot in experiments in Scotland (e.g. HGCA Project OS63, Burnett 2003), including those conducted as part of the PASSWORD project. Low fungicide dose and spray timing issues may be involved in some cases, but in the Aberdeen experiments use of full dose applications has not overcome poor control. In England, light leaf spot remains common but satisfactory control is being achieved through direct management in high-risk areas and as a consequence of phoma and lodging control strategies elsewhere. Careful monitoring of product performance is required, as there are few alternatives to the triazole fungicides. MBC products may no longer give satisfactory control of light leaf spot and mean yield responses were low (<0.1 t/ha) in HGCA experiments in 1995-1997 (HGCA Project OS28, Gladders et al., 1998). Resistance to MBC products is present in Scotland in *Pyrenopeziza brassica*, though the situation in England has not been monitored for some years.

Chapter 6

Evaluation of commercial practice

Recent research with fungicides indicates that individual applications often produce positive yield responses and there are additive effects from multiple applications. Large responses are usually related to good control of severe disease, potentially 0.5-0.7 t/ha from stem canker and >1.0 t/ha from light leaf spot. Fungicides applied at the wrong time may not be cost-effective and lost yield is not recovered. Seasonal, regional and crop factors influence disease risk and the development of epidemics and inputs should be carefully selected for individual crops. Uptake of new guidance on disease management should improve the consistency of yield and profitability. The use of farm records of crop inputs and yield should allow influential crop inputs to be identified and indicate how the industry has responded to research messages. Such farm data has been made available to this project by the ProCam Group.

The ProCam Group 4cast database has collated actual data on yield, costs and profitability of participating farms since 1994. Records are drawn from over 400,000 hectares of field walked crops, particularly in southern, eastern and northern England (Fig. 1). Computer trend analysis is available from the largest known database of arable production results in the UK (using farm records on Farmade and Muddy Boots). Comparisons of the performance of different farms and farming systems can be made locally and nationally, and incorporate seasonal trends. The database acts as a unique source of agronomic and economic information which, when combined with ProCam Group expertise, adds value and profit to ProCam clients. It may be used to forecasts the impact of key decisions on yield and profitability of individual crops.

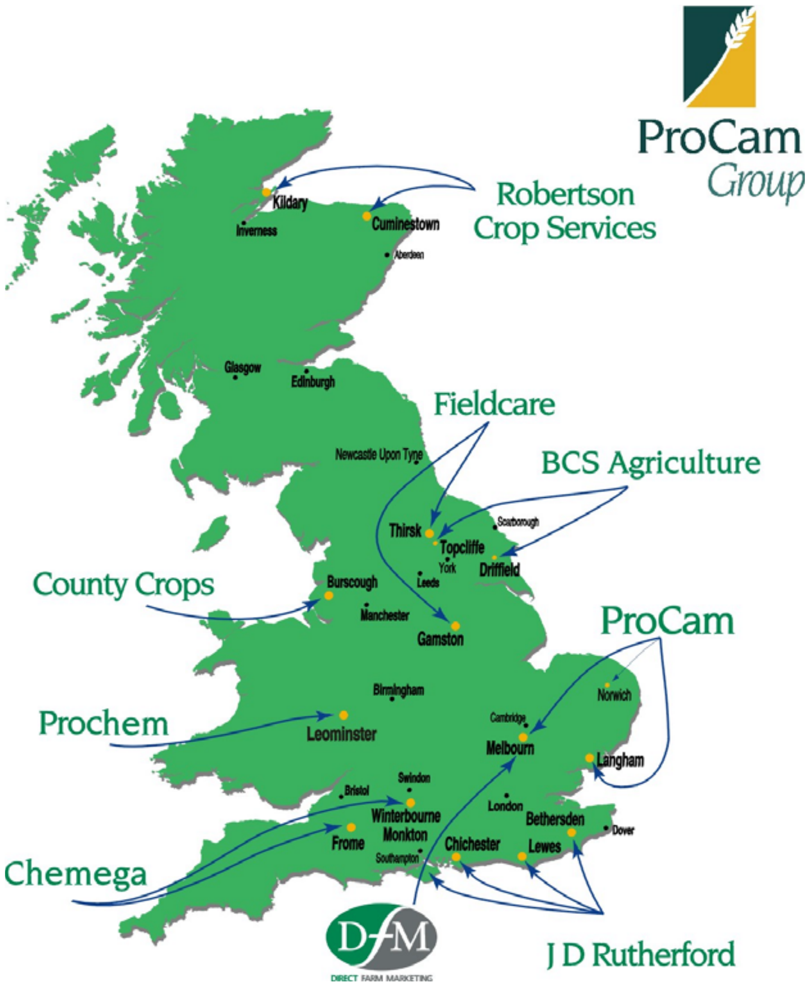

Figure 6.1. ProCam Group in 2004.

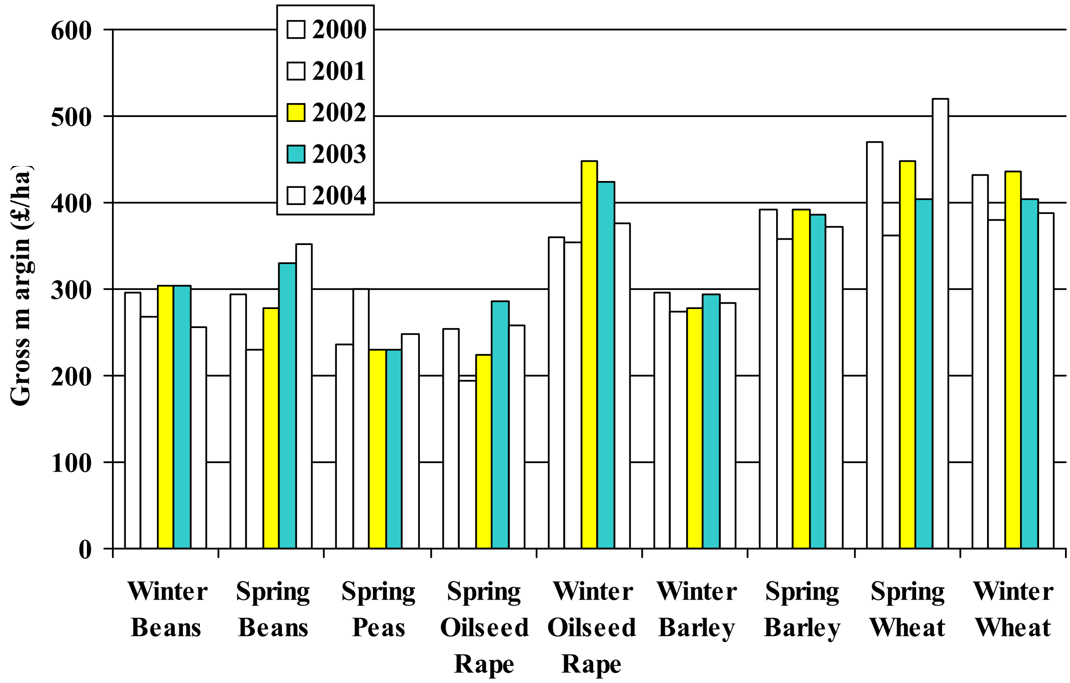

Figure 6.2. Crop gross margins for the top 25% of crops, based on yields, 2000-2004.

Gross margin data have been 'normalised' to allow direct comparisons to be made across years, unconfounded by changes in prices. Records for the top 25% of crops (based on yields) provide a benchmark for the quality of the data available (Fig. 2). Winter oilseed rape gave gross margins that were higher than winter wheat in 2002 and 2003 and was the most profitable break crop. Winter wheat showed less variation in gross margin from year to year than winter oilseed rape. Spring wheat and spring barley also performed well.

The average yield of winter oilseed rape showed positive trends with increasing fungicide inputs during 2000-2004 (Fig. 3). Treatments in autumn were targeted against phoma leaf spot and light leaf spot, whilst stem extension sprays were used for plant growth regulation and/or disease control. Flowering sprays were used mainly for sclerotinia control and suppression of pod diseases. Flowering and stem extension treatments were associated with higher yields than autumn sprays. A combination of stem extension and flowering sprays gave an extra 0.21 t/ha. The addition of an autumn spray to a spring spray or to a stem extension + flowering programme produced an additional 0.1t/ha.

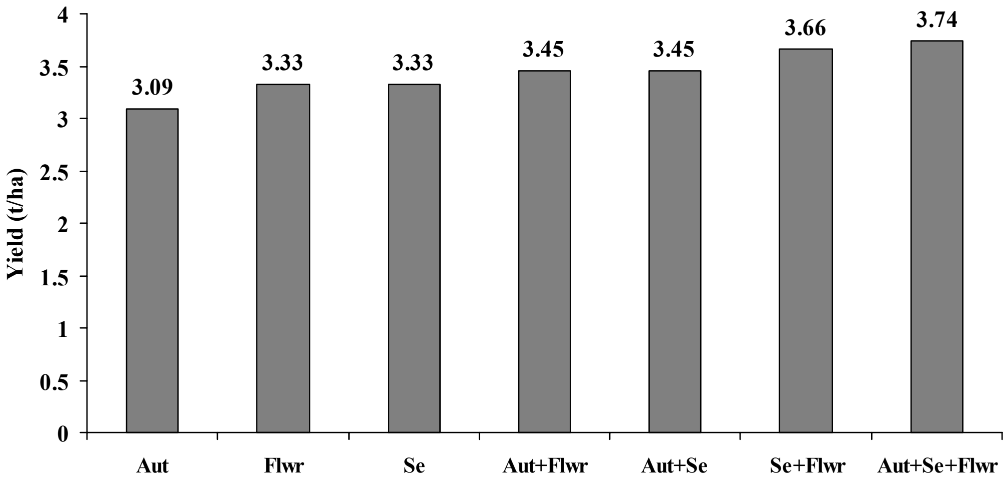

Figure 6.3. Interaction of winter oilseed rape yield with fungicide timing, 1999-2004.

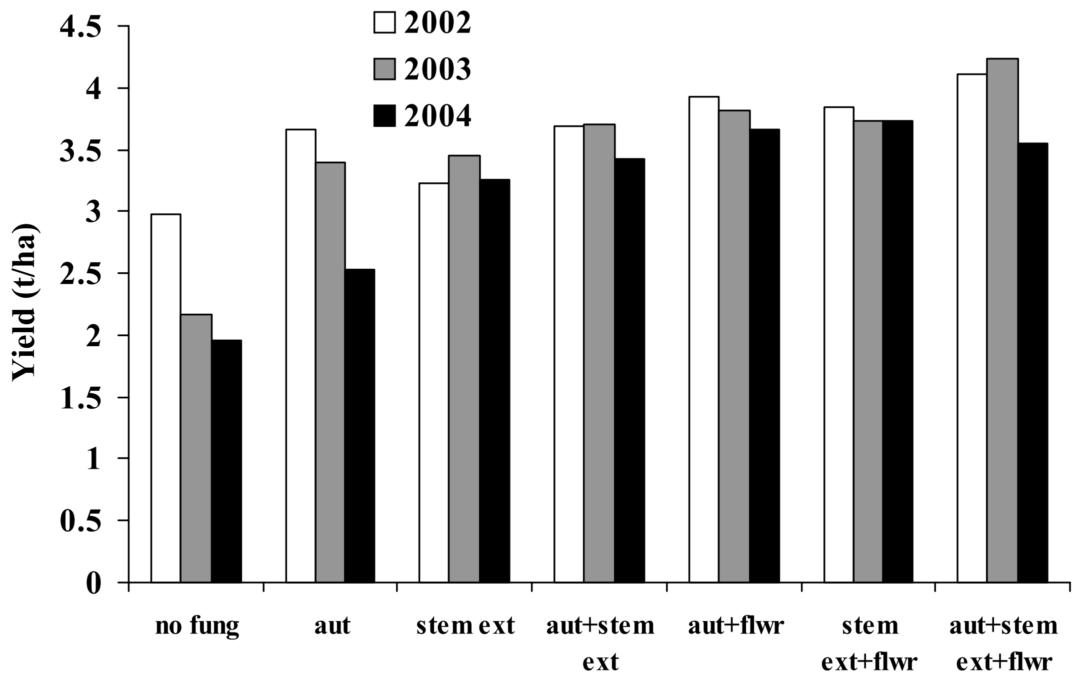

Figure 6.4. Interaction of winter oilseed rape yield with fungicide timing by year 2002-2004.

Examination of fungicide effects by year during 2002-2004 allows more detailed interpretation of effects and inputs in relation to disease epidemics (that have been quantified at experimental sites). Caution is required when interpreting these effects as decisions may have made to minimise inputs to poor crops. Untreated yields may therefore not have responded to fungicide inputs. Nevertheless higher yields are associated with two or three applications of fungicide. In autumn 2003, phoma leaf spot was delayed by the dry conditions and this also affected crop establishment in parts of the east. There were large variations in the yield of untreated (1.95-2.98 t/ha) and autumn treated crops (2.55-3.66 t/ha) during 2002-2004, much less where stem extension sprays (3.23-3.45 t/ha) or programmes were used (3.43-4.23 t/ha) (Fig. 4). For average yields, autumn treatments were particularly beneficial in crops harvested in 2002 and stem extension treatments in 2004. The trends suggest large responses to autumn sprays (compared with untreated crops) each year; 0.68, 1.22 and 0.58 t/ha for 2002, 2003 and 2004, respectively. The highest yields came from a three-spray programme in 2002 and 2003 but two-sprays were optimal in 2004 (from a stem extension + flowering programme). Seasonal variation and selection of inputs is therefore likely to have significance impact on crop performance.

