March 2020

Project Report No. 617

Sclerotinia risk live-reporting system for oilseed rape

Caroline Young[1], Jon West[2], Velcourt R&D[3], and John Clarkson[4]

[1]RSK ADAS Ltd, Rosemaund, Preston Wynne, Herefordshire, HR1 3PG

[2]Rothamsted Research, Harpenden, Hertfordshire AL5 2JQ

[3]Velcourt R&D Dept, Oakham, Rutland LE15 7QT

[4]Warwick University Crop Centre, Wellesbourne, Warwickshire CV35 9EF

This is the final report of a 48-month project (2140020105) that started in March 2015. The work was funded by a contract for £160,360 from AHDB and BASF (in-kind, £52,545).

CONTENTS

1. Abstract

This project aimed to combine forecasting and monitoring approaches to provide a sclerotinia disease risk reporting system for oilseed rape. It had two specific objectives: [1] To provide forecast alerts and reports of infection-risk factors during the flowering phase. Such information can help guide the timing of the first fungicide application and establish the need for and timing of a subsequent application, and [2] Demonstrate that the forecasting and risk evaluation scheme provided improved control of sclerotinia disease with an economic benefit.

The project recorded sclerotinia infection risk factors at 15 sites (including six AHDB Monitor Farms) across England and Scotland during 2015–18. Records included 48-hour forecast weather data, crop growth stage and the amount (percentage) of petals that tested positive for sclerotinia. Five of the 15 sites had Burkard traps to detect airborne spores. Seven of the 15 sites (BASF) included monitoring of sclerotial germination. Three of the 15 sites (ADAS, two sites, and Velcourt) included a fungicide timing trial. Forecast weather and crop growth stage data were used to provide updates three times a week for each site for conditions conducive to infection by sclerotinia: temperatures $\geq$ 7°C and RH $\geq$ 80% for $\geq$23 consecutive hours. Data from 2010–17 (including results from a 2010–12 AHDB-LINK project) were also analysed. Key messages are:

- Weather-based infection alert dates aid fungicide timing. Good control of sclerotinia was achieved from fungicides applied before a forecast weather alert.
- Under high disease pressures, fungicides applied in response to alerts resulted in an average yield response of 0.3 t/ha (compared to the untreated control). Where sprays were made at early flower (in the absence of alerts), average yield responses were reduced to 0.22 t/ha.
- Inoculum levels on petals and in the air (from spore traps) help to indicate infection risk.
- The most reliable predictor of low-infection risk was inoculum. When inoculum is zero, infection risk is zero. Positive inoculum indicates risk, but variable infection.
- Combining inoculum with weather alerts provides the greatest potential reduction in the number of sites needing a fungicide treatment.
- Use of the alert scheme based on weather and inoculum resulted in 26% fewer crops treated.
- Infection alerts from a weather-based model and in-field inoculum tests are useful for fungicide timing guidance at a local level.
- Air sampler inoculum data is helpful for regional forecasts and, in association with site-specific weather alerts, to provide fungicide timing guidance.
- The infection alerts are risk averse, and overestimate the risk of high sclerotinia incidence.

2. Introduction

The aim of this project was to provide a practical system for oilseed rape growers to target the timing of fungicide treatments against sclerotinia (*Sclerotinia sclerotiorum*) more effectively. Targeting can be difficult due to the sporadic but persistent nature of the disease, and because the period when the crop is at risk of infection during flowering is longer than the period of fungicide protection. The long-term mean UK sclerotinia stem rot incidence from 2009-2017 is 7%, based on fungicide treated crops (www.CropMonitor). Incidence has declined in recent years, but 95% or more of the UK oilseed crop area is treated three times with fungicides (Pesticide Usage Statistics, https://secure.fera. defra.gov.uk/pusstats), and over 50% of fungicide applications are timed during flowering (Garthwaite et al, 2016) so are targeted mainly at sclerotinia control. However, high disease pressure has occurred in recent years in some regions, as seen in untreated trial plots, e.g. 43% incidence in 2017 (Gosling & Ritchie, 2018). Therefore, infection risk can be high and the use of protectant fungicides is justified in some cases, but not all. There is good potential to reduce the number of fungicide applications or even omit treatment for sclerotinia if a forecasting scheme is used, resulting in cost savings, helping to reduce the rate of development of resistance to fungicides by sclerotinia and providing environmental benefits from lower pesticide use.

The sclerotinia fungus has two main phases, a winter phase when fungal resting bodies called sclerotia are dormant on or below the soil surface, and spring phase, when sclerotia germinate to produce above-ground structures called apothecia. The apothecia release many thousands of airborne ascospores which infect oilseed rape stems mainly via petals (Young & Werner 2004). Once sclerotinia lesions are visible on stems, it is too late for effective control because infection has already taken place. Protectant foliar fungicide treatment is needed ahead of infection. In practice, without a scheme to alert farmers to periods of high infection risk, it is not clear what fungicide timing will be effective, or necessary. For sclerotinia infection, the key risk factors include weather, inoculum levels, crop growth stage and infection history on-farm (Twengstrom et al 1998; Young et al 2013).

Disease forecasting models and schemes have been developed previously for sclerotinia control, and some are of particular relevance to the UK but have not been developed for practical use. Most schemes for sclerotinia make use of monitoring some key risk assessment factors (e.g. measurements of spore inoculum) and prediction of other variables (e.g. forecast weather). Inputs to disease forecasting models include regional and in-field factors. The regional factors for sclerotinia risk include data on weather, ascospore inoculum, and germinating sclerotia, which give growers a general indication of when crops are at risk of infection. Local factors also include weather and inoculum if recorded on-site, which will help improve the accuracy of predictions for that site.

Several forecasting models for sclerotinia infection have been produced. A model to predict sclerotial germination, based on soil temperature and soil moisture (Clarkson et al. 2007) was developed for use in lettuce and predicts when apothecia, and hence ascospores, are produced. A practical version of this model which uses rainfall instead of soil moisture was developed from this and used to time a single fungicide spray for control of sclerotinia in lettuce which resulted in a similar level of disease control to a two- or three-spray programme (Young 2008, HDC FV294). This approach is independent of crop species and subsequent testing in a recent LINK project (HGCA 3579) found that the model predicted the general pattern of sclerotial germination well, but was not accurate enough to guide the exact date of a fungicide application. Hence it is more appropriate as a regional risk indicator rather than an in-field forecasting tool. This model has been further refined in a PhD project supervised by John Clarkson at Warwick Crop Centre (funded by BASF and University of Warwick, 2014-19). A forecasting model using weather to predict infection by *S. sclerotiorum* ascospores was developed in Germany ('SkleroPro', Koch et al., 2007). It was demonstrated to have potential use to target fungicides in the UK (Young et al. 2013, HGCA 3579): fungicide treatments for oilseed rape timed according to alerts generated by the model gave 76–100 % control, whereas sprays applied at standard timings gave 25-100% control.

Monitoring risk factors for sclerotinia, such as measuring levels of airborne spores, is helpful for forecasting the risk of infection. Various PCR tests have been developed to determine timing and quantity of airborne *S. sclerotiorum* spores, and can be used to detect spores at both regional and local scales (West et al. 2009; HGCA 3579) using oilseed rape petals or spore traps. Regional detection of sclerotinia inoculum is useful in risk assessment (Parker et al 2014).

Ultimately, the aim is to increase yields of UK oilseed rape by improving control of sclerotinia, reducing the number of fungicide applications needed for control, and reducing crop losses. A single well timed fungicide spray in a high disease pressure year can give a very large yield benefit, > 2 t/ha (Gladders et al, 2011), or £500/ha for a crop priced at £250/t. The average yield response to fungicide treatment (compared with untreated plots) is greater with higher sclerotinia disease pressure, and therefore yield gains from using fungicides will vary depending on the location and the season, but can be very large. In a 'high disease' year where untreated crops have 80% stem rot incidence, the yield response could be as high as 2.1 t/ha if 100% control is achieved, and 1.1 t/ha with 50% control. In a low disease year, the yield benefits would be much lower. It is helpful to have information that justifies a decision to apply, or not apply, a fungicide targeted at sclerotinia, and which provides guidance on the optimum time for application.

The aim of this project was to combine forecasting and monitoring approaches to provide a sclerotinia disease risk reporting system during the key infection phase for oilseed rape, to help guide fungicide timing, improve sclerotinia control, and reduce crop losses. There were two specific objectives:
[1] Provide forecast alerts and reports of risk factors for sclerotinia infection to growers during the oilseed rape flowering phase, to guide the timing of the first fungicide application needed during flowering, and the need for and timing of a subsequent application.
[2] Demonstrate that the forecasting and risk evaluation scheme provided improved control of sclerotinia disease and an economic benefit.

3. Materials and methods

3.1. Project overview

Sclerotinia infection risk factors were measured using regional and in-field measurements, with the number of sites monitored for each factor differing across the UK (Table 1). Fungicide timing field experiments and inoculum monitoring were conducted from 2015-2017 to provide data for reporting risk alerts and evaluation of the forecasting scheme. 2018 was a project extension year in which reporting of infection alerts was based only on observed and forecast weather data.

Sites for field trials, petal samples, air samplers, sclerotial germination monitoring and forecast weather data were located across England and Scotland (Figure 1). The exact site locations were amended for most sites from year to year with changes in field trial locations but were in similar areas.

Table 1. Location of field trials, inoculum assessments and observed and forecast weather.

Year	**2015**	**2016**	**2017**	**2018**
Field trial	Herefordshire Devon Lincolnshire	Herefordshire Devon Lincolnshire	Herefordshire Devon Lincolnshire	None
Air samplers	Devon Hereford Rothamsted Yorkshire Lincolnshire Yorkshire	Devon Hereford Rothamsted Yorkshire Lincolnshire Yorkshire	Devon Hereford Rothamsted Yorkshire Lincolnshire Yorkshire	None
Petal testing	3 field trials, 6 AHDB monitor farms	3 field trials, 6 AHDB monitor farms	3 field trials, 6 AHDB monitor farms	None
Sclerotial germination, weekly	7 sites	7 sites	7 sites	
Weather-based alerts, 3 per week	15 sites, 48 hr forecast, each site	15 sites, 48 hr forecast each site	15 sites, 48 hr forecast each site	15 sites, 48 hr forecast each site
AHDB website report, weekly	Text overview Data, 15 sites: • Crop GS • %petals positive Weather alert • Text comments • Risk category • Map, colour coded • Chart, spores/m^3/day	Text overview Data, 15 sites: • Crop GS • %petals positive Weather alert • Text comments • Risk category • Map, colour coded • Chart, spores/m^3/day	Text overview Data, 15 sites: • Crop GS • %petals positive Weather alert • Text comments • Risk category • Map, colour coded • Chart, spores/m^3/day	Text overview • Weather alerts, 15 sites • Map, colour coded
Evaluation	Accuracy	Accuracy	Accuracy	Overall accuracy & benefits 2010-17

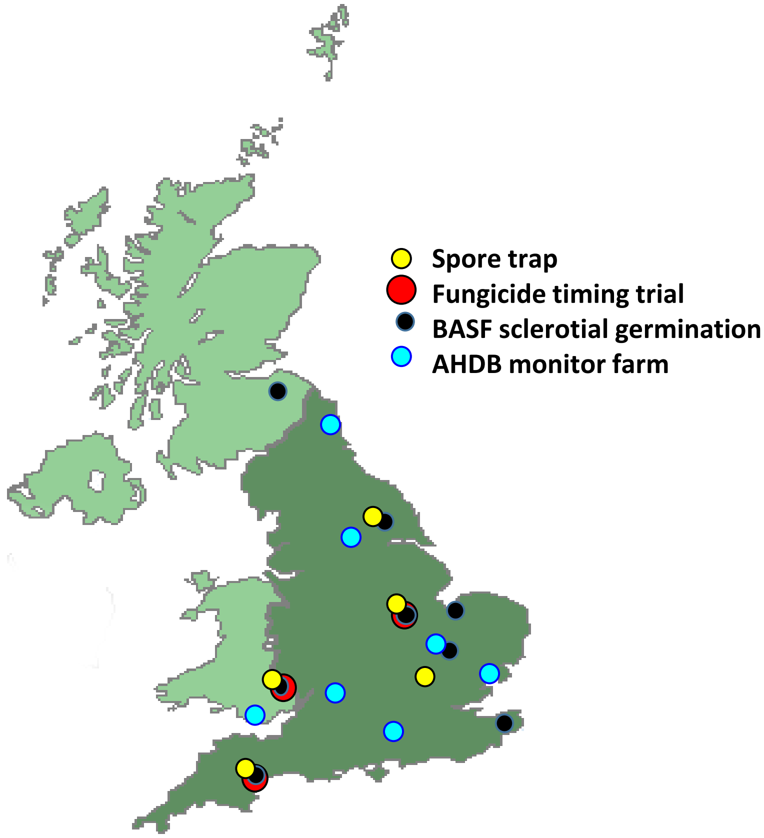


Figure 1. Locations of fungicide field timing experiments, petal sampling, spore traps (air samplers), sclerotial germination and AHDB monitor farmers involved in sclerotinia risk reporting, 2015-2018.

3.2. Weather: forecast-alerts

Forecast and actual weather data was purchased from the MetOffice, under a contract agreement where the outputs of the data analysis could be reported, but not raw data. Each year for three years 2015-2017, data feeds were supplied by the MetOffice to ADAS, each Monday, Wednesday and Friday from March-September, for 15 sites each year specified by grid reference and GPS coordinates. The hourly forecast data supplied for 48 hours ahead was air temperature, rain totals, and % relative humidity (RH). The hourly observed data supplied for the previous 24 hours was for the same variables. The data was processed each Monday, Wednesday and Friday by ADAS at around 11-12 midday, to calculate for each site the start time and duration of events when both temperature and humidity were above threshold for 23 or more consecutive hours (criteria were: temperature $\geq$ 7°C and %RH $\geq$ 80). The start time and duration of alerts, or a 'no alert' message as appropriate, were e-mailed to each site, around midday each Monday, Wednesday and Friday, from the start of first flowering in the earliest crops to the end of flowering in the latest crops.

3.3. Inoculum: petal tests

Petals were sampled at all field trial sites from untreated plots only (12 petals per plot, 4 plot reps), after noon on a fine day, at growth stages 4.2 (BBCH 62), 4.5 (BBCH 65), 4.7 (BBCH 67), 4.9 (BBCH 69) and placed on agar (potato dextrose agar + 50 ug/L streptomycin sulphate) within two hours of collection. Older, intact flowers (i.e., those nearest the bottom of the open flower zone) were selected. Petals were taken using sterilised forceps and placed face down onto agar, 4 per plate. Plates were examined after 8-10 days incubation at room temperature for the presence or absence of sclerotinia. Samples of petals from the same flower, and leaf discs from the same plant, as used for the agar plate test, were sent to Rothamsted Research for PCR tests for sclerotinia.

Petals were also sampled by AHDB monitor farmers who had responded to a request to participate in this project. Petals were sampled and posted in labelled envelopes from 6-7 farms per year to Rothamsted Research, for PCR tests for sclerotinia. The locations varied from south west England to Scotland, with some differences from year to year depending on changes in AHDB monitor farmers. Each farm sampled petals at three or four key growth stages during flowering, from untreated areas or if from fungicide treated area, before any fungicide treatment. Farmers were provided with tweezers and alcohol wipes, and asked to sample one individual petal from each of ten fully open flowers on the main stem, from ten randomly selected plants in each of four locations (40 petals total), avoiding plants at the very edge of the crop. Tweezers were cleaned between each location.

From one location, all ten petals were placed in one small envelope. For each sampling date, four separate locations were sampled, resulting in four envelopes each with ten pooled petals, tested by PCR (Appendix 3) to give one pooled result for each envelope.

3.4. Inoculum: air samplers

Burkard seven day spore traps (Figure 2) were operated throughout the oilseed rape flowering period each year of the project (2015 to 2018), at five sites each year (Table 1).

Figure 2. Burkard seven day spore trap operating in an oilseed rape field at Rothamsted.

The spore traps were operated from 12V leisure batteries according to methods described in Lacey & West (2006). New collection drums with sticky tape for trapping over a period of seven days were sent to each site from Rothamsted and exposed drums were returned to Rothamsted by post/courier.

For DNA extraction, tape was cut into single day sections and each single-day section (48 x 20mm) was cut in ½ lengthways (two sections 48 x 10mm) and each ½ tape section was spiralled into 1.5ml screw cap tubes for DNA extraction, with the start or earliest spore deposit kept towards the top of the tube. The tubes were labelled and kept at minus 20°C. Only one ½ section was used with the other duplicate kept in a different freezer. The DNA extraction procedure is described in Appendix 1.

Petals were collected from sampling sites at ADAS Rosemaund and ADAS Boxworth (Terrington in 2012). Sclerotinia DNA was extracted from flower petals and leaf discs using MycroLysis Plus (Microzone Ltd), as described in Appendix 2.

3.5. Inoculum: sclerotial germination

Where possible for each site, sclerotia were collected from infected oilseed rape stems from a nearby location in the previous year, and if not, were supplied from ADAS Rosemaund, from infected Herefordshire fields. Unbroken sclerotia approx. 4mm in size were selected where possible. Sclerotia were buried in grids in mid-end October, one sclerotium per cell, 1-2 cm depth, 25 cells per grid, four grids per experiment. The grids located at field experiment sites where air samplers were deployed were placed 1-2m from samplers. The soil surface was 'prepared' by gently raking the top 5 cm to break up large clumps and to remove any stones. Grids were assessed for the presence and numbers of apothecia at 7day intervals from before flowering to at least the end of flowering.

3.6. Reporting infection risk

The results for forecast weather-based alert occurrences were e-mailed to individual sites three times a week (Monday, Wednesday and Friday) during oilseed rape flowering. A report covering 15 Monitor sites in the UK was updated weekly by ADAS and sent to AHDB for checking and inputting onto the map and text sections as appropriate, for publication on the sclerotinia section of the AHDB disease monitoring webpage.

The AHDB report included further results of inoculum testing in addition to the occurrence of weather-based alerts, and showed a map of the UK with each site coded as red (high risk), amber (moderate risk) and green (low risk). The colour coding was based on integrating all available sources of relevant data to produce a qualitative risk category. All crops were considered low risk until the onset of flowering. Once flowering had been reported as early flower, sites were reported as low, moderate or high risk. The risk categories reported on the AHDB website were assigned according to the following criteria:

LOW: Crop not yet flowering, even if weather is conducive and/or inoculum positive

LOW: Crop at early flower or beyond, but no weather-based alert and zero inoculum.

MODERATE: Weather-based alert only (forecast or current) or inoculum positive only (in-field test results for petals and/or air-samplers)

HIGH: Weather-based alert and positive inoculum

Based on previous work, there is no certainty about the definition of exact threshold levels of inoculum that can be interpreted as low, moderate or high inoculum. Field experiment results in the current project indicated that for petal tests, any positive result above 10% (approx.) indicated an inoculum presence which posed an infection risk. For air sampler tests, spore concentrations above about 200 spores/m^3 are generally thought to indicate infection risk, but the concentrations depend on proximity of the sampler to the crop being assessed.

A one-two line text comment was provided to AHDB for each site to highlight any additional potential risk issues, such as: susceptible flowering stage reached, petals noted adhering to crop, prolonged flowering which could justify a second fungicide treatment, etc.

In 2018, the alerts were based on forecast weather only, so the categorisation of risk was quantifiable based on duration of temperature and humidity at or above thresholds as described previously.

3.7. Fungicide timing field experiments

Oilseed rape experiments were conducted at three sites per year, over three years (Table 1), at sites with a known history of sclerotinia infection. At all sites, the experimental treatments were randomised within complete blocks, with three or four replicates. Plot size varied but was a minimum of 12 x 3 m. Fungicide treatments were applied in 200 litres water/ha at a pressure range of 200-300 kPa, using suitable nozzles to achieve a medium spray quality. See Table 3 for varieties, drilling dates and dates of application. Herbicides and insecticides were used according to local farm practise to minimise the incidence of weeds and pests. Sclerotia were buried at each site in the autumn (see above, section 3.5).

Fungicide applications included single timing treatments, scheduled by growth stage: at yellow bud, early-, mid- or late-flower. Additional timing treatments included application according to a weather-based alert only, or according to weather-based alert coinciding with a positive inoculum test result. All fungicide treatments were Pictor at 0.5 l/ha (BASF, boscalid + dimoxystrobin). The weather based infection model was run on 48-hour forecast RH% and temperature data for each individual site, purchased from the MetOffice. This model was run and risk alerts generated three times each week, Monday, Wednesday, and Friday, and e-mailed to designated contact staff at all sites.

Background disease was assessed in untreated plots immediately prior to the first fungicide application, and pre-harvest, when stems were still green so that sclerotinia lesions were clearly identifiable in plots. 200 plants per plot were assessed non-destructively pre-harvest for incidence and severity (EPPO standard PP1/078(3)). Other diseases were assessed where present (alternaria, light leaf spot and powdery mildew in particular), on leaves, stems or roots using NIAB whole plot methods. The seed weight and moisture content were measured and the yield at 91% dry matter was calculated.

4. Results

4.1. Weather: forecast-alerts

The frequency of alerts from 2015-17 based on the threshold criteria ($\geq$7°C & $\geq$ 80% RH for at least 23 consecutive hours) ranged from zero to three during the flowering phase for each site involved (Figure 3). Based on past years of ADAS field experiments with winter oilseed rape, 2015 and 2016 were typical years in which weather conditions conducive to infection occurred more frequently in south west and southern areas of the UK. However, in 2017 the frequency of alerts in eastern regions, including Scotland, was higher than usual, due mainly to easterly wind conditions in that year with occurrences of coastal mists and generally higher humidity than normally experienced in the east during oilseed rape flowering.

