Project title:	**Field evaluation of natural plant elicitors with or without a reduced fungicide programme for control of botrytis in blackcurrants and effects on yield and quality parameters**
Project number:	SF 169 ORETO 18/007, 18/008
Project leader:	Dr A M Berrie, NIAB EMR
Report:	Final report, May 2019
Previous report:	Annual report 2018
Key staff:	Dr A Berrie Dr R Saville
Location of project:	NIAB EMR
Industry Representative:	Harriet Prosser
Date project commenced:	1 April 2017
Date project completed (or expected completion date):	31 March 2019

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.

Dr Angela Berrie

Research Leader

NIAB EMR

Signature .... Date ....

Report authorised by:

[Name]

[Position]

[Organisation]

Signature .... Date ....

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GROWER SUMMARY

Headline

- AHDB9916 shows some promise as an alternative to traditional fungicides for Botrytis control in blackcurrant.

Background and expected deliverables

Blackcurrant production in the UK occupies an area of around 2,552 ha, producing a total tonnage of around 15,700 tonnes, which in 2018 had a farm gate value of approximately £22 million (Defra Horticulture Statistics). Much of the crop is currently grown on contract for processing, Botrytis fruit rot (*Botrytis cinerea*) is by far the most important disease problem which seriously compromises fruit quality at harvest. The fear of rapid degeneration of ripening fruit due to developing fungal infection as fruit ripens causes growers to pick fruit prematurely before optimum sugar (BRIX) and colour have developed. Losses after harvest are minimal as the fruit, if not rapidly processed, is stored frozen. Unlike *B. cinerea* infection on strawberry and raspberry, infection of blackcurrant flowers can result in flower abscission (McNicol & Williamson, 1989) and significant yield loss, so control of the disease during flowering is vitally important. Fruit infection usually occurs via the flowers where the fungus can remain latent until the fruit matures, when, under conditions of high humidity, rapid colonisation of the fruit can occur (Xu *et al*, 2009).

Fungicides are currently relied on for control and are applied routinely during flowering and fruit development (Jorg *et al*, 2003; Walter *et al*, 2007), especially in wet seasons. Intensive use of fungicides in this way is undesirable and unsustainable and may result in residues in the fruit. In 2010 a Defra Horticulture LINK project (HL01105) was initiated with the main objective of developing new management methods for key pests and diseases of blackcurrants, giving priority to alternative, biological methods, and integrating them into an Integrated Pest and Disease Management system (IPDM). *Botrytis cinerea,* was the main disease target in the project. The use of biocontrol agents (BCAs), either alone or as part of an integrated programme with fungicides, offers a means of achieving good control of *B. cinerea* while minimising residues in the fruit. Similarly, alternative chemicals such as elicitors which stimulate resistance mechanisms and increase host resistance to diseases, also offer an alternative. BCAs were evaluated in trials over three seasons. However, the BCAs were only effective in reducing botrytis in one of the three years. In addition, they were expensive compared to fungicides making their use uneconomic in blackcurrants, particularly with the unreliability of performance.

In the trial in 2013, a natural product AHDB9916 (plant strengthener), based on flavonoids, gave comparable control of Botrytis rot compared to the standard fungicide programme on cv. Ben Tirran at a third of the cost. Further work on AHDB9916 was conducted in 2014. However, winter 2013/2014 was relatively mild which resulted in insufficient chilling for blackcurrants especially cv. Ben Tirran. Consequently, bush development was very variable and yield also poor. Results in 2014 were therefore inconclusive. Further trials are needed to properly assess the effect of AHDB9916 on fruit rots and other crop parameters and particularly consistency of performance.

Summary of the project and main conclusions

In 2017 in a replicated small plot trial, the effect of the biostimulants AHDB9916 and AHDB9915 and a plant extract AHDB9957 on the botrytis incidence in flowers and fruit on cvs. Ben Hope and Ben Tirran, was compared to that of a standard fungicide programme and an untreated control in a blackcurrant plantation, located at NIAB EMR. There were several practical issues which affected the performance of the two cultivars and the outcome of the trial. Late frosts in April and May resulted in poor fruit set in Ben Hope and the mild winter resulted in insufficient winter chilling in Ben Tirran, which resulted in the poor performance of the cultivar. In addition, a late infestation of spotted wing drosophila in the Ben Tirran fruit at harvest, resulted in the rapid deterioration of the Ben Tirran fruit in the post-harvest test and poor expression of botrytis in the fruit. There were no significant effects of treatments on any of the assessed parameters in Ben Hope. There was significantly less botrytis recorded in the fungicide treated fruit in green fruit tests in Ben Tirran and significantly less botrytis recorded in the fungicide-treated fruit and the AHDB9916 treated fruit in the post-harvest tests. However, as the incidence of botrytis rot in the post-harvest tests was very low (1-5%) these results should be treated with caution. In 2018, the trial was repeated at NIAB EMR with the same treatments. An additional treatment was included where AHDB9916 was applied to the same plots as in 2017, as the effects of this product are reported to be cumulative and such effects have been observed in trials on apples. AHDB9916, with or without the addition of the wetter Wetcit, was applied from pre-flowering at 3-4 week intervals, reaching a total of 3 sprays. AHDB9915 was applied from pre-flowering at 2 week intervals, with a total of 6 sprays and AHDB9957 were applied from pre-flowering at 7-10 day intervals, a total of 6 sprays. The fungicide treatment was applied from first flower at 7-10 day intervals, a total of 3 sprays. A similar trial was also conducted on a commercial plantation of blackcurrant cv. Ben Tirran, located at Rosemary Farm, Flimwell, Kent, by kind permission of Peter and Michael Reeves. At this site the effects of AHDB9916 alone or with a standard fungicide programme was compared with a standard fungicide programme and an untreated control. Treatment applications were similar to those at NIAB EMR. Fruit set was recorded and the incidence of botrytis assessed on flowers, green fruit and mature fruit pre-harvest. In addition, 300 fruit were harvested from each plot, weighed to give a measure of fruit size, and then incubated in high humidity and assessed after seven days for botrytis and other fruit rots.