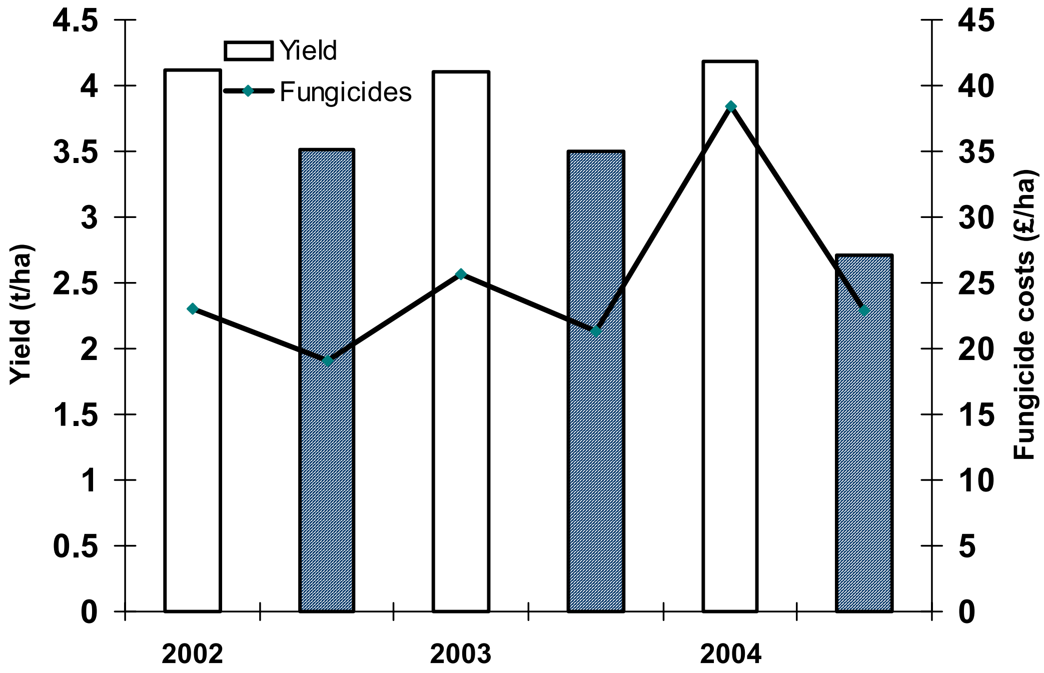

Figure 6.5. Comparison of winter oilseed rape yields in the north (plain histograms) and south/east (diagonal hatching) by year, 2002-2004.

Fungicide data from the south and east has been compared with the north for 2002-2004 (Fig. 5). Different inputs might be expected because of the higher risk of light leaf spot in the north and the better crop establishment in the north in autumn 2004. Fungicide costs were similar in the east /south (£19-23/ha) during 2002-2004, but were much higher in the north in 2004 (£38/ha). Yields were higher in the north in all three years (4.11-4.18 t/ha); yield was low (2.71 t/ha) in the east/south in 2004 compared with 3.50-3.51 t/ha in 2002 and 2003. Inputs were therefore modified differentially in the north in 2004, but there was no evidence of reduced inputs in the east/south despite poorer crops in 2004.

Fungicide data for the south and east show additive effects with programmes. Yields were consistently higher in 2003 than 2004 (Fig. 6). Autumn + flowering gave the highest yield in 2003 (3.85 t/ha) whilst stem extension + flowering was most successful (3.28 t/ha) in 2004. Responses to autumn fungicide sprays were low in 2004 because phoma developed very late and had little effect on yield. In the north, yield variation was much lower than in the south and east. In both 2003 and 2004, crops receiving autumn + stem extension programmes gave the highest yields (4.34 and 4.65 t/ha). Two spray treatments gave higher yields than a three-spray programme (4.16 t/ha in 2003 and 2004). Not all combinations of fungicide timings were represented in the dataset. Despite this limitation, there are indications that fungicide strategies need to be changed from year to year and optimal strategies will differ between regions.

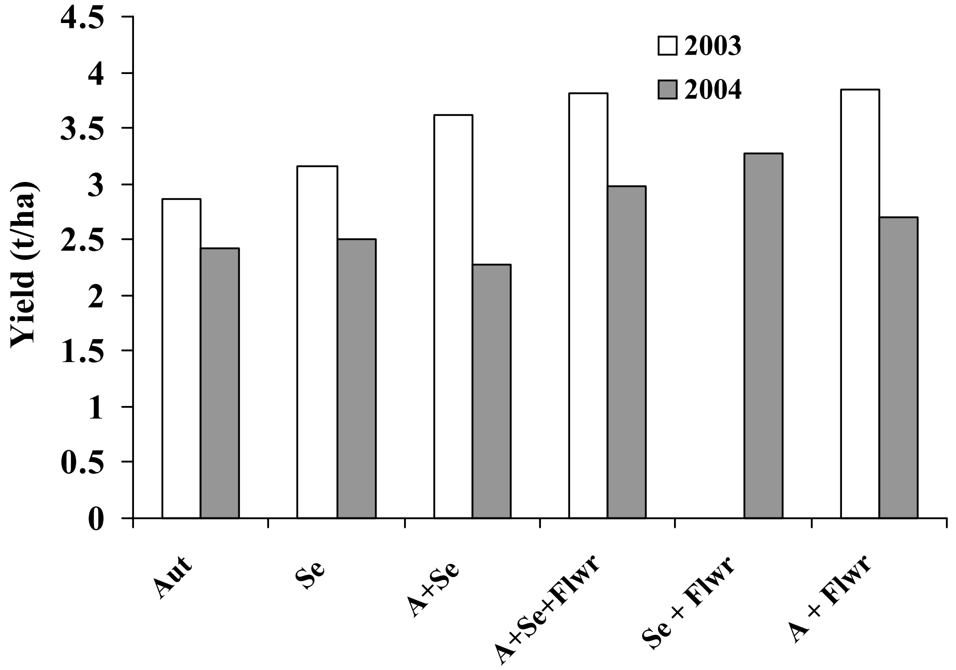

Figure 6.6. Yield of winter oilseed rape in the south and east in relation to fungicide inputs 2003 and 2004.

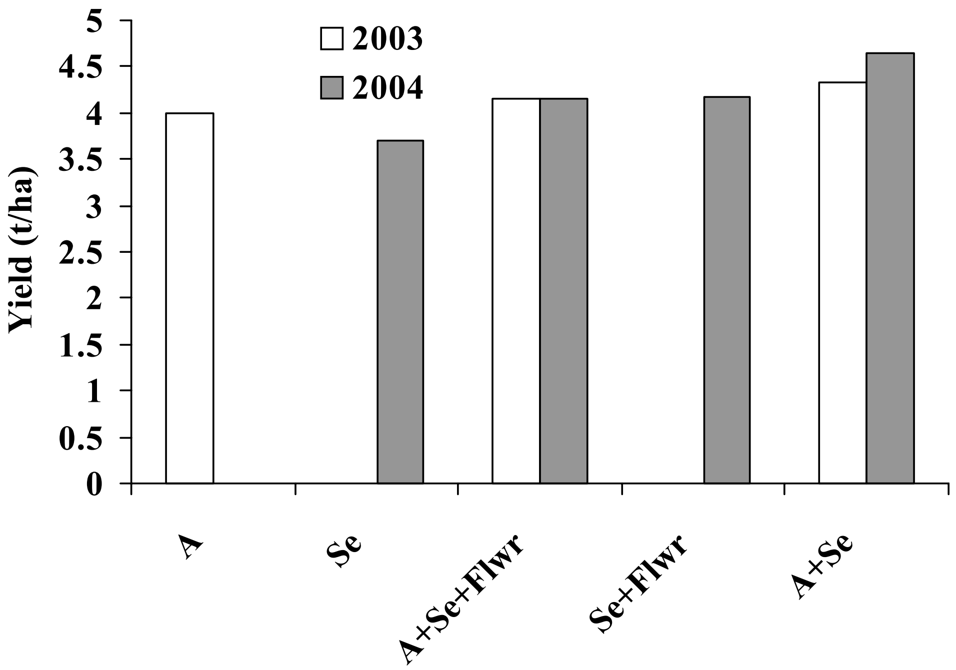

Figure 6.7. Yield of winter oilseed rape in the north in relation to fungicide inputs 2003 and 2004.

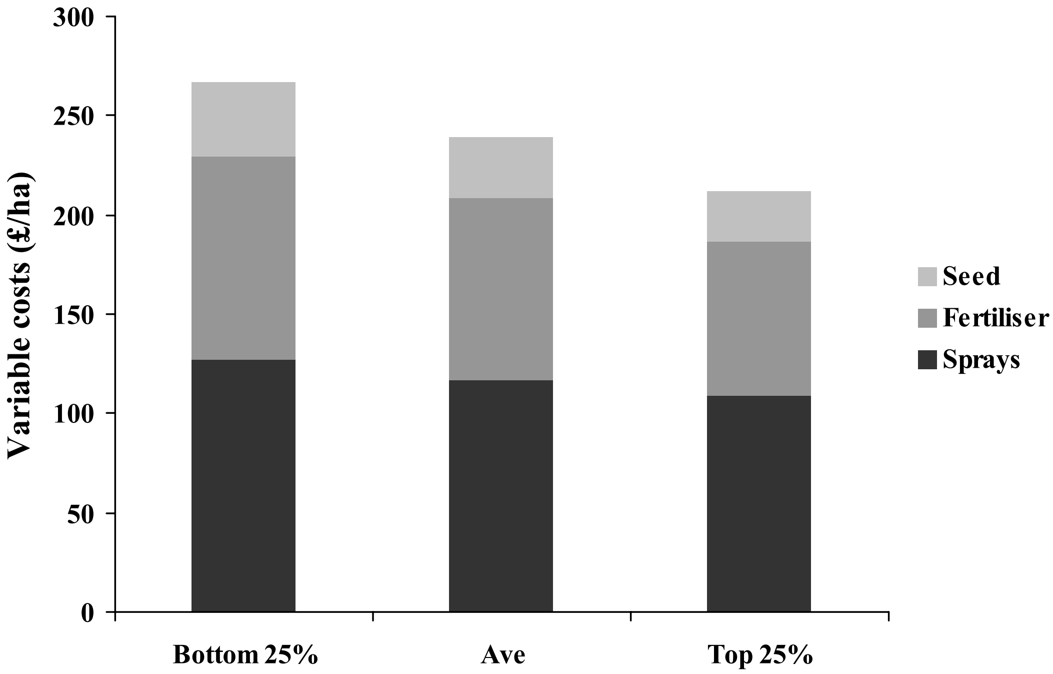

Figure 6.8. Farm variable costs per hectare in relation to gross margin performance at harvest 2004.

There were large differences in variable costs for winter oilseed rape when the top 25% of farms were compared with the bottom 25% (Fig. 8). Seed, fertiliser and spray costs were lower by £17, £25 and £12/ha respectively on the top 25% of farms in 2004. This differential is more marked when compared for yield on a per tonne basis (Fig. 9). The top farms were producing higher yields and their variable costs for seed, fertiliser and sprays per tonne were less than half those of the bottom 25% of farms. The variable costs of sprays per tonne were greater across all pesticide groups for the bottom 25% of farms (Fig. 10). Herbicide costs had the largest variation (£31/t for the bottom 25% compared with £14/t for the top 25%) whilst fungicide costs were less variable at £9/t for the bottom 25% compared with £7/t for the top 25%.

