Project title:	Blackcurrants: Control of Phomopsis dead arm in flailed down plantations
Project number:	SF 012 (GSK226)
Project leader:	John Atwood, ADAS
Report:	Annual report, December 2012
Previous report:	December 2011
Key staff:	John Atwood, ADAS Erika Wedgwood, ADAS Harriet Roberts, ADAS
Location of project:	Coggeshall Hall Farm, Kelvedon
Industry Representative:	Mr. R. Saunders Cherry Tree House, Dorothy Avenue, Cranbrook, Kent, TN17 3AL
Date project commenced:	1st March 2011
Expected completion date:	31st December 2015

DISCLAIMER

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

AUTHENTICATION

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

John Atwood
Principal Horticultural Consultant
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Signature Date 1 November 2012

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GROWER SUMMARY

Headline

- *Phomopsis ribicola* has been successfully isolated from blackcurrant plants in 2012 within the trial site, but development of the disease remains slow and no treatment effects were observed from the fungicide and biocontrol agents used.

Background and expected deliverables

Phomopsis dead arm on blackcurrant has become an increasing problem in recent years with plantations of cultivars Ben Tirran, Ben Avon and Ben Dorain particularly affected. In severe cases plantations as young as five years old have had to be grubbed. The disease has been observed to develop particularly in plantations where bushes have become stressed due to drought or where the soil conditions are unfavourable.

Blackcurrant plantations already receive a wide spectrum of fungicides through the growing season to control other diseases. Therefore a knowledge of the most useful active ingredients and the timing of application which best controls the spread of this disease is very important.

The species of *Phomopsis* responsible has recently been determined by Project SF 12 (223) as *Phomopsis ribicola/Diaporthe strumella* (*Diaporthe strumella* being the sexual state of the fungus) carried out by Fera. As part of study SF 12 (223), some fungicides and biological control agents (BCAs) such as Switch (cyprodinil + fludioxonil), Bravo 500 (chlorothalonil), Systhane 20EW (myclobutanil), Signum (boscalid + pyraclostrobin) and Serenade ASO (*Bacillus subtilis*) have been tested in culture and have shown some promising levels of control of the fungus. Several of these products are already used on blackcurrant plantations with little obvious control of the disease; therefore it is possible that the timing of applications in the current standard programmes misses critical stages for control of the fungus.

Phomopsis species are also responsible for causing branch die-back in blueberries and grapes where the problem is worldwide. In grapes, a system of control based on dormant season sprays using lime sulphur or copper fungicides followed by growing season treatments has been successful, and a predictive model has been developed to help target spray applications. This approach has reduced the number of sprays required to give control. It has also improved the level of control as the treatment timing is matched to infection events (i.e. when the environmental conditions are conducive to spore release and infection).

This study aims to evaluate biological control agents and fungicides for control of *Phomopsis* when applied following flailing down in a blackcurrant plantation affected by the disease.

Project objectives:

- Evaluate the efficacy of dormant season treatments applied after flailing, then repeated annually for the control of *Phomopsis*;

- Evaluate the efficacy of targeted spray treatments applied during the growing season with spray intervals varied in response to a predictive model developed on grapes for *Phomopsis viticola* control.

Summary of the project and main conclusions

2012 was the second year of this trial; the experiment was set up as a fully randomised block design with four replicates and eight treatments with one untreated control (Table 1). The trial site is located in an infected field of cv. Ben Avon which was flailed down for rejuvenation on 14 March 2011. Prior to flailing, the trial area was selected for uniformity and moderate levels of *Phomopsis* dead arm, and an assessment of the levels of dead branches prior to the dormant season spray was carried out. The experimental treatments were applied to the dormant bushes on 15 March 2012 to 4 m row length plots. This dormant season treatment was then followed by a programme of sprays with spray intervals of 10 to 12 days from 27 April - 17 July 2012. Treatments were all applied at 1,000 L water/ha. All treatments were applied under Extrapolated Experimental Approval 1382 COP 2011/00370.

Table 1. Treatments, rates and timings of applications to plots cv. Ben Avon at Coggeshall Hall Farm, Kelvedon, 2012

Treatment No.	**Dormant season Applied once 15 March 2012**		**Growing season - 7 applications April – July 2012**	
	Treatment	**Rate**	**Treatment**	**Rate**
1	Untreated	-	Untreated	-
2	BCA 1 + wetter	10 kg/ha 0.25%	Untreated	-
3	BCA 1 + wetter	10 kg/ha 0.25%	BCA 1 + wetter	10 kg/ha 0.25%
4	Prestop	6 kg/ha	Untreated	-
5	Prestop	6 kg/ha	Prestop	6 kg/ha
6	Cuprokylt	3 kg/ha	Untreated	-
7	Cuprokylt	3 kg/ha	Karamate	1.5 kg/ha
8	Cuprokylt	3 kg/ha	Signum	1.5 kg/ha

Table 2. Active ingredients and approval status on blackcurrants for products used

Product name	Active ingredient	Approval status Blackcurrants
Cuprokylt	copper oxychloride 50% w/w	Full approval
Karamate Dry Flo Neotec	mancozeb 75% w/w	Not approved
Prestop	*Gliocladium catenulatum* $2x10^8$ cfu/g 32% w/w	Not approved
Signum	boscalid + pyraclostrobin (26.7:6.7% w/w)	Full approval
BCA 1	Not disclosed	Not approved

At each application the bushes were assessed for any phytotoxic effects of the treatments and signs of *Phomopsis* dead arm developing on the new growth. No phytotoxicity was observed on any of the treatments and symptoms of *Phomopsis* dead arm were observed from May with a small number of branches wilting. A full assessment of disease development was carried out in August when individual shoots in some plots were wilting and showing symptoms of dead arm. Samples were taken of these diseased branches for confirmation in the laboratory as *Phomopsis* spp. by a damp chambering method.

