

Reducing the impact of sclerotinia disease on arable rotations, vegetable crops and land use

Project number	RD-2008-3579	Final Project Report	PR538
Start date	1 October 2009	End date	31 March 2013
HGCA funding	£175,000	Total cost	£895,056

What was the challenge/demand for the work?

Sclerotinia disease, caused by the fungus *Sclerotinia sclerotiorum*, is a recurring problem in the UK. Many vegetable and arable crops in rotations are affected each year, including carrots, lettuce, green beans, vining peas, potatoes and oilseed rape. The risk of sclerotinia infection varies across regions and seasons, and major outbreaks are difficult to predict. Foliar fungicides are currently the mainstay of control and can be very effective against sclerotinia, provided they are applied at the correct time, before infection occurs. There is good potential to improve the targeting of fungicides, and to reduce sclerotial numbers in soil using control and management practices.

This LINK project was structured around the two key phases of the pathogen life cycle: airborne spores and soil-borne sclerotia, with two main objectives, achieved by a combination of research and industry partner field experiments and contributions. In objective [1], focused on the airborne phase, the aim was to improve timing of foliar fungicide applications, by testing infection prediction models and by detecting inoculum. In objective [2], focused on the soil phase, the aim was to reduce the number of sclerotia in soil. The latter included a modelling approach to determine optimum crop rotations for minimising disease and maximising profit. Field work aimed at providing inputs to this model included experiments to determine whether crop species differ in the number of sclerotia produced, and the influence of minimum-tillage versus ploughing on spore production.

How did the project address this?

- 1. Germination model:** this was validated using ten years of past germination data and three years of data from the current work. The model was run weekly, before and during flowering, using temperature and rain data from on-site loggers or nearest weather station. Predicted dates for onset of germination were sent weekly for each site and later compared to observed germination.
- 2. Weather-based infection model:** this was based on infection criteria in an existing model, SkleroPro, which uses current weather data (not forecast). For this project, forecast temperature and humidity data were purchased and used to generate 24 and 48 hour forecast infection alerts for oilseed rape, peas and beans. Alerts were sent three times a week during flowering to each site, and sprays were applied if the crop had petal fall. Alerts were monitored and a second spray applied if a three-week protection window had elapsed and the crop was still in flower. Control using sprays applied according to alerts was compared with control using standard spray times.

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3. *Sclerotinia inoculum detection*: petals were sampled and tested for sclerotinia using agar plate and qPCR tests. Burkard spore traps were deployed at selected oilseed rape sites to record spore levels continuously during flowering. RotoRod spore traps were used at one of these sites to measure 48 hr periods of spore production, and spatial variability.
4. *Biological control*: Contans was applied at drilling of oilseed rape, using methods agreed with the distributor and manufacturer, in a large field plots (24 x 24 m). Sclerotial germination was monitored in all plots, and subsequent spore production measured by testing petal samples from each plot. Petal tests were also made on adjacent min-till and ploughed fields to compare inoculum production from the two tillage methods.
5. *Rotational model*: Dynamic programming was used to calculate cropping sequences which maximised the financial returns in the short and long term. Data inputs to the model were obtained from literature (e.g. disease-yield loss relationships) and from work in this project (e.g. numbers of sclerotia produced in different crop species). The model was run for three main scenarios: only crops susceptible to sclerotinia (no rotation); one non-susceptible crop included; one non-susceptible crop and treated susceptible crops.
6. *Sclerotial production in different crops*: Oilseed rape, carrots, peas, beans, potato and lettuce were grown in a polytunnel and inoculated at flowering or young leaf stage. Sclerotia were counted in mature infected plants, and tested for germination and apothecial production.
7. *Growers views on approaches to sclerotinia control*: Q methodology was used to investigate which sclerotinia control issues were important to growers, and what methods they might be willing to use. There were 45 responses to a survey distributed at workshops and meetings.

What outputs has the project delivered?