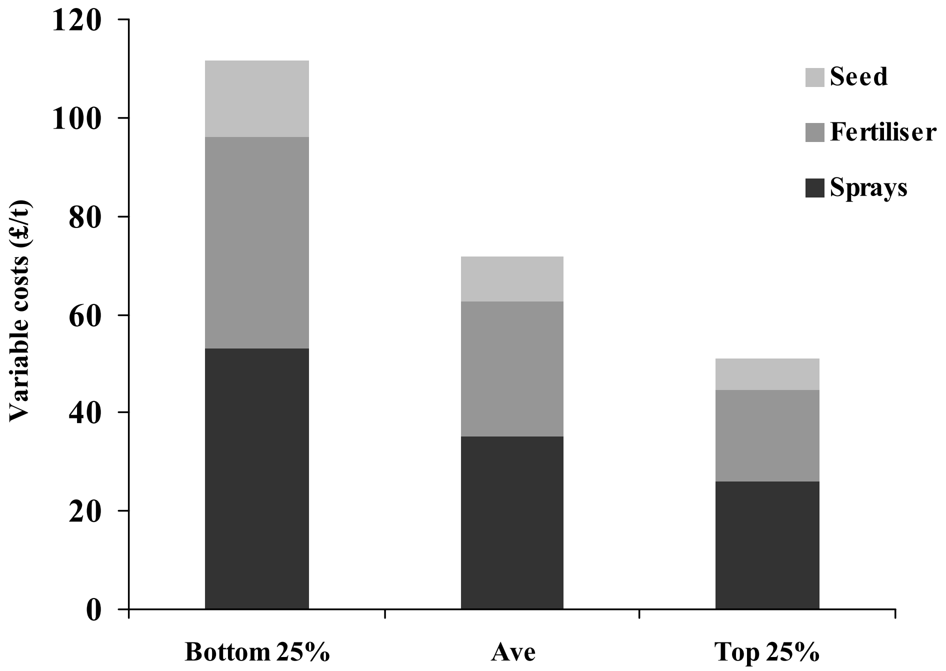

Figure 6.9. Farm variable costs per tonne in relation to gross margin performance at harvest 2004.

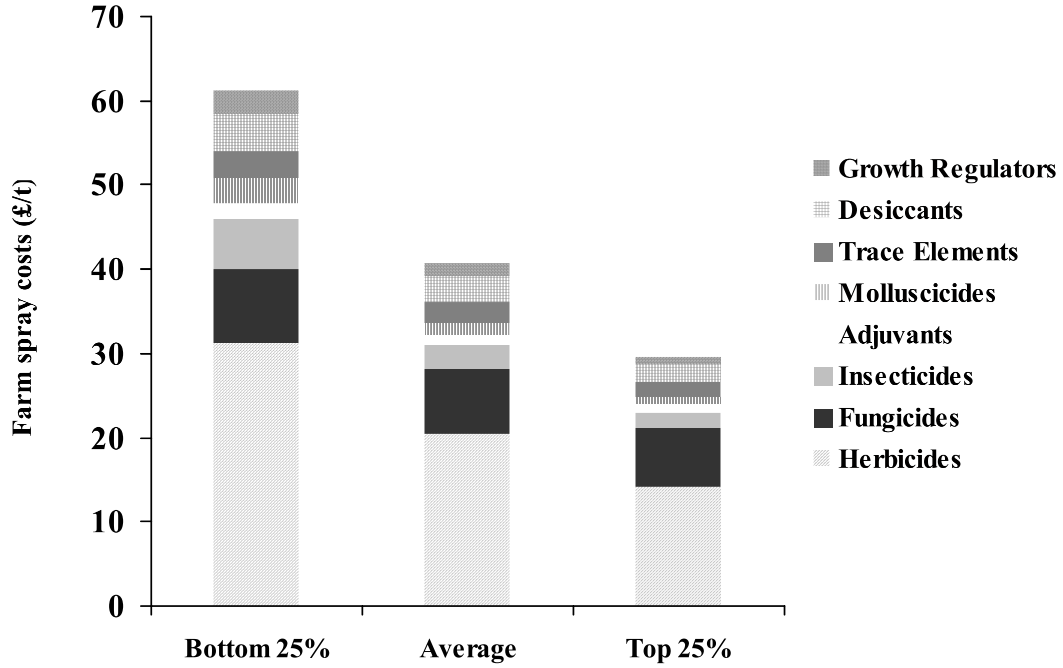

Figure 6.10. Variable costs per tonne of pesticides in relation to gross margin performance at harvest 2004.

The database provides encouraging detail that the most profitable farms were producing good yields with managed inputs. There was some variation in inputs from year to year and regional differences were apparent. The better farms were producing higher yields with lower inputs than poorly performing farms. Some of these differences may have been related to soil type rather than better decision making. Crops with robust fungicide treatments appear to have produced consistent yields despite variability in crop growth and disease pressure. The highest yields were associated with two and sometimes three applications of fungicide. Experiments in PASSWORD indicate that strategic and specific guidance on fungicide decisions can improve margins by £30 /ha. There remains a clear role for PASSWORD in guiding future decisions to improve profitability.

Chapter 7

PASSWORD Module Development

7.1 Introduction

The project requirements with regards to the software and development of the PASSWORD module were to keep the system updated and to incorporate any modifications arising as a result of the model testing. New fungicide data was investigated (see Chapter 5). However, the results showed that there was little difference between the fungicides evaluated and the addition of this data would not improve the models. The information generated, however, could be included in the systems encyclopaedia. The results of the model testing indicated that the disease model components were satisfactory and they were maintained within the DSS. In future, further development of the models would enhance the DSS.

7. 2 Oilseed Rape Pest Manager (formerly DORIS)

7.2.1 Launch

The ArableDS module, Oilseed Rape Pest Manager (ORPM) was released alongside an updated version of Wheat Disease Manager in the Spring 2005.

7.2.2 Updates

Prior to the release of this module, the system went through a final checking process to ensure that the models were functioning correctly and that the interactions between the module and the databases were providing the correct information. Amendments were made to the system to ensure that the module specific database was accessible by the program regardless of where the user installed ArableDS on their computer. Several other internal procedural amendments were made. The latest pesticide information was added to the database and checked to see which products were approved for each pest. The encyclopaedic information was amended to take account of the latest pesticide approval data and to include the latest information on some of the natural enemies of pests found within the whole of the cereals rotation. The Help files were amended to take account of any changes.

7.2.3 Installation Program

A new installation program was developed to fit in with the new installation management program developed for the ArableDS system as a whole. The installation program and the module functionality were tested on five different operating systems (Windows 98, 2000, NT, ME and XP). Any issues arising from this testing were dealt with so that the final installation version was compatible with all these systems.

7.2.4 Documentation

A user guide for ORPM was developed for inclusion with the overall user guide that is provided with the CD. This guide provides information on how to install and use the ArableDS system and how to use the two modules (WDM & ORPM). Licensing issues for the DSE and all the modules were dealt with in one licence agreement.

7.2.5 Training Provision for New and Existing Users

Training course materials were developed and training provided to both new and existing users of the ArableDS system. These took place at various locations around the country (Swindon, Boxworth, Peterborough, Lincoln, York) and ensured that the attendees were given comprehensive background and instructions for the use of the system. As we have now gone through all these processes for ORPM, the completion of the same elements for the combined pest and disease version will be relatively straightforward. However, it should be noted that the development of PASSWORD was begun with the version of ORPM that was current in 2001 and, although many of the amendments since then have been transferred into the PASSWORD module, the amendments made prior to ORPM's final release will need to be incorporated.

7.3 PASSWORD module (Oilseed Rape Manager)

The PASSWORD module is a combined pest and disease system that also includes information on beneficial organisms (Table 7.1).

Table 7.1. Organisms incorporated into the module and their status with regards to modelling and information provision.

Common Name	*Scientific Name*	*Model*	*Information*
PESTS			
Brassica pod midge	*Dasineura brassicae*	√	√
Cabbage aphid	*Brevicoryne brassicae*	√	√
Cabbage leaf miner	*Phytomyza rufipes*		√
Cabbage seed weevil	*Ceutorynchus assimilis*	√	√
Cabbage stem flea beetle	*Psylliodes chrysocephala*	√	√
Cabbage stem weevil	*Ceutorhynchus quadridens*		√
Peach potato aphid	*Myzus persicae*	√	√
Pollen beetle	*Meligethes spp.*	√	√
Rape winter stem weevil	*Ceutorhynchus picitarsis*	√	√
Slugs	*Deroceras reticulatum*		√
DISEASES			
Light leaf spot	*Pyrenopeziza brassicae*	√	√
Phoma stem canker	*Leptosphaeria maculans*	√	√
BENEFICIAL INSECTS			
Bees	*Apis spp*	***n/a***	√
Marmalade hoverfly	*Episyrphus balteatus*	***n/a***	√
Parasitic wasp	*Trichomalis perfectus*	***n/a***	√
Parasitic wasp	*Diaretiella rapae*	***n/a***	√
Rain beetle	*Pterostichus melanarius*	***n/a***	√

7.3.1 Data requirements

The data requirements of the modules vary depending upon the model. They are:

1. Field samples (e.g. beating tray counts of cabbage seed weevil),
2. Daily temperature data (min and max) and daily rainfall data (e.g. for prediction of 10% of plants with phoma symptoms)
3. Hourly temperature data and hourly readings from wetness sensor (e.g. for prediction of likely light leaf spot infection events)

The user must collect the field data and the system provides the daily meteorological data. Unfortunately, sourcing the hourly data is more problematic. The ArableDS meteorological data provider is only able to provide daily temperature within the current agreement, so this element of the system will not be available to most users. It is possible for users to have their own meteorological stations to record the necessary data and then upload it into ArableDS databases. However, these databases are currently set up to take daily data only and would require amending to allow this data upload. The vast majority of current users do not upload their own data, so to enable the system to have maximum relevance, derivations of the models that use hourly data should be modified to use daily data. Clearly this change from daily to hourly data will lead to a loss of precision, but is the only way that users will gain maximum benefit from the system. There is a phoma progress model that provides information on the predicted epidemic. However, whilst infection events can be identified for light leaf spot, models to predict disease progress throughout the life of a crop require further development.

7.3.2 Arable DS uncertainties

The future funding of the ArableDS system is currently under review. Negotiations cover not just the updates, but also the method of delivery and technical support, with the possibility of a shift away from the current CD-based delivery to a more Internet based system. The outcome of these negotiations will determine the next step in the delivery of the PASSWORD module and its future development to include all the diseases of oilseed rape.

7.3.3 Requirements prior to module release

Prior to module release, there are a number of tasks that must be undertaken:

1. Incorporate model derivations that will allow all users to gain some use from the system
2. Incorporate the latest amendments of ORPM into the pest part of the PASSWORD system
3. Complete a user manual for the system
4. If ArableDS is to continue as a CD based system, it will be necessary to create a new installation program

5. Beta testing of the system once tasks 1-3 have been undertaken

7.4 Conclusions

The PASSWORD DSS provides a new system to guide decisions on the major pests and diseases of winter oilseed rape. It is being made available to the Arable DS community for operation in autumn 2006.There is potential to extend the module to make it comprehensive for all diseases of oilseed rape and to include other agronomic inputs. To be successful, the module will need to be maintained, supported and kept up to date. New research projects are underway that could provide new data to enhance the system.

Chapter 8

Final Discusssion

The model testing phase of the PASSWORD project has produced encouraging results and highlighted the complexity of variation which farmers and their advisers have to deal with. Regional forecasts for light leaf spot (Evans *et al*., 2002; Welham *et al*., 2004) have been supplemented by equivalent strategic forecasts for stem canker. The stem canker model was successful within the limits of meteorological data on which it was based and extends the forecast beyond the preliminary scheme identified for eastern counties (Gladders and Symonds, 1995). Extreme weather, such as the low rainfall in August 2003, will remain a problem for disease prediction, but such anomalies can be identified and allow forecasts to used with caution or discarded. The use of live crop monitoring provides a safety net for disease forecasts and enables decisions to be made at crop level. There is growing awareness of the oilseed rape disease forecasts judged by 'hits' on the CSL, HGCA and Rothamsted websites and commercial support via Syngenta's SPAWS system and DuPont's website.

The light leaf spot forecast has remained successful. The very low incidence of light leaf spot in spring 2005 indicates that good control can still be achieved in England. This is partly due to more effective use of autumn sprays for phoma control as the same azole fungicides also control light leaf spot. Light leaf spot control is a serious problem in Aberdeenshire and this provides an early warning that the disease has potential to become more serious in future. Control of light leaf spot relies heavily on resistant cultivars in Scotland and breeders will require new sources of resistance. Recent increases in the susceptibility of cv. Recital in England suggest that a new race of the light leaf spot pathogen has emerged. Further investigation of such changes is required to understand the molecular basis of host plant resistance and development of new races of *Pyrenopeziza brassica*. The search for fungicides with new modes of action against light leaf spot remains a high priority.

Whilst regional disease forecasts provide strategic guidance on year to year variation in disease risk, monitoring disease development in individual crops is required to guide use of fungicides. Prediction of 10% plants affected worked well in autumn 2004 and could be developed further with access to local rainfall data. Records of local rainfall, particularly when this is higher than in surrounding areas, should assist the identification of 'hot spots' of early disease. Collaboration with Australian researchers (Salam *et al*., 2003) may lead to improved forecasts for ascospore release as incorporation of more diverse environmental conditions should produce a more robust model. Disease risk at the field level depends on the proximity to stem residues from the previous year's crops and the quantity of stem material on the soil surface (Marcroft *et al*., 2004) wind direction, plant size (mostly a sow date factor) and cultivar resistance to stem canker. Field to field variation is large and is identified most effectively by direct field observations. Forecasts provide early warning that disease symptoms are appearing and can therefore identify key periods when field observations should be made.