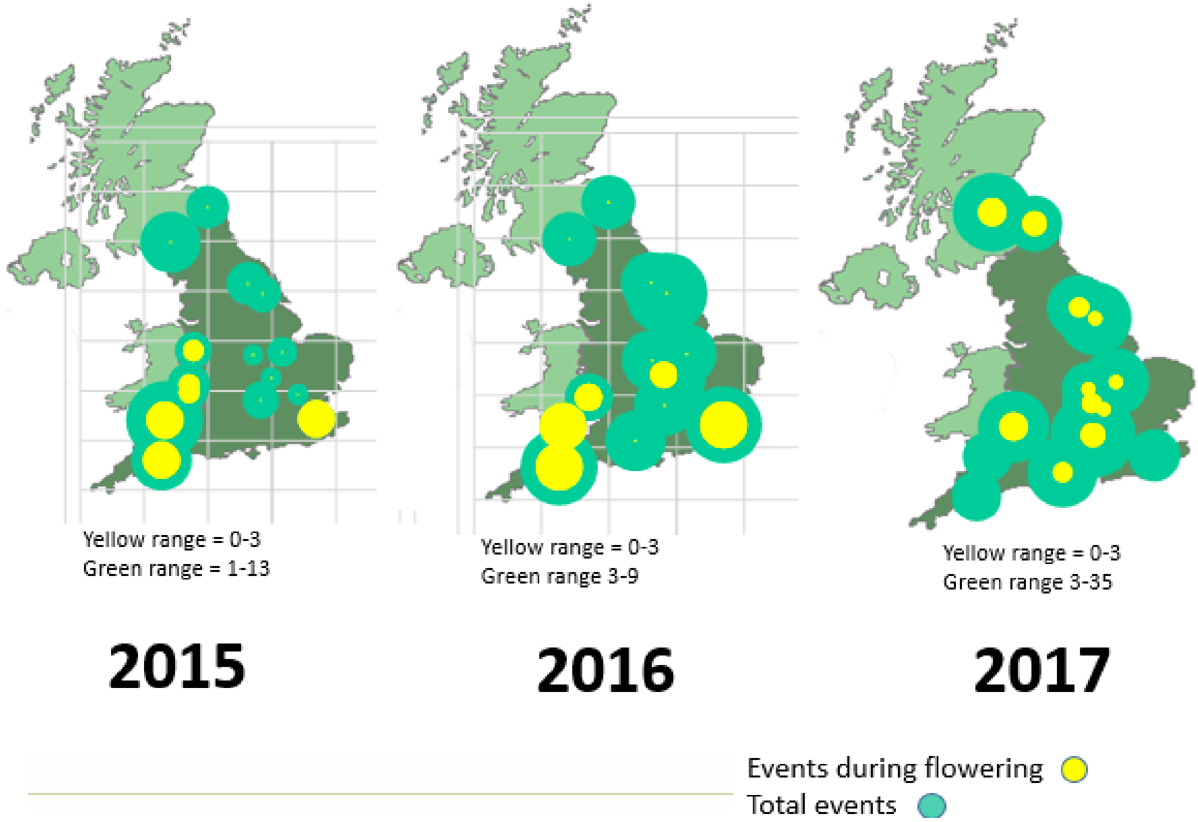


Figure 3. Frequency of sclerotinia infection alerts 2015-2017, based on 48 hour forecast weather, for 15 sites per year. Alerts occurred when there were ≥ 23 consecutive hours of air temperature ≥7°C and %RH ≥80. Size of circles indicates the number of weather-based infection events, yellow: during flowering only, green: from 1st March through to 31st May. The range of frequencies is shown under each map.

There were many phases when either air temperature or humidity were above threshold (e.g. 2017, all three sites, Figure 4) but fewer occurrences when both of these thresholds were met at the same time, for at least 23 consecutive hours (e.g., Figure 4 shows three 2017 Herefordshire alerts during flower).

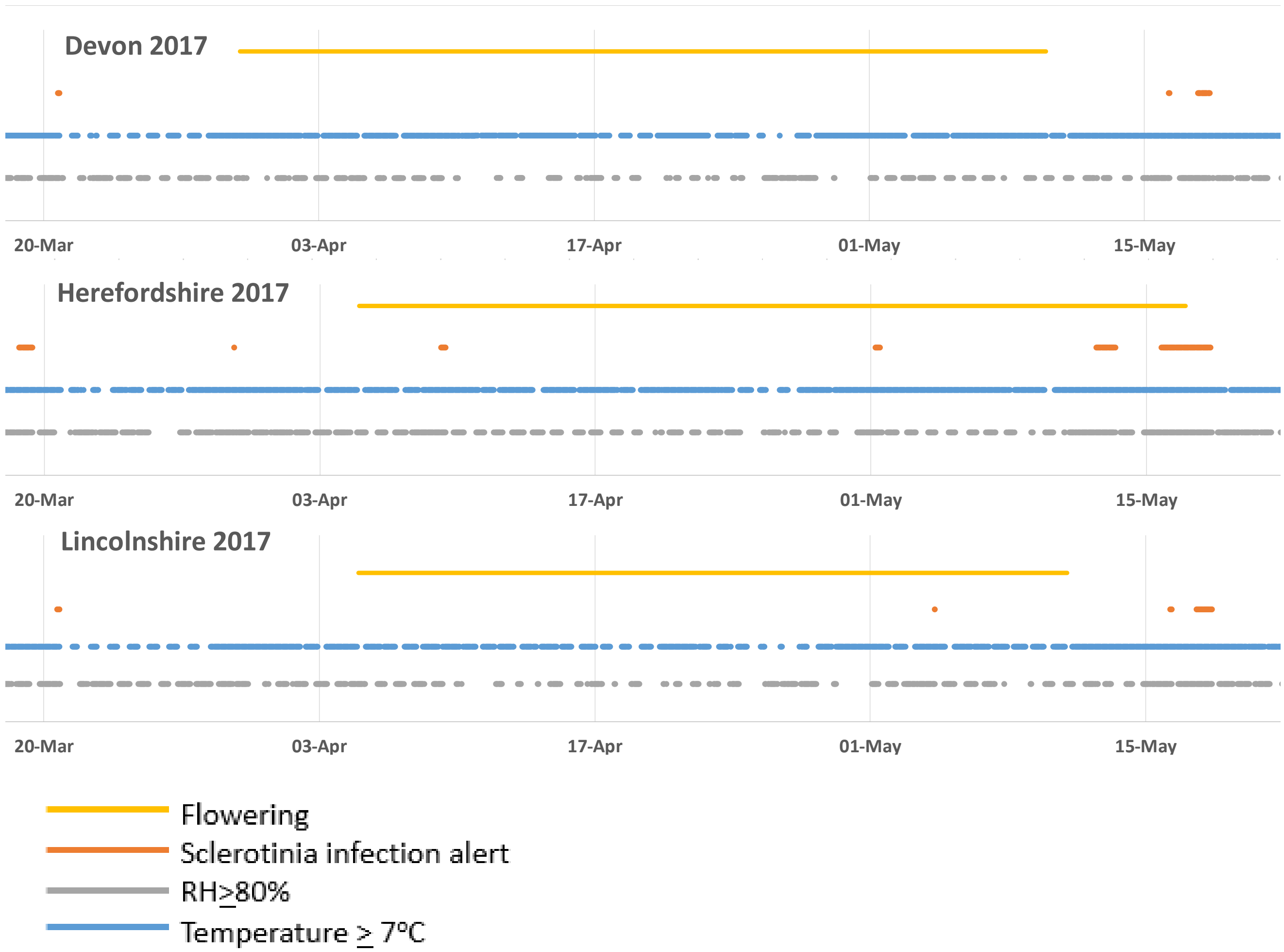


Figure 4. 2017 Sclerotinia infection alerts (orange bars) during flowering (yellow bars), based on when temperature (blue) and humidity (grey) are both above their respective thresholds for 23 hours or more (see figure legend), at three fungicide-timing field experiment sites.

The timing of occurrence of weather-based infection alerts during crop flowering varied by site. Alerts at early or mid flower, e.g. Herefordshire 2017 (Figure 4), were potentially the most important for guiding the timing of a protectant fungicide treatment, as early- or mid-flower infections more often occur on the main stem than lateral branches and are the most damaging to yield. At some sites, alerts occurred just before yellow bud, when the crop was not considered at risk, but there were no further alerts (e.g. Devon 2017, Figure 4) during flowering. Alerts tended to occur more frequently at the end of flower when the main infection risk phase was over, as in Herefordshire 2017, or just after flowering, e.g. Lincolnshire 2017 (Figure 4). Post-flowering, temperatures are generally warming which can increase the frequency of weather-based alerts if there is sufficient rain to keep humidity high. In most years, however, humidity is a limiting factor post-flowering for the occurrence of alerts, with temperatures normally above 7°C both day and night by the end of May but generally drier conditions at this time, particularly during daytimes.

4.2. Inoculum: petal tests

The relationship between the % of petals testing positive for sclerotinia and the subsequent incidence of sclerotinia infection in untreated field experiment plots was variable, and changed with the flowering stage at which petals were sampled (Figure 5). The yellow-bud sample test results were the best predictor of infection, but no petal sample test provided an accurate prediction of sclerotinia stem rot incidence. Many samples which tested positive were associated with sites where there was no sclerotinia infection. There were a few samples which had low-positive test results that were associated with high infection. But zero petals testing positive was associated with no infection.

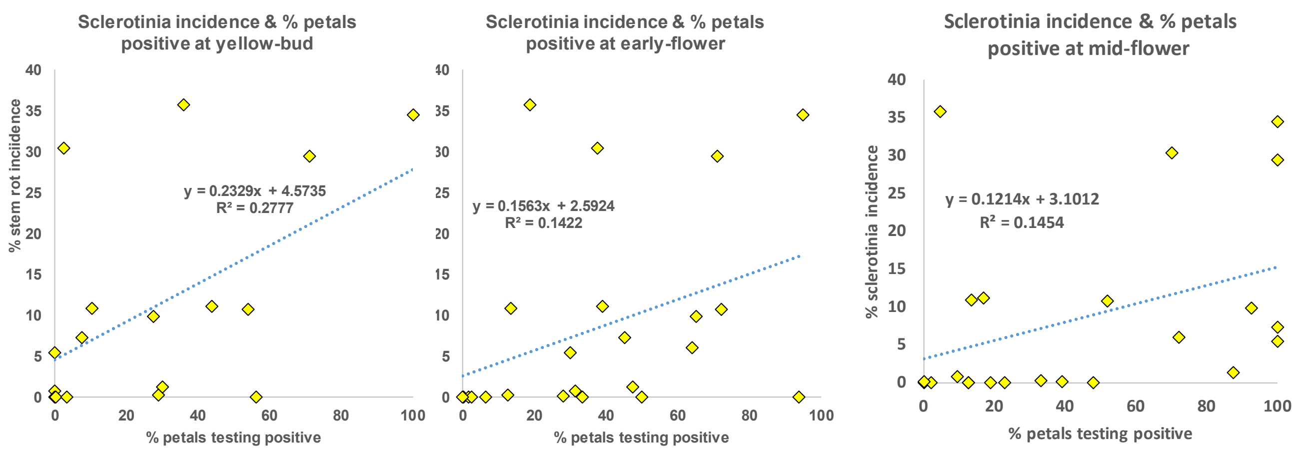


Figure 5. % petals testing positive for sclerotinia, and incidence of sclerotinia stem rot in winter oilseed rape, from untreated plots in field experiments 2010-2017. Each value is the mean of four untreated plots per site, based on 40 petals sampled per plot, tested individually by agar plating.

PCR tests and agar plate tests were done on opposite petals sampled from the same flowers at a subset of sites. Combining all sample results from 2010-2017 there was a variable relationship between the PCR spore equivalent levels and the agar plate % positive petals (Figure 6).

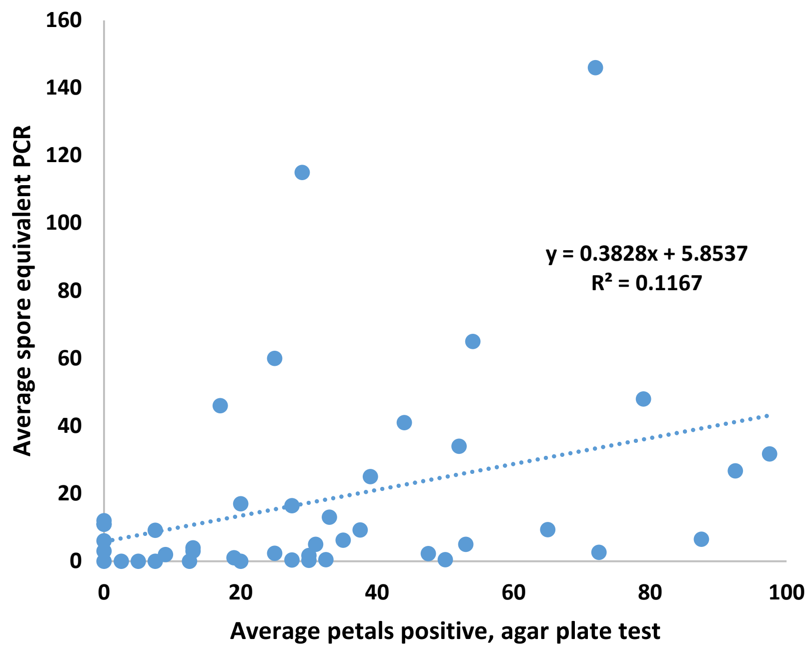


Figure 6. Winter oilseed rape petals: agar plate vs PCR test results for sclerotinia, 2010-2017. For each value, petals were sampled from the same location on the same date. Agar plate values are mean values of 40 petals tested, PCR values are based on 40 pooled petals (spore equivalent = pg DNA/0.72; Rothamsted Research).

Results of PCR tests on petal samples from participating AHDB monitor farms in 2015-17 showed that many farms had zero or low sclerotinia DNA on petals, particularly in 2015 and 2017 (Table 2). The monitor farms did not submit samples for all of the flowering stages requested, but the available results can be compared with the samples from the ADAS field experiment sites which were specifically selected to be high-risk for sclerotinia infection. Where the % of petal samples testing positive was high, the average amount of sclerotinia DNA in these same samples was variable, i.e. a high % positive value sometimes indicated a high amount of sclerotinia DNA on petals, but not in all cases.

Table 2. Sclerotinia PCR petal test results, 2015-2017, AHDB Monitor farm sites and Research partner field experiment sites.

Year	Monitor farm and Field trial locations	Name	GS	Sample date	PCR +/- (%)	DNA pg, average of positives	GS	Sample date	PCR +/- (%)	DNA pg, average of positives	GS	Sample date	PCR +/- (%)	DNA pg, average of positives	GS	Sample date	PCR +/- (%)	DNA pg, average of positives
2015	Cardiff, S Wales	Radcliffe	4.3	15-Apr	38	15.1	4.8	27-Apr	38	6.1	-	-	-		-	-	-	-
	Fawley, Hereford	Wood	4.2	13-Apr	100	5.2	4.5	29-Apr	40	5.1	-	-	-	-	5.1	13-May	0.0	0.0
	Fordham, Essex	Bradshaw	4.1	21-Apr	0	0.0	-	-	-	-	-	-	-	-	-	-	-	-
	Newport, Shropshire	W-Jones	4.1	14-Apr	0	0.0	4.5	28-Apr	0	0.0	-	-	-	-	4.9	12-May	0.0	0.0
	Driffield, E Yorks	Meadley	4.1	21-Apr	0	0.0	4.5	04-May	0	0.0	-	-	-	-	-	-	-	-
	Berwick, Borders	Reed	4.1	04-May	75	3.4	-	-	-	-	-	-	-	-	4.9	19-May	0.0	0.0
	Rosemaund, Heref.	ADAS	4.1	20-Apr	100	6.6	4.5	04-May	67	17.7	4.8	11-May	100	8	-	-	-	-
	Starcross, Devon	ADAS	4.1	19-Apr	0	0.0	-	-	-	-	4.9	04-May	0	0	-	-	-	-
	Stamford, Lincs.	Velcourt	4.1	20-Apr	0	0.0	4.5	27-Apr	0	0.0	5.5	11-May	0	0	5.7	18-May	0	0
2016	Alresford, Hants.	Bason	4	18-Apr	63	2.5	4.1	26-Apr	0	0.0	4.3	03-May	25.0	21.0	-	-	-	-
	Huntingdon, Cambs	McKenzie	-	-	-	-	4.1	04-May	0	0.0	-	-	-	-	-	-	-	-
	Berwick upon Tweed	Reed	4.1	03-May	25	1.5	4.5	10-May	75	7.8	4.5	24-May	50.0	4.5	-	-	-	-
	Driffield, E Yorks	Meadley	4.1	11-Apr	50	4.0	5.0	04-May	38	1.6	-	-	-	-	-	-	-	-
	Fawley, Herefordshire	Wood	4.1	20-Apr	13	2.4	4.5	11-May	38	2.1	-	-	-	-	4.9	17-May	38	1.4
	Penmark, Glamorgan	Radcliffe	-	-	-	-	4.2	27-Apr	25	4.0	4.4	03-May	38.0	1.9	4.7	09-May	0	0
	Wantage, Oxfordshire	Gold	4.1	18-Apr	13	2.3	4.1	26-Apr	13	3.3	4.4	03-May	50.0	7.2	-	-	-	-
	Rosemaund, Heref.	ADAS	3.8	12-Apr	81	5.5	4.1	18-Apr	100	6.7	-	-	-	-	-	-	-	-
	Starcross, Devon	ADAS	3.7	21-Mar	19	1.3	4.1	06-Apr	94	7.2	4.5	12-Apr	100.0	19.3	4.7	25-Apr	100	22.8
	Stamford, Lincs.	Velcourt	3.9	05-Apr	0	0.0	4.1	18-Apr	50	2.5	4.3	26-Apr	50.0	3.2	4.9	09-May	13	1.7
2017	Alresford, Hampshire	Bason	3.9	28-Mar	25	2.1	4.4	10-Apr	25	1.9	-	-	-	-	-	-	-	-
	Huntingdon, Cambs	McKenzie	4.1	03-Apr	0	0.0	4.4	10-Apr	0	0.0	4.6	25-Apr	13	1.1	4.8	02-May	13	1.3
	Berwick upon Tweed	Reed	4.1	03-Apr	0	0.0	-	-	-	-	4.6	02-May	13	1.0	-	-	-	-
	Driffield, E Yorks	Meadley	3.9	05-Apr	38	2.4	4.5	18-Apr		0.0	-	-	-	-	-	-	-	-
	Fawley, Herefordshire	Wood	4.1	04-Apr	13	1.0	-	-	-	-	48	03-May	0	0	-	-	-	-
	Wantage, Oxfordshire	Gold	4.4	10-Apr	0	0.0	4.5	18-Apr	0	0.0	4.8	25-Apr	0	0	4.9	02-May	0	0
	Starcross, Devon	ADAS	4.2	27-Mar	14	12.1	4.5	03-Apr	25	1.5	4.8	10-Apr	75	2.5	5	17-Apr	25	1.4

4.3. Inoculum: sclerotial germination

The timing of apothecial appearance in relation to the start of flowering in the same seven regions monitored each year from 2015-2017 was not consistent, with apothecia developing before the start of flowering at some sites, but well into flowering at other sites.

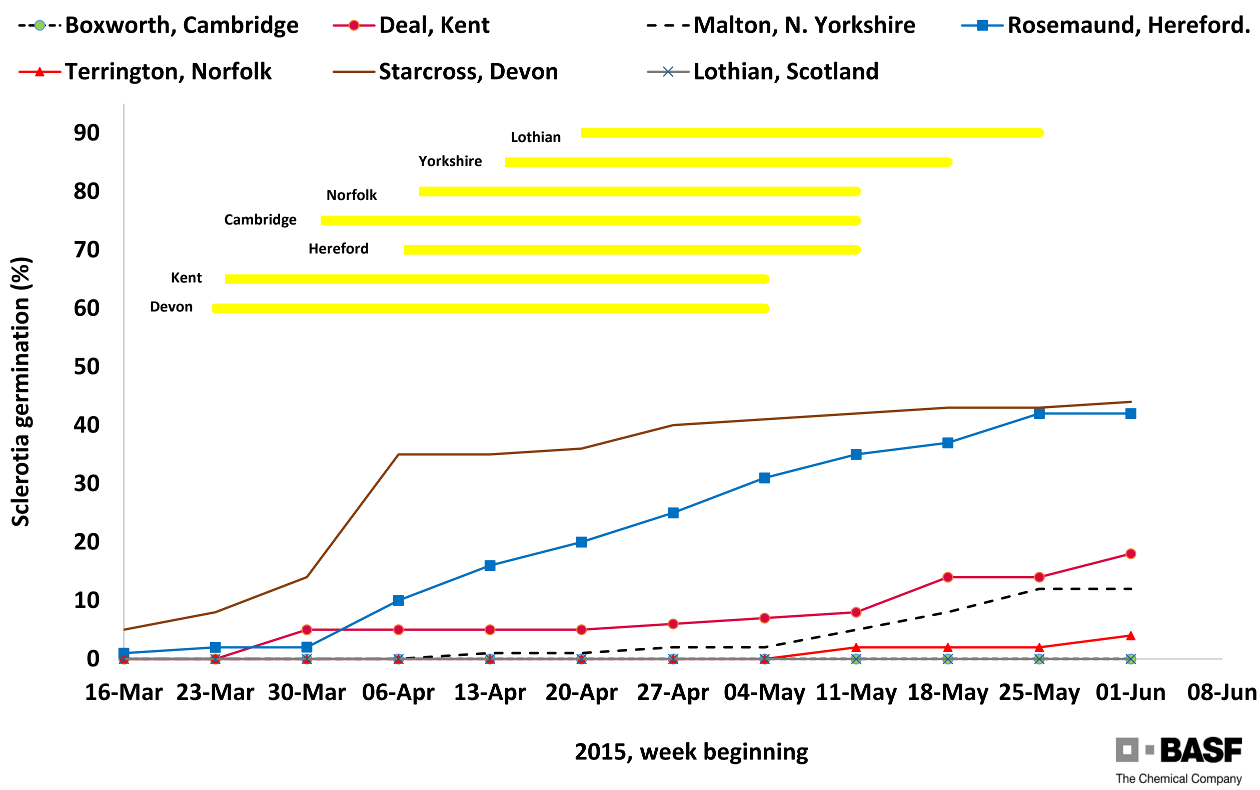


Figure 7. 2015 Germination of sclerotia of *Sclerotinia sclerotiorum* at BASF winter oilseed rape monitor sites. Yellow lines = flowering duration. % germination values are based on +/- germination of sclerotia of 100 sclerotia buried 2-4 weeks post-drilling at 2cm depth.