Despite favourable wet weather during flowering at both sites the incidence of botrytis in green fruit was very low. The subsequent weather in June and July was hot and dry and not favourable for botrytis spread and development. Botrytis incidence in flowers and fruit pre-harvest and in post-harvest tests was also low, although at the Rosemary Farm site there was significantly less botrytis in fruit from AHDB9916 only treated plots compared to the standard fungicide plots. However, little importance can be placed on this result because of the low incidence of botrytis. There was no effect of treatments on fruit set and fruit size at either site.

Unfortunately, the low incidence of botrytis in the fruit at both sites makes it impossible to come to any firm conclusions on the effect of alternative treatments on botrytis fruit rot.

Financial benefits

AHDB9916 gave promising results in control of botrytis in one trial and was also a third of the cost of the standard fungicide programme. This product shows great promise as an alternative approach to fungicides but further trials are needed to evaluate the consistency of performance and possible benefits on yield.

Action points for growers

- As there have been no clear results over the two years due to various practical difficulties such as lack of disease, it is not possible to offer any clear action points.

SCIENCE SECTION

Introduction

Blackcurrant production in the UK occupies an area of around 2,300 ha, producing a total tonnage of around 14,000t, which in 2008 had a farm gate value of approximately £8 million. Much of the crop is currently grown on contract for processing. Botrytis fruit rot (*Botrytis cinerea*) is by far the most important disease problem which seriously compromises fruit quality at harvest. The fear of rapid degeneration of ripening fruit due to developing fungal infection as fruit ripens causes growers to pick fruit prematurely before optimum sugar (BRIX) and colour have developed. Losses after harvest are minimal as the fruit, if not rapidly processed, is stored frozen. Unlike *B. cinerea* infection on strawberry and raspberry, infection of blackcurrant flowers can result in flower abscission (McNicol & Williamson, 1989) and significant yield loss so control of the disease during flowering is vitally important. Fruit infection usually occurs via the flowers where the fungus can remain latent until the fruit matures, when, under conditions of high humidity, rapid colonisation of the fruit can occur (Xu *et al*, 2009).

Currently fungicides are relied on for control and are applied routinely during flowering and fruit development (Jorg *et al*, 2003; Walter *et al*, 2007), especially in wet seasons. Intensive use of fungicides in this way is undesirable and unsustainable and may result in residues in the fruit. In 2010 a Horticulture LINK project (HL01105) was initiated with the main objective of developing new management methods for key pests and diseases of blackcurrants, giving priority to alternative, biological methods, and integrating them into an Integrated Pest and Disease Management system (IPDM). *Botrytis cinerea,* was the main disease target in the project. The use of biocontrol agents (BCAs), either alone or as part of an integrated programme with fungicides, offers a means of achieving good control of *B. cinerea* while minimising residues in the fruit. Similarly, alternative chemicals such as elicitors which stimulate resistance mechanisms and increase host resistance to diseases, also offer an alternative. BCAs were evaluated in trials over three seasons. However, the BCAs were only effective in reducing botrytis in one of the three years. In addition, they were expensive compared to fungicides making their use uneconomic in blackcurrants, particularly with the unreliability of performance.

In the trial in 2013 the natural product AHDB9916 (plant strengthener), based on flavonoids gave comparable control of *Botrytis* rot compared to the standard fungicide programme on cv. Ben Tirran at a third of the cost. Further work on AHDB9916 was conducted in 2014. However, winter 2013/2014 was relatively mild which resulted in insufficient chilling for blackcurrants especially cv. Ben Tirran. Consequently, bush development was very variable and yield also poor. So results in 2014 were inconclusive.

A trial was conducted in 2017 to assess the effect of AHDB9916 on fruit rots and other crop parameters and particularly consistency of performance. However, late frosts in April and May resulted in poor fruit set in Ben Hope and the mild winter resulted in insufficient winter chilling in Ben Tirran which resulted in the poor performance of the cultivar. In addition, a late infestation of spotted wing Drosophila in the Ben Tirran fruit at harvest, resulted in the rapid deterioration of the Ben Tirran fruit in the post-harvest test and poor expression of botrytis in the fruit. There were no significant effects of treatments on any of the assessed parameters in Ben Hope. There was significantly less botrytis recorded in the fungicide treated fruit in green fruit tests in Ben Tirran and significantly less botrytis recorded in the fungicide-treated fruit and the AHDB9916-treated fruit in the post-harvest tests. However, as the incidence of botrytis rot in the post-harvest tests was very low (1-5%) these results should be treated with caution. In 2019 it was decided to repeat the trial at East Malling and in addition conduct an additional trial on a commercial site.