No significant treatment effects were noted in this second year (Table 3). That is not unexpected as *Phomopsis* dead arm is a disease that is slow to develop initially. The project will continue to treat and monitor these plots for the next three years. At the August assessment, there was a high level of rust in certain areas within the trial. There was a slight effect of treatment on rust levels with higher disease severity for the three treatments which did not receive growing season applications. Interestingly, the plots that received only Cuprokylt treatments in March and no growing season treatments were also clear of rust initially.

Table 3. Average levels of branch dieback caused by Phomopsis dead arm per 4 m plot and rust in treated plots assessed 17 August 2012, Coggeshall Hall Farm, Kelvedon

Treatment		**Average no. of diseased branches / plot**	**Average % plants affected**	**Average no. of dead plants**	**Average Rust score**
Dormant spray	**Growing season**				
1. Untreated	Untreated	0.0	0.0	0.0	1.2
2. BCA 1	Untreated	8.3	2.2	0.0	0.7
3. BCA 1	BCA 1	8.7	3.5	0.0	0.0
4. Prestop	Untreated	10.6	2.0	0.2	1.5
5. Prestop	Prestop	12.0	3.5	0.0	0.0
6. Cuprokylt	Untreated	8.9	0.7	0.0	0.0
7. Cuprokylt	Karamate	4.9	1.2	0.0	0.0
8. Cuprokylt	Signum	5.6	0.5	0.0	0.0

Rust score: 0 - none, 1 - slight, 2 - moderate, 3 - severe

A weather station has been installed in the trial field, set up to monitor rainfall, soil and air temperature, relative humidity and leaf wetness. This data was fed into a disease prediction model developed for *Phomopsis viticola* on grape, to indicate when conditions were likely to be conducive for infection.

Infection of grape leaves by *P. viticola* can occur when temperatures are between 5 and 35°C, with leaf wetness durations as low as 5 hours. However, infection is more likely at temperatures between 12.5 and 24°C with a leaf wetness duration of 15 hours. Maximum infection occurred when leaves were wet for more than 15 hours and temperatures were around 17°C.

In the model developed for vine *Phomopsis*, two infection risk levels were defined: a **minimal** threshold at 12.5 to 25ºC for more than 10 hours leaf wetness, and an **optimal** infection threshold of 15 to 20ºC for more than 15 hours leaf wetness. Infection via stem tissue (as may possibly occur on blackcurrant) may require longer periods of foliar wetness. From these criteria, possible dates of infection in 2011 and 2012 (Figure 1) were calculated. The relative infection periods for 2011 and 2012 are compared in Table 4. Although there were many minimal infection periods in both 2011 and 2012 there were only two optimal infection periods in 2012 and none in 2011. Interestingly an optimal infection event in 2012 was triggered on 10 September. If the disease is sporulating at this time, any recent damage caused by harvesters to wood could provide infection sites directly into woody tissues. However it must be stressed that specific infection studies for *Phomopsis* infection in blackcurrants are required to confirm whether the predicted conditions for infection on grapes also hold true for blackcurrants.

Table 4. Number of days per month with optimal and minimal risk of *Phomopsis* infection - Coggeshall Hall farm 2011 and 2012

No. of minimal events 12.5 ^{o}C – 25 ^{o}C >10 hrs		**No. optimal events** 15 ^{o}C – 20 ^{o}C >15 hrs	
2011	**2012**	**2011**	**2012**
44	**16**	**0**	**2**

Many of the infection periods fell in August and September in both years. Understanding whether infection is possible at these times is very important to development of an effective fungicide programme. More research (outside the scope of this project) is required on the epidemiology of *Phomopsis ribicola/Diaporthe strumella* to refine the disease prediction model and to understand parameters such as how rain intensity and duration will affect spore splash and wash off.

Work in 2013 will continue with a similar spray programme applied to the same plots to continue to assess these products' efficacy as protectant sprays through the growing season.