1. *Sclerotial germination model*: this correctly predicted onset of germination by region (SW earliest, NW latest) and by year, but with an error of \pm two weeks for individual sites. The model provides a useful forecast guide to the main onset of spore inoculum release by region.
2. *Weather-based spore infection model*: this was tested with sprays applied according to forecast alert dates. The model could provide forecast alerts up to two days in advance, and gave 76–96% control of sclerotinia disease in oilseed rape, equivalent to the best control determined in retrospect with a standard fungicide timing. Where a sclerotinia spray was needed, forecasting could inform whether one or more sprays were justified. For crops such as green beans and peas with a short flowering duration, the model was useful for decisions to spray or not. For peas, the model resulted in 43% control, but compared favourably with standard spray timings; in beans, disease was very low during the project. The use of risk factors in addition to forecasting was important. The key factors for assessing sclerotinia risk in-field were infection model alerts, rain (heavy or light), petal infection and crop stage. The key regional risk factors were predicted dates of sclerotial germination, forecast temperature and rain and regional spore trap data.
3. *Sclerotinia inoculum detection*: in oilseed rape petal tests, very high infection (90–100%) was associated with 15–30% stem rot. Zero or very low petal infection often resulted in low stem rot.

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Air samples from Burkard spore traps were tested with quantitative PCR tests. Peaks of inoculum detected by rooftop spore traps 25 miles from experiment sites coincided with the timing of peaks from spore traps within-field, suggesting that regional traps can indicate infection risk.

4. *Biological control*: Contans did not reduce viability of sclerotia in oilseed rape field plots. There was no difference determined between adjacent ploughed or minimum-tilled field areas for sclerotinia spores produced in spring.
5. *Rotational model*: The model showed that inclusion of at least one crop non-susceptible to sclerotinia in the rotation, even at low frequency, would reduce the long-term build-up of sclerotia in land, reduce financial losses and keep land at a low level of sclerotia infestation. Rotation gave the greatest financial benefits when soil sclerotial infestation was high, but was also the best financial strategy for land with low sclerotinia. For oilseed rape, in the short-term (i.e. approx. five years), a low frequency use of non-susceptible crops was the best decision only if soil sclerotial levels were very low. At moderate to high levels of soil sclerotia, the optimum decision was to grow non-susceptible crops more frequently. Foliar fungicide treatment, although beneficial to profitability compared to not treating, was not as profitable as including non-susceptible crops. The model results suggest that in the long-term, inclusion of a non-susceptible crop in an oilseed rape rotation would almost double the average profitability of land with all sclerotinia levels.
6. *Sclerotial production in different crops*: Carrots produced several thousand sclerotia m² (high plant density, small sclerotia), whereas oilseed rape produced a few hundred (lower plant density and large sclerotia), and numbers in lettuce, peas, beans and potatoes were intermediate. However, when size and germination ability of sclerotia were accounted for, sclerotia derived from oilseed rape, pea and carrot could in theory all produce up to 4000 apothecia m⁻². This assumes that all the sclerotia had optimum conditions for germination, but in reality a high proportion do not, so the viable numbers across crops are lower. However, the ranking of crops in terms of inoculum potential will hold true and could be informative for crop rotation decisions.
7. *Growers' views on approaches to sclerotinia control*: Growers were all in favour of using foliar fungicides to control sclerotinia. Many were willing to consider lengthening rotations. Biological control and co-operation with neighbours to treat soil were not popular. But > 80% of growers would be willing to cooperate with neighbours to spray crops and reduce disease pressure.

Who will benefit from this project and why?

Farmers and growers will benefit in the following ways with improved Sclerotinia disease control:

1. Increased yields and more flexible crop rotations from improved sclerotinia control may make it economic to include more than one susceptible crop in rotations. In the long-term this will safeguard UK production capacity.
2. In the short term, the weather-based infection model will predict times of high risk for infection and allow targeting of sprays to reduce crop losses. This is applicable to oilseed rape and peas,

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and is likely to be useful for other susceptible crops, e.g. carrots, lettuce, with some modification.