In addition to *L. maculans*, there is also *Leptosphaeria biglobosa* (previously referred to as B-type phoma) in many crops. The small dark leaf spots are not easy to identify and confirmation may require molecular diagnostic tests or culturing onto agar. There are some differences between the two species (Huang, 2002; Toscano-Underwood *et al*., 2001), but *L. biglobosa* is usually associated with upper stem lesions to a greater extent than stem cankers (West *et al*., 2001). Molecular techniques will enable interactions between these two *Leptosphaeria* species to be investigated more comprehensively. *L. maculans* is the dominant pathogen in the UK and fungicide decisions should continue to be made using thresholds for the characteristic large phoma leaf spots.

Reliable prediction of disease infection periods and hence development of phoma leaf spot and light leaf spot requires hourly weather data. This may not be readily available. The provision of weather data remains a significant issue for DSS users, as there is a cost for providing it. On-farm weather stations would overcome this problem provided they are regularly checked and calibrated.

The relationship between disease severity and yield loss has been reviewed within the PASSWORD project. Early disease is the most damaging and late epidemics may be of limited economic importance (Zhou *et al*., 1999). There was a marked difference between the two seasons covered by this validation project. In autumn 2003, there was opportunity to reduce or omit the number of phoma sprays because of the late epidemic. Experiments in 2003/04 confirmed that fungicide treatments are not required for late epidemics unless plants are small. This extends the range of epidemic development x crop interactions that have been encountered and will assist decision making (Gladders *et al*., 1998). Autumn 2004 provided a different risk after a wet August and a severe epidemic was averted because of below average rainfall in September. In future years, the potential for severe phoma leaf spot epidemics in September should not be overlooked. Some of the responses to fungicides in 2004/05 were large and reflected effects on crop lodging as well as disease control. There appear to be smaller yield responses to fungicides where plants were large when the phoma epidemic was initiated. Further data from early sown crops are required to extend the current datasets. In future, greater account will need to be taken of crop nitrogen requirements and lodging risk to improve decision making on agrochemical usage.

Cultivar resistance has made a small but significant contribution to stem canker control within PASSWORD cultivar x fungicide experiments. Cultivar resistance is not stable and widely grown cultivars have often shown increased susceptibility after a few years of commercial production (Delourme *et al.,* 2006; Li et al., 2003; Rouxel *et al.,* 2003; Sprague *et al*., 2006). Recent examples include Apex, Escort and Winner; the stem canker rating of Escort has falen from 7 to 5 since 2004 (Anon., 2004). Progress has been made in understanding the resistance to *L. maculans* and variation in *L. maculans* itself. Host resistance to stem canker is based on major genes operating within a polygenic background resistance (Delourme *et al.,* 2006). Major resistance genes can be overcome rapidly by new races of the pathogen, a situation that is more familiar in diseases such as yellow rust of wheat. Few major genes are still providing effective control of stem canker (Stachowiak *et al.,* 2006), an exception being resistance gene *Rlm7* which is present in the high erucic acid cultivar Hearty. Regular monitoring of races of *L. maculans* is advised to support exploitation of cultivar resistance. Improved strategies to ensure cultivar resistance becomes more durable (McDonald and Linde, 2002) are being developed under the EU-funded SECURE project. A component of this strategy will involve isolation of new crops from stubbles of previous crops and/or incorporation of stubble residues in autumn (Marcroft *et al.,* 2004). Current interest in growing oilseed rape alternating with wheat will not be sustainable unless oilseed rape stubbles are managed to reduce spread of air-borne spore inoculum.

Fungicides made a significant contribution to disease control and were cost-effective in some but not all situations. Late phoma leaf spot epidemics were identified as a situation where treatments can be omitted. There were also difficulties in the north of Scotland where light leaf spot has not been controlled very effectively. Progress was made on the flexibility of fungicide timing for phoma control. Where plants were well grown a delay of two weeks, possibly longer, had no adverse effect on yield. Previous work on smaller plants (ADAS, unpublished data) indicated that delays are more critical when leaves are small. New fungicide products are becoming available and comparative data on product efficacy is an area that needs to be strengthened in the DSS. Fungicide performance is influenced by the sensitivity of fungal pathogen populations to the fungicides. There is little current information on fungicide sensitivity in *L. maculans* or *P. brassicae* populations in England and some monitoring would be beneficial.

The sustainability of oilseed rape will be enhanced by the project through improved targeting of appropriate agrochemical doses. Annual expenditure is about £3.5 million for insecticides and £12 million on fungicides and the cost-effectiveness of these inputs needs to be improved. Improved use of fungicides and more effective disease control using guidance from the DSS has potential to increase average yields by up to 0.5 t/ha (equivalent to £75/ha or £15 million/annum if benefits occur on 200,000ha). Defra surveys indicate that substantial progress has been made in recent years by increasing autumn use of fungicides (Turner *et al.,* 2000). New disease models provide improved estimates of yield loss so that inputs can be adjusted in real time. Situations will be identified where fungicide responses are likely to be small so that treatments could be avoided. Closer attention to detail during crop monitoring (outside the scope of this project) is also expected to improve overall management of the crop, notably the crop canopy in the spring, with further yield improvements of up to 0.5 t/ha. Direct benefits in reduced pesticide costs and improved yield from the DSS are estimated to be £16 million/annum.

Environmental benefits will be achieved through PASSWORD by reduction in unnecessary spraying. The PASSWORD DSS also offers guidance on use of insecticides (Northing and Walters, 2005; Northing *et al*., 2005) though they are not directly included in this validation project. However, there are expected to be environmental benefits by reducing unnecessary insecticide applications by 160,000 spray ha (cost savings of £0.6 million/annum) for insect pests, which under current conditions rarely cause economic damage. This addresses Defra priorities of pesticide minimisation. More efficient crop production will improve utilisation of other agrochemicals including nitrogen. Changes in farm practice and improvements in control of pest and diseases could be monitored through the ADAS/CSL disease surveys of oilseed rape and through surveys of pesticide use.

The PASSWORD DSS has combined pest and disease decisions for the autumn and winter and other important diseases still need to be included to cover flowering and pod formation. Sclerotinia stem rot and dark pod spot (*Alternaria* spp.) are common diseases for which decisions on crop risk and fungicide inputs are required. A range of minor diseases including downy mildew, grey mould, powdery mildew, ringspot, virus diseases and white leaf spot also merit inclusion. Soil-borne diseases such clubroot appear to be increasing and verticillium wilt (*V. longisporum*) is a further threat. Farm yields of oilseed rape have not increased in recent years and pests and diseases are almost certainly part of the problem. A DSS has potential to improve crop management and improve yields. A wider vision to include all decisions on the oilseed rape crop itself and in the rotation may be required to achieve this. The PASSWORD DSS will be made available to ArableDS and make a significant contribution to its portfolio.

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Appendix – Further details of field experiments 2003-2005.

Appendix 1. ADAS cultivar x fungicide experiments at Boxworth, High Mowthorpe and Rosemaund;

Appendix 2. SAC Aberdeen; Appendix 3. ADAS fungicide timing experiments at Boxworth .

Appendix 1.

Table 1.1 Plant counts Boxworth, High Mowthorpe and Rosemaund 2003-04.

Treatmnt code	Treatment	Assessment dates					
		Boxworth		Rosemaund		High Mowthorpe	
		Plants per m²					
		18 Dec	28 July	20 Nov	9 Aug	20 Nov	27 Aug
1	Royal Untreated	42	25	68.0	26.8	68.0	61.0
2	Royal Forecast	40	23	63.2	26.0	63.2	65.8
3	Royal Onset	46	34	57.6	28.2	57.6	63.2
4	Royal Managed	36	32	65.6	37.8	65.6	53.6
5	Recital Untreated	75	48	108.0	27.4	108.0	56.2
6	Recital Forecast	67	59	115.2	37.6	115.2	53.0
7	Recital Onset	81	53	104.0	33.4	104.0	58.0
8	Recital Managed	81	63	106.8	26.8	106.8	40.6
9	Escort Untreated	72	35	100.8	33.2	100.8	60.0
10	Escort Forecast	76	44	93.2	23.2	93.2	48.2
11	Escort Onset	66	39	99.2	36.2	99.2	59.4
12	Escort Managed	67	44	98.8	28.4	98.8	48.6
Grand mean		62.4	41.6	11.12	30.42	90.0	55.6
SED		Cultivar 5 .11 Fungicide 5.67		Cultivar 1.186 Fung. 1.369 Int 2.372	Cultivar 4.82 Fung. 5.56 Int 9.63	10.30	9.45
F test	cultivar Fung Interaction	<0.1% ns 5%	<0.1% 5% ns	<0.1% ns ns	ns ns ns	<1% ns ns	ns ns ns

* Logit transformed data analysed

Table 1.2. Site details ADAS Boxworth Winter oilseed rape cultivar x fungicide site, 2003/04.

Site:	ADAS Boxworth, Cambs		
Field name:	Pamplins South		
Soil texture:	clay loam		
Drainage:	Good		
Previous cropping:	2003 Winter wheat 2002 Winter wheat 2001 Winter oilseed rape		
Soil analysis:	pH 8.1		
	ADAS Indices – P 20 mg/l (2), K 237 mg/l (2+), Mg 69 mg/l(2) Organic matter 3.61%		
Crop: Winter oilseed rape	Cultivar	:	Royal, Recital and Escort (Farm crop cv.Winner)
	Sowing date	:	03/09/03
	Seed treatment		As supplied
Seedbed NPK kg/ha	28 kg/ha N		11/08/03
	84 kg/ha P		
	Fertiliser N	:	34.5% N product 116 kg/ha 16/10/03 Ammonium sulphate 100 kg/ha 11/02/04 Nitram (Ammonium nitrate) 240 kg/ha 11/02/04; Ammonium nitrate 250 kg/ha 30/03/04
Herbicides:	Butisan S 1.25 l/ha + Trifluralin 480 2 l/ha 22/08/03 Falcon 0.7 l/ha + Kerb Flo 2.09 l/ha 6/12/03		
Fungicides:	Experimental treatments only.		
Insecticides:	Cypermethrin 100 0.25 l/ha on 06/12/03, 22/04/04 & 07/05/04		
Molluscicides:	Draza 5.0 kg/ha 13/09/03		
Growth regulator:	-		
Trace elements:	-		
Desiccant	Glyphosate 4 l/ha + Addit wetter 0.5 l/ha 13/07/04		
Harvest date:	27/07/04		

Table 1.3. Spray application details, Boxworth 2003/2004.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
Phoma onset Late October /November	Plover	24/11/03	1,5	Sunny but cool; crop dry after wet weather Temp max 8°C RH 72% Wind: calm (<2kph), slight drift
Phoma established November	Plover	18/12/03	1,6-1,7	Sunny, cool and frosty; crop and soil damp Temp 2-3°C Wind: 3-6 kph,slight drift
6 weeks after T2 December /January	Plover	23/01/04	1,7	Overcast, cool and damp after cool wet weather. Crop damp. Temperature 6°C Wind: 3-6 km/hr, gusting and slight drift.
Early stem extn February	Plover	12/02/04	1,13, 3,1	Overcast and cool after previous dry and cool conditions. Crop dry. Temp 11.5°C, RH 71% Wind: calm <2 kph, no drift

Spray application equipment

Sprayer: OPS with 3 m boom
Nozzles: LD02F110 (Lurmark).
Water volume: 200 litres
Pressure: 2.0 bar

Table 1.4. Site details ADAS Rosemaund Winter oilseed rape fungicide site, 2003/04.

Site:	ADAS Rosemaund Herefordshire		
Field name:	Flatfield		
Soil texture:	Silty clay loam Bromyard Series		
Drainage:	Good		
Previous cropping:	2003 Winter wheat 2002 Winter Oats 2001 Winter Wheat		
Soil analysis:	pH 7.1		
	ADAS Indices – P 24 mg/l (2), K 186 mg/l (2+), Mg 83 mg/l(2) Organic matter 2.21%		
Crop: Winter oilseed rape	Cultivar	:	Royal, Recital and Escort (Farm crop cv.Winner)
	Sowing date	:	02/09/03
	Seed treatment		As supplied
Seedbed NPK kg/ha	None		
	Fertiliser N	:	Amm.nitrate (34.5% N) product 87 kg/ha 20/10/03 Ammonium sulphate 145 kg/ha 03/03/04 Ammonium nitrate 285 kg/ha 30/03/04
Herbicides:	Fusilade Max 0.38l/ha + Katamarran 2.0l/ha 09/12/03		
Fungicides:	Experimental treatments only.		
Insecticides:	Cyperkill 0.25l/ha 17/10/03 Hallmark 0.075l/ha 19/04/04		
Molluscicides:	Mini Slugs 15.0kg/ha		
Growth regulator:	-		
Trace elements:	-		
Desiccant	Reglone 3.0l/ha 29/07/04		
Harvest date:	02/08/04 (reps 1 & 2), 06/08/04 (reps 3 & 4)		

Table 1.5. Spray application details, Rosemaund 2003/2004.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
Phoma onset Late October /November	Plover	11/11/03	1,6	Overcast, cool; crop dry after wet weather Temp max 11.9°C RH 92.3% Wind: calm (<1.2kph), no drift
Phoma established November	Plover	16/12/03	1,6-1,9	Sunny but cool and; crop and soil damp Temp max 5.4°C RH 95.1% Wind: 1.2-2kph,slight drift
6 weeks after T2 December /January	Plover	06/02/04	1,9-1,11	Overcast, cool and damp after cool wet weather. Crop damp. Temp max 8.2°C RH 91.3% Wind: calm (<1.2kph), no drift.
Early stem extn February	Plover	02/03/04	1,11-1,13	Overcast and cool after previous dry and frosty conditions. Crop dry. Temp max 6.8°C, RH 90.9% Wind: 1.2-2kph, slight drift.