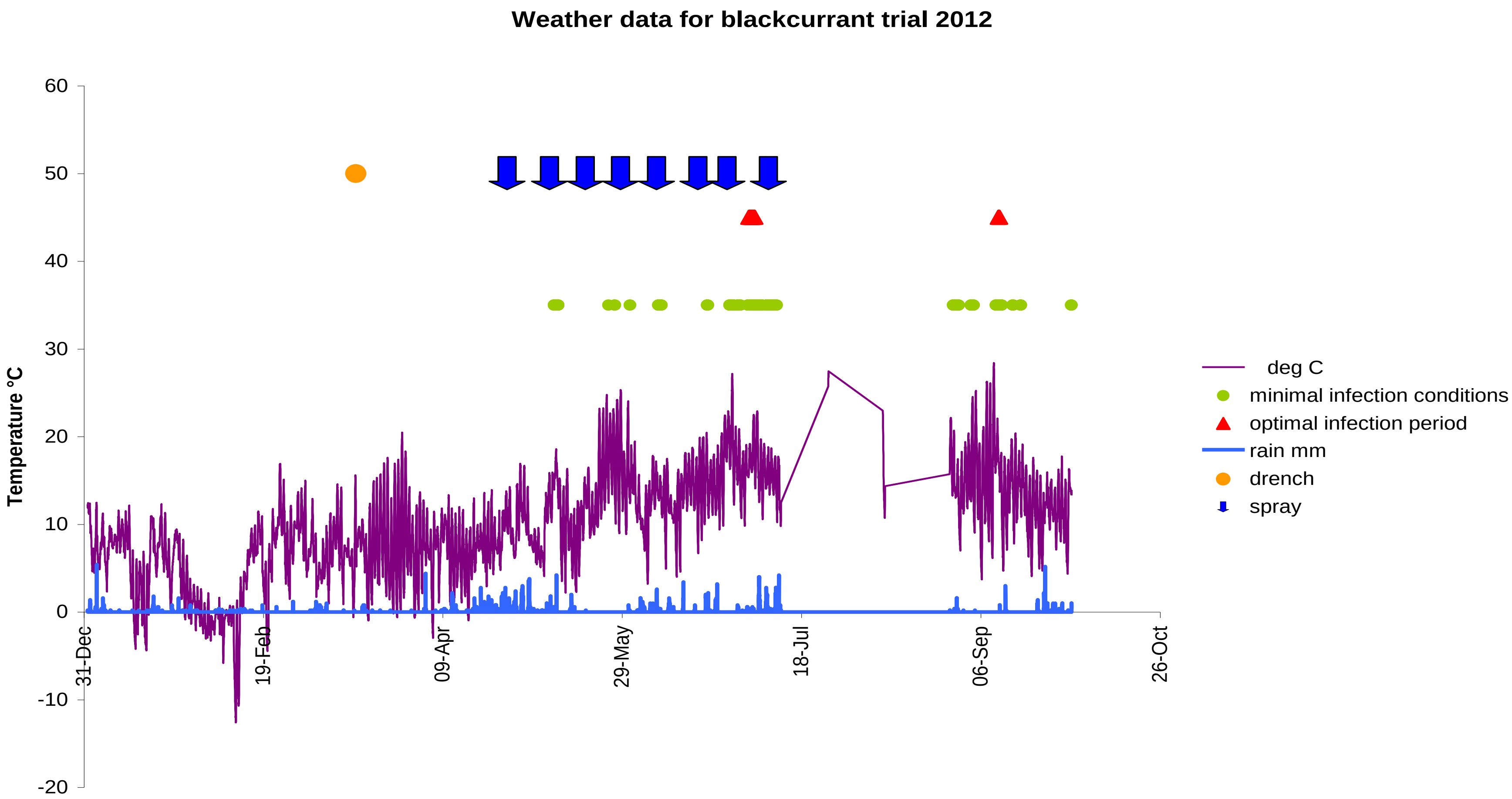

Figure 1. Summary of meteorological data and infection periods in Moorings field, Coggeshall Hall 2012 (Please note there was a technical error with the weather station logger between 12 July and 9 August so infection events for this period are not possible to determine)

Financial benefits

Plantation establishment costs amount to £4,000 per ha and plantations generally take three years for full production to be achieved. By grubbing prematurely, the number of useful cropping years can be reduced from 12 to two. This puts the future of useful varieties such as Ben Tirran, Ben Avon and Ben Dorain into question. This project should deliver guidance on treatments that can reduce the development of *Phomopsis* dead arm and prolong the life of plantations.

Action points for growers

- There are no action points at this stage of the project.

SCIENCE SECTION

Introduction

Phomopsis dead arm on blackcurrant has become an increasing problem in recent years with plantations of cultivars Ben Tirran, Ben Avon and Ben Dorain particularly affected. In severe cases plantations as young as five years old have had to be grubbed. The disease has been observed to develop particularly in plantations where bushes have become stressed due to drought or where the soil conditions are unfavorable.

Blackcurrant plantations already receive a spectrum of fungicides through the growing season to control other diseases, but which appear to have little if any impact on the suppression of this disease. Therefore knowledge of the most promising actives to control this disease, and the timing of application in the field to best control the spread of this disease, are vitally important to prolong the lives of plantations. Currently plantations where levels of Phomopsis are high have to be grubbed after just five years reducing the useful cropping years from up to 12 to just two.

The species of Phomopsis responsible has been determined by another study SF 12-223 as *Phomopsis ribicola/Diaporthe strumella* (*Diaporthe strumella* being the sexual state of the fungus) (Scrace *et al*., 2011). As part of study SF 12-223a, (Webb and Scrace, 2011) several fungicides and biological control agents (BCAs) such as Switch (cyprodinil + fludioxonil), Bravo 500 (chlorothalonil), Systhane 20EW (myclobutanil), Signum (boscalid + pyraclostrobin) and Serenade ASO (*Bacillus subtilis*) have been tested *in vitro* and have shown promising levels of control of the pathogen. Several of these fungicides are already in use on blackcurrant plantations with little obvious control on the disease, therefore it is possible that the timing of applications in standard programmes misses the critical period(s) for control in the pathogen life-cycle (Scrace *et al*., 2011).