4. Targeted fungicide use is likely to result in cost savings through fewer sprays or an increase in gross margins, or both. For example, of the total 2010 oilseed rape area of 686k ha (Defra, 2012), 79.6% was treated (Fera, 2010), and if this treated area was reduced by 20% through improved targeting, this would result in cost savings of approximately £4.7m/year (based on average fungicide costs £20 ha⁻¹, application costs £10 ha⁻¹, 1% wheeling losses £4.50 ha⁻¹).
5. Yields would be increased through better timing of fungicides for sclerotinia, e.g., for oilseed rape, if incidence is reduced by 5%, yield increases by 3% (0.6% yield loss for each 1% of disease; ADAS unpublished data). On a 4 t/ha crop this equates to a yield increase of 0.12 t/ha.
6. For a field vegetable crop such as lettuce, the most important financial benefit is prevention of crop loss from better timing of fungicides, rather than saving the cost of a spray. Lettuce value is estimated at £9000 / ha, with an area of 4,500 ha of susceptible types (round head) in the UK. If 5% of this crop has sclerotinia disease in one year, the loss would be £2 million.

Uptake:

1. *Germination model*: observational data from the sclerotinia sclerotia depots used in this project to help develop the germination model are currently being used by BASF as part of their 'Sclerotinia Watch' website, along with a preliminary prediction model. The website has a high number of visitors and there is interest in viewing general and/or specific predictions of sclerotinia germination activity. The full germination model will require development to enable it to be run using individual weather stations, or location by postcode, grid reference or GPS.
2. *Weather-based infection model*: The grower survey results in this project suggest that spray timing problems are an important issue. A robust model that is easy to use is likely to have good uptake. Control using fungicide timings according to model alerts in conjunction with inoculum assessments needs to be demonstrated to growers, to take this work forward.
3. *Sclerotinia inoculum detection*: it is likely that growers and/or advisors would measure inoculum in-field if this was cheap and quick to do. Regional indications of inoculum, e.g. germination and/or Burkard trap tests, would be useful. The availability of in-field and/or regional inoculum measurements would increase uptake of the weather-based infection model.
4. *Biological control*: it is unlikely that Contans will be used by growers of outdoor crops. Aside from the lack of efficacy found in this project, there are difficulties with advance application on rented fields, the need for repeat applications and the relatively high cost.
5. *Rotational model*: This model confirms rotation as best practice, but also provides an economic assessment for different rotations. If a practical version of this model is developed, uptake by growers or advisors to determine their maximum theoretical profits is likely to be high.

HGCA return on investment: HGCA contributions were 19.6% (£175,000) of the total (£895,056). The overall budget enabled work on multiple aspects of sclerotinia disease, and produced evidence for improved sclerotinia disease prediction and risk assessment systems. A range of scientific messages were also produced, which underpin disease control and future developments.

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These include an improved understanding of: sclerotial germination variability; in-field and regional spore inoculum dynamics; conditions which promote spore release; quantification of sclerotial production in different crops and the potential numbers of apothecia produced from these sclerotia.

If the challenge has not been specifically met, state why and how this could be overcome

The biological control agent Contans was not effective. It is possible that amending the application method may help, e.g. apply to oilseed rape stubble. Increasing the Contans rate may help but unless the price reduces it will not be economic for oilseed rape. There is little incentive to use Contans in rented fields. For protected crops and some high-value crops it is worth pursuing.

Lead partner	ADAS UK Ltd
Scientific partners	Rothamsted Research, Warwick University Crop Centre, SRUC
Industry partners	BASF plc, Belchim, Burkard, Microzone, Velcourt R&D, PGRO, AHDB-HDC, AHDB- Potato Council, Worcester University – NPARU
Government sponsor	Sponsored by Defra and Scottish Government through the Sustainable Arable LINK programme.

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