In 2015, Devon apothecia were visible before flowering, with most of the new apothecia appearing by early April. By contrast, new apothecia appeared in most weeks in Herefordshire to reach numbers similar to those in Devon, while Kent apothecia were not seen until very late flower, in very low numbers (Figure 7). There was relatively high final % germination reached at the Devon and Herefordshire sites compared to other sites. There was no germination at the Cambridge or Lothian sites.

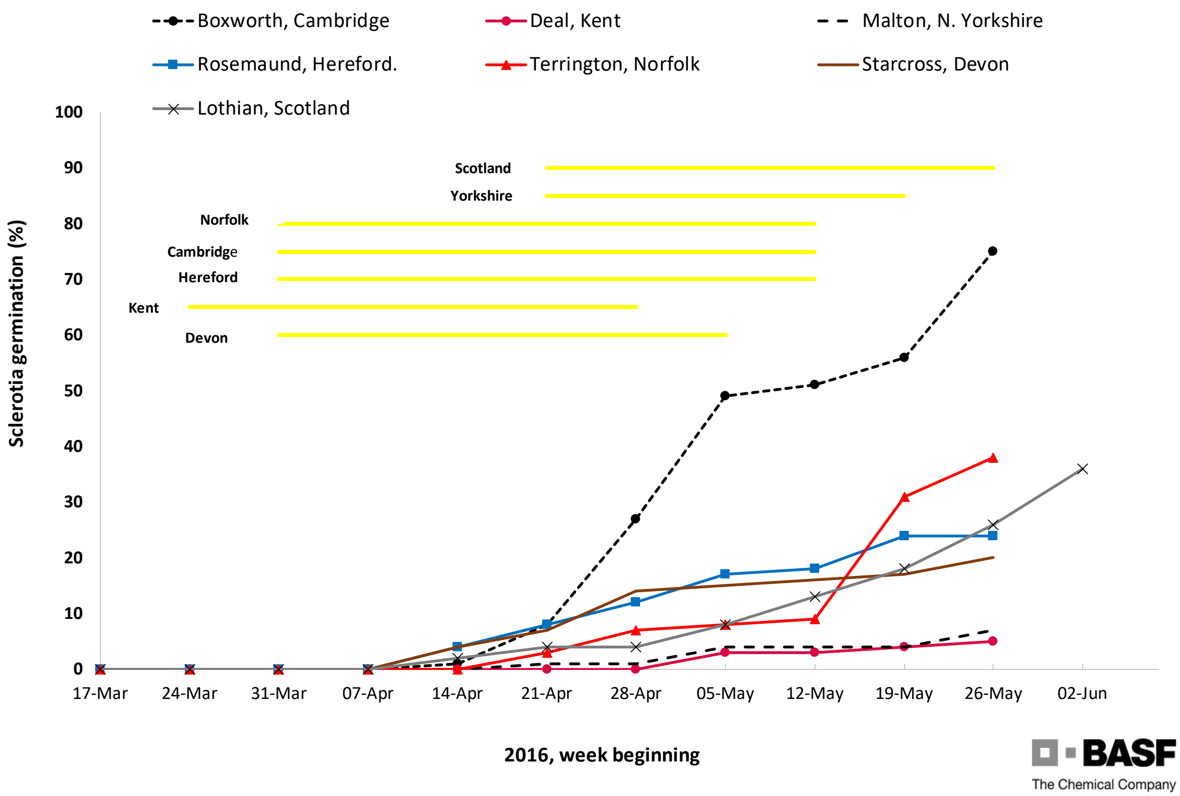


Figure 8. 2016 Germination of sclerotia of *Sclerotinia sclerotiorum* at BASF winter oilseed rape monitor sites. Yellow lines = flowering duration. % germination values are based on +/- germination of sclerotia, of 100 sclerotia buried 2-4 weeks post-drilling at 2cm depth.

In 2016, apothecia were late to appear at all sites (Figure 8), starting mid- to late-April, at mid-flower onwards for all sites.

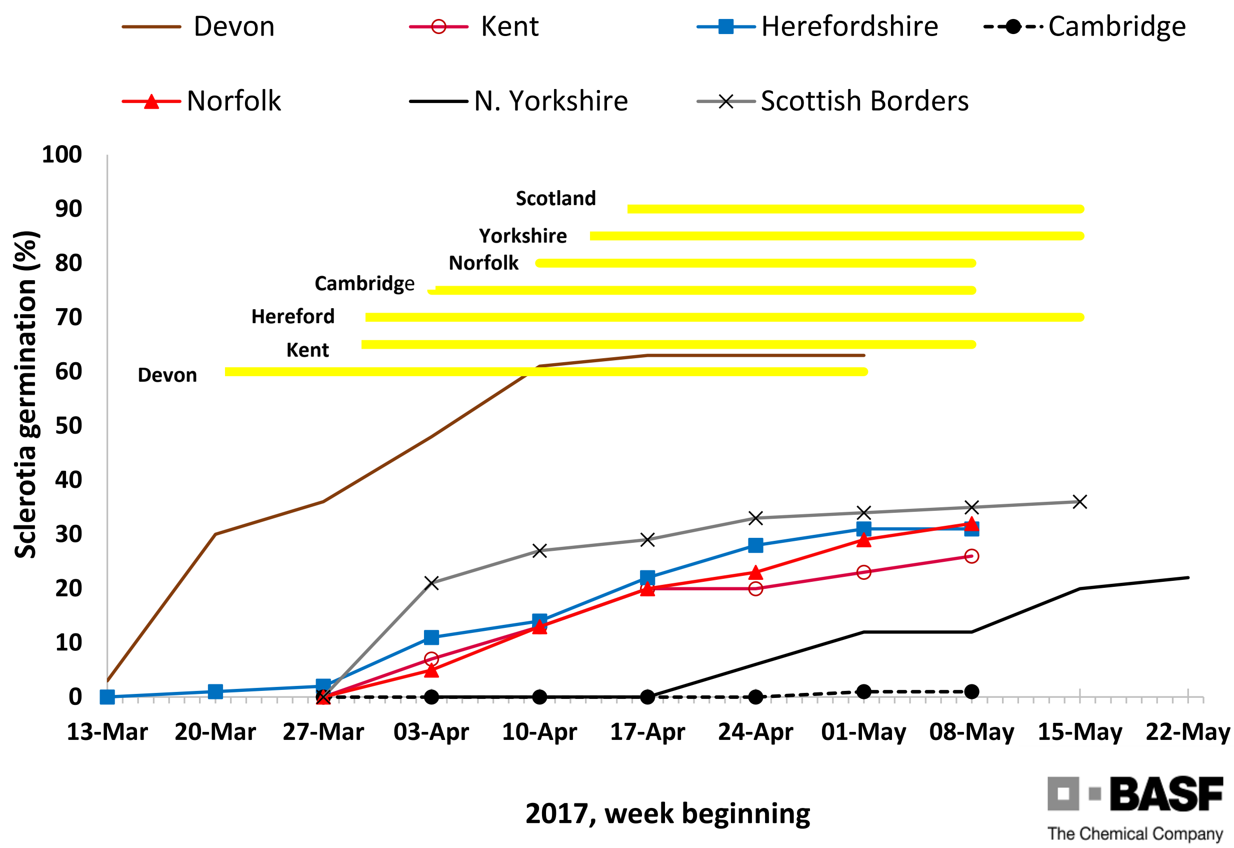


Figure 9. 2017 Germination of sclerotia of *Sclerotinia sclerotiorum* at BASF winter oilseed rape monitor sites. Yellow lines = flowering duration. % germination values are based on +/- germination of sclerotia, of 100 sclerotia buried 2-4 weeks post-drilling at 2cm depth.

In 2017, Devon sclerotia germinated earlier and in greater numbers than other sites. Very few Cambridge sclerotia germinated (Figure 9), which is a situation often seen in previous years for sclerotia buried in grids in this region, with the exception of 2016 when the highest % germination across all sites was recorded at Boxworth, Cambridge.

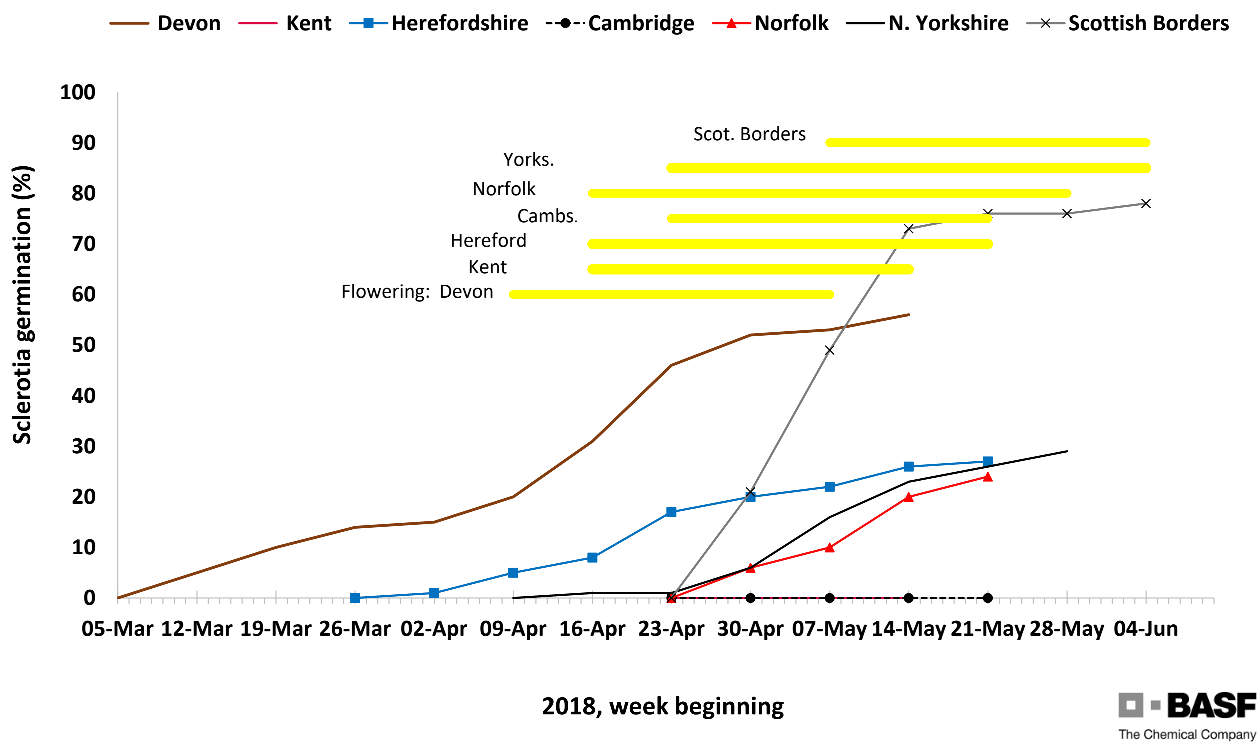


Figure 10. 2018 Germination of sclerotia of *Sclerotinia sclerotiorum* at BASF winter oilseed rape monitor sites. Yellow lines = flowering duration. % germination values are based on +/- germination of sclerotia, of 100 sclerotia buried at 2cm depth, 2-4 wk post-drilling.

In 2018, as in most of the previous years, the Devon sclerotia started to germinate earlier than at other sites, and very early (second week in March) compared to flowering onset in early-April. In this year, the Scottish border site had relatively high numbers of apothecia.

The variation from year to year in germination onset and rate of new sclerotia germinating each week is likely to reflect the spring soil temperatures, soil moisture levels and the size of the sclerotia buried. In particular, dry soil conditions will hold back germination, which is likely to have been the situation at the Cambridge site each year.

The data for sclerotial germination activity at the same seven locations from year to year provided an additional indicator of inoculum presence at the sites, but it did not always tie in with petal test results, and could not be used to guide decisions on timing of fungicide treatments.

4.4. Inoculum: air samplers

Air sampler results indicated that spore release can begin well before flowering at some sites in some years, and that there are large variations in the amount of spores in the air during flowering within one site, as well as large variation between sites.

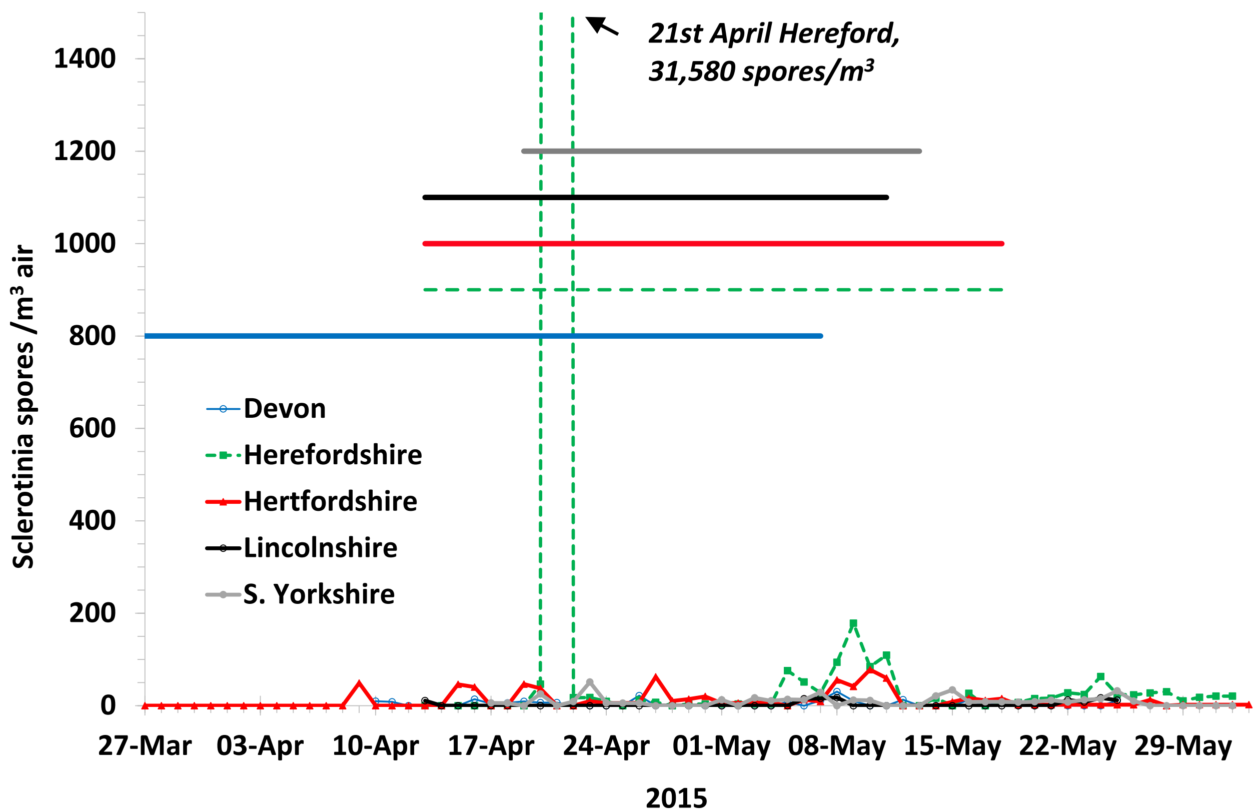


Figure 11. *Sclerotinia sclerotiorum* spore concentrations in air samples at winter oilseed rape monitor field sites, 2015. Horizontal lines = flowering duration for each site. Total untreated sclerotinia incidence (main stem + laterals) at field trials sites were: Devon 0%, Herefordshire 6% and Lincolnshire 0.03%.

In 2015 the levels of airborne spores were mostly low, with one exception of a high peak in the third week of April during early-mid flower in Herefordshire. The airborne spore test results did not relate consistently to the sclerotial germination timing, for example, in 2017, Devon sclerotia germinated rapidly in the first week of April, yet no airborne spore peak(s) were recorded around that time.

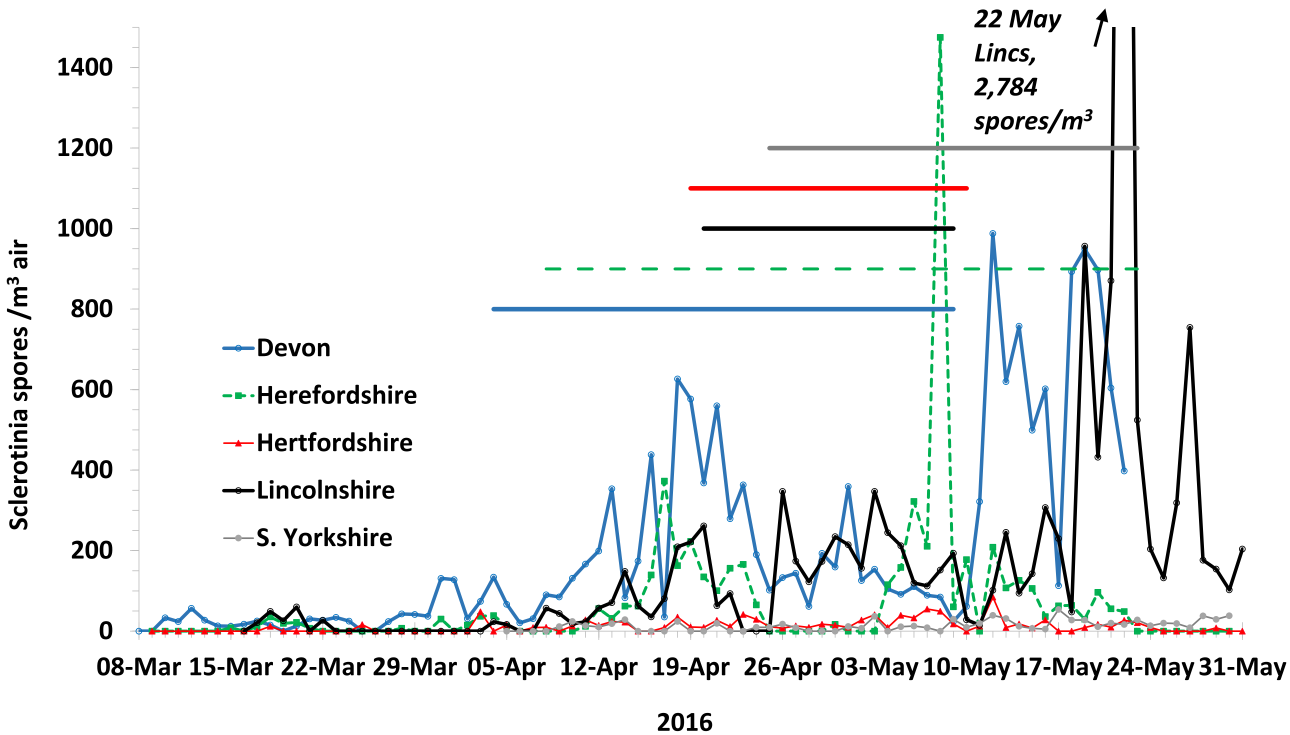


Figure 12. *Sclerotinia sclerotiorum* spore concentrations in air samples at winter oilseed rape monitor field sites, 2016. Horizontal lines = flowering duration for each site. Total untreated sclerotinia incidence (main stem + laterals) at field trials sites were: Devon 8%, Herefordshire 30% and Lincolnshire 1.3%.

In 2016, there were clear peaks of spore production in early-mid flower in Devon, Herefordshire and Lincolnshire, but larger peaks of spores appeared at or after the end of flower at these sites. The timing of the larger peaks is possibly associated with the generally late germination of sclerotia in this year.

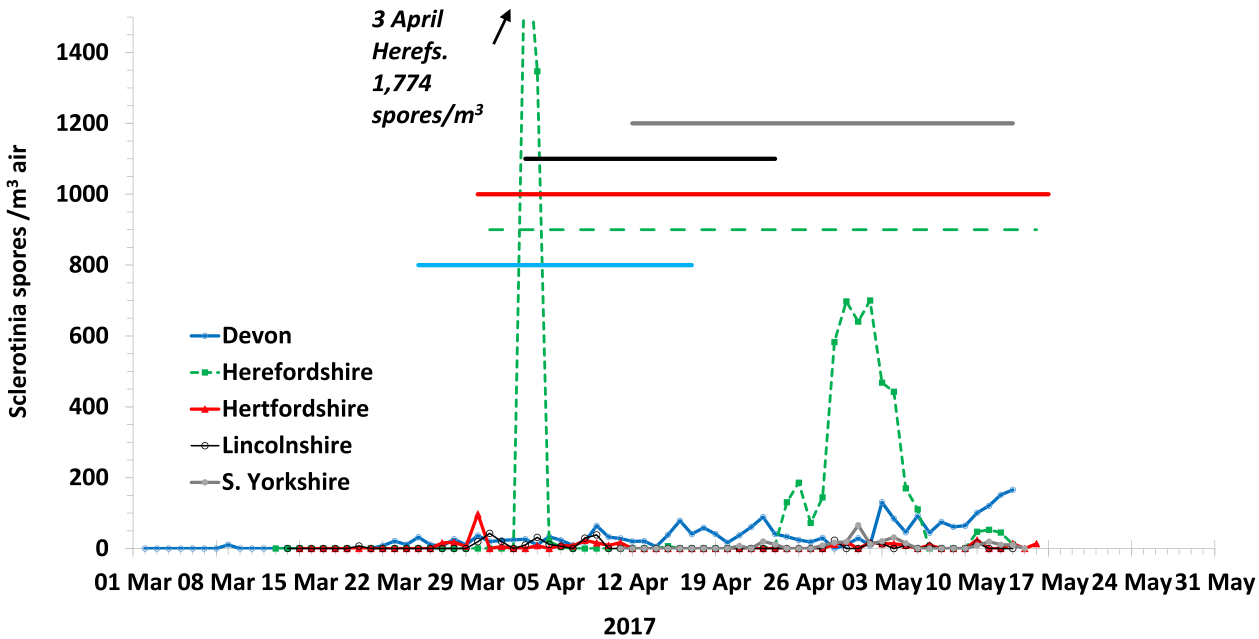


Figure 13. *Sclerotinia sclerotiorum* spore concentrations in air samples at winter oilseed rape monitor field sites, 2017. Horizontal lines = flowering duration for each site. Total untreated sclerotinia incidence (main stem + laterals) at field trials sites were: Devon 5.4%, Herefordshire 34.5% and Lincolnshire 0.2%.