Objectives

1. To evaluate programmes of AHDB9916 and other elicitors in comparison with fungicides for control of botrytis fruit rot and other rots

2. To assess the effects of elicitors on fruit set, yield and crop vigour

SOPS and Guidelines followed (EPPO or internal)

This study was conducted in compliance with the requirements of the UK Official Recognition of Efficacy Testing scheme. Methodology conforms with:

EPPO PP1/135(4) (Phytotoxicity assessment),

EPPO PP1/152(4) Guideline on design and analysis of efficacy evaluation trials

EPPO PP 1/181(4) Conduct and reporting of efficacy trials

EPPO PP 1/225 (2) Minimum effective dose

East Malling Research is an officially recognised efficacy testing organisation (Certification No. ORETO 411)

Site 1 – NIAB EMR

Materials and methods

Site location

The blackcurrant plantation (CE186) is located at NIAB EMR, East Malling, Kent (Longitude 51.2834 N, Latitude 0.4421 E) and was planted in 2004 and consists of separate blocks of cvs. Ben Hope and Ben Tirran. The bushes were cut down in winter 2014. The trial was conducted on both cultivars. Plots contained 6 bushes spaced 0.5 m in row and 3.0 m between rows.

Experimental treatments

All plots received a standard programme for pest and disease as required up to the start of the trial. Treatments started in April at Grape stage (BBCH56/57). Treatments in Table 1 were applied to the plots. Treatment 3 (AHDB9916 Year 2) was applied to the same plots as in 2018. This treatment was included as the effects of AHDB9916 are reported to be cumulative and such benefits have been observed in other trials on apples. Treatments for pests were applied to all plots. Each treatment was applied according to schedule in Table 1 and shown in Tables 2-3.

Spray application

All treatments were applied using a Birchmeier motorised knapsack sprayer at 500 L/ha following EMR SOP GEP 725. Details of weather conditions during spray application and accuracy of spray delivery are given in Tables 4-6.

Experimental design

Each plot consisted of 6 bushes. Treatments were replicated five times in a randomised block design. All treatments were randomised apart from Treatment 3 where the plots were the same as in 2018.

Assessments

<u>*Meteorological records*</u>

Records of daily maximum and minimum temperature and rainfall were taken from a weather station located adjacent to the trial block at NIAB EMR (Fig. A1 appendix).

Growth stages at application

The phenological stage using the BBCH scale (Meier,2001) was recorded at application and assessment times (Tables 2 and 3).

Phytotoxicity

Symptoms of phytotoxicity were checked for after each treatment and recorded. Records taken were any chlorosis / necrosis to foliage, growth regulatory effects to shoots, assessed on a scale 0-5. (EPPO Guideline PP 1/135(4)).

Phytotoxicity scale: 0 = No symptoms, 1 = 1-5% leaves very slight, 2 = 6-10% leaves slight,

3 = 11-25% leaves moderate, 4 = 26-50% leaves high, 5 = >50% leaves very high

Fruit set

Fruit set was recorded by marking 5 branches in each plot and counting the number of flowers present (9 May Ben Hope, 15 May Ben Tirran) followed by number of green fruit in June (4 June Ben Hope, 11 June Ben Tirran).

Botrytis

The incidence of botrytis on flowers was assessed soon after flowering on 5 branches per plot by recording the total number of flowers and the number with botrytis.

Latent fruit infection was assessed by sampling 50 green fruit per plot (4 June Ben Hope, 11 June Ben Tirran). The fruit were surface sterilised in sodium hypochlorite, rinsed in sterile water, dried and plated onto paraquat agar and incubated under UV light for one month. Numbers of fruit infected with botrytis were recorded after 4 weeks.

Plots were also assessed at harvest for visible botrytis on fruit by counting all the berries on at least 5 branches per plot and recording the number with botrytis.

Other diseases

Assessments were also made for other diseases (e.g. leaf spot, rust) as needed.

Harvest

At harvest (18 July Ben Hope, 26 July Ben Tirran), 300 berry fruit samples were collected from each plot, weighed (to give a measure of fruit size) and then incubated post-harvest in high humidity in polythene-covered plastic trays at ambient temperature (approximately

20°C) to encourage development of botrytis rot if present. Numbers of botrytis-rotted fruit were recorded after 7 and 14 days. Other fungal rots present were also recorded.

Yield

Yield was assessed by comparing plots visually and scoring compared to the untreated control.

Statistical analysis

The data were analysed using ANOVA. All percentage figures were transformed to the angular scale before analysis.