Spray application equipment

Sprayer: OPS with 3.5 m boom
Nozzles: SD02F110 (Lurmark).
Water volume: 225 litres
Pressure: 2.5 bar

Table 1.6. Leaf assessment High Mowthorpe 4 December 2003.

Cultivar	GS	No. of leaves	Length of largest leaf (cm)	Width of largest leaf (cm)	Length of petiole (cm)
Escort	1.8	4.75	29.65	9.13	16.52
Recital	1.8	5.20	32.23	9.63	17.67
Royal	1.9	6.15	37.15	11.17	19.27
SED	0.53	0.264	1.127	0.452	0.549
F test	ns	<0.01%	<0.01%	<0.01%	<0.01%

Table 1.7. Leaf assessment High Mowthorpe, 18 December 2003.

Cultivar	GS	No. of leaves	Length of largest leaf (cm)	Width of largest leaf (cm)	Length of petiole (cm)
Escort	1.9	4.30	32.55	9.10	17.50
Recital	1.9	4.45	33.42	10.13	18.12
Royal	1.9	4.93	36.88	10.70	19.48
SED	0.35	0.160	0.935	0.191	0.473
F test	ns	<0.05%	<0.01%	<0.01%	<0.01%

Table 1.8. Site details ADAS High Mowthorpe Winter oilseed rape cultivar x fungicide site, 2003/04.

Site:	ADAS High Mowthorpe, North Yorkshire	
Field name:	Old Type	
Soil texture:	Silty clay loam	
Drainage:	Good	
Previous cropping:	2003 Winter barley 2002 Winter barley 2001 Winter wheat	
Soil analysis:	pH 8.0	
	ADAS Indices – P (2), K (2), Mg (1) Organic matter 3.81%	
Cultivar:	Royal, Recital and Escort	
Sowing date:	27/08/03	
Seed treatment:	As supplied	
Seedbed NPK:	01/08/03	16:16:16 @ 344 kg/ha
Fertiliser N:	08/03/04 11/03/04 31/03/04	Ammonium sulphate @ 122 kg/ha Ammonium nitrate @ 261 kg/ha Ammonium nitrate @ 309 kg/ha
Herbicides:	23/08/03 11/09/03	Katamaran @ 2.0 l/ha Falcon @ 0.35 l/ha
Fungicides:	Experimental treatments only	
Insecticides:	11/09/03 19/04/04	Permasect C @ 0.25 l/ha Cypermethrin @ 0.25 l/ha
Molluscicides:	None	
Growth regulator:	None	
Trace elements:	None	
Swathed:	23/07/04	
Harvest date:	02/08/04	

Table 1.9. Spray application details, ADAS High Mowthorpe 2003/2004.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
Phoma onset Late October /November	Plover	02/12/03	1.9	Humid and overcast Temp 9.0°C Crop and ground wet Wind: 2km/h easterly
Phoma established November	Plover	16/12/03	1.10	Overcast, dry and cool Temp 5.2°C Crop dry, ground frozen Wind: 2 km/h, south westerly
6 weeks after T2 December /January	Plover	08/03/04	3.2	Overcast, dry and warm Temp 5.4°C Crop dry, ground damp Wind: 2-5 km/h, gusting north north east
Early stem extn February	Plover	02/04/04	3.3	Overcast ,dry and cool Temp 11.6°C Crop damp, gound dry Wind: 2 km/h, south westerly

Spray application equipment

Sprayer: OPS with 2 m boom
Nozzles: 03F110 (Lurmark).
Water volume: 200 litres
Pressure: 2.0 bar

Table 1.10. Plant counts Boxworth, High Mowthorpe and Rosemaund 2004-05

Treatmnt code	Treatment	Assessment dates					
		Boxworth		Rosemaund		High Mowthorpe	
		Plants per m²		Plants per m²		Plants per m²	
		15 Dec	26 July	28 Oct	10 Aug	28 Oct	8 Aug
1	Royal Untreated	39	29	114.8	70.4	54.4	41.6
2	Royal Forecast	35	30	82.0	47.8	56.2	43.4
3	Royal Onset	37	27	93.4	51.0	53.6	46.8
4	Royal Managed	33	26	82.2	52.8	54.4	50.6
5	Recital Untreated	43	34	115.8	50.0	70.6	54.8
6	Recital Forecast	46	36	102.8	77.2	74.0	64.0
7	Recital Onset	44	35	116.6	65.4	79.4	62.4
8	Recital Managed	46	40	95.6	56.6	68.6	57.6
9	Escort Untreated	54	46	122.8	68.2	85.4	57.2
10	Escort Forecast	55	44	108.4	57.6	93.2	67.2
11	Escort Onset	67	48	104.2	53.4	87.2	62.0
12	Escort Managed	61	48	103.0	58.0	87.8	73.0
Grand mean		46.6	37.0	103.5	59.0	72.1	56.7
SED (33 df)	Cultivar	5.64	3.27	9.08	5.86	2.48	3.13
	Fungicide	6.52	3.78	10.49	6.77	2.86	3.62
	Interaction	11.28	6.54	18.16	11.72	4.96	6.26
F test	Cultivar	<0.1%	<0.1%	ns	ns	<0.001	<0.001
	Fungicide	ns	ns	ns	ns	ns	0.089
	Interaction	ns	ns	ns	ns	ns	ns

* Logit transformed data analysed

Table 1.11. Site details ADAS Boxworth Winter oilseed rape cultivar x fungicide site, 2004/05.

Site:	ADAS Boxworth, Cambs		
Field name:	Grange Piece		
Soil texture:	clay loam		
Drainage:	Good		
Previous cropping:	2004 Winter wheat 2003 Winter wheat 2002 Winter oilseed rape		
Soil analysis:	pH 8.0		
	ADAS Indices – P 25 mg/l (2), K 264 mg/l (3), Mg 96 mg/l(2) Organic matter 3.61%		
Crop: W. oilseed rape	Cultivar	:	Royal, Recital and Escort (Farm crop cv.Winner)
	Sowing date	:	31/08/04
	Seed treatment		As supplied
Seedbed NPK kg/ha	-		
	Fertiliser NKS	:	7:21:0:0 product 333 l/ha 13/09/04 37% N product 50 l/ha 14/09/04 Ammonium nitrate 240 kg/ha 15/03/05 Ammonium sulphate 100 kg/ha 15/03/05 Ammonium nitrate 307 kg/ha 29/03/05
Herbicides:	Katarmaran 2.0 l/ha + Trifluralin 480 2.0 l/ha 05/09/04 Falcon 0.4 l/ha + mineral oil 0.5 l/ha 26/10/04		
Fungicides:	Experimental treatments only.		
Insecticides:	Cypermethrin 100 0.25 l/ha on 26/10/04		
Molluscicides:	Draza 5.0 kg/ha 22/09/04 and 21/10/04		
Growth regulator:	-		
Trace elements:	-		
Desiccant	Roundup 4 l/ha 11/07/05		
Harvest date:	23/07/05		

Table 1.12. Spray application details, Boxworth 2004/2005.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
Phoma onset Late October /November	Plover	24/10/04	1,5	Dry but cool; crop damp after dry, cool weather Temp max 7-7.2°C RH 77-92% Wind: light breeze (3-6kph), slight drift
Phoma established November	Plover	11/11/04	1,4-1,9	Dry and cool after cool showery weather. Crop damp Temp 9.1-9.9°C RH 55-61% Wind: breezy 3-6 kph, slight drift
6 weeks after T2 December /January	Plover	08/12/04	1,13-1,18	Overcast, cool and damp after previous dry and cool conditions. Crop damp. Temp 7.5-7.6°C, RH 90-91% Wind: breezy 5-7 kph, slight drift
Early stem extn February	Plover	13/01/05	3,1	Sunny and cool after cool showery weather. Crop damp. Temperature 3.9-4°C RH 70-73% Wind: 6-9 km/hr, gusting and moderate drift.

Spray application equipment

Sprayer: OPS with 3 m boom
Nozzles: LD02F110 (Lurmark).
Water volume: 200 litres
Pressure: 2.0 bar

Table 1.13. Site details ADAS Rosemaund Winter oilseed rape cultivar x fungicide site, 2004/05.

Site:	ADAS Rosemaund, Herefordshire		
Field name:	Holbach		
Soil texture:	Silty clay loam Bromyard Series		
Drainage:	Good		
Previous cropping:	2004 Winter Barley 2003 Winter Wheat 2002 Maize		
Soil analysis:	pH 7.1		
	ADAS Indices – P (3), K (3), (3)		
Crop: W. oilseed rape	Cultivar	:	Royal, Recital and Escort (Farm crop cv.Winner)
	Sowing date	:	8/09/04
	Seed treatment		As supplied
Seedbed NPK kg/ha	None		
	Fertiliser N	:	21:0:0:60 product 129.3 kg/ha 10/03/05 Ammonium nitrate (34.5% N) product 123.7 kg/ha 16/03/05 Ammonium nitrate 123.5 kg/ha 04/04/05
Herbicides:	Fusilade Max 0.38l/ha + Katamarran 2.0l/ha 27/09/04 Laser 1l/ha + Dow Shield 0.35l/ha 08/03/05		
Fungicides:	Experimental treatments only.		
Insecticides:	Cyperkill 0.25l/ha 17/10/03		
Molluscicides:	Mini Slugs 7.129kg/ha		
Growth regulator:	-		
Trace elements:	-		
Desiccant	-		
Harvest date:	3/08/05		

Table 1.14. Spray application details, Rosemaund 2004/2005.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
Phoma onset Late October /November	Plover	26/10/04	1,5-1,6	Overcast, cool; crop dry after wet weather Temp max 13.0°C RH 97.0% Wind: calm (<1.2kph), no drift
Phoma established November	Plover	11/11/04	1,6-1,7	Sunny but cool and; crop and soil damp Temp max 11.1°C RH 91.2% Wind: calm, no drift
6 weeks after T2 December /January	Plover	09/12/04	1,6-1,7	Overcast, cool and wet after cool dry weather. Crop damp. Temp max 5.7°C RH 87.4% Wind: calm (<1.2kph), no drift.
Early stem extn February	Plover	13/01/05	1,6-1,8	Sunny and warm after previous showery and cool conditions. Crop damp. Temp max 9.0°C, RH 93.2% Wind: calm, no drift.

Spray application equipment

Sprayer: OPS with 3.5 m boom
Nozzles: SD02F110 (Lurmark).
Water volume: 225 litres
Pressure: 2.5 bar

Table 1.15. Leaf assessment High Mowthorpe, 17 November 2004.

Cultivar	GS	No. of leaves	Length of largest leaf (cm)	Width of largest leaf (cm)	Length of petiole (cm)
Escort	1,7	6.53	9.93	6.61	5.58
Recital	1,8	6.33	9.97	6.60	4.88
Royal	1,7	6.43	9.70	6.31	5.34
SED		0.427	0.457	0.339	0.413
F test		ns	ns	ns	ns

Table 1.16. Leaf assessment High Mowthorpe, 5 January 2005.

Cultivar	GS	No. of leaves	Length of largest leaf (cm)	Width of largest leaf (cm)	Length of petiole (cm)
Escort	2,0	5.38	10.84	5.15	4.16
Recital	2,0	5.60	10.36	4.75	4.18
Royal	2,0	6.00	11.72	5.80	4.44
SED		0.384	1.364	0.553	0.564
F test		ns	ns	ns	ns

Table 1.17. Site details ADAS High Mowthorpe Winter oilseed rape cultivar x fungicide site, 2004/05.