Phomopsis species are also responsible for causing branch die-back in blueberries, requiring integrated control programmes to be adopted (Schilder *et al.,* 2006), and grapes, where the problem is worldwide. In grapes a system of control based on dormant season sprays using lime sulphur or copper fungicides followed by growing season treatments has been successful (Nita *et al.,* 2006). A predictive model developed by Erincik *et al*. (2003) which uses temperature and leaf wetness duration was used to target spray applications. This approach has reduced the number of sprays required to give control but also improved level of control as the treatment timing is matched to infection events i.e. when the environmental conditions are conducive to spore release and infection.

This study aims to evaluate biological control agents and fungicides for control of Phomopsis when applied following flailing down an infected blackcurrant plantation.

Project objectives:

- Evaluate the efficacy of dormant season treatments applied after flailing, then repeated annually for the control of Phomopsis;
- Evaluate the efficacy of targeted spray treatments applied during the growing season with spray intervals varied in response to a predictive model developed on grapes for *Phomopsis viticola* control.

Materials and methods

The trial was set up at Coggeshall Hall Farm, Essex in an established field of cultivar Ben Avon planted in 2005, as a fully randomised design with four replicate blocks, with 4 m long plots (trial design, soil type and crop husbandry details can be found in Appendix 1). The crop was flailed on 15 March 2011 to rejuvenate the bushes due to high levels of Phomopsis dead arm infection. 2012 dormant season treatments listed below (Tables 5 and 6) were applied on 15 March 2012 to the one year old growth using an air assisted knapsack sprayer and 2 m boom at 1,000 L/ha water. A visual assessment of dead or diseased branches was carried out 15 March 2012, wood samples were taken and *Phomopsis* spp infection was confirmed by damp chamber from wood and bud tissue samples collected from the trial area.

The growing season treatments were applied with spray intervals of 10-12 days from 27 April to 17 July 2012, again using an air assisted knapsack sprayer and 2 m boom at 1,000 L/ha water. All treatments were applied under Extrapolated Experimental Approval 1382 COP 2011/00370.

Table 5. Treatments, rates and timings of applications to plots cv. Ben Avon at Coggeshall Hall Farm, Kelvedon 2012

Treatment No.	Dormant season Applied once 15 March 2012		Growing season - 7 applications April – July 2012	
	Treatment	**Rate**	**Treatment**	**Rate**
1	Untreated	-	Untreated	-
2	BCA 1 + wetter	10 kg/ha 0.25%	Untreated	-
3	BCA 1 + wetter	10 kg/ha 0.25%	BCA + wetter	10 kg/ha 0.25%
4	Prestop	6 kg/ha	Untreated	-
5	Prestop	6 kg/ha	Prestop	6 kg/ha
6	Cuprokylt	3 kg/ha	Untreated	-
7	Cuprokylt	3 kg/ha	Karamate	1.5 kg/ha
8	Cuprokylt	3 kg/ha	Signum	1.5 kg/ha

Table 6. Active ingredients and approval status on blackcurrants for products used

Product name	Active ingredient	Approval status - Blackcurrants
Cuprokylt	copper oxychloride 50% w/w	Full approval
Karamate Dry Flo Neotec	mancozeb 75% w/w	Not approved
Prestop	*Gliocladium catenulatum* $2x10^8$ cfu/g 32% w/w	Not approved
Signum	boscalid + pyraclostrobin (26.7:6.7% w/w)	Full approval
BCA 1	Not disclosed	Not approved (EEA only)

At each visit prior to the next treatment application the plots were assessed for any phytotoxicity effects (scored on a 0-9 scale, 9 being no effect and 0 being complete kill) and signs of Phomopsis dead arm developing on the new growth. A full assessment of disease development was carried out on 17 August 2012 recording the number of dead and diseased branches per bush. Samples were taken of wilting and dead branches likely to be caused by Phomopsis. These were inspected in the laboratory; discoloured tissue and shrunken buds were examined, both by culturing on potato dextrose agar + streptomycin and by damp chambering – plant tissue incubated in a sealed humid environment and held at ambient conditions.

A weather station (Delta-T GSM modem system MD-GSM-1 + Data logger DL2e) with the ability to remotely access the data was installed near to the plots at the trial site in year one, set to monitor rainfall, soil and air temperature, relative humidity and leaf wetness. These parameters were fed into the vine disease prediction model developed by Erincik *et al.* (2003) and used successfully in field trials on grape (Nita *et al,* 2006). Using this model as a starting point, along with disease observations in the trial, this will be modified to help develop a model for blackcurrant.

Results and discussion

Due to the slow nature of disease development, so far only low levels of Phomopsis have been identified, with only one to two branches being affected on a small proportion of the bushes. At the first plot inspection, 15 March 2012, 12 plots out of 32 had bushes with dead arm symptoms; the presence of dead branches and/or branches with buds unlikely to break (Figure 2). Also at this assessment it was noted that the wood debris around the base of the bushes was showing clear development of *Diaporthe* spp. fruiting bodies, a likely source of inoculum. Table 7 shows the results from this March assessment; there were no treatment effects obvious at this stage.

During the growing season any plots showing new signs of dead arm with either buds failing to break or branches wilting were noted. The first instance of branch wilting was noted on 28 May 2012, and one to two more branches showing symptoms were observed as the growing season progressed.

On 17 August 2012 a full assessment was carried out recording dead and diseased branches per plot (Table 8). Sixteen of the 32 plots showed some signs of Phomopsis dead arm. From those showing symptoms, samples were taken of the diseased tissue (Figure 3) and isolated and cultured in the lab. It was not possible to isolate *Phomopsis* spp. from all of the samples taken but it was confirmed on either wood or bud tissue on 12 of the 15 samples. No treatment effects were observed at this stage (Table 8). No phytotoxicity effects were observed for any of the treatments.