Table 1. Products evaluated in Blackcurrant Botrytis trial at NIAB EMR in 2018

Treatment	Product	Active ingredient	Product rate per ha	Timing
1	Untreated control	-	-	-
2	Signum Switch Teldor	pyraclostrobin + boscalid cyprodinil + fludioxonil fenhexamid	1.5 kg 1.0 kg 1.5 kg	3 sprays at 7-10 day intervals from 1st open flower
3	AHDB9916 2nd year	flavonoids	300 ml 300 ml 400 ml 400 ml	1 Grape stage 2 + 18-21 days 3 + 18-21 days 4 + 18-21 days Maximum of 4 sprays
4	AHDB9916 1st year	flavonoids	300 ml 300 ml 400 ml 400 ml	1 Grape stage 2 + 18-21 days 3 + 18-21 days 4 + 18-21 days Maximum of 4 sprays
5	AHDB9916 + Wetcit	flavonoids + alcohol ethoxylate	300 ml 300 ml 400 ml 400 ml + Wetcit at 0.2% with each spray	1 Grape stage 2 + 18-21 days 3 + 18-21 days 4 + 18-21 days Maximum of 4 sprays
6	AHDB9915	Blend of several organic compounds	2.5% concentration	First spray at grape stage 5 Sprays
7	AHDB9957	N/D	1 L	First spray at grape stage. 7-10 day intervals

Table 2. Treatment application dates in 2018 – Ben Hope

Trt No.	Treatment	Product / Timing/Growth stage									
		23 April BBCH55/56	**1 May BBCH60/61**	**8 May BBCH65**	**16 May BBCH72**	**22 May BBCH71/72**	**29 May BBCH72/73**	**6 June BBCH73/74**	**15 June BBCH 74/75**	**19 June BBCH 75/76**	**25 June BBCH 77/78**
1	-	-	-	-	-	-	-	-	-	-	-
2	Fungicides	-	Signum	Switch		Teldor					
3	AHDB9916	AHDB9916			AHDB9916			AHDB9916			AHDB9916
4	AHDB9916	AHDB9916			AHDB9916			AHDB9916			AHDB9916
5	AHDB9916 + Wetcit	AHDB9916 + Wetcit			AHDB9916 + Wetcit			AHDB9916 + Wetcit			AHDB9916 + Wetcit
6	AHDB9915	AHDB9915		AHDB9915		AHDB9915		AHDB9915		AHDB9915	
7	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957		AHDB9957	AHDB9957	AHDB9957

Table 3. Treatment application dates in 2018 – Ben Tirran

Treatment Number	Treatment	Product / Timing								
		1 May BBCH55	8 May BBCH61	16 May BBCH69	22 May BBCH67	29 May BBCH70	15 June BBCH72/73	19 June BBCH73/74	25 June BBCH 75/76	2 July BBCH 79
1	-	-	-	-	-	-	-	-	-	-
2	Fungicides	-	Signum	Switch		Teldor				
3	AHDB9916	AHDB9916			AHDB9916		AHDB9916			AHDB9916
4	AHDB9916	AHDB9916			AHDB9916		AHDB9916			AHDB9916
5	AHDB9916 + Wetcit	AHDB9916 + Wetcit			AHDB9916 + Wetcit		AHDB9916 + Wetcit			AHDB9916 + Wetcit
6	AHDB9915	AHDB9915		AHDB9915		AHDB9915	AHDB9915		AHDB9915	
7	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957

Table 4. Air temperature and humidity conditions at NIAB EMR at the time of spray applications – Ben Hope

Date	At start of spray applications					At end of spray applications					Weather conditions
	Time	Temp ºC			Wind speed (kmph) Direction	Time	Temp ºC			Wind speed (kmph) Direction	
		Dry bulb	Wet bulb	RH%			Dry bulb	Wet bulb	RH%		
23 April	14.45	15.0	14.0	89.8	3.9 S	16.05	13.5	13.0	94.6	1.8 SW	Overcast
1 May	10.20	14.5	12.0	74.7	2.8 W	11.50	12.5	10.5	78.3	4 SW	Sunny
8 May	11.00	21.0	19.0	82.8	1.9 S	11.53	22.0	20.5	87.3	1.5 S	Sunny
16 May	10.18	17.5	17.0	95.2	2 W	11.35	15.0	14.5	94.8	4 NW	70% Cloud
22 May	12.00	17.5	17.0	95.2	2.7 W	13.45	23.5	21.0	80.0	4 NW	Sunny
29 May	15.00	18.5	18.0	95.3	0.9 NE	16.15	20.0	20.0	100	1.1 NE	Overcast
6 June	9.50	14.0	13.5	94.7	3.8 NE	11.10	15.5	15.0	94.9	2.2 N	Overcast
15 June	9.25	15.0	14.0	89.8	0.5 NW	9.45	17.5	16.0	85.8	0	Overcast
19 June	10.12	20.0	19.0	91.0	2.0 SW	11.12	20.0	19.0	91.0	3 W	Overcast
25 June	9.50	22.0	19.5	79.3	0	11.00	23.5	19.5	68.8	1.6 SW	Sunny

Table 5. Air temperature and humidity conditions at NIAB EMR at the time of spray applications – Ben Tirran

Date	At start of spray applications					At end of spray applications					Weather conditions
	Time	Temp ºC			Wind speed (kmph) Direction	Time	Temp ºC			Wind speed (kmph) Direction	
		Dry bulb	Wet bulb	RH%			Dry bulb	Wet bulb	RH%		
1 May	10.20	14.5	12.0	74.7	2.8 W	11.50	12.5	10.5	78.3	4 SW	Sunny
8 May	11.00	21.0	19.0	82.8	1.9 S	11.53	22.0	20.5	87.3	1.5 S	Sunny
16 May	10.18	17.5	17.0	95.2	2 W	11.35	15.0	14.5	94.8	4 NW	70% Cloud
22 May	12.00	17.5	17.0	95.2	2.7 W	13.45	15.0	14.5	94.8	4 NW	70% Cloud
29 May	15.00	18.5	18.0	95.3	0.9 NE	16.15	20.0	20.0	100	1.1 NE	Overcast
15 June	8.35	15.0	14.0	89.8	0.5 NW	9.45	17.5	16.0	85.8	0	50% Cloud
19 June	10.12	20.0	19.0	91.0	2 SW	10.33	20.0	19.0	91.0	3 W	Overcast
25 June	11.00	23.5	19.5	68.8	1.6 SW	11.25	24.0	20.0	69.2	1.6 SW	Sunny
2 July	9.40	21.0	19.0	82.8	0.8 NE	10.30	22.0	20.0	83.3	2 NE	Sunny spells