Site:	ADAS High Mowthorpe, North Yorkshire	
Field name:	Kirby Field	
Soil texture:	Silty clay loam	Panholes series
Drainage:	Good	
Previous cropping:	2004 Winter barley 2003 Winter wheat 2002 Winter wheat	
Soil analysis:	pH 7.5	
	ADAS Indices – P (2), K (2-), Mg (1) Organic matter 3.43%	
Cultivar:	Royal, Recital and Escort	
Sowing date:	02/09/2004	
Seed treatment:	As supplied	
Seedbed NPK:	None	
Fertiliser N:	12/09/2004 07/03/2005 12/03/2005 08/04/2005	Ammonium nitrate @ 109 kg/ha Ammonium sulphate @ 147 kg/ha Ammonium sulphate @ 264 kg/ha Ammonium nitrate @ 321 kg/ha
Herbicides:	04/09/2004 11/11/2004	Katamaran @ 2.0 l/ha Falcon @ 0.6 l/ha
Fungicides:	Experimental treatments only	
Insecticides:	11/11/2004	Toppel 10 @ 0.2 l/ha
Molluscicides:	13/09/2004 18/10/2004	Rivet slug pellets @ 3.4 kg/ha Rivet slug pellets @ 4.5 kg/ha
Growth regulator:	None	
Trace elements:	None	
Swathed:	21/07/05	
Harvest date:	04/08/05	

Table 1.18. Spray application details, ADAS High Mowthorpe 2004/05.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
Phoma onset Late October /November	Plover	01/11/04	1.5	Sunny and warm Temp 11.5°C Crop and ground damp Wind: 2 km/h, no drift
Phoma established November	Plover	25/11/04	1.9	Overcast, damp and cool Temp 8.0°C Crop and ground wet Wind: <2 km/h, no drift
6 weeks after T2 December /January	Plover	13/01/05	2.0	Sunny and cool Temp 3.1°C Crop and ground damp Wind: 2-5 km/h, slight drift
Early stem extn February	Plover	03/02/05	2.1	Overcast, dry and cool Temp 11.6°C Crop dry, gound damp Wind: 2 km/h, slight drift

Spray application equipment

Sprayer: OPS with 2 m boom
Nozzles: 03F110 (Lurmark).
Water volume: 200 litres
Pressure: 2.0 bar

Appendix 2. Additional disease assessments and site details Aberdeen.

Table 2.1. Effect of fungicide on levels of Phoma leaf spot, Aberdeen, 2003 – 2004.

Cultivar	Fungicide	% plants affected							% leaves affected						
Date		24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun	24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun
GS		1.03-1.05	1.06-1.08	1.07-1.09	3.1	3.1-3.3	4.0/4.1	5.1	1.03-1.05	1.06-1.08	1.07-1.09	3.1	3.1-3.3	4.0/4.1	5.1
Synergy	Untreated	0	0	0	0	2.5	0	0	0	0	0	0	0.3	0	0
	Full	-	-	0	-	2.5	0	0	-	-	0	-	0.33	0	0
	Autumn	-	-	0	-	2.5	0	0	-	-	0	-	0.33	0	0
	Managed	-	-	0	-	0	0	0	-	-	0	-	0	0	0
Mendel	Untreated	0	0	0	0	2.5	0	0	0	0	0	0	0.31	0	0
	Full	-	-	0	-	0	0	0	-	-	0	-	0	0	0
	Autumn	-	-	0	-	0	0	0	-	-	0	-	0	0	0
	Managed	-	-	0	-	0	0	0	-	-	0	-	0	0	0
Winner	Untreated	0	0	2.5	2.5	0	0	0	0	0	5.1	0.51	0	0	0
	Full	-	-	0	-	0	0	0	-	-	0	-	0	0	0
	Autumn	-	-	2.5	-	2.5	0	0	-	-	0.42	-	0.32	0	0
	Managed	-	-	0	-	0	0	0	-	-	0	-	0	0	0
SED		-	-	1.46	2.04	2.31	-	-	-	-	2.095	0.461	0.292	-	-
df		-	-	33	6	33	-	-	-	-	33	6	33	-	-
LSD		-	-	2.98	5.00	4.70	-	-	-	-	4.263	1.019	0.595	-	-
Signif. Cv x Treat		-	-	ns	-	ns	-	-	-	-	ns	-	ns	-	-
Signif. Cv			-	ns	ns	ns	-	-		-	ns	ns	ns	-	-
Signif. Treat			-	ns	-	ns	-	-		-	ns	-	ns	-	-

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at p≤0.001

Table 2.1 (cont). Effect of fungicide on levels of Phoma leaf spot, Aberdeen , 2003 – 2004.

Cultivar	Fungicide	% leaf area infected							% plants with stem cankers	% stem area affected
	Date	24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun	08 Jul	08 Jul
	GS	1,03-1,05	1,06-1,08	1,07-1,09	3,1	3,1-3,3	4,0/4.1	5,1	6,3	6,3
Synergy	Untreated	0	0	0	0	0.002	0	0	0	0
	Full	-	-	0	-	0.01	0	0	0	0
	Autumn	-	-	0	-	0.002	0	0	0	0
	Managed	-	-	0	-	0	0	0	0	0
Mendel	Untreated	0	0	0	0	0.01	0	0	0	0
	Full	-	-	0	-	0	0	0	0	0
	Autumn	-	-	0	-	0	0	0	0	0
	Managed	-	-	0	-	0	0	0	0	0
Winner	Untreated	0	0	0.01	0.02	0	0	0	0	0
	Full	-	-	0	-	0	0	0	0	0
	Autumn	-	-	0.01	-	0.002	0	0	0	0
	Managed	-	-	0	-	0	0	0	0	0
SED		-	-	0.007	0.02	0.007	-	-	-	-
df		-	-	33	6	33	-	-	-	-
LSD		-	-	0.015	0.05	0.015	-	-	-	-
Signif. Cv x Treat		-	-	ns	-	ns	-	-	-	-
Signif. Cv			-	ns	ns	ns	-	-	-	-
Signif. Treat			-	ns	-	ns	-	-	-	-

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at p≤0.001

Table 2.2. Plant counts, Aberdeen, 2003 – 2004.

Cultivar	Fungicide	Plants/m^2 10 Dec 03 1.06-1.08	Plants/m^2 17 Aug 02 Post-harvest	Plant loss Over winter %
Synergy	Untreated	46.6	41.3	10.1
	Full	47.6	35.8	25.5
	Autumn	47.4	36.7	22.6
	Managed	48.4	42.7	10.5
Mendel	Untreated	48.0	50.9	-8.2
	Full	55.0	60.1	-9.2
	Autumn	53.6	49.1	-0.9
	Managed	60.2	56.0	3.8
Winner	Untreated	97.2	76.6	21.8
	Full	90.2	64.7	27.9
	Autumn	87.6	77.1	10.7
	Managed	93.6	66.1	28.6
SED		6.69	6.59	13.34
df		33	33	33
LSD		13.60	13.41	27.15
Signif. Cv x Treat		ns	ns	ns
Signif. Treat		ns	ns	ns
Synergy		47.5	39.1	17.2
Mendel		54.3	54.0	-3.6
Winner		92.1	71.1	22.3
SED		3.34	3.29	6.67
df		33	33	33
LSD		6.80	6.70	13.57
Signif. Cv		***	***	***

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at p≤0.001

Table 2.3. Effect of fungicide on levels of downy mildew, Aberdeen, 2003 – 2004.

Cultivar	Fungicide	% plants affected							% leaves affected						
Date		24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun	24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun
GS		1.03-1.05	1.06-1.08	1.07-1.09	3.1	3.1-3.3	4.0/4.1	5.1	1.03-1.05	1.06-1.08	1.07-1.09	3.1	3.1-3.3	4.0/4.1	5.1
Synergy	Untreated	40.0	81.7	7.5	2.5	0	0	5.0	13.4	22.6	1.36	0.63	0	0	0.42
	Full	-	-	0	-	0	0	0	-	-	0	-	0	0	0
	Autumn	-	-	5.0	-	0	0	0	-	-	1.35	-	0	0	0
	Managed	-	-	5.0	-	0	0	2.5	-	-	0.98	-	0	0	0.08
Mendel	Untreated	67.0	92.5	0	5.0	0	0	2.5	17.6	32.8	0	0.95	0	0	0.26
	Full	-	-	2.5	-	0	0	2.5	-	-	0.52	-	0	0	0.12
	Autumn	-	-	2.5	-	0	0	0	-	-	0.54	-	0	0	0
	Managed	-	-	2.5	-	0	0	0	-	-	0.49	-	0	0	0
Winner	Untreated	60.0	90.0	0	10.0	0	0	5.0	19.4	31.3	0	2.55	0	0	0.37
	Full	-	-	2.5	-	0	0	0	-	-	0.49	-	0	0	0
	Autumn	-	-	2.5	-	0	0	0	-	-	0.52	-	0	0	0
	Managed	-	-	5.0	-	0	0	0	-	-	0.94	-	0	0	0
SED		10.87	4.25	4.48	6.35	-	-	2.80	4.49	3.17	0.907	1.633	-	-	0.222
df		6	6	33	6	-	-	33	6	6	33	6	-	-	33
LSD		26.61	10.40	9.12	15.53	-	-	5.70	10.99	7.76	1.846	3.997	-	-	0.451
Signif. Cv x Treat		-	-	ns	-	-	-	ns	-	-	ns	-	-	-	ns
Signif. Cv		ns	ns	ns	ns	-	-	ns	ns	*	ns	ns	-	-	ns
Signif. Treat			-	ns	-	-	-	ns		-	ns	-	-	-	*

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at p≤0.001

Table 2.3 (cont). Effect of fungicide on levels of downy mildew, Aberdeen , 2003 – 2004.

Cultivar	Fungicide	% leaf area infected						
	Date	24 Nov	12 Dec	19 Jan	08 Mar	30 Mar	11 May	10 Jun
	GS	1,03-1,05	1,06-1,08	1,07-1,09	3,1	3,1-3,3	4.0/4.1	5.1
Synergy	Untreated	1.46	4.79	0.02	0.05	0	0	0.12
	Full	-	-	0	-	0	0	0
	Autumn	-	-	0.02	-	0	0	0
	Managed	-	-	0.02	-	0	0	0.12
Mendel	Untreated	2.67	6.20	0	0.05	0	0	0.12
	Full	-	-	0	-	0	0	0.10
	Autumn	-	-	0.02	-	0	0	0
	Managed	-	-	0	-	0	0	0
Winner	Untreated	2.33	7.51	0	0.45	0	0	0.12
	Full	-	-	0.08	-	0	0	0
	Autumn	-	-	0	-	0	0	0
	Managed	-	-	0.02	-	0	0	0
SED		0.483	0.870	0.038	0.309	-	-	0.088
df		6	6	33	6	-	-	33
LSD		1.184	2.129	0.079	0.756	-	-	0.179
Signif. Cv x Treat		-	-	Ns	-	-	-	ns
Signif. Cv		ns	ns	Ns	ns	-	-	ns
Signif. Treat			-	Ns	-	-	-	ns

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at p≤0.001

Table 2.4. Other Diseases on stems and pods, 08 Jul 04, GS 6.3, Aberdeen 2004.

		STEMS		PODS					
Cultivar	Fungicide	Sclerotinia		Alternaria		Botrytis		Bird damage	
		% Incidence	% Severity	% Incidence	% Severity	% Incidence	% Severity	% Incidence	% Severity
Synergy	Untreated	9.0	0.85	26.0	0.72	1.0	0.005	7.0	0.03
	Full	2.0	0.15	0	0	0	0	13.0	0.43
	Autumn	9.0	1.10	2.0	0.15	1.0	0.005	10.0	0.33
	Managed	6.0	0.60	8.0	0.14	0	0	3.0	0.06
Mendel	Untreated	6.0	0.75	1.0	0.02	1.0	0.005	13.0	0.66
	Full	4.0	0.70	4.0	0.18	2.0	0.02	6.0	0.09
	Autumn	1.0	0.10	0	0	0	0	13.0	0.50
	Managed	6.0	0.95	8.0	0.30	0	0	10.0	0.38
Winner	Untreated	2.0	0.08	13.0	0.55	1.0	0.005	12.0	0.42
	Full	3.0	0.55	11.0	0.48	1.0	0.005	22.0	0.89
	Autumn	0	0.00	1.0	0.005	0	0	15.0	1.07
	Managed	7.0	0.28	0	0	1.0	0.005	18.0	0.88
SED		3.96	0.546	10.70	0.416	1.33	0.012	11.05	0.593
df		33	33	33	33	33	33	33	33
LSD		8.05	1.111	21.78	0.846	2.71	0.024	22.48	1.205
Signif. Cv x Treat		ns	ns	ns	ns	ns	ns	ns	ns
Signif. Cv		ns	ns	ns	ns	ns	ns	ns	ns
Signif. Treat		ns	ns	ns	ns	ns	ns	ns	ns

ns = not significant; * significant at p=0.05; ** significant at p=0.01; *** significant at $p \leq 0.001$

% Incidence = % plants affected
% severity = % stem/pod area infected

Table 2.5. Growth Stage in early season and leaves/plant Aberdeen 2004.