Further analysis was carried out using the 2011 pre-flailing assessment levels of Phomopsis per plot as a covariate to the 2012 data. Again no significant treatment effects were suggested from this analysis.

At the August assessment there was rust (*Cronartium ribicola*) developing in some of the trial plots and there appeared to be a reduced level associated with all of the growing season treatments applied and initially, an effect of single Cuprokylt application in March. Although not significant, this suggests that both biological treatments and fungicides were having an effect on the levels of rust seen (Table 9).

Figure 2: Phomopsis dead arm symptoms and wood debris displaying *Diaporthe* spp. fruiting bodies, March 2012

Figure 3. Phomopsis symptoms, August 2012

Table 7. Average levels of branch die-back per m row length in treated plots assessed 15 March 2012 Coggeshall Hall Farm Kelvedon

Treatment					
Dormant spray	**Growing season**	**Number of dead branches/m**	**Number of diseased branches/m**	**Number of dead plants/m**	**Total number of diseased plants/m**
Untreated	**Untreated**	0.0	0.1	0.0	0.1
BCA 1	**Untreated**	0.0	0.3	0.0	0.1
BCA 1	**BCA 1**	0.0	0.0	0.0	0.0
Prestop	**Untreated**	0.0	0.2	0.0	0.2
Prestop	**Prestop**	0.1	0.7	0.1	0.3
Cuprokylt	**Untreated**	0.0	0.0	0.0	0.0
Cuprokylt	**Karamate**	0.0	0.1	0.0	0.1
Cuprokylt	**Signum**	0.0	0.4	0.0	0.2
	P. value	ns (0.459)	ns (0.204)	ns (0.459)	ns (0.284)
	LSD (21 Df.)	0.065	0.568	0.065	0.269

Table 8. Average levels of branch dieback per m row length in treated plots assessed – 17 August 2012 Coggeshall Hall Farm Kelvedon

Treatment					
Dormant spray	**Growing season**	**Number of dead branches/m**	**Number of diseased branches/m**	**Number of dead plants/m**	**Total number of diseased plants/m**
Untreated	**Untreated**	0.0	0.0	0.0	0.0
BCA 1	**Untreated**	0.0	0.6	0.0	0.2
BCA 1	**BCA 1**	0.0	0.9	0.0	0.2
Prestop	**Untreated**	0.6	0.5	0.1	0.2
Prestop	**Prestop**	0.1	0.9	0.0	0.3
Cuprokylt	**Untreated**	0.0	0.2	0.0	0.2
Cuprokylt	**Karamate**	0.0	0.3	0.0	0.1
Cuprokylt	**Signum**	0.0	0.1	0.0	0.1
	P. value	ns (0.505)	ns (0.550)	ns (0.459)	ns (0.664)
	LSD (21 Df.)	0.669	1.049	0.065	0.307
Covariate	P. value	ns (0.421)	ns (0.645)	ns (0.566)	ns (0.676)

Analysis *	LSD (20 Df.)	0.667	1.080	0.068	0.325

*Covariate Analysis with equivalent pre flailing March 2011 assessment

Table 9. Average rust score in treated plots assessed – autumn 2012 Coggeshall Hall Farm Kelvedon (0 - none, 1 - slight, 2 moderate, 3 – severe)

Treatment			
Dormant spray	**Growing season**	**Rust score 17th August 2012**	**Rust score 8th October 2012**
Untreated	**Untreated**	1.3	2.8
BCA 1	**Untreated**	0.8	2.8
BCA 1	**BCA 1**	0.0	2.0
Prestop	**Untreated**	1.5	2.3
Prestop	**Prestop**	0.0	2.5
Cuprokylt	**Untreated**	0.0	2.5
Cuprokylt	**Karamate**	0.0	2.3
Cuprokylt	**Signum**	0.0	1.5
	P. value	ns (0.100)	ns (0.085)
	LSD (21 Df.)	1.318	0.841

The meteorological data from the field weather station was fed into the *Phomopsis viticola* grape disease prediction model to identify the periods when the temperature and leaf wetness duration were conducive to infection. In 2012 the parameters were reviewed to try to improve the model to better suit blackcurrant Phomopsis, taking into account expertise from other UK disease models e.g. *Sclerotinia* on oil seed rape. Weather data consisted of half hourly in-field readings of air and soil temperature, relative humidity, and two leaf wetness monitors, one horizontal and one at 45 degrees. These data were plotted as scatter graphs and the drench and spray dates were added for both 2011 and 2012 (Figures 4 and 5).

Leaf wetness can be estimated from averaging data from the leaf wetness meters. From Scrace's (2011) work it appears that Phomopsis could infect through flowers, leaves or cuts to the bark. Erincik *et al.* (2003) give the conditions for infection by Phomopsis through wet leaves of grapes and although these may not be the conditions ideally suited to infection of other tissues, without a full study of the specific epidemiology of *Phomopsis ribicola* this is at least a starting point.

Erincik *et al.* (2003) showed vine infection can occur when temperatures are between 5 and 35°C which is supported by laboratory growth tests on *Phomopsis ribicola (*Scrace *et al*., 2011). Erincik *et al.* (2003) also showed that at these temperatures leaf infection is possible with just 5 hours of leaf wetness but at this duration, lesions were just 15% of the highest infection level at 17 °C (the optimum temperature). Half maximum infection levels occurred at between 12.5 and 24°C for 15 hours whereas maximum infection occurred when leaves were wet for over 15 hours and temperatures were approximately 17°C. Leaf infections in the two varieties of grapes (measured by number of lesions) were similar with exposures of 15 and 20 hours.