Table 6. % accuracy of spray applications (volume applied / volume required expressed as a percentage) – Ben Hope and Ben Tirran

Spray date	Treatment number						
	1	2	3	4	5	6	7
Ben Hope							
23 April			113	110	105.7	100	108.8
1 May		108.8					115.5
8 May		106.6				104	112
16 May			111	111	113		106.6
22 May		93				91	102
29 May							107.7
6 June			99	99	100	96	
15 June							97
19 June						96	104
25 June			84.4	97.7	100		106.6
Ben Tirran							
1 May			116	116	122	115.5	115.5
8 May		111					112
16 May		111				106.6	106.6
22 May			107	107	102		102
29 May		100				102	107.7
15 June			107	107	100	100	97
19 June							104
25 June						100	106.6
2 July			104	104	102		104

Results

Treatment and weather

Rainfall for the 7 days before treatment and the 14 days following are shown in Tables 7 and 8. For both cultivars the weather during the flowering period was relatively wet and should have been favourable for the spread, infection and development of botrytis. However, June and July were hot and dry which was not conducive to the development of Botrytis in the fruit.

Phytotoxicity

There were no obvious phytotoxic effects of the treatments observed on leaves or fruit.

Fruit set

Fruit set for Ben Hope and Ben Tirran is shown in Table 9. Fruit set in Ben Tirran was higher than that in Ben Hope. There were no significant effects of treatments on fruit set.

Table 7. Rainfall and rain days recorded before and after the treatment periods in 2018 for Ben Hope

Treatment timing / spray date	Rainfall (mm) in 7 days before treatment	No. of rain days in 7 days before treatment	Rainfall (mm) in 14 days after treatment	No. of rain days in 14 days after treatment
23 April	0.2	1	49.6	7
1 May	45.8	5	13.0	4
8 May	3.8	2	9.4	3
16 May	9.2	2	25.2	5
22 May	0	0	25.2	6
29 May	13.6	4	0.6	2
6 June	0.2	1	0.6	2
15 June	0.6	2	0	0
19 June	0.6	2	0	0
25 June	0	0	0	0

Table 8. Rainfall and rain days recorded before and after the treatment periods in 2018 for Ben Tirran

Treatment timing / spray date	Rainfall (mm) in 7 days before treatment	No. of rain days in 7 days before treatment	Rainfall (mm) in 14 days after treatment	No. of rain days in 14 days after treatment
1 May	45.8	5	13.0	4
8 May	3.8	2	9.4	3
16 May	9.2	2	25.2	5
22 May	0	0	25.2	6
29 May	13.6	4	0.6	2
15 June	0.6	2	0	0
19 June	0.6	2	0	0
25 June	0	0	0	0
2 July	0	0	0	0

Table 9. % fruit set for Ben Hope and Ben Tirran following treatment with different programmes of fungicides and natural elicitors at NIAB EMR in 2018 (Figures in parenthesis are back transformed data)

Treatment	Products	Ben Hope	Ben Tirran
1	Untreated	29.0 (23.6)	43.2 (46.8)
2	Signum Switch Teldor	29.9 (24.9)	43.8 (47.9)
3	AHDB9916 year 2	20.2 (11.9)	40.7 (42.6)
4	AHDB9916 Year 1	33.3 (30.2)	42.2 (45.2)
5	AHDB9916 Year 1 + Wetcit	31.5 (27.2)	41.9 (44.7)
6	AHDB9915	26.0 (19.2)	42.9 (46.4)
7	AHDB9957	30.1 (25.1)	49.7 (57.9)
	F Prob	0.392	0.802
	SED (24)	5.83	5.72
	LSD (p=0.05)	12.04	11.8

Yield and fruit size

There were no obvious differences in yield between plots, assessed by a comparison of treated plots with the untreated, apart from Plot 14 in Ben Tirran where most bushes had died (reason unknown) and no harvest measurements were taken. Fruit size, measured as weight of 300 fruit (Table 10), was greater for Ben Tirran than Ben Hope. Reasons for the larger fruit size in Ben Tirran are not clear but a similar result was recorded in 2017. There were no significant effects of treatments on fruit size.

Disease

There was no botrytis observed on flowers or on fruit pre-harvest. The results for Ben Hope and Ben Tirran for latent botrytis in green fruit and botrytis and penicillium in post-harvest tests are shown in Tables 11 and 12. The incidence of botrytis was very low for both cultivars in green fruit and in post-harvest tests. There was no significant effect of treatment on botrytis incidence in green fruit or on botrytis in post-harvest tests. The incidence of penicillium in post-harvest tests was also low with no significant effects of treatments. Despite the low incidence of botrytis in green fruit, in both Ben Hope and BenTirran only around 30% of the fruit were healthy. The predominant fungus present was an unidentified saprophytic fungus, which was also present in the post-harvest tests.