Cultivar	06 Nov	13 Nov	19 Nov	24 Nov	05 Dec	11 Dec	12 Dec	19 Jan	08 Mar	30 Mar	11 May
					Growth Stage						
Synergy	1.25	1.34	1.47	1.36	1.49	1.54	1.6-1.8	1.7-1.9	3.1	3.1-3.3	4.0-4.1
Mendel	1.25	1.40	1.43	1.48	1.56	1.52	1.6-1.8	1.7-1.9	3.1	3.1-3.3	4.0-4.1
Winner	1.32	1.39	1.46	1.48	1.52	1.52	1.6-1.8	1.7-1.9	3.1	3.1-3.3	4.0-4.1
SED	0.024	0..019	0.029	0.033	0.028	0.023	-	-	-	-	-
df	48	48	48	6	48	48	-	-	-	-	-
LSD	0.048	0.038	0.059	0.080	0.057	0.047	-	-	-	-	-
Signif.	**	**	ns	*	ns	ns	-	-	-	-	-
					Leaves/plant						
Synergy	2.52	3.36	4.72	3.45	4.92	5.44	5.12	17.9	4.35	7.45	9.63
Mendel	2.48	3.96	4.28	4.65	5.56	5.16	5.23	5.30	5.32	7.72	10.80
Winner	3.16	3.92	4.56	4.68	5.20	5.24	4.78	5.00	4.88	7.25	10.20
SED	0.241	0.190	0.293	0.303	0.288	0.232	0.337	5.10	0.435	0.658	0.557
df	48	48	48	6	48	48	6	33	6	33	33
LSD	0.484	0.382	0.589	0.740	0.570	0.466	0.826	10.37	1.065	1.339	1.133
Signif.	**	**	ns	**	ns	ns	ns	ns	ns	ns	ns

Establishment was very slow early in the season so plants not sampled but assessed in situ

Table 2.6. Leaf dimensions Aberdeen 2004.

Cultivar	24 Nov 1.03-1.05	12 Dec 1.06-1.07	19 Jan 1.07-1.09	08 Mar 3.1	24 Nov 1.03-1.05	12 Dec 1.06-1.07	19 Jan 1.07-1.09	08 Mar 3.1
	Leaf length (mm)				Petiole length (mm)			
Synergy	34.9	46.2	56.1	40.30	21.5	23.4	23.35	24.12
Mendel	51.2	57.0	56.5	48.92	26.3	24.6	27.52	25.55
Winner	52.5	55.1	56.8	52.27	27.2	30.6	28.65	30.02
SED	4.77	6.20	3.25	1.440	2.67	3.60	1.561	1.611
df	6	6	6	6	6	6	6	6
LSD	11.66	15.18	7.95	3.524	6.54	8.81	3.819	3.942
Signif.	*	ns	ns	***	ns	ns	ns	*
	Leaf breadth (mm)				Leaf + petiole length (mm)			
Synergy	31.4	37.3	44.4	32.83	58.3	69.6	81.5	64.4
Mendel	47.6	47.1	45.2	36.10	77.5	81.6	84.1	74.5
Winner	39.2	42.5	44.7	39.00	79.7	85.7	85.5	82.3
SED	3.57	3.89	2.80	1.987	7.11	9.34	4.33	2.49
df	6	6	6	6	6	6	6	6
LSD	8.74	9.52	6.86	4.862	17.40	22.85	10.59	6.10
Signif	*	ns	ns	ns	*	ns	ns	***
	Leaf area (mm^2)							
Synergy	1094	1735	2542	1326.0				
Apex	2508	2779	2581	1785.0				
Escort	2099	2393	2604	2049.0				
SED	353.3	530.3	319.1	123.3				
df	6	6	6	6				
LSD	864.5	1297.7	780.8	301.7				
Signif.	*	ns	ns	**				

Table 2.7. Site details, Aberdeen, 2003 – 2004.

Site:	Field S, Sunnybrae Farm, SAC, Craibstone Estate, Bucksburn, Aberdeen
Soil Association:	Countesswells
Soil Series:	Dreghorn
Soil Type:	Sandy clay loam
Drainage:	Poorly drained
Soil analysis: (mg/l)	pH: 6.0 Organic Matter (%): 6 P: 9 (mod) K: 91.5 (mod) Mg: 70.4 (mod) S: 9 (mod); Mn 3 (mod)
Cultivations:	Ploughed, Oyjord drill, rolled
Sowing date:	01 September 2003
Seed rates:	Synergy & Mendel 3.6 kg/ha; Winner 6.0 kg/ha
Basal Fertilser:	250 kg/ha 10:25:25 N:P:K + 6 kg/ha SO_3
Spring N:	05 Mar 02 90 kg N/ha + 48 kg SO_3/ha
Spring N:	20 Mar 02 90 kg N/ha + 48 kg SO_3/ha
Herbicide:	1.0 l/ha Butisan S pre-emergence
Slug pellets:	4.0 kg/ha Metarex green
Swathing date:	22 July 2003
Harvest date:	31 July 2003
Removal of straw:	Chopped and carted
Previous crop:	2003: Winter barley 2002: Winter wheat

Table 2.8. Effect of fungicide on levels of Phoma leaf spot, Aberdeen, 2004 – 2005.

Cultivar	Fungicide	% plants affected								
Date GS		6 Oct 1.3-1.4	25 Oct 1.5-1.6	8 Nov 1.6-1.7	22 Nov 1.9	6 Dec 1.8-1.10	13Dec 1.8-1.10	16 Mar 3.1	11 Apr 3.4	5 May 4.0/4.1
Synergy	Untreated	0	0	0	0	16	10.0	0	0	0
	Forecast						0	0	0	0
	Onset						0	0	0	0
	Managed						0	0	0	0
Mendel	Untreated	0	0	0	0.8	0.9	5.0	0	0	0
	Forecast						2.5	0	0	0
	Onset						0	0	0	0
	Managed						0	0	0	0
Winner	Untreated	0	0	0	0	0	2.5	0	0	0
	Forecast						0	0	0	0
	Onset						2.5	0	0	0
	Managed						7.5	0	0	0
SED							3.44	0	0	0
df							33	-	-	-
LSD							7.01	0	0	0
Signif. Cv x Treat							0.09	Ns	Ns	Ns
Signif. Cv							Ns	Ns	Ns	Ns
Signif. Treat							Ns	Ns	Ns	Ns

Ns = not significant;

Table 2.9 (Cont). Effect of fungicide on levels of Phoma leaf spot, Aberdeen, 2004 – 2005.

Cultivar	Fungicide	% Leaves affected								
Date		6 Oct	25 Oct	8 Nov	22 Nov	6 Dec	13 Dec	16 Mar	11 Apr	5 May
GS		1.3-1.4	1.5-1.6	1.6-1.7	1.9	1.8-1.10	1.10	3.1	3.4	4.0/4.1
Synergy	Untreated	0	0	0	0	0.16	1.81	0	0	0
	Forecast						0	0	0	0
	Onset						0	0	0	0
	Managed						0	0	0	0
Mendel	Untreated						1.14	0	0	0
	Forecast						0.61	0	0	0
	Onset						0	0	0	0
	Managed						0	0	0	0
Winner	Untreated	0	0	0	0.04	0.04	0.54	0	0	0
	Forecast						0	0	0	0
	Onset						0.56	0	0	0
	Managed						2.23	0	0	0
SED		0	0	0	0	0	0.90	0	0	0
df							33	-	-	-
LSD							1.83	0	0	0
Signif. Cv x Treat							Ns	Ns	Ns	Ns
Signif. Cv							Ns	Ns	Ns	Ns
Signif. Treat							Ns	Ns	Ns	Ns

Ns = not significant;

Table 2.9 (cont). Effect of fungicide on levels of Phoma leaf spot, Aberdeen, 2004-05.

Cultivar	Fungicide	% Leaf area infected				% plants with stem cankers	% stem area affected
Date		13 Dec	16 Mar	11 Apr	5 May	13Jul	13 Jul
GS		1.10	3.1	3.4	4.0/4.1	6.1	6.1
Synergy	Untreated	0.14	0	0	0	0	0
	Forecast	0	0	0	0	0	0
	Onset	0	0	0	0	0	0
	Managed	0	0	0	0	0	0
Mendel	Untreated	0.05	0	0	0	0	0
	Forecast	0	0	0	0	0	0
	Onset	0	0	0	0	0	0
	Managed	0	0	0	0	0	0
Winner	Untreated	0.01	0	0	0	0	0
	Forecast	0	0	0	0	0	0
	Onset	0.01	0	0	0	0	0
	Managed	0.04	0	0	0	0	0
SED		0.055	0	0	0	0	0
df		33	-	-	-	-	-
LSD		0.112	0	0	0	0	0
Signif. Cv x Treat		Ns	Ns	Ns	Ns	Ns	Ns
Signif. Cv		Ns	Ns	Ns	Ns	Ns	Ns
Signif. Treat		Ns	Ns	Ns	Ns	Ns	Ns

Ns = not significant;

Table 2.10. Plant counts, Aberdeen, 2004 – 2005

Cultivar	Fungicide	Plants/m^2 6 Dec 03 1,8-1,1-	Plants/m^2 15 Sep 05 Post harvest	Plant loss over-winter %
Synergy	Untreated	40.6	42.2	-3.8
	Forecast	53.0	53.0	0.0
	Onset	45.4	46.4	-2.2
	Managed	45.4	50.6	-10.3
Mendel	Untreated	90.0	86.8	3.7
	Forecast	106.0	100.8	5.2
	Onset	91.4	90.4	1.1
	Managed	84.8	81.8	3.7
Winner	Untreated	89.8	87.0	3.2
	Forecast	93.6	89.0	5.2
	Onset	96.0	89.6	7.1
	Managed	95.2	91.4	4.2
SED		6.74	7.01	
df		33	33	
LSD		13.71	14.26	
Signif. Cv x Treat		Ns	Ns	
Signif. Treat		0.05	Ns	
Synergy		46.1	48.0	-4.0
Mendel		93.1	89.9	3.6
Winner		93.7	89.2	5.0
SED		3.37	3.51	
df		33	33	
LSD		6.86	7.13	
Signif. Cv		<.001	<.001	

Ns = not significant;

Table 2.11. Other Diseases on Stems and Pods and stem height , 13 Jul 05, GS 6.1, Aberdeen

Cultivar		Roots	Stem height
	Fungicide	Clubroot	(cm)
		% Incidence	
Synergy	Untreated	22.5	143.8
	Forecast	47.5	161.3
	Onset	35.0	150.0
	Managed	52.5	167.0
Mendel	Untreated	5.0	158.8
	Forecast	7.5	153.8
	Onset	12.5	163.8
	Managed	5.0	157.5
Winner	Untreated	25.0	138.8
	Forecast	37.5	133.8
	Onset	32.5	136.3
	Managed	50.0	137.5
SED		17.04	2.43
df		33	33
LSD		34.67	4.94
Signif. Cv x Treat		Ns	<0.1%
Signif. Cv		1%	<0.1%
Signif. Treat		Ns	<0.1%

Ns = not significant;

% Incidence = % plants affected
% severity = % stem/pod area infected

Table 2.12. Growth stage in early season and leaves/plant, Aberdeen 2004/05.

Date	Variety	Average GS	Number of leaves	No leaves with LLS	No leaves with Phoma	No leaves with Alternaria	No leaves with Downy mildew
06-Oct-04	Winner	1.3 - 1.4	3.48	0	0	0	0
06-Oct-04	Mendel	1.3 - 1.4	3.36	0	0	0	0
06-Oct-04	Synergy	1.3 - 1.4	2.84	0	0	0	0
25-Oct-04	Winner	1.5 - 1.6	5.36	0	0	0	0
25-Oct-04	Mendel	1.5 - 1.6	5.12	0	0	0	0
25-Oct-04	Synergy	1.5 - 1.6	5.04	0	0	0	0
08-Nov-04	Winner	1.6 - 1.7	4.52	0	0	0	0
08-Nov-04	Mendel	1.6 - 1.7	5.12	0	0	0	0
08-Nov-04	Synergy	1.6 - 1.7	5.2	0	0	0	0
22-Nov-04	Winner	1.9	5.08	0.48	0	0	0
22-Nov-04	Mendel	1.9	5	0.36	0.04	0	0
22-Nov-04	Synergy	1.9	5.52	0.36	0	0	0
06-Dec-04	Winner	1.9	4.56	2.36	0	0	0
06-Dec-04	Mendel	1.8-1.9	4.4	2.28	0.04	0	0
06-Dec-04	Synergy	1.9 -1.10	5.92	2.44	0.16	0	0

Table 2.13. Leaf dimensions, Aberdeen 2004/05.

Date	Variety	Average GS	Length Petiole (mm)	Length Leaf + Petiole (mm)	Breadth Leaf (mm)
06-Oct-04	Winner	1.3 - 1.4	28.7	92.5	49.4
06-Oct-04	Mendel	1.3 - 1.4	35.6	102.2	52.3
06-Oct-04	Synergy	1.3 - 1.4	25.4	73.4	41
25-Oct-04	Winner	1.5 - 1.6	57.1	151	66.5
25-Oct-04	Mendel	1.5 - 1.6	59.1	152.9	64.7
25-Oct-04	Synergy	1.5 - 1.6	41.5	114.4	55.5
08-Nov-04	Winner	1.6 - 1.7	65.3	148.7	57.6
08-Nov-04	Mendel	1.6 - 1.7	57	145.3	66.2
08-Nov-04	Synergy	1.6 - 1.7	41.2	112.8	49.7
22-Nov-04	Winner	1.9	52.2	141.6	65.9
22-Nov-04	Mendel	1.9	61.7	158.3	71.4
22-Nov-04	Synergy	1.9	40.6	110.5	52.1
06-Dec-04	Winner	1.9	67	149	70
06-Dec-04	Mendel	1.8-1.9	49.4	129.7	62.6
06-Dec-04	Synergy	1.9 -1.10	43.6	116.2	54.3

Table 2.14. Site details, Aberdeen, 2004 – 2005.