Using the model of Erincik *et al.* (2003), two infection types were defined: a **minimal** condition of exposure at 12.5 to 25ºC for more than 10 hours leaf wetness and an **optimal** infection of 15 to 20º C for more than 15 hours leaf wetness. Stem infection, however, is likely to require longer periods of leaf wetness, so the optimal infection criteria may prove a better threshold if stem infection through wound sites is the route of infection.

Dates of the periods when these conditions were found are displayed in Appendix 2, summarised for 2011 and 12 in Table 10 and are also displayed on the graphs (Figures 4 and 5). During 2011 there were no optimal infection events but over 40 of the minimal infection events and these were often associated with heavy dews.

In 2012 there were two optimal events, with one falling in early July that would correspond to the growing season programme of sprays and one in early September. If sporulating pycnidia or Diaporthe fruiting bodies are present at this time, the damage caused by harvesters to wood in late July - August could provide infection sites directly into woody tissues. However it must be stressed that specific infection studies for Phomopsis infection in blackcurrants are required to confirm whether the predicted conditions for infection on grapes also hold true for blackcurrants.

Table 10. Number of days per month with optimal and minimal risk of Phomopsis infection - Coggeshall Hall Farm 2012

No. of minimal events 12.5 ^{o}C – 25 ^{o}C >10 hrs		**No. optimal events** 15 ^{o}C – 20 ^{o}C >15 hrs	
2011	**2012**	**2011**	**2012**
44	**16**	**0**	**2**

There was a technical fault with the weather station data logger between 12 July and 9 August. During this time several attempts to rectify the problem were tried however unfortunately some data was lost for this period leading to the gaps on the graph (Figure 3). It is not possible to state whether there were infection periods during this time; average weather records for Essex during this period are shown Table 11. There was considerable rain and temperatures on average were between 15 and 20^{o}C suggesting there could have been further minimal and/or optimal infection periods during this time.

Table 11. Weekly temperature and rainfall in Essex during the period when the weather station was out of action (source ADAS agromet)

Week ending	Temperature ^{o}C	Rainfall mm
17 July	15.20	37.90
24 July	16.50	15.80
31 July	16.60	9.10
7 August	16.90	13.70
14 August	18.40	3.80