In 2017, airborne spore levels were relatively low except at the Herefordshire site. Sclerotial germination onset and timing did not tie in with the airborne spore results, for example, Devon sclerotia germinated relatively early and quickly, but airborne spore levels at this site were relatively low throughout flowering.

The air samples indicate the time of onset of spore release, and the time of peaks during flowering, which may be associated with the extent and timing of infection. For example, the Herefordshire sites 2015 and 2017 (Figure 11 and Figure 13) had high spore concentrations during early-mid flower, with 8% and 35% sclerotinia incidence, respectively. The Devon site 2016 (Figure 12) had high spore concentrations during mid-flower and 8% sclerotinia incidence. The Lincolnshire site had spores present during flower but less than 400 spores/m^3 on each individual day, followed by very high amounts after late flower (Figure 12), but too late for high infection, with 1.3 % final sclerotinia incidence.

Exact quantities of spores may be difficult to use as thresholds because the amounts depend on proximity of the air sampler to sclerotinia apothecia. However, the data from 2015-2017 (Figure 11, Figure 12 and Figure 13) indicate that there were often clear peaks of spores/m^3 during flowering, among phases of low or no spores, and sites which had subsequent sclerotinia stem rot symptoms experienced peaks of approximately 400 spores/m^3 or more measured during flowering by in-field air samplers.

4.4.1. Sclerotinia risk reports

The report format was amended each year of the project to take into account improvements. Each year, the reports included a map with red, amber and green coded dots for every location (Figure 14, Figure 15, Figure 16, Figure 17), a text overview with commentary, and a chart showing airborne spore concentrations. Examples of the underlying data and of the weather-based alert e-mails sent to sites are shown in the appendices 13 to 23.

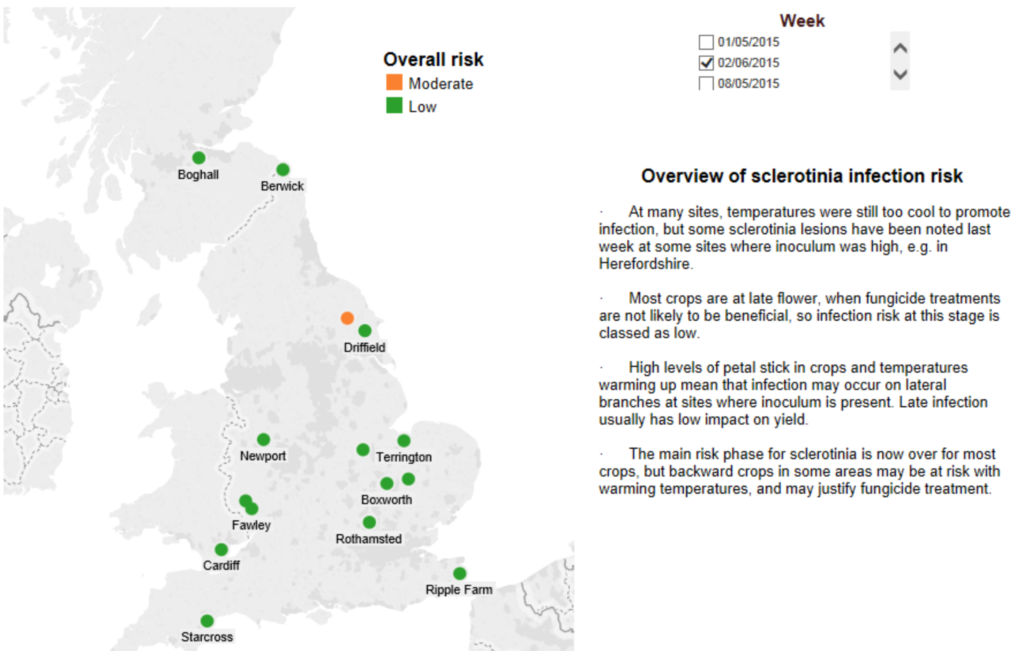


Figure 14. 2015 example of map and chart on AHDB website, 48 hour forecast starting 2 June (weather data source: MetOffice), updated once per week.

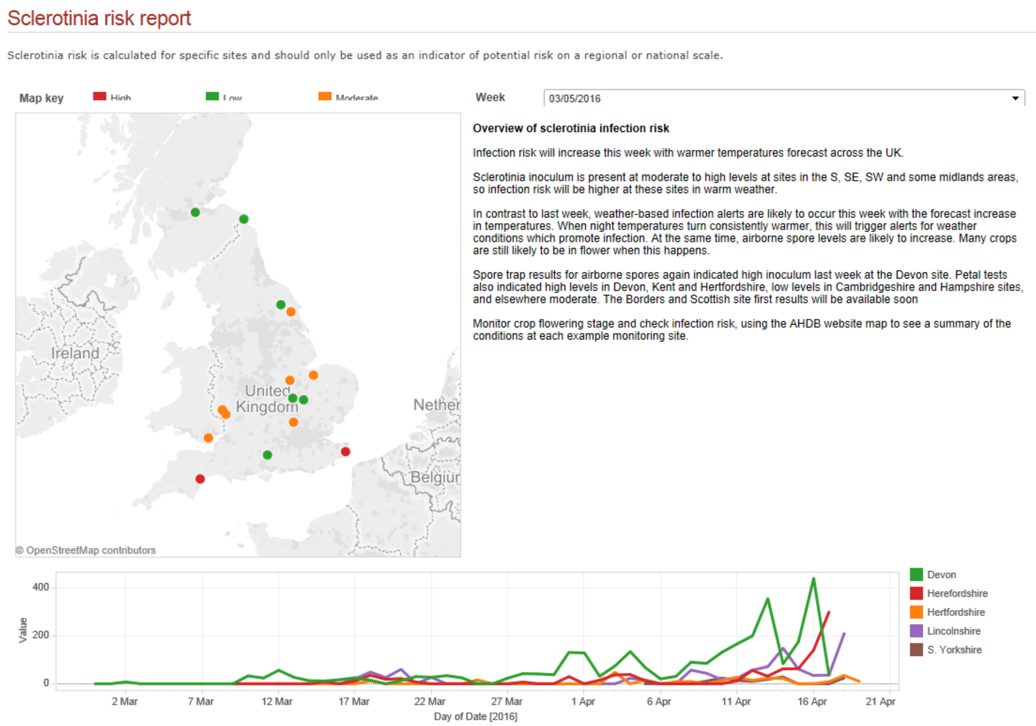


Figure 15. 2016 example of map and chart on AHDB website, 48 hour forecast starting 3 May (weather data source: MetOffice), updated three times per week.

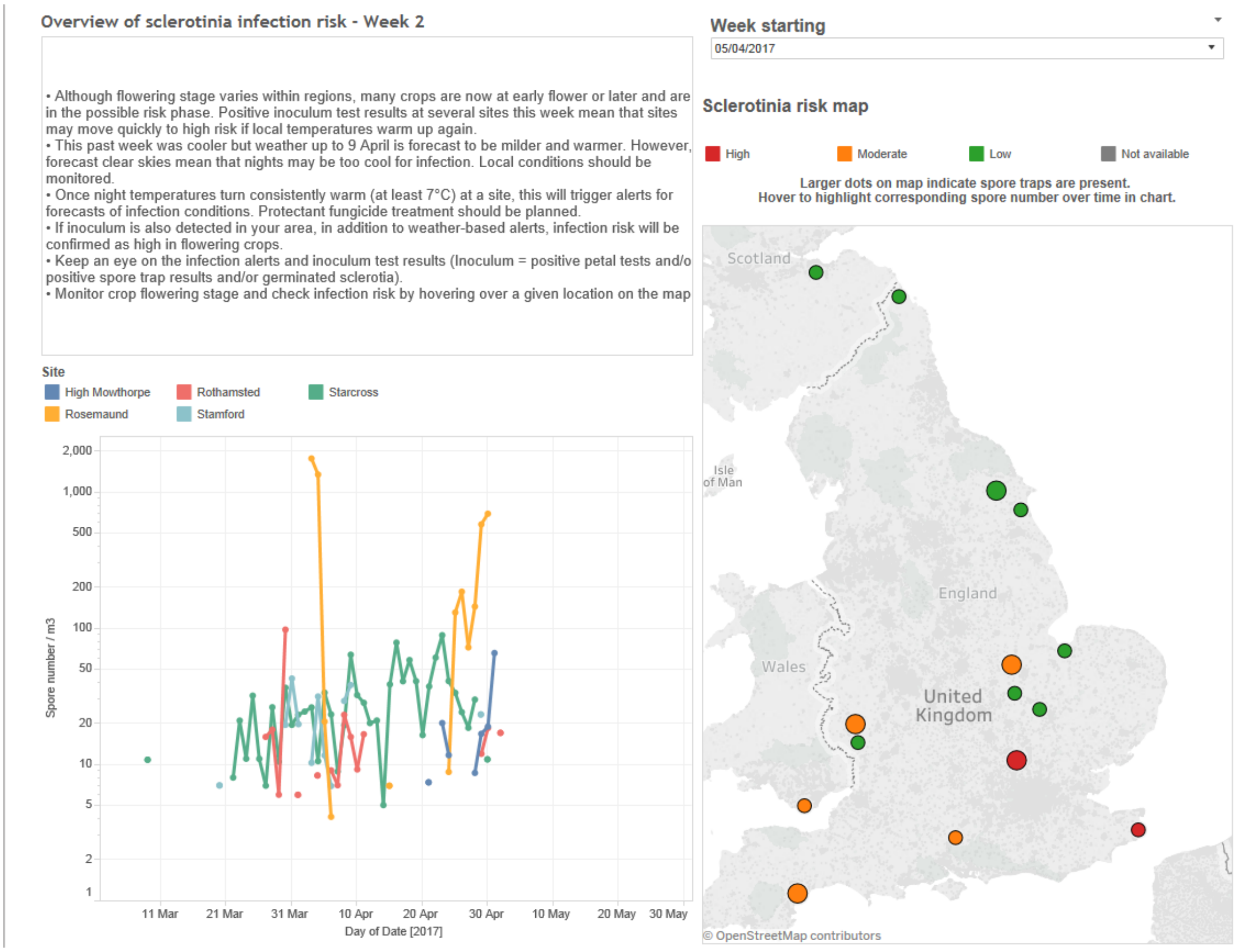


Figure 16. 2017 example of map and chart on AHDB website, week starting 3 April (weather data source: MetOffice), updated weekly.

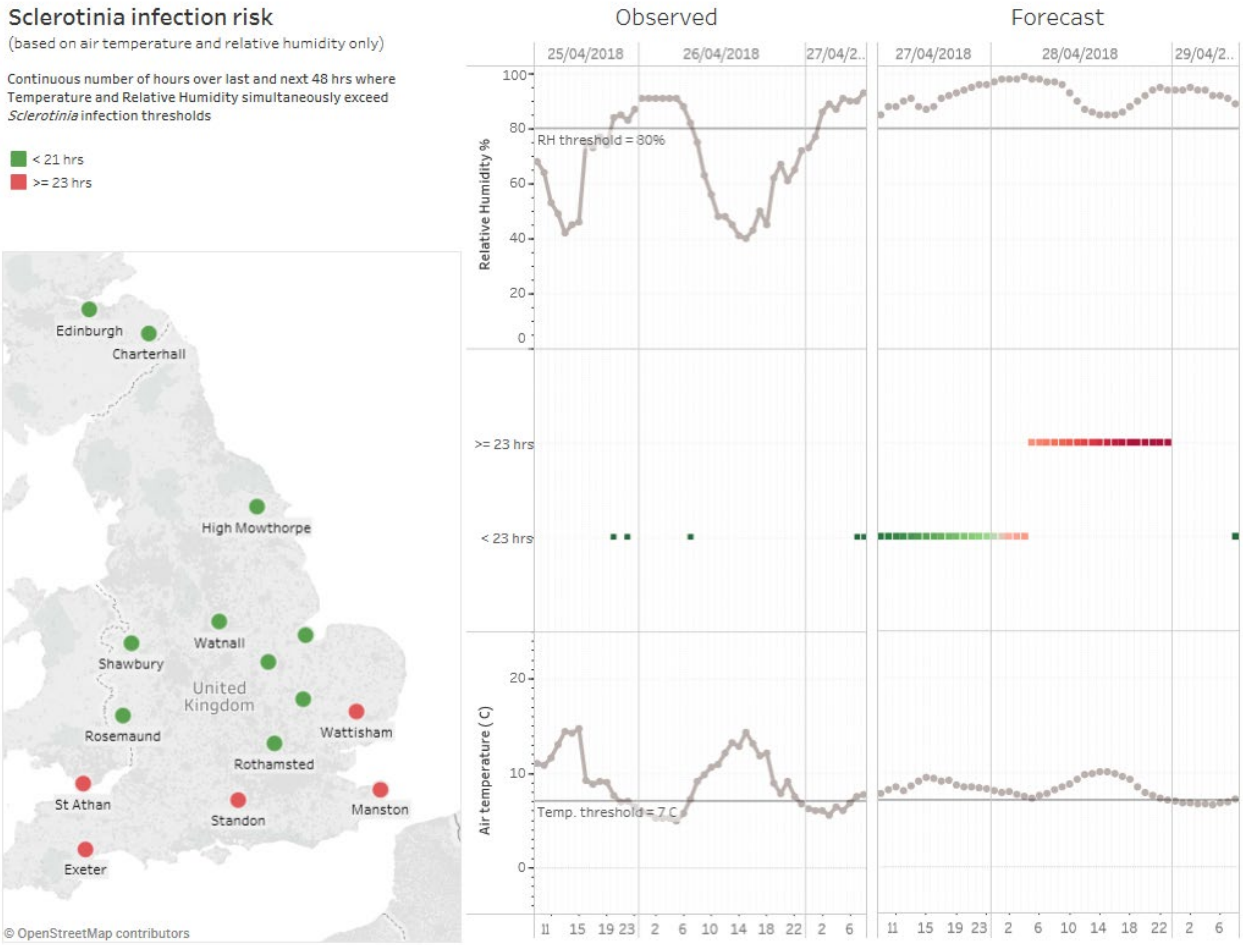


Figure 17. 2018 example of map and chart on AHDB website, 48 hour forecast starting 27 April (weather data source: MetOffice), updated three times per week.

4.5. Fungicide timing field experiments

Data on fungicide timing dates, disease (main stem and lateral branches), weather alert dates and petal test results are summarised in Table 3, with charts and data in Appendices 7.4 to 7.13. The effects of different fungicide timing treatments for each site depended on the date of flowering onset and progress, inoculum levels and weather, and therefore the results for each site have to be interpreted on a case-by-case basis.

2015

Herefordshire: only one weather-based alert at late flower, but inoculum was high particularly at late flower. Infection was fairly low and most likely occurred during late flower, especially as there were lateral branch infections (incidence of 4.6% on main stems and 2.7% on lateral branches).

Devon: no sclerotinia, despite weather alerts during flowering. But petals tests indicated low inoculum. (Early sprays were missed because the project funding had not started).

Lincolnshire: no weather-based alerts and no petals testing positive. No sclerotinia infection seen.

2016

Herefordshire: a relatively high disease site, with 30.4% total incidence, of which 9.5% was lateral branch infections. The best control was achieved with the scheduled mid-flower spray on 5 May prior to a weather-based alert forecast for 9 May, coinciding with high % of mid-flower petal samples testing positive for sclerotinia.

Devon: Weather alerts and high petal test results – and nearly 10% total sclerotinia infection. Best control was with the mid-and late-flower fungicides, when petal inoculum was highest.

Lincolnshire: very low sclerotinia infection. High petal inoculum at mid and late flower, but only one weather alert at late flower.

2017

Herefordshire: One very early weather-based alert but high petal inoculum at this time, and a high incidence of main stem infection (30%), so the infection most likely occurred early. The earliest fungicide spray on 31 March at yellow-bud gave the least control, possibly because fungicide activity from this application timing had decreased by the time petal fall started around mid-flower (mid-flower spray timing was 13 April) which was the most likely time for infection events to begin.

Devon: Low infection, possibly because the high petal inoculum timing did not coincide with a weather alert.

Lincolnshire: very low infection. No weather alerts, but the early- and mid-flower petals were more than 25% positive.

Table 3. Winter oilseed rape site details, fungicide application dates, forecast weather-based infection alert dates, % petals testing positive for *Sclerotinia sclerotiorum* and sclerotinia stem rot incidence pre-harvest in untreated plots.

	2015 ADAS Herefordshire	**2015 ADAS Devon**	**2015 Velcourt Lincs.**	**2016 ADAS Herefordshire**	**2016 ADAS Devon**	**2016 Velcourt Lincs.**	**2017 ADAS Herefordshire**	**2017 ADAS Devon**	**2017 Velcourt Lincs.**
Grid reference	SO 41156 41605	SX 97711 81790	TF 06493 05687	SO 41218 41621	SX 954 825	TF 06493 05687	SO 41249 41315	SX 954 825	TF 06493 05687
Variety	Troy	Quartz	Rocca	Wembley	Quartz	Rocca	Troy	Nikita	Rocca
Spring plants/m^2 GS3.7-4.5	47	Not done	40	38	Not done	35	Not done	Not done	Not done
Spring plant height UT cm	71	Not done	110-130	70-85	Not done	100-120	120	83	Not done
Yellow bud spray	13 Apr	Missed	13 Apr	8 Apr	25 Mar	20 Apr	31 Mar	25 Mar	3 Apr
Early-flower spray	20 Apr	Missed	20 Apr	18 Apr	5 Apr	26 Apr	7 Apr	27 Mar	10 Apr
Mid-flower spray	1 May	17 Apr	27 Apr	5 May	*12 Apr	3 May	13 Apr	3 Apr	19 Apr
Late-flower spray	11 May	*7 May	5 May	*12 May	3 May	*9 May	3 May	24 Apr	24 Apr
Weather-based forecast alert(s) during flower	no	2 Apr 24 Apr 2 May 7 May	no	11 Apr 9 May	3 Apr 13 Apr 9 May	10 May	29 Mar	28 Mar nr miss 8 Apr 30 Apr	no
Additional spray dates during flower (up to 4d after late-flower spray) in response to alerts not covered by scheduled spray dates	no	no	no	*13 Apr	no	*13 May	no	*7 Apr	no
Petal inf. yellow bud %	7.5	Not done	0	2.5	28	5	100	0	Not done
Petal inf. early-flower%	45.0	2.5	0	38	65	48	95	30	28
Petal inf. mid-flower %	100.0	12.5	0	70	93	88	100	100	39
Petal inf. late-flower %	100	7.5	0	0	98	30	85	65	0
Average petal inf. %	63.1	8.5	0	27.5	71	42.8	95.0	48.8	22.3
Sclerotinia total % inc. UT	7.3	0	0	30.4	9.8	1.3	34.5	5.4	0.2
Main stem % inc.	4.6	0	0	20.9	7.5	Not done	29.9	2.4	Not done
Lateral branches % inc.	2.7	0	0	9.5	2.3	Not done	4.4	3.0	Not done

***** indicates dates that fungicide treatments were applied in response to a weather-based alert. Some of the 'alert' treatments coincided with those applied at specified crop flowering stages.

4.6. Evaluating the accuracy of risk predictions

Data from the fungicide timing field experiments 2015--2017 in this report was combined with data from similar field experiments in 2010-2012 from a previous AHDB LINK project (Young *et al*, 2014). The fungicide timing experiments provided the data for evaluating the use of key observed risk factors (inoculum and crop stage) and a forecast risk factor (forecast weather conditions conducive to infection) for predicting the likelihood of stem rot symptoms developing post-flower.

In total there were 23 sites contributing data on sclerotinia disease and yield, with different fungicide timing treatments, petal infection and occurrence of forecast weather-based alerts during flowering (Table 4). This is a relatively small data set and therefore the focus was to investigate the differences in weather alerts and petal inoculum levels between sites that had sclerotinia infection (>1%), and those that had very low infection (≤ 1% incidence). For this analysis, disease and yield from an 'alert' spray was for the first alert recorded during flower, or at early-flower if no weather alert occurred.

Sites were categorised according to true and false positive and negatives, as follows:

	Disease present	**Disease absent**
Test positive	TRUE POSITIVES	FALSE POSITIVES
Test negative	FALSE NEGATIVES	TRUE NEGATIVES

It is of practical importance that the number of cases of false negatives is minimised, so that the scheme avoids a situation when the advice is not to treat, but subsequent disease is high. In the current work, minimising the occurrence of false negative situations was achieved by setting a threshold of 10% for the petal test resuls i.e. <10% testing positive indicates a negative and ≥10% indicates a postive petal test result.

When sites were categorised according to weather based alerts only (see right hand column of Table 4), there were no 'false negative' sites ('no alert, sclerotinia >1%), as follows:

WEATHER-BASED ALERT	**Sclerotinia infection >1%**	**Sclerotinia infection UT≤1%**
Alert during flower	12 sites	6 sites
No alert	0 site	5 sites

However, using only weather-alerts as a risk factor, there would have been 6 false-positive sites, i.e. 6 sites treated unnecessarily.