Table 10. Weight of 300 fruit at harvest for Ben Hope and Ben Tirran following treatment with different programmes of fungicides and natural elicitors at NIAB EMR in 2018

Treatment	Products	Ben Hope	Ben Tirran
1	Untreated	131.1	211.1
2	Signum Switch Teldor	138.7	184.0
3	AHDB9916 year 2	129.9	210.8
4	AHDB9916 Year 1	146.1	211.6
5	AHDB9916 Year 1 + Wetcit	140.3	222.6
6	AHDB9915	135.6	184.6
7	AHDB9957	138.0	213.8
	F Prob	0.324	0.100
	SED (24)	7.04	14.87
	LSD (p=0.05)	14.53	30.77

Table 11. % Fruit botrytis recorded in green fruit and botrytis and penicillium rot in fruit in post-harvest tests for Ben Hope following treatment with different programmes of fungicides and natural elicitors at NIAB EMR in 2018. (Figures in parenthesis are back transformed data)

Treatment	Products	Green fruit % Botrytis	Green Fruit % Healthy	Post-harvest % Botrytis	Post-harvest % Penicillium
1	Untreated	8.9 (2.4)	34.6 (32.2)	4.2 (0.6)	7.5 (1.7)
2	Signum Switch Teldor	6.2 (1.2)	34.6 (32.2)	1.2 (0.04)	8.0 (1.9)
3	AHDB9916 year 2	4.9 (0.7)	33.9 (31.2)	2.0 (0.1)	11.4 (3.9)
4	AHDB9916 Year 1	3.3 (0.3)	35.1 (33.0)	2.3 (0.2)	10.7 (3.4)
5	AHDB9916 Year 1 + Wetcit	7.3 (1.6)	30.7 (26.0)	1.2 (0.04)	9.2 (2.6)
6	AHDB9915	5.6 (0.9)	31.3 (27.0)	0.7 (0.01)	12.6 (4.7)
7	AHDB9957	4.9 (0.7)	36.8 (35.9)	2.3 (0.2)	11.8 (4.2)
	F Prob	0.711	0.862	0.552	0.754
	SED (24)	3.31	4.74	1.83	3.69
	LSD (p=0.05)	6.83	9.78	3.77	7.61

Table12. % Fruit botrytis recorded in green fruit and botrytis and penicillium rot in fruit in post-harvest tests for Ben Tirran following treatment with different programmes of fungicides and natural elicitors at NIAB EMR in 2018. (Figures in parenthesis are back transformed data)

Treatment	Products	Green fruit % Botrytis	Green Fruit % Healthy Fruit	Post-harvest % Botrytis	Post-harvest % Penicillium
1	Untreated	5.6 (0.9)	34.8 (32.5)	9.9 (3.0)	10.7 (3.4)
2	Signum Switch Teldor	8.4 (2.1)	33.8 (30.9)	9.4 (2.7)	14.4 (6.2)
3	AHDB9916 year 2	6.2 (1.2)	36.4 (35.1)	5.1 (0.8)	10.4 (3.3)
4	AHDB9916 Year 1	6.2 (1.2)	37.3 (36.8)	7.0 (1.5)	16.0 (7.6)
5	AHDB9916 Year 1 + Wetcit	6.8 (1.4)	36.8 (35.8)	7.4 (1.7)	12.7 (4.8)
6	AHDB9915	3.9 (0.5)	33.5 (30.5)	7.7 (1.8)	9.0 (2.4)
7	AHDB9957	11.4 (3.9)	32.0 (28.0)	7.8 (1.9)	9.5 (2.7)
	F Prob	0.512	0.946	0.684	0.300
	SED (24)	3.54	5.37	2.77	3.28
	LSD (p=0.05)	7.31	11.08	5.74	6.79

Site 2 – Rosemary Farm, Flimwell, Kent

Materials and methods

Site location

The blackcurrant plantation is a commercial planting of cv Ben Tirran located at Rosemary Farm, Rosemary Lane, Flimwell, Kent, TN5 7PT (Latitude 51.072 N, Longitude 0.411721 W) by kind permission of Peter and Michael Reeves.

Experimental treatments

All plots received a standard programme for pest and disease as required up to the start of the trial. Treatments started in April at Grape stage (BBCH56/57). Treatments in Table 1 were applied to the plots. Treatments for pests were applied to all plots. Each treatment was applied according to schedule in Table 13 and shown in Table 14.

Table 13 Details of products evaluated in the trial at Rosemary Farm in 2018

Treatment	Product	Active ingredient	Product rate per ha -	Timing
1	Untreated control	-	-	
2	Signum Switch Teldor	pyraclostrobin + boscalid cyprodinil + fludioxonil fenhexamid	1.5 kg 1.0 kg 1.5 kg	3 sprays at 7-10 day intervals from 1st open flower
3	AHDB9916	flavonoids	300 ml 300 ml 400 ml 400 ml	1 Grape stage 2 + 18-21 days 3 + 18-21 days 4 + 18-21 days Maximum of 4 sprays
4	AHDB9916 + Fungicide programme as in treatment 2	flavonoids + pyraclostrobin + boscalid cyprodinil + fludioxonil fenhexamid	300 ml 300 ml 400 ml 400 ml 1.5 kg 1.0 kg 1.5 kg	1 Grape stage 2 + 18-21 days 3 + 18-21 days 4 + 18-21 days Maximum of 4 sprays 3 sprays at 7-10 day intervals from 1st open flower

Spray application

All treatments were applied using a Birchmeier motorised knapsack sprayer at 500 L/ha following EMR SOP GEP 725. Details of weather conditions during spray application and accuracy of spray delivery are given in Tables 15 and 16.