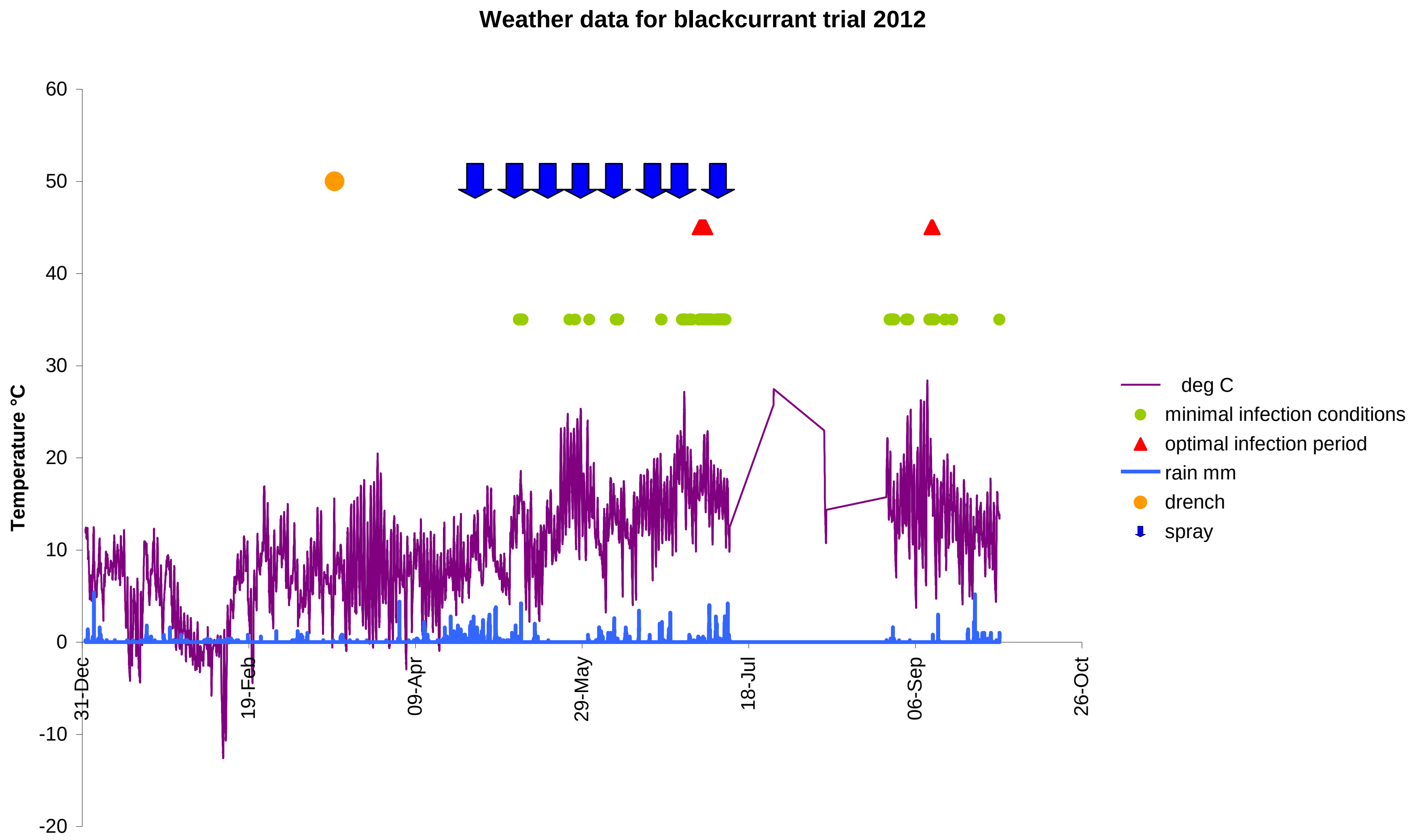

Figure 4. Summary of meteorological data for 2012, showing spray timings and potential infection periods, Coggeshall Hall 2012 (Please note due to equipment malfunction there was a data logging error 12 July - 9 August)

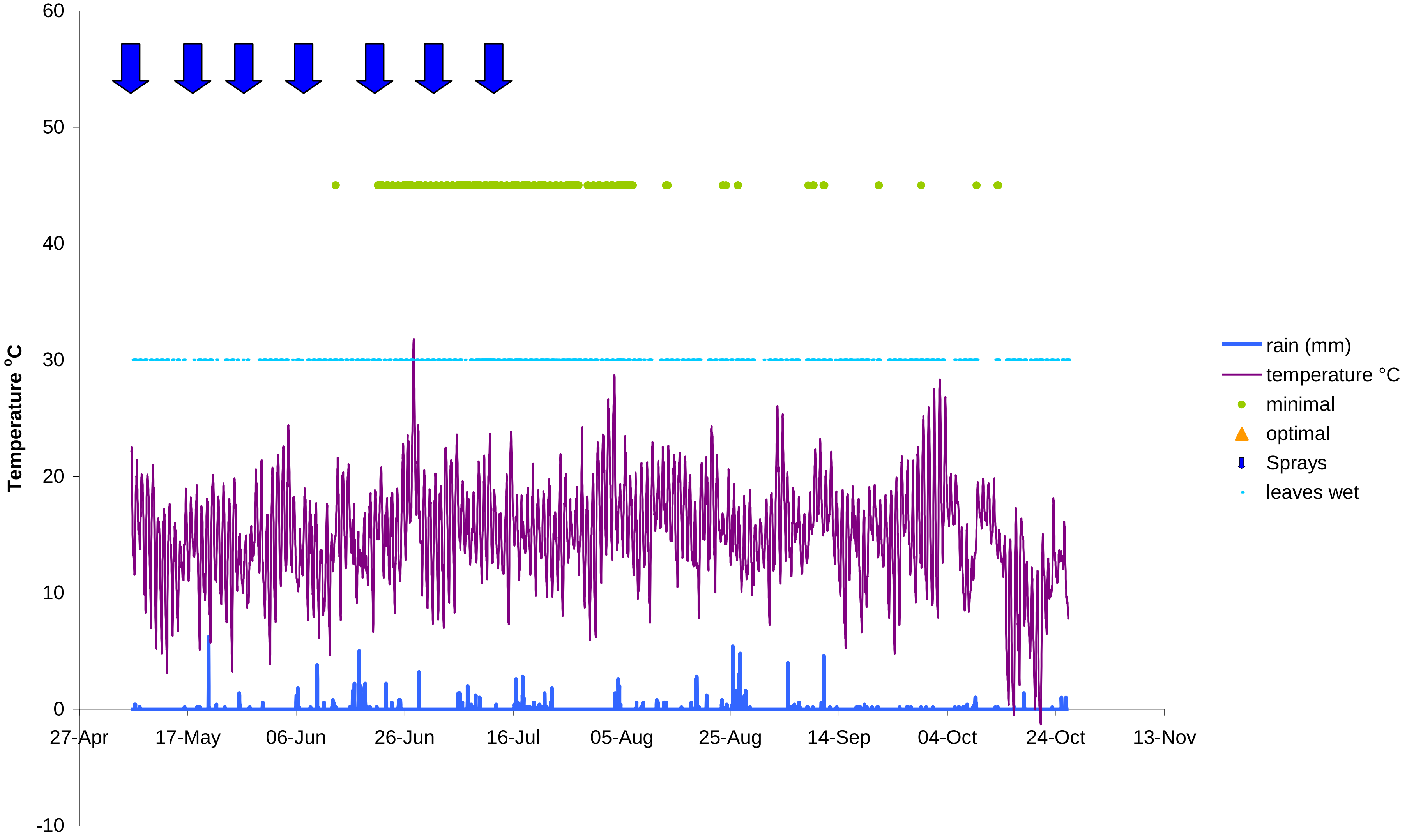

Figure 5. Summary of meteorological data for 2011, showing spray timings and potential infection periods, Coggeshall Hall 2011

Many of the sub-optimal infection periods fell in August and September in both years. Understanding whether infection is possible at these times, how inoculum pressure varies according to environmental conditions and the variation in susceptibility of the plant material to infection at different times, are all important questions that need to be addressed when attempting to target a fungicide programme more precisely. More research is therefore required on the epidemiology of *Phomopsis ribicola/Diaporthe strumella* to refine the disease prediction model. In addition a better understanding is needed of how and when *Phomopsis ribicola/Diaporthe strumella* is infecting blackcurrants, and whether parameters such as rain intensity and duration affect spore splash and wash off.