Table 4. Data from field experiment sites 2010-2017 used to evaluate the accuracy and benefits of sclerotinia monitoring and forecasting

Site name	Untreated yield t/ha	Early-flower spray yield t/ha	Early-flower spray yield response t/ha	Alert spray yield t/ha	Alert spray yield response t/ha	Untreated sclerotinia total % incidence	Early- flower spray sclerotinia % incidence	Alert spray sclerotinia % incidence	Petals positive yellow-bud %	Petals positive early-flower %	Petals positive mid-flower %	Petals positive late-flower %	Petals positive average of samples %	Weather alert(s) during flower
LINCS'12	3.34	3.65	0.31	3.65	0.31	0.0	0.0	0.0	*	6.2	12.5	48.8	22.5	1
KENT'12	4.40	4.52	0.12	4.52	0.12	0.0	0.0	0.0	*	33.3	47.9	66.6	49.3	1
LINCS'11	5.60	5.57	-0.03	5.84	0.24	0.0	0.0	0.0	56.3	50.0	22.9	52.1	45.3	1
KENT'11	3.68	3.77	0.09	3.83	0.15	0.0	0.0	0.0	*	93.8	18.8	*	56.3	1
ESSEX'10	4.82	4.74	-0.09	4.93	0.11	0.2	0.0	0.0	29.0	12.5	33.0	43.8	29.6	1
NORF'12	3.74	3.99	0.25	3.96	0.22	0.8	0.1	0.0	0.0	31.3	9.4	53.1	23.4	1
CAMBS'11	2.97	2.85	-0.12	3.15	0.18	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0
YORKS'11	4.63	4.26	-0.37	4.65	0.03	0.0	0.0	0.0	3.2	1.6	2.1	3.3	2.6	0
DEVON'15	4.56	4.56	0.00	4.68	0.12	0.0	0.0	0.0	*	2.5	12.5	7.5	7.5	0
LINCS'15	4.36	4.54	0.18	4.49	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
LINCS'17	2.19	2.58	0.39	2.55	0.37	0.2	0.0	0.1	*	28.0	39.0	0.0	22.3	0
LINCS'16	2.19	2.58	0.39	2.55	0.37	1.3	0.5	0.0	30.0	47.5	87.5	30.0	48.8	1
DEVON'17	4.58	4.74	0.16	4.88	0.30	5.4	2.0	0.0	0.0	30.0	100.0	65.0	48.8	1
YORKS'12	2.97	3.01	0.04	2.93	0.00	6.0	2.3	2.5	*	64.1	72.0	56.3	64.1	1
DEVON'16	3.69	3.95	0.26	4.04	0.35	9.8	4.8	3.5	27.5	65.0	92.5	97.5	70.6	1
HEREF'10	4.68	4.91	0.23	4.62	0.00	10.8	2.1	1.1	54.0	72.0	52.0	79.0	64.3	1
YORKS'10	3.28	3.51	0.23	3.77	0.49	10.9	2.5	0.0	10.2	13.4	13.5	7.2	11.1	1
HEREF'11	4.69	4.97	0.28	4.98	0.29	11.1	6.5	9.8	43.8	39.0	17.0	2.0	25.5	1
Kent'10	5.52	5.30	-0.22	5.30	0.00	29.4	7.1	7.1	71.0	71.0	100.0	100.0	85.5	1
HEREF'16	4.51	4.38	-0.13	4.76	0.25	30.4	23.0	23.0	2.5	37.5	70.0	0.0	27.5	1
HEREF'17	4.29	4.64	0.35	4.64	0.35	34.5	7.5	9.0	100.0	95.0	100.0	85.0	95.0	1
HEREF'12	2.71	3.26	0.56	3.65	0.94	35.8	21.5	2.8	35.9	18.8	4.7	7.8	16.8	1
HEREF'15	5.66	6.15	0.49	5.78	0.12	7.3	2.1	2.1	7.5	45.0	100.0	100.0	63.1	1

Brown = sclerotinia incidence ≥ 1%; yellow = petals ≥ 10% positive; blue = weather-based alert during flowering.

When sites were categorised according to early-flower petal test results (this sample time was selected because early flower petals provided similar results to other sample times, but early results allow time for spray decisions (see Figure 5), there were no false negative sites, as follows:

Petal test alert early sample	**Sclerotinia infection >1%**	**Sclerotinia infection UT≤1%**
> 10% positive	12 sites	6 sites
≤ 10% positive	0 sites	5 sites

There were only 5 sites which had <10% petals testing positive. Using only petal tests as a risk factor, there would have been 6 sites treated unnecessarily. Therefore, weather alerts alone or petal tests alone provided similar results.

When sites were categorised according to a requirement for both factors to occur (early-flower petal test >10% and a weather-based alert), there were no false negative cases:

Weather alert and petals	**Sclerotinia infection >1%**	**Low infection ≤1%**
Weather alert + early-flower petals >10 %	12 sites	5 sites
No alert, or petals ≤10%, or neither	0 sites	6 sites

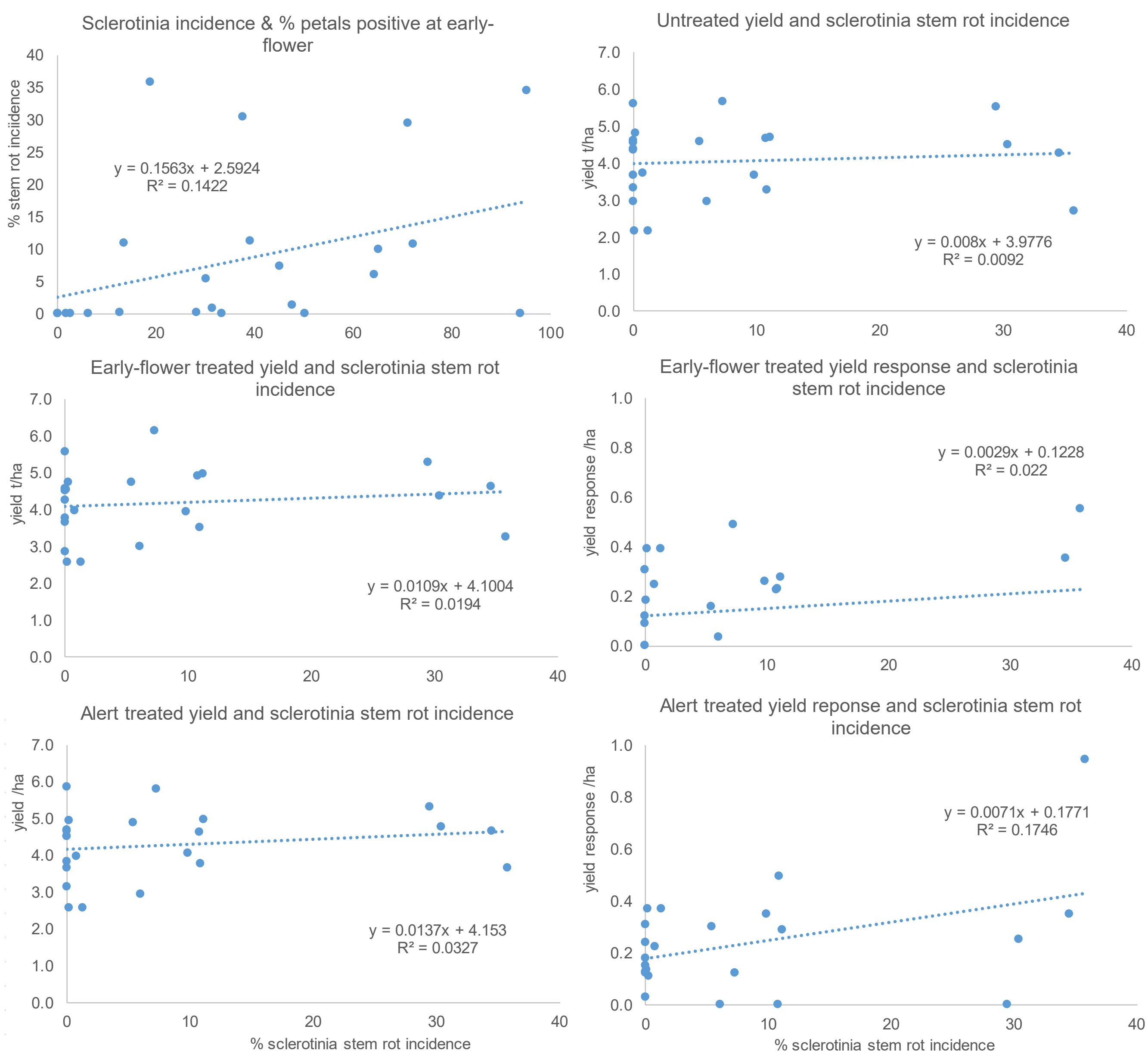
A fungicide treatment advised only if there is a both a weather-alert and petals above threshold would have resulted in the lowest number of false positive sites (5 sites treated unnecessarily).

In practice, the occurrence of a weather alert only, or positive petals only, gave zero false negative cases. This would be the most risk-averse strategy for triggering a decision to apply a fungicide treatment. A strategy based on weather only would be applicable to the majority of crops, as most crops in the near future are unlikely to have data from an in-field inoculum test to help assess infection risk.

The analysis showed that the scheme correctly identified very low risk sites. But where the scheme predicted a site as higher risk, infection did not always occur. All 12 sites with sclerotinia infection above 1% incidence had both a weather based alert and petals >10% positive. But 5 sites with low sclerotinia incidence (<1%) also had a weather alert and petals >10% positive. Lack of weather alerts and low petal test results correctly identified low risk sites. But weather alerts and higher petal test results tended to overestimate the number of sites with sclerotinia infection >1%.

The relationships between sclerotinia incidence and untreated yield and yield response, and ‘alert treated’ yield and yield response were investigated (Figure 18, with petal test charts included for reference). The strongest relationship was between yield response and disease, with an overall increase in yield response with fungicide treatment, whether applied at early-flower or in response to an alert.

Figure 18. Relationships between sclerotinia stem rot incidence and petal test results (agar plate tests), yield, and yield responses, field experiments 2010-2017.



The data set has a relatively high number of zero or low sclerotinia incidence sites, and the regression analysis does not take into account the variation between sites in the timing of inoculum peaks and conducive weather, and whether conditions allowed fungicides to be applied on the target dates.

4.7. Evaluating the benefits of risk monitoring

The data set was relatively small, with a low number of sites with more than 20% sclerotinia incidence in untreated plots. Therefore, analysing the benefits of the forecasting scheme was focused on two key questions: [a] did the scheme provide improved control of sclerotinia? and [b] did fungicides timed according to the scheme result in higher yield responses compared with fungicides applied according to flowering stage?

Use of the forecasting scheme gave comparable control to results from a scheduled early-flower spray. Early-flower fungicide yield responses were selected for comparison with untreated yield responses, because in the absence of any other risk factors, a fungicide treatment close to mid-flower stage is the timing most often advised if sclerotinia has occurred in previous years in the location. In the current study, treatment with fungicides applied either at the timing of an alert during flowering, or at early flower, decreased the average incidence of sclerotinia (compared with untreated) as follows:

Timing of fungicide treatment	% of Crops treated	Average sclerotinia incidence %
Untreated	-	8.4
Early-flower, all (23)	100	3.6
Inoculum alert (18)	78	3.4
Weather alert (18)	78	3.4
Inoculum AND weather alert (17)	74	3.6

Over 50% control was achieved with all strategies. But there was little difference in the average control of sclerotinia achieved using alert timings compared to a scheduled early-flower treatment, and moreover, limited differences between using only petals, only weather, or both risk factors together. However, the main benefit of a strategy using both inoculum and weather is that it would have justified a reduction in the number of sites requiring a fungicide treatment (17 out of 23 sites, 26% reduction).

Treatment with fungicides, either at early flower or applied at the timing of an alert during flowering, gave higher yield responses (compared with untreated) in field trials which had higher sclerotinia infection 'pressure' (as measured by untreated sclerotinia incidence), as follows:

Timing of fungicide treatment (no. sites)	% of Crops treated	Yield response t/ha, UT sclerotinia ≤1%	Yield response t/ha, UT sclerotinia ≥1%
Early-flower, all (23)	100	0.07	0.22
Inoculum alert (18)	78	0.20	0.29
Weather alert (18)	78	0.19	0.30
Inoculum AND weather alert (17)	74	0.17	0.30

Fungicides timed according to an alert produced a higher average yield response than fungicide timed at early flower. Yield responses were higher in both treatment strategies in crops with higher sclerotinia infection pressure. However, it should be noted that Pictor can increase oilseed rape yield by 0.2 t/ha in the absence of visible disease control effects, which may explain some of the yield benefit seen with fungicide treatment in the current project, at sites with ≤ 1% sclerotinia infection.

The analysis indicates that results are similar for a scheme based on inoculum or weather. However, it does not take into account the timing of the inoculum measurements and weather alert dates. The forecast weather alerts provide very specific information on the date, start time and duration of conditions which are conducive to infection. Inoculum measured by petal tests has a less defined time-frame, and a positive result indicates that inoculum is already present. If fungicide treatment timing is based only on inoculum measurements, without the use of weather alerts, it is likely that infection events may occur before fungicides are applied.

4.8. Key messages

- Weather-based infection alert dates help with fungicide timing, based on the criteria of at least 23 consecutive hours of ≥7°C and ≥80%RH.
- Good control of sclerotinia was achieved from fungicides applied before a forecast weather alert.
- Inoculum levels on petals and in the air (from spore traps) help to indicate infection risk.

- The most reliable predictor of low infection risk was inoculum. When inoculum is zero, infection risk is zero. Positive inoculum indicates risk, but variable infection.
- Combining inoculum with weather alerts provides the greatest potential reduction in the number of sites needing a fungicide treatment.
- Infection alerts from a weather-based model and in-field inoculum tests are useful for fungicide timing guidance at a local level.
- Air sampler inoculum data is helpful for regional forecasts, and is helpful in association with site-specific weather alerts to provide fungicide timing guidance.
- The infection alerts are risk averse, with few instances of false negatives. Consequently, the alerts used in the project tended to overestimate the risk of high sclerotinia incidence.
- Oilseed rape growers would be recommended to use fungicide timing guidance based on weather forecasts only

5. Discussion

Overall, the sclerotinia forecasting scheme based on predicted weather alerts and petal tests was successful at identifying very low risk sites where a foliar fungicide treatment for sclerotinia could be safely omitted. However, where sites were predicted to be high risk, they did not always develop high levels of sclerotinia stem rot. The scheme is therefore risk averse, as are most other schemes developed (e.g. Twengstrom at al 1998, Koch et al 2007), but it is more important to make the correct decision not to spray, rather than apply a spray which in hindsight was not necessary. Where schemes have been tested, they usually conclude that risk has been overestimated (e.g. Jensen et al, 2011).

The scheme evaluated in this study used three main data inputs: forecast weather data, petal test results, and crop flower stage. In practice, each of these factors is quantitative, but integrating them to produce a risk assessment and a decision on fungicide treatment requires some judgement by the farmer, agronomist or researcher. Many disease forecasting models use additional factors for sclerotinia, e.g. farm history of disease, rotation length, cultivation practices (Twengstrom at al 1998) but schemes with fewer and simpler inputs are likely to have better uptake by farmers. A conclusion from the current study is that a weather-based only approach could be used to make decisions on sclerotinia fungicides, requiring the user only to assess the flowering stage as susceptible and consult the weather alerts for a nearby location on the AHDB sclerotinia monitoring webpage.

However, adding in petal test data or air sampler results is helpful for confirming a weather-based decision.

The weather feeds provided 48 hour forecast data, which was helpful for planning fungicides ahead of a potential infection date, but in practice a longer forecast would be helpful provided it is accurate. Since the start of this project, there have been changes in weather forecast providers and improvements to the accuracy of forecasts, and 72 hour forecasts have been used in 2019 for sclerotinia risk monitoring, allowing more time for decisions. The accuracy of forecasts can be determined by comparison with observed data for the same location, and air temperature forecasts are more accurate than those for relative humidity, as evaluated by the previous sclerotinia project (Young et al 2014). However, evaluating the relationship between forecast and observed data was not possible in the current work because the weather data feeds provided 6 days a week of continuous forecast data, but observed data had 24 hour gaps. Future work with forecast weather should ideally plan to secure a continuous set of forecast and observed data which can be easily analysed post-season, to assess the occurrence of forecast weather alerts versus actual.

The frequency of weather-based alerts during flowering for each site ranged from zero to three, with a general pattern of alerts occurring more often at south west and southern sites, but less in eastern regions which tend to have drier conditions. The weather-alert monitoring highlights the unpredictability ahead of the flowering phase as to the occurrence and timing of alerts in relation to flowering progress, and the provision of daily alert updates is an important aspect of the scheme. In most cases, humidity was more often a limiting factor than temperature when the weather warmed up during flowering, so the frequency of alerts did not increase during warmer weather towards the end of flowering. The definition of the earliest onset of flowering and the last flowers finishing that defines the phase when weather-based alerts should be acted on does need some further investigation, because in this study some trials had very early (yellow-bud) or very late (post-late flower spray) weather alerts, but sprays applied for these alerts resulted in significant disease control. This suggests that infection occurring at either end of the flowering phase may still cause damage to yield that would justify fungicide treatment.

Sclerotinia inoculum measurements also provided important risk information, but in this project the data updates were weekly for air samplers (albeit providing daily DNA results) and four occasions during flowering for petals, compared with hourly weather data. The relationship between % positive petals and stem rot incidence was variable, as has been demonstrated in other trials (Davies et al

1990, Turkington et al 1991), and high levels of positive petals indicate risk but this is not a guaranteed indicator that infection will occur. However, very low or zero positive petals was a reliable predictor of low or zero stem rot, as has been found in other work (Becka et al 2016).

Daily spore concentrations from air samplers at five sites each year showed that inoculum levels vary a great deal during flowering, and from site to site. In other countries, sclerotinia inoculum may be present during the whole flowering phase (Koch *et al*, 2007) and it is not necessary to monitor it, but this does not appear to be the case in the UK. There were some very large peaks of spore production, often around the dates of weather-based alerts, and often when the % petals positive was high. Weather conditions that lead to weather-based alerts also tend to be associated with environmental conditions that encourage sclerotial germination and spore release, so the co-incidence of spore peaks with some or all of the weather alerts is not surprising. Development of automated air samplers that provide daily results on the day of sampling would be helpful for assessing sclerotinia infection risk, but currently, such samplers are likely to be of regional use. Development of quick and cost-effective PCR tests for petal samples would be a realistic method for farmers to obtain a specific in-field result for sclerotinia inoculum levels. With current methodology, sclerotinia inoculum measurements provide at best an up-to-date measurement of inoculum, so the more frequent the better, while weather alerts provide both up-to-date and forecast information.

Monitoring the germination of sclerotia from year to year provided information on the variability of the onset of germination in relation to flowering, and the rate of new activity week by week. Air samplers often detected spores before germination had started. Sclerotinia infects many other host plants besides susceptible crops, e.g. buttercup (Clarkson et al 2017), which are a potential source of spores produced at earlier dates than oilseed rape flowering. Sclerotial germination can be predicted but current models have an error of +/- one week, which is helpful for regional risk but cannot guide a fungicide timing date.

The accuracy of the forecasting scheme was assessed using fungicide timing field experiment data from the current project and a previous AHDB project, which provided 23 sites in total. The assessment was based on the occurrence of forecast weather alerts and petal test results, and the levels of stem rot incidence that developed in untreated plots. It was not possible to examine actual weather alerts because the observed weather data for each site was incomplete, but previous analysis showed that the forecast weather data slightly overestimated the occurrence of alerts, i.e. it was less likely to miss an alert. The occurrence of forecast alerts during flowering was reviewed for all years and sites included in the analysis, to ensure that the criteria for including only alerts during flowering was the same for all sites. The data set was limited in size, and skewed towards low-infection sites, which limited the scope of analysis. Other studies have had much larger data sets for evaluating accuracy (e.g. Koch et al 2007, 108 sites). However, combining all the site data available from 2010-2017, using forecast weather alerts and petal tests, it was clear that the weather and the petal test data gave similar prediction results. All sites which had more than 1% sclerotinia incidence experienced both a weather alert and high petal test results. Nearly all sites which had less than 3% petals positive had very low sclerotinia incidence. Prediction of very low risk sites was correct, but prediction of high risk sites was not always correct. Therefore, the scheme is very risk averse.

The benefits of the forecasting scheme were best evaluated by examining the effects of treatments on yield response, because there was high variation in yield across sites and years. The average yield responses were similar when using an early flower spray, or a treatment timed according to an alert. Therefore, on average the ‘alert’ spray treatments could not be demonstrated to give improved yields compared with an early flower spray, but they were as effective, and moreover, using the alert system resulted in 26% fewer sites requiring a fungicide treatment. The greater yield response from ‘alert’ sprays is most likely due to better targeting of these sprays, which are timed to provide optimum protection prior to a likely infection event. It is debatable whether the yield response for alert sprays of 0.30 t/ha is significantly higher than the yield response from early flowering sprays (0.22 t/ha), however, relatively small yield benefits provide financial benefits, e.g. a yield benefit of 0.08 t/ha equates to at least £20/ha (estimate based on current prices).

Data from additional sites would be needed to investigate more fully some of the other key variables, such as the effect of timing within flowering of the various factors involved. For example, timing of weather-based alerts, i.e. are those occurring in early flower more important than those in late flower, for infection and determining the timing of fungicide treatments.

In summary, (a) when there were no weather based alerts, or inoculum was zero, infection risk was zero, and (b) the occurrence of weather-based alerts and positive inoculum correctly predicted infection, but the infection levels were variable. Spore trap results helped explain where infection did or did not occur, by showing daily levels of spores in air samples varying during flowering for each site. The current study has shown that there is great variability in the presence of sclerotinia inoculum in the UK, so inclusion of inoculum detection in weather-based infection models is helpful for sclerotinia infection predictions. The scheme correctly predicts the very low risk sites, but is risk averse i.e.

allocates more sites into the high risk category than in hindsight is necessary, but the degree of risk acceptable to growers will need more investigation.