Experimental design

Each plot consisted of 6 bushes, separated in the row by two bushes. Treatments were replicated four times in a randomised block design

Assessments

Meteorological records

Records of daily maximum and minimum temperature and rainfall were taken from a weather station located at Lamberhurst, located two miles east of the trial. Rain fall is given in Fig. A2 in the appendix.

Growth stages at application

The phenological stage using the BBCH scale (Meier,2001) was recorded at application and assessment times (Table 14).

Phytotoxicity

Symptoms of phytotoxicity were checked for after each treatment and recorded. Records taken were any chlorosis / necrosis to foliage, growth regulatory effects to shoots, assessed on a scale 0-5. (EPPO Guideline PP 1/135(4)).

Phytotoxicity scale: 0 = No symptoms, 1 = 1-5% leaves very slight, 2 = 6-10% leaves slight,

3 = 11-25% leaves moderate, 4 = 26-50% leaves high, 5 = >50% leaves very high

Fruit set

Fruit set was recorded by marking 5 branches in each plot and counting the number of flowers present on 16 May, followed by number of green fruit on June 15.

Botrytis

The incidence of botrytis on flowers was assessed soon after flowering on 5 branches per plot by recording the total number of flowers and the number with botrytis.

Latent fruit infection was assessed by sampling 50 green fruit per plot on 15 June. The fruit were surface sterilised in sodium hypochlorite, rinsed in sterile water, dried and plated onto paraquat agar and incubated under UV light for one month. Numbers of fruit infected with botrytis were recorded after 4 weeks on 28 June.

Plots were also assessed at harvest for visible botrytis on fruit by counting all the berries on at least 5 branches per plot and recording the number with botrytis.

Other diseases

Assessments were also made for other diseases (e.g. leaf spot, rust) as needed.

Harvest

At harvest on 24 July, 300 berry fruit samples were collected from each plot, weighed (to give a measure of fruit size) and then incubated post-harvest in high humidity in polythene-covered plastic trays at ambient temperature (approximately 20°C) to encourage development of botrytis rot if present. Numbers of botrytis-rotted fruit were recorded after 7 and 14 days. Other fungal rots present were also recorded.

Statistical analysis

The data were analysed using ANOVA. All percentage figures were transformed to the angular scale before analysis.

Results

Treatment and weather

Rainfall for the 7 days before treatment and the 14 days following is shown in Table 17. The weather during the flowering period was relatively wet and should have been favourable for the spread, infection and development of botrytis. However, June (3.4 mm rain) and July (9 mm rain from 1-27 July) were hot and dry which was not conducive to the development of Botrytis in the fruit.

Phytotoxicity

There were no obvious phytotoxic effects of the treatments observed on leaves or fruit.

Fruit set

Fruit set for Ben Tirran is shown in Table 18. The lowest fruit set was recorded in untreated plots but there was no significant effect of treatments on fruit set.

Table 14. Treatment application dates in 2018 on Ben Tirran at Rosemary Farm

Treatment Number	Treatment	Product / Timing						
		1 May BBCH55	**8 May BBCH61**	**16 May BBCH69**	**22 May BBCH67**	**1 June BBCH69**	**14 June BBCH72/73**	**2 July BBCH 79**
1	-	-	-	-	-	-	-	-
2	Fungicides	-	Signum	Switch		Teldor		
3	AHDB9916	AHDB9916			AHDB9916		AHDB9916	AHDB9916
4	AHDB9916 + Fungicides	AHDB9916	Signum	Switch	AHDB9916	Teldor	AHDB9916	AHDB9916

Table 15. Air temperature and humidity conditions at the time of spray applications – Ben Tirran

Date	At start of spray applications					At end of spray applications					Weather conditions
	Time	Temp ºC			Wind speed (kmph) Direction	Time	Temp ºC			Wind speed (kmph) Direction	
		Dry bulb	Wet bulb	RH%			Dry bulb	Wet bulb	RH%		
1 May	9.00	10.0	10.0	100	1.1 S	9.15	10.0	10.0	100	0.6 S	Sunny spells
8 May	9.40	18.5	17.0	86.2	1.3 S	10.05	19.0	18.0	90.8	1.0 S	Sunny
16 May	9.00	13.5	13.5	100	0.7 N	9.07	13.5	13.5	100	0.7 N	Sunny Spells
22 May	9.45	14.5	14.0	94.8	1.0 SW	10.00	14.5	14.0	94.8	0	Sunny
1 June	7.50	15.5	15.5	100	0	8.05	16.0	16.0	100	1.1 S	Overcast
14 June	9.45	14.0	14.0	100	1.9 SW	10.00	14.0	14.0	100	3.9 SW	Overcast
2 July	11.40	21.0	20.0	91.3	1.5 SW	12.05	21.5	20.0	87.2	1.0 SW	Sunny spells