Site:	Old Craig, Meikle Wartle, Inverurie, Aberdeen
Grid Reference:	NJ738 298
Soil Association:	Insch
Soil Series:	Myrton
Soil Type:	Medium
Drainage:	Average
Soil analysis:	pH6.3, P mod K Mod, Mg mod .S high ,Organic Matter 5.8%
Cultivations:	
Sowing date:	1/9/04
Seed rates:	Winner 120 m^2 Synergy & Mendel 70 m^2
Basal Fertiliser:	0:90:90 kg/ha
Spring N:	90 kg/ha 14/3/05
Spring N:	90 kg/ha 4/4/05
Herbicide:	Kerb 3 kg/ha + Laser @ 0.7 l/ha 10/11/04
Slug pellets:	7 kg/ha 2/9/04
Swathing date:	3/8/05
Harvest date:	11/8/05
Removal of straw:	
Previous crop:	2004 W.Barley 2003 W.Wheat 2002 S.Barley

Appendix 3

Appendix 3.1. Site details ADAS Boxworth. Winter oilseed rape fungicide spray timing experiment , 2003/04

Site:	ADAS Boxworth, Cambs		
Field name:	Pamplins South		
Soil texture:	clay loam		
Drainage:	Good		
Previous cropping:	2003 Winter wheat 2002 Winter wheat 2001 Winter oilseed rape		
Soil analysis:	pH 8.1		
	ADAS Indices – P 20 mg/l (2), K 237 mg/l (2+), Mg 69 mg/l(2) Organic matter 3.61%		
Crop: Winter oilseed rape	Cultivar	:	Winner (Farm crop cv.Winner)
	Sowing date	:	21/08/03
	Seed treatment		As supplied
Seedbed NPK kg/ha	28 kg/ha N		11/08/03
	84 kg/ha P		
	Fertiliser N	:	34.5% N product 116 kg/ha 16/10/03 Ammonium sulphate 100 kg/ha 11/02/04 Nitram (Ammonium nitrate) 240 kg/ha 11/02/04; Ammonium nitrate 250 kg/ha 30/03/04
Herbicides:	Butisan S 1.25 l/ha + Trifluralin 480 2 l/ha 22/08/03 Falcon 0.7 l/ha + Kerb Flo 2.09 l/ha 6/12/03		
Fungicides:	Experimental treatments only.		
Insecticides:	Cypermethrin 100 0.25 l/ha on 06/12/03, 22/04/04 & 07/05/04		
Molluscicides:	Draza 5.0 kg/ha 13/09/03		
Growth regulator:	-		
Trace elements:	-		
Desiccant	Glyphosate 4 l/ha + Addit wetter 0.5 l/ha 13/07/04		
Harvest date:	27/07/04		

Appendix 3.2 Spray application details, Boxworth 2003/2004.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
Phoma onset Late October /November	Punch C	27/11/03	1,5	Sunny, cool and damp; crop wet after overnight frost and soil damp Temp max 7°C Wind: 2-4 kph, slight drift
Phoma established November	Punch C	18/12/03	1,5-1,7	Sunny, cool and frosty; crop and soil damp Temp 3-4°C Wind: 0-3 kph, no drift
6 weeks after T2 December /January	Punch C	23/01/04	1,4-1,9	Overcast, cool and damp after cool wet weather. Crop damp. Temperature 6°C Wind: 6-9 km/hr, breezy and moderate drift.
Early stem extn February	Punch C	16/02/04	1,13, 3,1	Overcast and cool after previous dry and cool conditions. Crop dry. Temp 5°C, Wind: calm <2 kph, no drift

Spray application equipment

Sprayer: OPS with 3 m boom
Nozzles: LD02F110 (Lurmark).
Water volume: 200 litres
Pressure: 2.0 bar

Appendix 3.3. Site details ADAS Boxworth Winter oilseed rape fungicide spray timing experiment, 2004/05.

Site:	ADAS Boxworth, Cambs		
Field name:	Grange Piece		
Soil texture:	clay loam		
Drainage:	Good		
Previous cropping:	2004 Winter wheat 2003 Winter wheat 2002 Winter oilseed rape		
Soil analysis:	pH 8.0		
	ADAS Indices – P 25 mg/l (2), K 264 mg/l (3), Mg 96 mg/l(2) Organic matter 3.61%		
Crop: Winter oilseed rape	Cultivar	:	cv.Winner
	Sowing date	:	28/08/04
	Seed treatment		As supplied
Seedbed NPK kg/ha	-		
	Fertiliser NKS	:	7:21:0:0 product 333 l/ha 05/09/04 37% N product 50 l/ha 05/09/04 Ammonium nitrate 240 kg/ha 15/03/05 Ammonium sulphate 100 kg/ha 15/03/05 Ammonium nitrate 307 kg/ha 29/03/05
Herbicides:	Katarmaran 2.0 l/ha + Trifluralin 480 2.0 l/ha 05/09/04 Falcon 0.4 l/ha + mineral oil 1.0 l/ha 27/09/04		
	Falcon 0.4 l/ha + mineral oil 0.5 l/ha 26/10/04		
	Falcon 0.39 l/ha + mineral oil 1.0 l/ha 10/03/05		
Fungicides:	Experimental treatments only.		
Insecticides:	Cypermethrin 100 0.25 l/ha on 26/10/04		
Molluscicides:	Draza 5.0 kg/ha 22/09/04		
Growth regulator:	-		
Trace elements:	-		
Desiccant	Roundup 4 l/ha 04/07/05		
Harvest date:	23/07/05		

Appendix 3.4. Spray application details, Fungicide spray timing experiment Boxworth 2004/2005.

Target date	Products Applied	Actual Date	Growth Stage	Daily Weather
T1 Phoma onset Late October /November	Punch C	19/10/04	1,5	Overcast, damp and cool; crop dry after cool showery weather Temp max 9-15°C RH 55-78% Wind: light wind (<2 kph), slight drift
T2 Phoma established November	Punch C Sanction	11/11/04	1,4-1,9	Dry and cool after cool showery weather. Crop damp Temp 9.1-9.9°C RH 55-61% Wind: breezy 3-6 kph, slight drift
T3 6 weeks after T2 December /January	Punch C Caramba	09/12/04	1,13-1,18	Sunny and cool after previous dry and cool conditions. Crop dry, but misty after application Temp 7.0-7.6°C, RH 70-76% Wind: none
T4 Early stem extn February	Punch C Sanction	07/03/05	3,1	Overcast, dry and cool after frosty and showery weather. Crop dry. Temperature 5.2-5.3°C RH 71-72% Wind: light breeze 3-6 km/hr, slight drift.
T5 Stem extn March	Folicur	25/03/05	3,1	Overcast and warm after showery weather. Crop dry. Temperature 14.3-14.6°C RH 57-58% Wind: light breeze 2-5 km/hr, slight drift.

Spray application equipment:
Sprayer: OPS with 3 m boom
Nozzles: LD02F110 (Lurmark).
Water volume: 200 litres
Pressure: 2.0 bar

Appendix 4

List of publications and technology transfer activities relating to PASSWORD project (LK0917 and LK0944)

Refereed papers

Evans, N., Baierl, A., Brain, P., Welham, S.J.& Fitt, B.D.L. (2003). Spatial aspects of light leaf spot (*Pyrenopeziza brassicae*) epidemic development on winter oilseed rape (*Brassica napus*) in the United Kingdom. *Phytopathology* **93**: 657-665.

Gladders, P., Evans, N., Marcroft, S. & Pinochet, X. (2006). Dissemination of information about management strategies and changes in farmong practices for exploitation of resistance to *Leptosphaeria maculans* (phoma stem canker) in oilseed rape cultivars. *European Journal of Plant Pathology* **114**. 117-126.

Karolewski, Z., Evans, N., Fitt, B.D.L., Todd, A.D. & Baierl, A. (2002). Sporulation of *Pyrenopeziza brassicae* (light leaf spot) on oilseed rape (Brassica napus) leaves inoculated with ascospores or conidia at different temperatures and wetness durations. *Plant Pathology* **51**: 654-665

Sun, P., Fitt, B.D.L., Gladders, P. & Welham, S.J. (2000). Relationships between phoma leaf spot and development of stem canker (Leptosphaeria maculans) on winter oilseed rape (Brassica napus) in southern England. *Annals of Applied Biology* **137**: 113-125.

Sun, P., Fitt, B.D.L., Steed, J.M., Underwood, C.T. & West, J.S. (2001). Factors affecting development of phoma canker (Leptosphaeria maculans) on stems of winter oilseed rape (*Brassica napus*) in southern England. *Annals of Applied Biology* **139**: 227 - 242.

Walters, K.F.A., Lane, A., Cooper, D.A. and Morgan, D. 2001. A commercially acceptable assessment technique for improved control of cabbage stem flea beetle feeding on winter oilseed rape. *Crop Protection* **20**: 907-912.

Walters, K.F.A. and Northing, P. (In prep.). Incidence and forecasting of pests of winter oilseed rape in England and Wales. *Crop Protection*.

Walters, K.F.A., Young, J.E.B., Kromp, B. and Cox, P.D. 2003. *Management of oilseed rape pests.* In: *Biocontrol of oilseed rape pests*, D.V. Alford (ed). Blackwell Science Ltd., Oxford, *pp. 43- 71.*

Welham, S.J., Turner, J.A., Gladders, P., Fitt, B.D.L.., Evans, N. & Baierl, A. (2005). Predicting light leaf spot (*Pyrenopeziza brassicae*) risk on winter oilseed rape (*Brassica napus*) in England and Wales, using survey, weather and crop information. *Plant Pathology* 53: 713-724.

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Yong-ju, H., Fitt, B.D.L., Jedryczka, M., Dakowska, S., West, J.S., Gladders, P., Steed, J.S. & Li, Z-Q. (2005). Patterns of ascospore release in relation to phoma stem canker epidemiology in England (*Leptosphaeria maculans*) and Poland (*Leptosphaeria biglobosa*). *European Journal of Plant Pathology* **111**: 263-277.

Conference papers

Baierl, A., Evans, N., Fitt, B.D.L. & Gladders, P. (2003). Potential benefits of crop specific models for forecasting light leaf spot severity. GCRIC Bulletin (in press) (Insert page numbers).

Baierl, A., Evans, N., Steed, J.M., Fitt, B.D.L. & Sutherland K.G. (2002). Effects of light leaf spot (*Pyrenopeziza brassicae*) infection on winter survival and yield of oilseed rape (*Brassica napus*). *Proceedings of the BCPC Conference – Pests and Diseases 2002* **2**,629-634.

Evans, N., Antoniw, J., Fitt, B.D.L., Gladders, P. & Welham, S.J. (2000). Introducing an interactive Internet based forecasting system for light leaf spot of winter oilseed rape in the UK. *GCIRC Bulletin* **17,** *October 2000,* 49-52

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Steed, J.M., Fitt, B.D.L., Gladders, P. & Naik, A. (2002). Optimising control of phoma stem canker in winter oilseed rape in the UK. *International Organisation for Biological Control Bulletin* **25**, 87-92.

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Turner, J.A, Elcock, S.J., Walters, K.F.A., Wright, D.M. & Gladders, P. (2002). A review of pest and disease problems in winter oilseed rape in England and Wales. *Proceedings of the BCPC Conference – Pests and Diseases 2002*, **2**,555-562.

Welham, S.J., Papastamati, K., Fitt, B.D.L., Turner, J.A. & Gladders, P. (2000). A comparison of modelling methods for forecasting light leaf spot (*Pyrenopeziza brassicae)* on winter oilseed rape in the UK. *The BCPC Conference - Pests and Diseases 2000,* 801-808.

West, J.S., Huang, Y-J., Steed, J.M., Leech, P.K., Fitt, B.D.L. & Gladders, P. (2002). New perspectives on the epidemiology and management of phoma stem canker of winter oilseed rape in England. *Proceedings of the BCPC Conference – Pests and Diseases 2002*, **2**,563-568.

Topic sheets, demonstrations , workshops and seminars (Talk or Poster) Abstracts

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Crop notes

Both ADAS and SAC use information from forecasts, disaese monitoring and fungicide experiments in advisory publications and websites for farmers. Technical updates for advisers are given to advisers formally and informally on a weekly basis duringthe key periods for decision making

E,g . SAC reports (300 copies each edition to farmers/advisers/trade):

Project groups

Farmer user focus group workshops 2001– CSL York (13 February) and Boxworth, Cambs (14 February)

Web sites

The project has its own closed web site. Free access to disease forecasts and other information is also available via Rothamsted Research, CSL Crop Monitor and HGCA websites. DuPont and Syngenta (SPAWS early warning system on www.syngenta-crop.co.uk website) have provided technical support on pest and disease control in oilseed rape via their websites.