Suggestions for further research and development:

1. Continue the sclerotinia-risk monitoring scheme, which has been well received in 2019 by farmers, and monitor the visits to the AHDB sclerotinia risk webpage. However, evaluation of the accuracy of the scheme should be ongoing every year to help assess and improve the scheme. Field experiments would provide robust data but a low-cost evaluation of accuracy could be achieved by measuring sclerotinia disease in untreated crops. Monitor farmers could be asked to keep a length of tramline unsprayed. Petal tests as well as stem rot incidence assessments could be conducted in this untreated strip to provide valuable inoculum data. In addition, sclerotinia stem rot assessments of untreated plots in a range of commercial field trials could be negotiated as contributions from companies, which would provide data from a larger geographic spread. Unless data on untreated sclerotinia incidence in the UK is collected each year, there will be no way of evaluating the benefits of using risk monitoring schemes.
2. Develop a cost-effective PCR or LAMP test for petals, so that farmers can send samples and get quick results.
3. Develop air sampler test methods to provide daily updates, rather than weekly, on regional sclerotinia spore levels.
4. The weather feeds and charts developed for the sclerotinia forecasting scheme could be made applicable to other field crops such as carrots and lettuce, and potentially to other diseases.
5. A desk study to review previous projects for data on petal tests, sclerotinia infection and yields would strengthen the data set for evaluation of the forecasting scheme, using observed (actual) temperature and %RH across all sites.

Acknowledgements

We thank Bastiaan Brak (AHDB) for helping with forecast weather data inputs and display charts on the AHDB disease monitoring webpage in 2017 and 2018. We also thank all the ADAS field team staff involved in extensive field work on fungicide timing, petal sampling and air-sampler operations.

6. References

Almquist, C. & Wallenhammar A.C. 2014: Monitoring of plant and airborne inoculum of Sclerotinia sclerotiorum in spring oilseed rape using real-time PCR. Plant Pathology online 14 May 2014.

Becka, D., Prokinova, E., Simka, J., Cihlar, P., Beckova, L., Bokor, P. & Vasak, J. 2016: Use of petal test in early-flowering varieties of oilseed rape (Brassica napus L.) for predicting the infection pressure of Sclerotinia sclerotiorum (Lib.) de Bary. Crop Prot. 80:127-131.

Clarkson JP et al., 2007. Forecasting Sclerotinia disease on lettuce: A predictive model for carpogenic germination of S. sclerotiorum sclerotia. Phytopath. 97, 621-631.

Clarkson JP, Warmington RJ, Walley PG, Denton-Giles M, Barbetti MJ, Brodal G, Nordskog B, 2017. Population Structure of *Sclerotinia subarctica* and *Sclerotinia sclerotiorum* in England, Scotland and Norway. Frontiers in Microbiology **8**:article 490.

Davies J M Ll, Gladders P, Young CS, Dyer C, Hiron L, Locke T, Lockley D, Ottway C, Smith JA, Thorpe G, Watling M, 1999. Petal culturing to forecast Sclerotinia stem rot in winter oilseed rape: 1993-1998. Aspects of Applied Biology **55.** Protection and Production of Combinable Break Crops. p129-134.

Derbyshire MC, Denton-Giles, 2016. The control of Sclerotinia stem rot on oilseed rape (Brassica napus): Current practices and future opportunities. *Plant Pathology* **65**:859-877.

Garthwaite D.G., Barker I., L. Ridley, L., A. Mace, A.,G. Parrish, G.,R. MacArthur R.,, Y. Lu, L. 2016: Pesticide usage survey report 271 – Arable crops in the United Kingdom 2016. https://secure.fera.defra.gov.uk/pusstats/surveys/documents/arable2016-v9.pdf.

Gladders P, Ginsburg D, Smith JA. Sclerotinia in oilseed rape: A review of the 2007 epidemic in England. Cambridge: Home-Grown Cereals Authority; 2008.

Gosling P & Ritchie F. 2018. Fungicides for sclerotinia stem rot control in winter oilseed rape. https://cereals.ahdb.org.uk/media/1349054/fungicides-for-sclerotinia-control-in-winter-oilseed-rape-final-update.pdf.

Jensen PH et al., 2011. Forecasting Sclerotinia stem rot in winter rapeseed. Control strategies for pests, diseases and weeds, Kristianstad, Sweden, 30 Nov-Dec2011.

Koch S et al., 2007. A crop loss-related forecasting model for Sclerotinia stem rot in winter oilseed rape. Phytopath. 97, 1186-1194.

Parker M et al., 2014. Regional level disease forecasting of Sclerotinia sclerotiorum. Canadian Journal of Plant Pathology 36, 438-446.

Rogers, S.L., Atkins, S.D. & West, J.S. 2009: Detection and quantification of airborne inoculum of Sclerotinia sclerotiorum using quantitative PCR. Plant Pathology 58: 324–331.

Rothman LA, McLaren NW, 2018. Sclerotinia sclerotiorum disease prediction: a review and potential applications in South Africa. *S. African Journal of Science*, **114**:1-9.

Taylor AE, Coventry E, Handy C, West JS, Young CS, Clarkson JP, 2018. Inoculum potential of *Sclerotinia sclerotiorum* sclerotia depends on isolate and host plant. Plant Pathology **67**:1286-1295.

Turkington, T.K., Morrall, R.A.A. & Gugel, R.K. 1991: Use of petal infestation to forecast Sclerotinia sclerotiorum stem rot of canola: evaluation of early bloom sampling. Canadian Journal of Plant Pathology 13:50–9.

Twengstrom E et al., 1998. Forecasting Sclerotinia stem rot in spring sown oilseed rape. Crop Protection 17, 405-411.

West JS et al., 2009. Detection of airborne plant pathogens; halting epidemics before they start. Outlooks in Pest Management. February 2009, 11-14.

Young 2008. Lettuce HDC FV294

Young CS et al., 2013. Reducing the impact of sclerotinia disease on arable rotations, vegetable crops and land use. Final HGCA report project 3579.

Young, C.S., & Werner C.P. 2012: Infection routes for Sclerotinia sclerotiorum in apetalous and fully petalled winter oilseed rape. Plant Pathology 61:730–738.

Young, C.S., Ginsburg, D., Norman, K. & Waterhouse, S. 2014. Sclerotinia disease control in oilseed rape: disease forecasting, key risk factors and fungicide timing. Aspects of Applied Biology 127, 2014; Crop Production in Southern Britain: Precision Decisions for Profitable Cropping.

Young, CS et al., 2014, Sclerotinia disease control in oilseed rape: disease forecasting, key risk factors and fungicide timing, AAB Conference Paper, November 2014

7. Appendices

7.1. Appendix 1. DNA extraction procedure for air samples

A single scoop of ballotini beads (0.5 g x 400-455µm diameter) was added to each 2 ml screw cap tube containing a spore trap tape daily sub-section (48 x 10 mm), and, in a fume cupboard, 440µl of extraction buffer added using a new pipette tip for each sample (Buffer formula- 2XTEN [500mM NaCl, 400mM Tris-HCl, 50mM EDTA, pH8]; 0.95% SDS; 2% polyvinylpyrrolidone; 5mM 1,10-phenanthroline monohydrate). This was made up into a master mix and then 0.1%β-mercaptoethanol added just before use. Tubes were then placed into a FastPrep machine and processed 3 times at 6.0m/s, 40sec, with 2 minutes cooling on ice between cycles. Using a new tip each time, 400µl 2% SDS (sodium dodecyl sulphate) was added and mixed by inversion and a brief shake. These were incubated at 65°C in a water bath for 30mins. In a fume cupboard, 800µl of the bottom phase of phenol:chloroform (1:1) was added to each tube and vortexed briefly. This was then centrifuged at 13,000rpm for 10mins using a refrigerated centrifuge (4°C). An additional set of pre-autoclaved 1.5ml flip-top Eppendorf tubes was prepared with 30µl of 7.5M ammonium acetate + 480µl of isopropanol (both of which kept at -20°C). In a fume cupboard, the supernatant was pipetted from the original tubes into the new tubes using a new tip each time, leaving the beads and any solid residue in the tube. After gentle mixing, this was stored at -20°C overnight. The following day, the tubes were centrifuged at 13,000rpm for 30mins, again at 4°C, noting the orientation of the tubes in the centrifuge (a pen mark was made uppermost) as the DNA pellet was not always visible. In a fume cupboard, the supernatant was poured off carefully, leaving the DNA pellet which was washed with 200µl of 70% ethanol (kept at -20°C), centrifuge (pen mark uppermost) at 13,000rmp for 15mins. The ethanol was carefully removed using a new pipette tip each time and the DNA pellet left to dry in a sterile flow cabinet (approx 1 hour). The pellet was resuspended in 100µl sterile TE buffer (pH 8). Tubes were placed in a water bath at 65°C for 5mins and then tapped or shaken a little to aid DNA resuspension. DNA suspensions were stored at -20°C. A volume of 2 µL was used in qPCR reactions.

7.2. Appendix 2. DNA extraction procedure for petals

A petal sample (10 petals per tube in 2015, or 5 petals in each of two tubes in 2016 and 2017) was placed into a 1.5 ml screw-cap tube and heated for 5mins at 95ºC. Then 100µl of MicroLYSIS Plus (Microzone) was added and the following cycle run twice with vortex/spin between (Cycle: Step 1: 65ºC for 15mins, Step 2: 96ºC for 2mins, Step 3: 65ºC for 4mins, Step 4: 96ºC for 1mins, Step 5: 65ºC for 1mins, Step 6: 96ºC for 30secs, Step 7: 20ºC hold). To each tube was added 10mg PVPP (Polyvinylpyrrolidone- Sigma Cat No. P-6755) and 100µl of TE buffer (pH 8.0), and tubes were vortexed then spun at 13,000rpm for 15mins. The supernatant was removed to a new 1.5ml Eppendorf tube, 300µL ethanol and 25 µL 7.5M ammonium acetate was added and inverted to mix gently. Tubes were then incubated at -20°C for at least 2 hours to precipitate DNA and then spun at 13,000rpm for 15mins, the supernatant discarded, the pellet was washed with 200 µL 70% ethanol and respun at 13,000 rpm for 5 minutes. The supernatant was discarded and the pellet allowed to air dry in a sterile flow cabinet and then re-suspended in 20 µl of TE buffer (pH 8). A volume of 4 µL was used in qPCR reactions.

7.3. Appendix 3. qPCR Methods

The qPCR assay was performed using 2 or 4µl (respectively for air or petal sample DNA) of sample DNA in a total reaction volume of 20µl. The forward and reverse primers and the Taqman probe used in this qPCR were the same as described in Calderon et al (submitted). The reaction mix contained 10µl of 2 x KAPA probe mastermix ROX (Kapa-Sigma), 2µM Taqman probe, 3.75µM forward primer and 1.25µM reverse primer. The ratio of forward to reverse primer was optimised to account for their variable binding specificities. The amplification conditions consisted of an initial denaturation step at 95ºC for 10mins followed by 40 cycles at 95ºC for 15secs, 56ºC for 45 secs and 72ºC for 45 secs. The samples were tested in duplicate. Six serial log10 dilutions of purified *S. sclerotiorum* DNA ranging from 20ng to 2 x 10^{-4}ng per reaction were used to prepare a standard curve. The quantity of fungal DNA present in each reaction was calculated from the standard curve and then converted to an estimated (based on a regression of DNA quantities against known numbers of ascospores) concentration of ascospores present in the original sample.

.

7.4. Appendix 4. 2015 Herefordshire fungicide timing field trial.

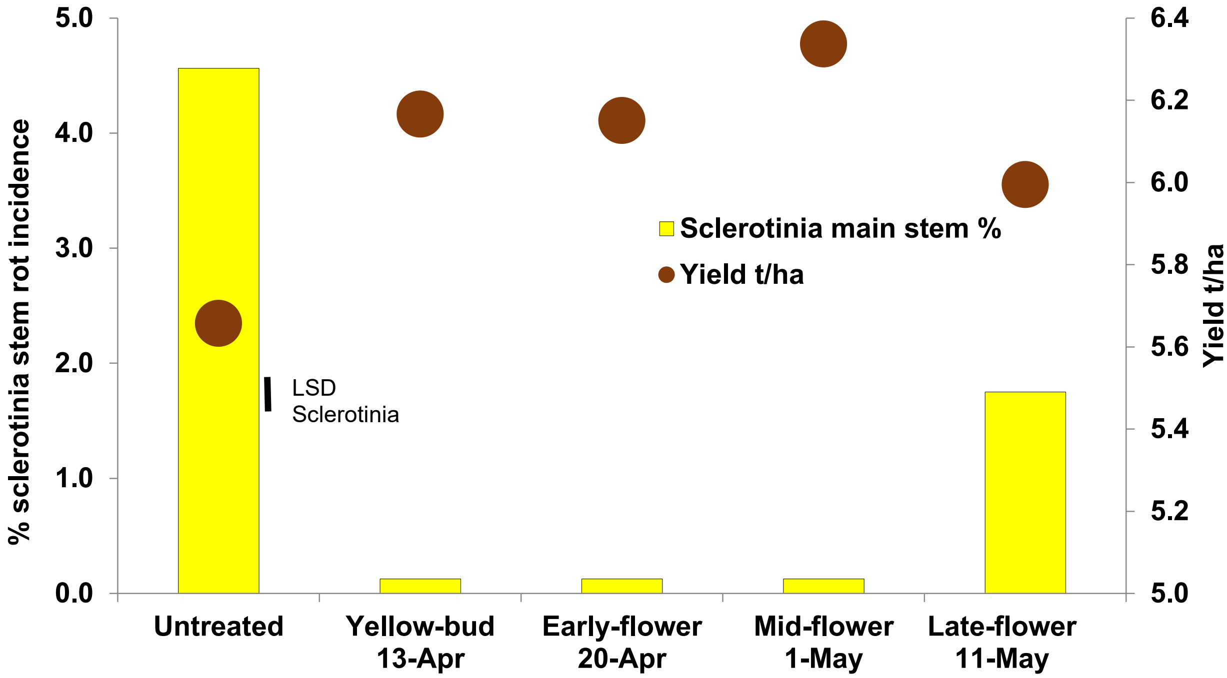


Figure 19. Effect of fungicide application timing on yield and sclerotinia main stem incidence, ADAS Rosemaund, Herefordshire 2015. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There was one weather-based spray alert during late flower. The % petals testing positive on agar at yellow-bud, early-, mid- & late flower were 7.5, 45, 100, 100, respectively.

Table 5. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, ADAS Rosemaund, Herefordshire 2015. (Fungicide product and application dates are the same as in the above figure).

Treatment	**Yield t/ha**	**Yield response t/ha**	**Sclerotinia total %**	**Sclerotinia main stem %**	**Sclerotinia lateral %**
Untreated	5.66		7.25	4.56	2.69
Yellow-bud 13-Apr	6.17	0.51	2.13	0.13	2.00
Early-flower 20-Apr	6.15	0.49	2.13	0.13	2.00
Mid-flower 1-May	6.34	0.68	1.63	0.13	1.50
Late-flower 11-May	6.00	0.34	6.00	1.75	2.50
	F = <0.001		*F = <0.001*	*F = <0.001*	*NS*
	SED 0.328		*SED 0.406*	*SED 0.440*	
	LSD 0.677		*LSD 0.838*	*LSD 0.908*	

7.5. Appendix 5. 2015 Devon fungicide timing field trial.

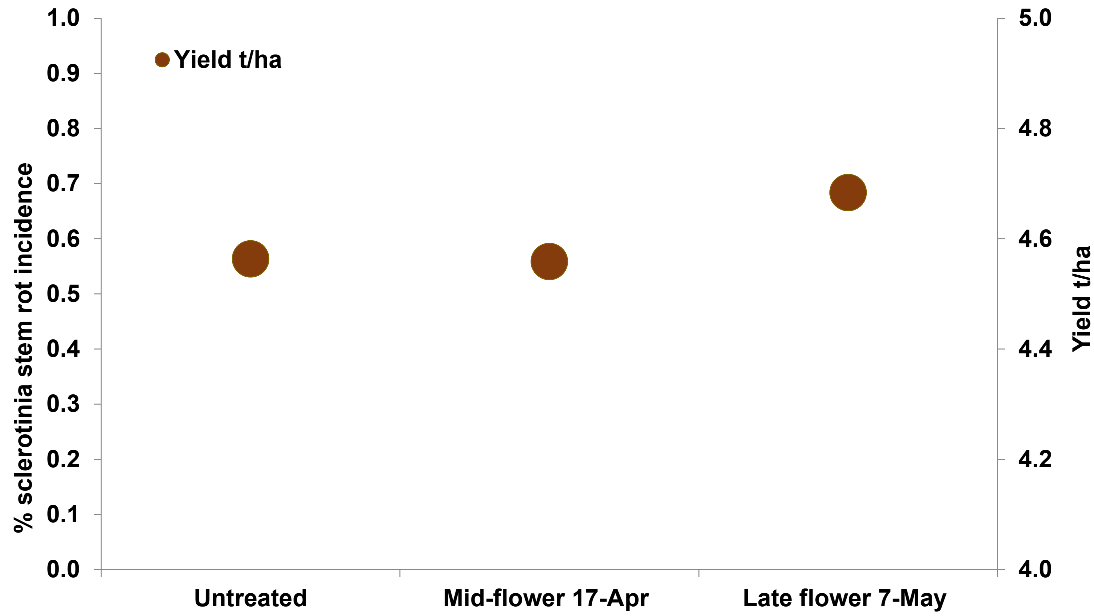


Figure 20. Effect of fungicide application timing on yield and sclerotinia main stem incidence, ADAS Starcross, Devon 2015 (no significant differences for yield between treatments). All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There were weather-based alerts on 2 & 24 April and on 2 & 7 May. The % petals testing positive on agar at early-, mid- & late flower was 2.5, 12.5 & 7.5, respectively.

Table 6. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, ADAS Starcross, Devon 2015. (Fungicide product and application dates are the same as in the above figure). Yellow-bud and early flower sprays missed because project funding had not started.

Trt	**Yield t/ha**	**Yield response**	**Sclerotinia total %**	**Sclerotinia Main stem**	**Sclerotinia lateral %**
Untreated	4.56		0.00	0.00	0.00
Mid-flower 17-Apr	4.56	-0.01	0.00	0.00	0.00
Late flower 7-May	4.68	0.12	0.00	0.00	0.00
	NS				

7.6. Appendix 6. 2015 Lincolnshire fungicide timing field trial.

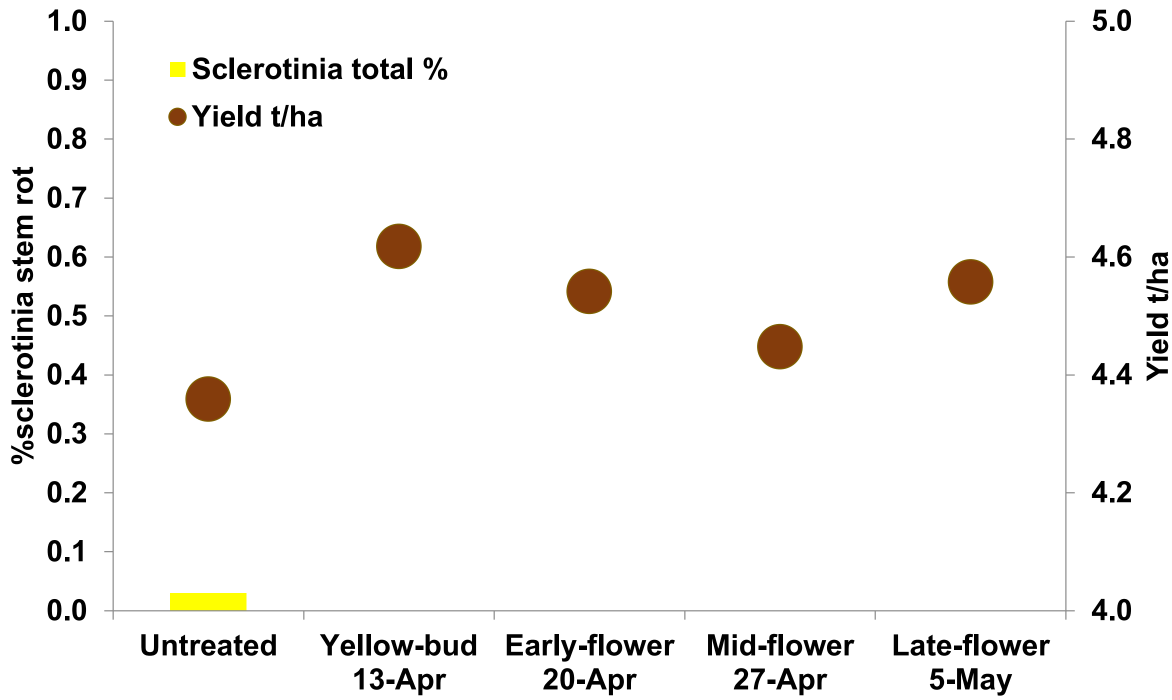


Figure 21. Effect of fungicide application timing on yield and sclerotinia main stem incidence, Velcourt, Pilsgate, Lincolnshire 2015. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There were no weather-based alerts during flowering. The % petals testing positive on agar at yellow-bud, early-, mid- & late flower was 0, 0, 0 & 0, respectively.

Table 7. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, Velcourt, Pilsgate, Lincolnshire 2015. (Fungicide product and application dates are the same as in the above figure).