Next year's work will continue with a similar spray programme applied to the same plots to assess these products' efficacy as protectant sprays through the growing season. As levels of Phomopsis are now developing, in 2013 it is proposed to extend the work by sampling, examining and culturing wood at monthly intervals to observe early onset of the disease and relate more closely to the weather station data.

Conclusions

- *Phomopsis ribicola* has been successfully isolated from blackcurrant plants in 2012 within the trial site, although development of the disease remains slow in year two after flailing.
- Disease levels were low in 2012 and no treatment effects were observed in the experimental plots treated with fungicides and biocontrol agents this year.
- Meteorological data (temperature and leaf wetness) collected at the trial site has been used to identify periods of infection risk based on extrapolation from a model developed for grape Phomopsis.
- Further work is required to develop the model for use on blackcurrants and to gain a better understanding of the epidemiology of blackcurrant Phomopsis.

Knowledge and Technology Transfer

No knowledge transfer activities took place during the reporting period covered by this report.

References

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Acknowledgements

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Appendices

Appendix 1: Trial design

Block	Plot	Treatment
1	1	8
1	2	7
1	3	3
1	4	1
1	5	6
1	6	4
1	7	5
1	8	2

Block	Plot	Treatment
2	9	2
2	10	7
2	11	6
2	12	5
2	13	4
2	14	8
2	15	3
2	16	1

Block	Plot	Treatment
3	17	1
3	18	4
3	19	5
3	20	2
3	21	3
3	22	8
3	23	7
3	24	6

Block	Plot	Treatment
4	25	3
4	26	6
4	27	1
4	28	7
4	29	8
4	30	5
4	31	2
4	32	4

Treatment No	**Dormant season**	**Growing season**
1	Untreated	Untreated
2	BCA 1	Untreated
3	BCA 1	BCA 1
4	Prestop	Untreated
5	Prestop	Prestop
6	Cuprokylt	Untreated
7	Cuprokylt	Karamate
8	Cuprokylt	Signum

Appendix 2: Weather station dates and times of infection periods

Minimal infection periods 12.5 ^{o}C – 25 ^{o}C >10 hrs				Optimal infection periods 15 ^{o}C – 20 ^{o}C >15 hrs			
2011		2012		2011		2012	
Date	Hours wet	Date	Hours wet	Date	Hours wet	Date	Hours wet
13-Jun 7:00	12	10-May 0:30	27			03-Jul 7:00	40
21-Jun 2:00	33	25-May 5:00	10.5			10-Sep 19:30	26
22-Jun 17:00	19	26-May 22:30	11.5				
23-Jun 17:30	15	31-May 4:30	11				
24-Jun 18:30	14.5	08-Jun 3:00	22.5				
25-Jun 17:30	52	21-Jun 17:30	10.5				
28-Jun 7:30	30.5	27-Jun 23:30	22.5				
29-Jun 18:00	15.5	30-Jun 5:30	15				
30-Jun 17:30	15.5	03-Jul 2:00	66				
01-Jul 17:30	15.5	08-Jul 5:00	60.5				
02-Jul 17:30	14.5	29-Aug 7:00	35.5				
03-Jul 17:30	17.5	03-Sep 6:00	18				
04-Jul 17:00	17	10-Sep 5:30	30.5				
05-Jul 17:00	67.5	14-Sep 22:00	11.5				
08-Jul 13:00	46.5	17-Sep 2:00	12.5				
10-Jul 17:00	21	01-Oct 5:00	13				
11-Jul 16:30	46						
13-Jul 17:00	16.5						
14-Jul 18:30	14						
15-Jul 17:30	41						
17-Jul 17:00	43						
19-Jul 18:00	17						
20-Jul 17:00	41.5						
22-Jul 18:00	15.5						
23-Jul 18:30	17.5						
24-Jul 18:00	15						
25-Jul 18:00	66.5						
29-Jul 17:30	14.5						
30-Jul 18:30	13.5						
31-Jul 17:30	19.5						
02-Aug 0:30	21						
03-Aug 2:00	19						
04-Aug 5:00	79.5						
13-Aug 4:30	18.5						
23-Aug 15:30	13.5						
24-Aug 6:00	11.5						
26-Aug 9:30	13						
08-Sep 9:30	10.5						
09-Sep 6:30	13.5						
11-Sep 4:30	15.5						
21-Sep 9:00	12						
29-Sep 5:00	11						
09-Oct 9:30	11.5						
13-Oct 6:30	14.5						

Appendix 3: Crop husbandry details

The trial area was not treated with fungicides but received the normal farm treatments of insecticides, herbicides and fertilisers – see below. No irrigation was applied in 2012.

Date	**Product**	**Rate**
23/3/12	Ronstar liquid Artist Harvest	4.0 L/Ha 2.5 kg/Ha 2.9 L/ha
17/5/12	Urea	60 kg/ha
25/6/12	Calypso	0.2 L/ha
Non trial areas of the field received the above plus fungicides listed below		
8/5/12	Stroby WG	0.2 kg/ha
23/5/12	Signum	1.5 kg/ha
25/6/12	Switch Stroby WG	1 kg/ha 0.2 kg/ha