Treatment	Yield t/ha	Yield response	Sclerotinia total %	Sclerotinia Main stem	Sclerotinia lateral %
Untreated	4.36		0.03	-	-
Yellow-bud 13-Apr	4.62	0.26	0.00	-	-
Early-flower 20-Apr	4.54	0.18	0.00	-	-
Mid-flower 27-Apr	4.45	0.09	0.00	-	-
Late-flower 5-May	4.56	0.20	0.00	-	-
	NS				

7.7. Appendix 7. 2016 Herefordshire fungicide timing field trial.

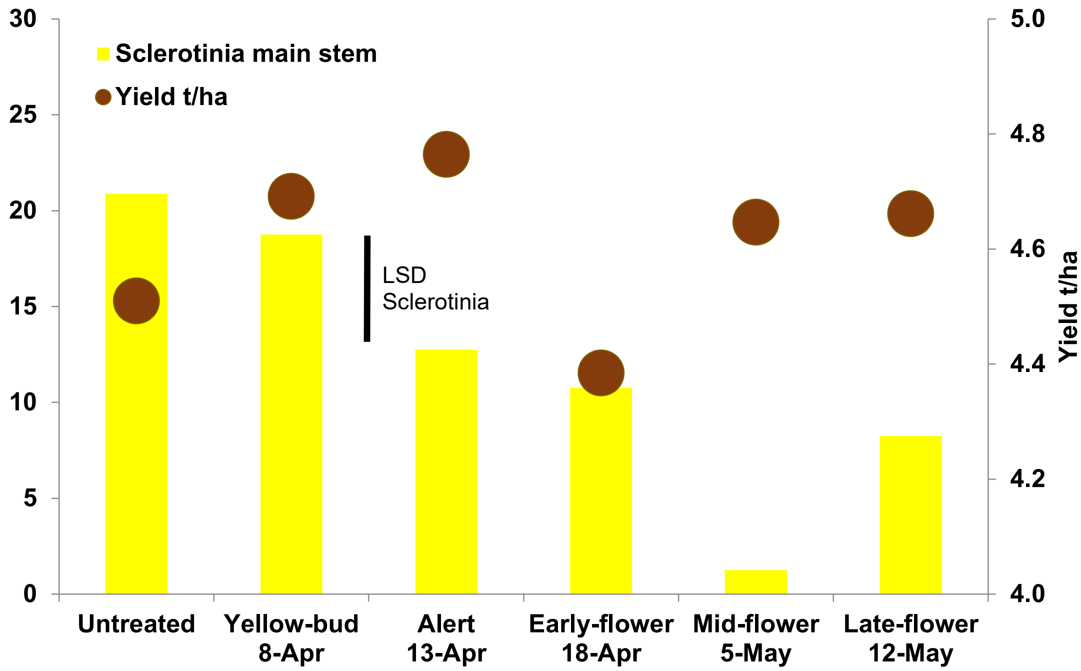


Figure 22. Effect of fungicide application timing on yield and sclerotinia main stem incidence, ADAS Rosemaund, Herefordshire 2016. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There were weather-based alerts on 11 April & 9 May. The % petals testing positive on agar at yellow-bud, early-, mid- & late flower was 2.8, 38, 70 & 0, respectively.

Table 8. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, ADAS Rosemaund, Herefordshire 2016. (Fungicide product and application dates are the same as in the above figure).

Treatment	Yield t/ha	Yield response	Sclerotinia total %	Sclerotinia Main stem	Sclerotinia lateral %
Untreated	4.51		30.38	20.88	9.50
Yellow-bud 8-Apr	4.69	0.18	26.25	18.75	7.50
Alert 13-Apr	4.76	0.25	23.00	12.75	10.25
Early-flower 18-Apr	4.38	-0.13	20.50	10.75	9.75
Mid-flower 5-May	4.65	0.14	5.25	1.25	4.00
Late-flower 12-May	4.66	0.15	11.25	8.25	3.00
	F = 0.036		*F <0.001*	*F <0.001*	*F = 0.025*
	SED 0.11		*SED 4.11*	*SED 2.73*	*SED 2.049*
	LSD 0.23		*LSD 8.49*	*LSD 5.63*	*LSD 4.23*

Comment: The best control was with the mid-flower spray on 5 May prior to a weather-based alert forecast on 9 May, coinciding with high % of mid-flower petal samples testing positive for sclerotinia.

7.8. Appendix 8. 2016 Devon fungicide timing field trial.

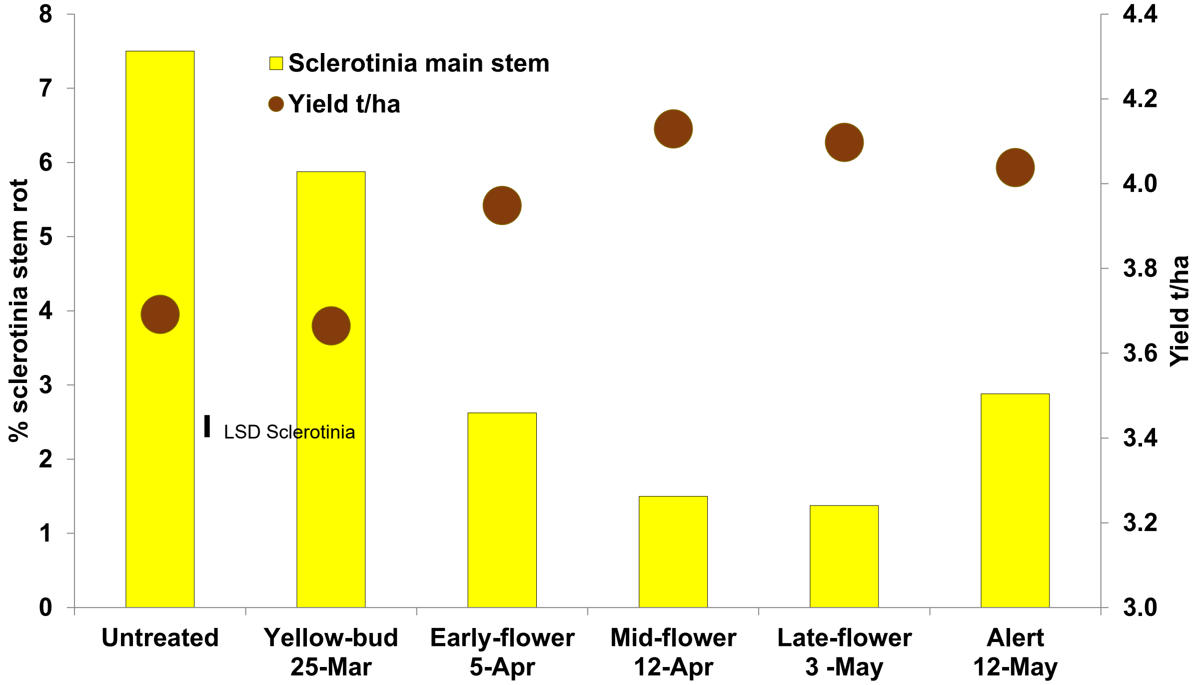


Figure 23. Effect of fungicide application timing on yield and sclerotinia main stem incidence, ADAS Starcross, Devon 2016. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There were weather-based alerts on 3 April, 13 April & 9 May. The % petals testing positive on agar at yellow-bud, early-, mid- & late flower was 28, 65, 93 & 98, respectively.

Table 9. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, ADAS Starcross, Devon 2016. (Fungicide product and application dates are the same as in the above figure).

Treatment	Yield t/ha	Yield response	Sclerotinia total %	Sclerotinia Main %	Sclerotinia lateral %
Untreated	3.69		9.81	7.50	2.31
Yellow-bud 25-Mar	3.66	-0.03	7.88	5.88	2.00
Early-flower 5-Apr	3.95	0.26	4.75	2.63	2.13
Mid-flower 12-Apr	4.13	0.44	2.50	1.50	1.00
Late-flower 3 -May	4.10	0.41	1.63	1.38	0.25
Alert 12-May	4.04	0.35	3.50	2.88	0.63
	F < 0.001		*F < 0.001*	*F < 0.001*	*NS*
	SED 0.10		*SED 1.30*	*SED 1.21*	
	LSD 0.21		*LSD 2.78*	*LSD 2.49*	

7.9. Appendix 9. 2016 Lincolnshire fungicide timing field trial.

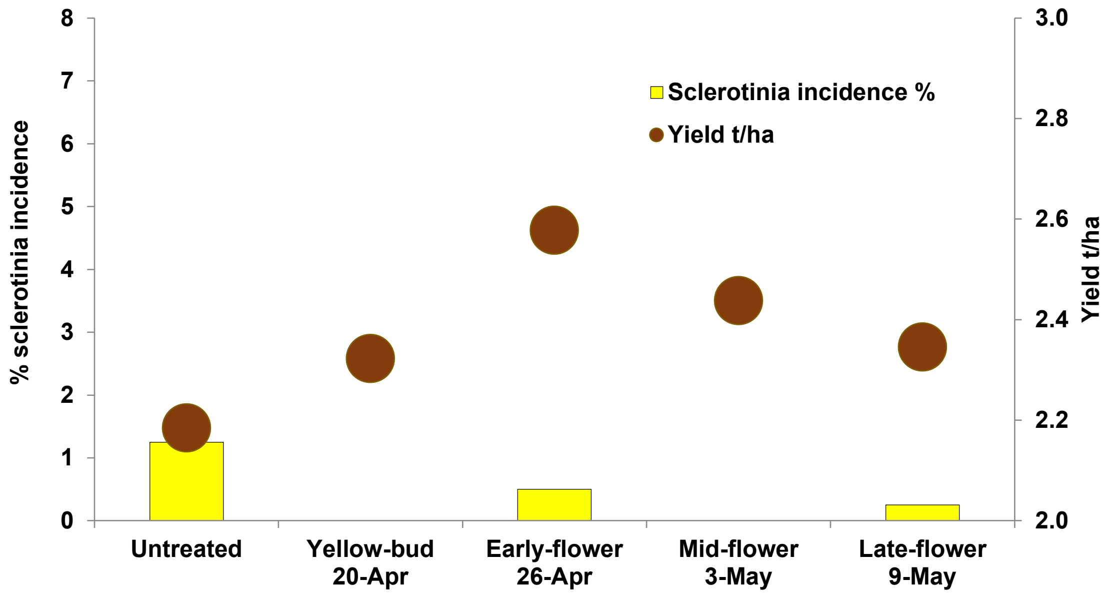


Figure 24. Effect of fungicide application timing on yield and sclerotinia main stem incidence, Velcourt, Pilsgate, Lincolnshire 2016. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There was a weather-based alert on 10 May. The % petals testing positive on agar at yellow-bud, early-, mid- & late flower was 5, 48, 88 & 30, respectively.

Table 10. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, Velcourt, Pilsgate, Lincolnshire 2016. (Fungicide product and application dates are the same as in the above figure).

Treatment	Yield t/ha	Yield response t/ha	Sclerotinia total %	Sclerotinia main %	Sclerotinia Lateral %
Untreated	2.19		1.25	-	-
Yellow-bud 20-Apr	2.32	0.14	0.00	-	-
Early-flower 26-Apr	2.58	0.39	0.50	-	-
Mid-flower 3-May	2.44	0.25	0.00	-	-
Late-flower 9-May	2.35	0.16	0.25	-	--
	NS		*NS*	*-= not done*	

7.10. Appendix 10. 2017 Herefordshire fungicide timing field trial

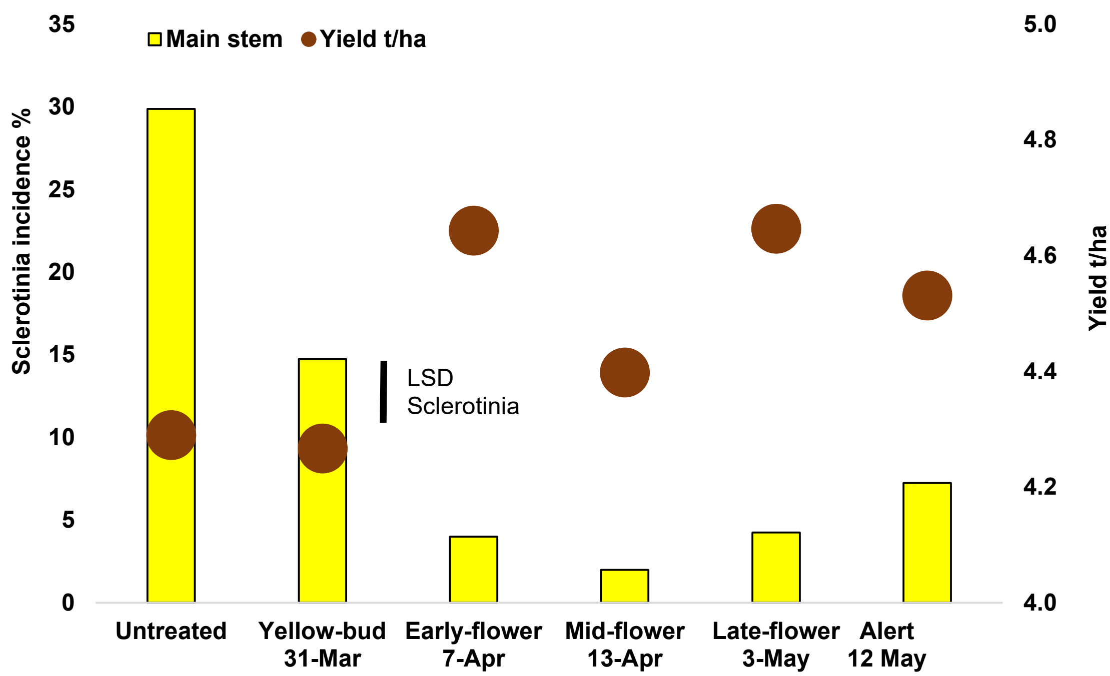


Figure 25.Effect of fungicide application timing on yield and sclerotinia main stem incidence, ADAS Rosemaund, Herefordshire 2017. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There was a weather-based alert on 29 March. Alert 12 May is more than 7 days after late flower spray so is not included in analysis of alerts during flowering. The % petals testing positive on agar at yellow-bud, early-, mid- & late flower was 100, 95, 100 & 85 respectively.

Table 11. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, ADAS Rosemaund, Herefordshire 2017. (Fungicide product and application dates are the same as in the above figure).

Treatment	Yield t/ha	Yield response t/ha	Sclerotinia total %	Sclerotinia main %	Sclerotinia Lateral %
Untreated	4.29		34.50	29.88	4.38
Yellow-bud 31-Mar	4.27	-0.02	21.75	14.75	7.00
Early-flower 7-Apr	4.64	0.35	7.50	4.00	3.50
Mid-flower 13-Apr	4.40	0.11	4.75	2.00	2.75
Late-flower 3-May	4.65	0.36	7.25	4.25	3.00
Alert 12-May	4.53	0.24	9.00	7.25	1.75
	NS		*F<0.001*	*F<0.001*	*NS*
			SED 3.26	*SED 3.26*	
			LSD 6.70	*LSD 6.72*	

7.11. Appendix 11. 2017 Devon fungicide timing field trial

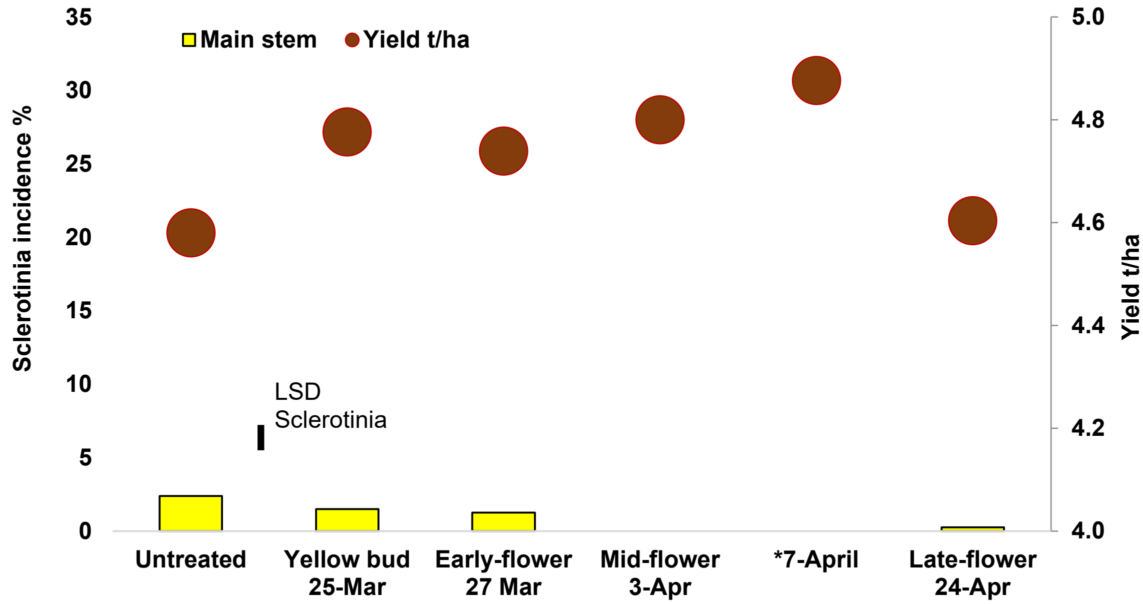


Figure 26.Effect of fungicide application timing on yield and sclerotinia main stem incidence, ADAS Starcross, Devon 2017. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There were weather-based alerts on 28 March (near miss, 22-23 hours) 8 April, 30 April. The % petals testing positive on agar at yellow-bud, early-, mid- & late flower was 0, 30, 10 & 65, respectively.

Table 12. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, ADAS Starcross, Devon 2017. (Fungicide product and application dates are the same as in the above figure).

Treatment	Yield t/ha	Yield response t/ha	Sclerotinia total %	Sclerotinia main %	Sclerotinia Lateral %
Untreated	4.58		5.38	2.38	3.00
Yellow bud 25-Mar	4.78	0.18	2.50	1.50	1.00
Early-flower 27 Mar	4.74	0.14	2.00	1.25	0.75
Mid-flower 3-Apr	4.80	0.20	0.00	0.00	0.00
Alert spray 7-April	4.88	0.28	0.00	0.00	0.00
Late-flower 24-Apr	4.60	0.00	0.25	0.25	0.00
	NS		*F<0.001*	*F= 0.008*	*F= 0.014*
			SED 0.998	*SED 0.943*	*SED 0.816*
			LSD 2.06	*LSD 1.947*	*LSD 1.684*

7.12. Appendix 12. 2017 Lincolnshire fungicide timing field trial

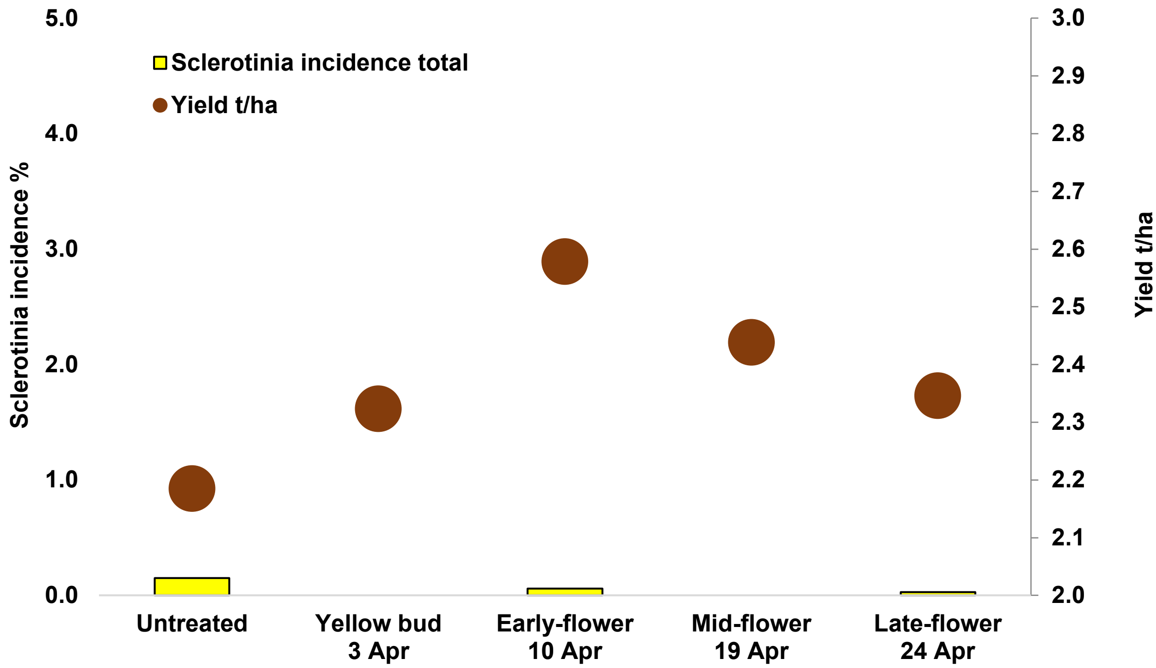


Figure 27. Effect of fungicide application timing on yield and sclerotinia main stem incidence, Velcourt, Pilsgate, Lincolnshire 2017. All applications were single treatment with Pictor, 0.5 L/ha (BASF: boscalid + dimoxystrobin). There were no weather-based alerts. The % petals testing positive on agar at early-, mid- & late flower was 28, 39, & 0, respectively.

Table 13. Effect of fungicide application timing on yield and sclerotinia incidence on main stems and lateral branches, Velcourt, Pilsgate, Lincolnshire 2017. (Fungicide product and application dates are the same as in the above figure).

Treatment		Yield t/ha	Yield response t/ha	Sclerotinia total %	Sclerotinia main %	Sclerotinia Lateral %
Untreated		2.19		0.15	-	-
Yellow bud	3 Apr	2.32	0.14	0.00	-	-
Early-flower	10 Apr	2.58	0.39	0.06	-	-
Mid-flower	19 Apr	2.44	0.25	0.00	-	-
Late-flower	24 Apr	2.35	0.16	0.03	-	-
		NS		*NS*		

7.13. Appendix 13. 2015 Example text report.

Example of weekly text update on AHDB website for sclerotinia risk, 14 May 2015.

Overview of sclerotinia infection risk

- Many crops from the south up to Lincolnshire are now at late flower, but some still have strongly flowering side racemes. Late infection is usually less damaging to yield than early-flower infection.
- Some crops may have flowering prolonged with cool temperatures. If these crops received an early spray, a second spray may be justified now because fungicides give a three week window of protection.
- Petals from northern sites are now testing positive. If not already treated, fungicide plans should be made, particularly if crops are at mid-flower.
- At many sites, particularly east and north east, nights are still cold. When night temperatures turn consistently warm for each site (above 7°C), infection forecast alerts are likely.
- Monitor crop flowering stage, and check infection risk (see the assessment routes described).

If there are reports of germinated sclerotia or positive petal tests in your area, then protectant fungicide treatment is advised on flowering crops which are untreated, or treated three or more weeks earlier.

Crop growth stages range from pods setting in the south west, to mid-flowering in the north. Petals which adhere to leaves are the main route for infection, so the onset of flowering is the start of the risk phase, when airborne spores are carried onto petals.

Sclerotinia inoculum levels were lower this week, but were noted at more northern sites, e.g. 20% petals tested positive at the Malton, S.Yorks site. So infection is possible if the weather turns warmer.

Soil temperatures continue to warm up and recent rain in some areas has encouraged new sclerotial germination in the last week. Rain showers will depress the number of airborne spores.

Air temperatures are still cool at night, and only the Devon and Yorkshire sites had infection alerts last week. Infection 'alerts' are reported on the map here. These are e-mailed to sites participating in the HGCA sclerotinia risk monitoring project, each Monday, Wednesday, Friday during flowering, and are based on 48hr forecast temperature and %RH.

The weather outlook at the end of this week (weekend 16-17 May) and into next week is for rain and sun, with heavier showers in the north. Looking at forecast temperatures for the sclerotinia monitoring locations, most sites are likely to be too cool for infection, as this needs at least 23 hr continuous temperatures $\geq$ 7°C and %RH $\geq$ 80%. In in practice this requires all night time temperatures to be above 7°C.

7.14. Appendix 14. 2015 Example data report

Example of weekly data update sent to AHDB for updating the risk map, 14 May 2015

	Site		**Region**	**Crop GS**		**Latest inoculum result (tbc = sample taken, result**	**Latest result, petals testing positive &**		**Infection alerts occurred this week**	**Overview for each site**	**Overall risk this week**
1	Starcross		Devon	5.1	10% pods developing	***positive***	*5 % at 4.7*		**YES**	Soil moist, lots of petal stick, but very late flower and low inoculum levels, therefore risk is now low at this site	**Low**
2	Ripple Farm		Kent	5.0	Late-flower	***positive***	*17.5% at 4.9*		No	Soil moist, petal stick, moderate inoculum detected on petals at late flower, therefore risk is now moderate	**Moderate**
3	Cardiff		S. Wales	5.0	Late-flower	***Positive***	*3/8 at 4.8*		No	Soil moist, petal stick, inoculum detected on petals, but late flower, therefore risk moderate (estimated GS)	**Moderate**
4	Rosemaund		Herefords	5.0	Late-flower	***Positive***	*27.5% at 4.5*		No	Very high inoculum levels on petals and in spore trap samples. Still many flowers on side racemes and lots of petal stick. High risk.	**High**
5	Fawley		Herefords	5.0	Late-flower	***Positive***	*2/5 at 4.5*		No	Some Inoculum on petals; nearby fields at high levels. High petal stick; high risk of infection if night temperatures go above 7ºC	**Moderate**
6	Rothamsted		Herts	4.7	Mid-flower	***Positive***	*1/4 at 4.5*		No	Crop at mid-flower, unusually high levels of spores detected 8-11 May. Crop mid-flower, risk if temperatures warmer.	**High**
7	Boxworth		Cambs	4.7	Mid-flower	***Positive***	*4% at 4.1*		No	Soil moist. Low inoculum detected on petals. Crop still at mid-flower, so at risk if night temperatures go above 7ºC on one or more days.	**Moderate**
8	Fordham		Essex	4.5	Mid-flower	*negative*	*0 at 4.4*		No	Soil moist, crop at mid-flower. No inoculum detected, and temperatures cool, therefore low risk	**Low**
9	Terrington		Norfolk	5.1	10% pods developing	***Positive***	*24% at 4.1*		No	Inoculum detected on petals, recent rain. This week was the first week with no ground frosts. Infection if temperatures go above 7ºC	**Moderate**
10	Stamford		Lincs	5.5	50% pods developing	*negative*	*0 at 4.8*		No	Soil and canopy both dry, but quite a lot of petal stick. No inoculum detected on petals, but spore trap positive. Very Late flower, risk	**Low**
11	Newport		Shropshire	5.1	10% pods developing	*negative*	*0 at 4.8*		No	No inoculum detected on petals, late flower and cool temperatures, therefore risk now low	**Low**
12	Driffield		E. Yorks	4.5	Mid-flower	*negative*	*0 at 4.5*		No	Crop at mid-flower, but cool temperatures and no inoculum detected at this site, therefore infection risk low	**Low**
13	Old Malton		S. Yorks	4.8	Late-flower	***Positive***	*20% at 4.1*		**YES**	Soils moist. Petal tests positive, crop still has flowers to open, therefore risk of infection if temperatures warm up.	**Moderate**
14	Berwick		Borders	4.5	Mid-flower	***Positive***	*3/4 at 4.1*		No	Soil moist, some petal stick on lower leaves. Inoculum detected on petals, risk of infection if temperatures go above 7ºC at night.	**Moderate**
15	Boghall		Edinburgh	4.4	Mid-flower	*tbc*	*tbc*		YES	Soil moist, crop mid-flower. Temperature and humidity have been warm enough to promote infection on a few days last week, so risk is moderate	**Moderate**

7.15. Appendix 15. 2015 Example alert e-mail

2015 example of weather-based alert results e-mailed to individual sites, generated 14 May (note, week starting 23 April) (weather data source: MetOffice), updated three times per week.

Week beginning		11/05/2015		
Report generated	site	date	time (24hr clock)	duration (hrs)
Friday	Boxworth	There are no events forecast today		
Friday	Terrington	There are no events forecast today		
Friday	Old Malton	There are no events forecast today		
Friday	Hereford	There are no events forecast today		
Friday	Starcross	There are no events forecast today		
Friday	Ripple Farm	There are no events forecast today		
Friday	Boghall	There are no events forecast today		
Friday	Stamford	There are no events forecast today		
Friday	Rothamsted	There are no events forecast today		
Friday	Essex	There are no events forecast today		
Friday	Newport	There are no events forecast today		
Friday	Berwick	There are no events forecast today		
Friday	Driffield	There are no events forecast today		
Friday	Fawley	There are no events forecast today		
Friday	Cardiff	There are no events forecast today		

7.16. Appendix 16. 2016 Example text report.

Example of weekly text update on AHDB website for sclerotinia risk, 3 May 2016.

Overview of sclerotinia infection risk

- Infection risk will increase this week with warmer temperatures forecast across the UK.
- Sclerotinia inoculum is present at moderate to high levels at sites in the S, SE, SW and some midlands areas, so infection risk will be higher at these sites in warm weather.
- In contrast to last week, weather-based infection alerts are likely to occur this week with the forecast increase in temperatures. When night temperatures turn consistently warmer, this will trigger alerts for weather conditions which promote infection. At the same time, airborne spore levels are likely to increase. Many crops are still likely to be in flower when this happens.
- Spore trap results for airborne spores again indicated high inoculum last week at the Devon site. Petal tests also indicated high levels in Devon, Kent and Hertfordshire, low levels in Cambridgeshire and Hampshire sites, and elsewhere moderate. The Borders and Scottish site first results will be available soon
- Monitor crop flowering stage and check infection risk, using the AHDB website map to see a summary of the conditions at each example monitoring site.

Crop growth stages range from late-flower to start of pods in some southern crops to early flower in the north. Infected petals which adhere to leaves are the main route for infection, so the onset of flowering is the start of the risk phase, when airborne sclerotinia spores land on petals.

The weather outlook over the week is for westerly winds at first which will bring warmer temperatures in general and a likelihood of rain particularly in western areas. More southerly winds are predicted by Friday, and the warm air from the continent will increase temperatures to mid-teens and possibly 20ºC in the south, and thundery showers are possible. Local conditions need to be monitored. Infection needs at least 23 hours continuous temperatures $\geq$ 7ºC and %RH $\geq$ 80%. In practice this can happen once the night time temperatures are all above 7ºC.

Sclerotinia inoculum is at high levels at some of the S and SE sites. Spore trap results for airborne spores indicated that inoculum was high last week at the Devon site, and moderate at the Lincolnshire site. Other sites were low. Recent petal tests showed high inoculum levels in Devon, Kent and Hertfordshire, moderate in S, SE and Mid Wales, Hampshire and Lincolnshire, and elsewhere low.

Soil temperatures continue to rise and sclerotial germination has now been recorded at all sites from Devon to Scotland, including Kent this week. Soils have remained generally moist.

Air temperatures have not been consistently warm enough so far for a weather-based infection model to trigger predictions of infection alerts, but are now forecast to increase this week. **Infection alerts** are e-mailed to sites participating in the AHDB sclerotinia risk monitoring project, sent each Monday, Wednesday and Friday during flowering, and are based on 48hr forecast temperature and %RH.

7.17. Appendix 17. 2016 Example data report.

Example of weekly data update sent to AHDB for updating the risk map, xx May 2016.

	Site	Region	Crop GS		Petals testing positive latest result	Spore trap	Most recent weather-based Infection alert	Infection alerts predicted next 48 hours	Overview for each site	Overall risk this week
1	Starcross	Devon	4.9	late-flower	85	high	No	No	No alerts now but they may occur later in the week with forecast warm weather. Also, inoculum is high, so risk for	High
2	Ripple Farm	Kent	4.9	Late-flower	68	-	No	**Yes**	Inoculum and temperatures have increased, so high risk of infection, although yield loss is reduced if infection is at late	High
3	Alresford	Hampshire	4.3	Early-flower	0	-	No	No	Forecast warm weather this week may trigger weather-based alerts. But currently, inoculum is low, therefore low	Low
4	Cardiff	S. Wales	4.4	Mid-flower	25	-	No	No	Forecast warm weather this week may trigger weather-based alerts. Currently, inoculum is moderate, therefore	Moderate
5	Rosemaund	Herefords	4.6	Mid-flower	35	-	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is moderate, therefore moderate risk.	Moderate
6	Fawley	Herefords	4.3	Early-flower	20	-	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is moderate, therefore moderate risk.	Moderate
7	Rothamsted	Herts	4.7	Late-flower	100	low	No	No	Forecast warm weather may trigger weather-based alerts. Currently, sclerotinia per petal is positive but low, so	Moderate
8	Boxworth	Cambs	4.5	Mid-flower	5	-	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is low, therefore low risk.	Low
9	Huntingdon	Cambs	4.3	Early-flower	-	-	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is low, therefore low risk.	Low
10	Terrington	Norfolk	5.1	10% pods	20	-	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum moderate and crop is at late flower, so	Moderate
11	Stamford	Lincs	4.4	Mid-flower	50	Mode-rate	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is moderate, therefore moderate risk.	Moderate
12	Driffield	E. Yorks	4.5	Mid-flower	50	-	No	No	Forecast warm weather later this week may trigger weather-based alerts. Currently, inoculum is low, therefore	Moderate
13	Old Malton	S. Yorks	4.3	Early-flower	2.5	low	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is low, therefore low risk.	Low
14	Berwick	Borders	4.2	Early-flower	-	-	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is low, therefore low risk.	Low
15	Boghall	Edinburgh	4.5	Mid-flower	-	-	No	No	Forecast warm weather may trigger weather-based alerts. Currently, inoculum is low,	Low

7.18. Appendix 18. 2016 Example alert e-mail.

2016 example of weather-based alert results e-mailed to individual sites, generated 3 May (note, week starting 2 May) (weather data source: MetOffice), updated three times per week.

All sites

Week beginning 02/05/2016

		expected infection condition period		
Report generated	site	date	time (24hr clock)	duration (hrs)
Tuesday	Boxworth	There are no events forecast toda		
Tuesday	Terrington	There are no events forecast toda		
Tuesday	High Mowthorpe	There are no events forecast toda		
Tuesday	Rosemaund	There are no events forecast toda		
Tuesday	Devon	There are no events forecast toda		
Tuesday	Ripple Farm	01-May	0.875:00	27
Tuesday	Boghall	There are no events forecast toda		
Tuesday	S. Lincs- velcourt	There are no events forecast toda		
Tuesday	Rothamsted	There are no events forecast toda		
Tuesday	Hampshire	There are no events forecast today		
Tuesday	Huntingdon	There are no events forecast today		
Tuesday	Berwick	There are no events forecast today		
Tuesday	Driffield	There are no events forecast today		
Tuesday	Fawley	There are no events forecast today		
Tuesday	Cardiff	There are no events forecast today		

7.19. Appendix 19. 2017 Example text report.

Example of weekly text update on AHDB website for sclerotinia risk, xx May 2017.

2017 example of text update on AHDB website for sclerotinia risk, 5 April, updated weekly.

Overview of sclerotinia infection risk

- Crops vary in flowering stage within regions, but many are now at early flower or later, therefore in the possible risk phase. Positive inoculum test results at several sites this week mean that sites may move quickly to high risk if local temperatures warm up again.
- This past week was cooler, but forecast weather this week up to 9 April will likely have milder, warmer days. However, predicted clear skies mean that nights may too cool for infection, but local conditions should be monitored.
- Once night temperatures turn consistently warm (at least 7°C) at a site, this will trigger alerts for forecasts of infection conditions. Protectant fungicide treatment should be planned.
- If there is inoculum detected in addition to weather-based alerts in your area, infection risk will be confirmed as high in flowering crops. So keep an eye on the infection alerts and inoculum test results (Inoculum = positive petal tests and/or positive spore trap results and/or germinated sclerotia).
- Monitor crop flowering stage, and check infection risk, using the website routes described.

Crop growth stages range from mid-flower in the SW to stem extension or yellow bud in the north. Petals which adhere to leaves are the main route for infection, so the onset of flowering is the start of the risk phase.

The weather outlook is for settled conditions for the rest of this week for most of the UK, with mild or warm daytime temperatures. But clear skies at night and lighter winds will mean a risk of frost. Next week from Monday 10 April is predicted to be colder, with rain in the north but not in the SE where it may be needed.

Infection alerts are e-mailed to sites in the AHDB sclerotinia risk monitoring project, sent each Monday, Wednesday and Friday during flowering, and are based on 48hr forecast temperature and %RH. Infection needs at least 23 hours continuous temperatures $\geq$ 7°C and %RH $\geq$ 80%. In practice this happens when night time temperatures become $\geq$ 7°C, usually occurring more frequently by late flower.

Sclerotinia inoculum Spore trap results for airborne spores indicated low levels of spores in Devon and Herefordshire, Hertfordshire and Lincolnshire over the last week. Spore trap tests will begin soon for the Yorkshire site. Petal tests are now under way and more results will be available soon.

Soil temperatures are warm and moist enough for sclerotial germination, which continues at many sites and is generally closer to flowering onset than in some recent years. If soils dry out, sclerotial germination will be slowed down or stopped, delaying spore release.

7.20. Appendix 20. 2017 Example data report.

2017 example of data sent to AHDB for updating the map and text-behind-dots on the map, 3 April, updated weekly.

	Site	Region	Crop GS		Petals testing positive latest result %	Spore trap	Infection alerts occurred this week?	Infection alerts predicted next 48 hours	Overview for each site	Overall risk this week	Germination
1	Starcross	Devon	4.5	Mid flower	65%	Mod	No	No	Mod risk because weather is cooler and no alerts. But crop is in flower, sclerotia germinated, spore	Mod	48
2	Ripple Farm	Kent	4.4	Mid flower	No test result yet	*	Yes	No	High risk because weather alert this week, crop in flower, sclerotia germinated. Cooler weather will	High	7
3	Alresford	Hampshire	4.1	Early flower	25%	*	No	No	Mod risk because weather is cooler and no alerts. But crop is in flower, and petals positive	Mod	*
4	Cardiff	S. Wales	4.1	Early flower	No test result yet	*	No	No	Estimated Mod risk because this site has similar results to Hereford site, but no petal test results to	Mod	*
5	Rosemaund	Herefords	3.9	Yellow bud	No test result yet	low		No	Mod risk because weather is cooler and no alerts. But nearly flowering, sclerotia germinated, spore	Mod	11
6	Fawley	Herefords	3.7	Yellow bud	No test result yet	*	No	No	Low risk because weather is cooler and no alerts. But crop is close to flower so needs monitoring; risk	Low	*
7	Rothamsted	Herts	4.2	Early flower	No test result yet	low	Yes	No	Risk is high with crop flowering, and weather alert this week. and spores detected in trap (although	High	*
8	Boxworth	Cambs	4.1	Early flower	No test result yet	*	No	No	Low risk because weather is cooler and no alerts, no inoculum. But crop is in flower so needs	Low	0
9	Huntingdon	Cambs	4.1	Early flower	No test result yet	*	No	No	Low risk because weather is cooler and no alerts, no inoculum. But crop is in flower so needs	Low	*
10	Terrington	Norfolk	3.7	Green bud	No test result yet	*	No	No	Low risk because weather is cooler and no alerts, no inoculum. But crop is in flower so needs	Low	5
11	Stamford	Lincs	3.7-4.1	YB to early flower	No test result yet	low	No	No	Mod risk because weather is cooler and no alerts. But crop is in flower, and spore trap positive	Mod	*
12	Driffield	E. Yorks	3.7	Yellow bud	No test result yet	*	No	No	Low risk because weather is cooler and no alerts, no inoculum. But crop is in flower so needs	Low	*
13	High Mowthorpe	S. Yorks	3.6	Green bud	No test result yet	Test soon	No	No	Low risk because weather is cooler and no alerts, no inoculum, and not flowering yet.	Low	0
14	Berwick	Borders	4.0	Yellow bud	No test result yet	*	No	No	Low risk because weather is cooler and no alerts. But crop nearly in flower so risk needs monitoring.	Low	*
15	Boghall	Edinburgh	3.6	Near YB	No test	*	No	No	Risk is low with crop not in flower, but sclerotia have germinated. Monitor crop stage and weather.	Low	21

7.21. Appendix 21. 2017 Example alert e-mail.

2017 example of weather-based alert results e-mailed to individual sites, generated 5 April (note, week starting 23 April) (weather data source: MetOffice), updated three times per week.

All sites					
Week beginning		03/04/2017			
		expected infection condition period			
Report generated	**site**	**comment**	**date**	**time (24 hr clock)**	**number hours**
Monday	Terrington	There are no events forecast today			
Monday	Boxworth	There are no events forecast today			
Monday	Old Malton	There are no events forecast today			
Monday	Hereford	There are no events forecast today			
Monday	Starcross	There are no events forecast today			
Monday	Ripple Farm	Sclerotinia infection event	04-Apr	08:00	36
Monday	Boghall	There are no events forecast today			
Monday	Stamford	There are no events forecast today			
Monday	Rothamsted	Sclerotinia infection event	03-Apr	21:00	23
Monday	Essex	There are no events forecast today			
Monday	Newport	There are no events forecast today			
Monday	Berwick	There are no events forecast today			
Monday	Driffield	There are no events forecast today			
Monday	Fawley	There are no events forecast today			
Monday	Cardiff	There are no events forecast today			

7.22. Appendix 22. 2018 Example text report.

Example of weekly data update sent to AHDB for updating the risk map, 27 April 2018.

- In southern regions, the 48 hr forecast as of today is showing humidity ≥ 80% and temperatures ≥ 7ºC for long enough to trigger weather based alerts today and over the weekend. For midlands and northern sites, the cooler temperatures are holding back the alerts whereas the humidity is generally higher for longer periods this week, which is in contrast to last week's drier warmer weather.
- Click on a site on the map below to have a look at temperature and humidity changes from the start of the previous 48 hrs to the end of the forecast 48 hrs.
- Forecast weather over the weekend is for cloud and some rain many areas, possibly drier on Sunday. Where soils are moist, temperatures will encourage sclerotial germination, and if there are dry spells during the day this is likely to result in spore release. The air-borne spores will land on oilseed rape petals, ready to infect after petal fall if weather conditions are conducive.
- Crop progress is variable. Forward crops in the SW are at late flower on the main raceme, with some petal fall and adherence to leaves. Kent monitor crops are at mid-flower but the Herefordshire crop is at yellow-bud but with nearby fields further on. Our Yorkshire and Norfolk sites are still at yellow bud and the Cambridge site is now just into earl-flower.
- Crops should be monitored for flowering progress. Note any petal fall, which is the start of the key infection phase. Protectant fungicides for sites at risk will need to be applied before any significant petal fall.
- View the report archive.

7.23. Appendix 23. 2018 Example alert e-mail.

Example of weather-based alert results e-mailed to individual sites, generated 27 April (note, week starting 23 April 2018) (weather data source: MetOffice), updated three times per week.

All sites

Week beginning 23/04/2018

		expected infection condition period				
Report generated	**site**	**comment**	**date**	**time (24 hr clock)**	**number hours**	**Postcode**
Friday	Exeter	Sclerotinia infection event	26-Apr	22:00	29	EX5 2EH
Friday	St Athan	Sclerotinia infection event	27-Apr	10:00	25	CF62 4DN
Friday	Rosemaund	There are no events forecast today				HR1 3SR
Friday	Standon	Sclerotinia infection event	27-Apr	08:00	41	SO21 2JH
Friday	Manston	Sclerotinia infection event	27-Apr	17:00	40	CT12 5DT
Friday	Rothamsted	There are no events forecast today				AL5 2JH
Friday	Histon	There are no events forecast today				CB24 9JS
Friday	Wattisham	Sclerotinia infection event	27-Apr	07:00	41	IP7 7RS
Friday	Holbeach	There are no events forecast today				PE12 9NJ
Friday	Shawbury	There are no events forecast today				SY4 4PA
Friday	Watnall	There are no events forecast today				NG6 1HU
Friday	Wittering	There are no events forecast today				PE8 6DX
Friday	High Mowthorpe	There are no events forecast today				YO17 8BW
Friday	Charterhall	There are no events forecast today				TD11 3RE
Friday	Edinburgh	There are no events forecast today				EH12 9DB