Table 16. % accuracy of spray applications (volume applied / volume required expressed as a percentage) – Ben Tirran

Spray date	Treatment number		
	2	3	4
1 May		111	111
8 May	113		113
16 May	116.6		116.6
22 May		105.5	105.5
1 June	104		104
14 June		100	100
2 July		111	111

Table 17. Rainfall and rain days recorded before and after the treatment periods in 2018 for Ben Tirran. Weather data from Lamberhurst

Treatment timing / spray date	Rainfall (mm) in 7 days before treatment	No. of rain days in 7 days before treatment	Rainfall (mm) in 14 days after treatment	No. of rain days in 14 days after treatment
1 May	34.4	7	16.2	3
8 May	6.6	1	15.6	4
16 May	9.6	2	37.6	8
22 May	1.8	1	35.0	8
1 June	23.2	5	2.4	2
14 June	2.4	7	1.0	3
2 July	0.6	1	6.8	1

Yield and fruit size

There were no obvious differences in yield between plots, assessed by a comparison of treated plots with the untreated. The lowest fruit size, measured as weight of 300 fruit (Table 19), was recorded in untreated plots but there were no significant effects of treatments on fruit size.

Disease

There was no botrytis observed on flowers or on fruit pre-harvest. The results for latent botrytis in green fruit and botrytis and penicillium in post-harvest tests are shown in Table 20. The incidence of botrytis was very low in green fruit, but least in fruit from plots treated with Cultigrow. Similarly, in post-harvest tests, botrytis incidence was very low. The lowest incidence was recorded in fruit from Cultigrow only treated plots (Treatment 3). The highest incidence was in fruit from plots receiving the routine fungicide programme. The incidence of penicillium in post-harvest tests was also low with no significant effects of treatments.

Table 18. % Fruit set Ben Tirran following treatment with different programmes of fungicides and natural elicitors at Rosemary Farm in 2018 (Figures in parenthesis are back transformed data)

Treatment	Products	Ben Tirran
1	Untreated	50.1 (58.9)
2	Signum Switch Teldor	54.2 (65.9)
3	AHDB9916	56.4 (69.4)
4	AHDB9916 + Signum Switch Teldor	55.2 (67.5)
	F Prob	0.314
	SED (9)	3.30
	LSD (p=0.05)	7.46

Table 19. Weight 300 fruit at harvest of Ben Tirran following treatment with different programmes of fungicides and natural elicitors at Rosemary Farm in 2018

Treatment	Products	Ben Tirran
1	Untreated	222.6
2	Signum Switch Teldor	259.8
3	AHDB9916	254.4
4	AHDB9916 + Signum Switch Teldor	252.0
	F Prob	0.276
	SED (9)	19.21
	LSD (p=0.05)	43.46

Table 20. % Botrytis recorded in green fruit and botrytis and penicillium rot in fruit in post-harvest tests for Ben Tirran following treatment with different programmes of fungicides and natural elicitors at Rosemary Farm in 2018. (Figures in parenthesis are back transformed data)

Treatment	Products	Green fruit % Botrytis	Green Fruit % Healthy	Post-harvest % Botrytis	Post-harvest % Penicillium
1	Untreated	7.0 (1.5)	54.0 (65.4)	4.3 (0.6) ab	15.4 (7.1)
2	Signum Switch Teldor	8.1 (2.0)	49.7 (58.1)	11.8 (4.2) c	18.1 (9.6)
3	AHDB9916	2.0 (0.1)	46.6 (52.7)	1.2 (0.04) a	19.9 (11.6)
4	AHDB9916 + Signum Switch Teldor	2.9 (0.3)	60.5 (75.8)	8.8 (2.3) bc	20.3 (12.0)
	F Prob	0.143	0.094	0.041	0.506
	SED (9)	2.79	5.01	3.26	3.45
	LSD (p=0.05)	6.30	11.32	7.37	7.79

Overall discussion

There were sufficient cold days during winter to satisfy the winter chill requirements for both cultivars in the trials. Flowering of the cultivars in the trial was therefore as expected. A low incidence of botrytis inoculum on mummified fruit was present in the trial plots at NIAB EMR prior to flowering. Similarly, at the Rosemary Farm site there was a botrytis problem at harvest reported in 2018 and inoculum present in the trial plots at flowering. Weather during flowering was wet and conducive to botrytis infection. Therefore, it is difficult to understand the low incidence of botrytis in the green fruit samples at both sites. Subsequent weather in June and July was hot and dry and not conducive to the development and spread of botrytis in fruit. Hence, the incidence of botrytis in post-harvest tests in fruit from both sites was very low. There were no significant effects of treatments on botrytis incidence in post-harvest tests on both cultivars at NIAB EMR, but at the Rosemary Farm site fruit from the AHDB9916-treated plots had significantly less botrytis than in the routing fungicide-treated plots. However, the incidence of botrytis was so low it is difficult place any importance on this result, apart from the fact it repeats that from the earlier trial. There were no significant effects of treatments on any of the other parameters measured at either of the two trial sites.

Over the two years of the project there have been various difficulties such as lack of winter chilling and issues with Spotted Wing Drosophila in 2017 and hot dry weather in the summer in 2018 which have impacted on the trial and prevented any meaningful results. There is a hint from the trial at Rosemary Farm that supports the result from 2013 where the use of AHDB9916 was as effective as the standard fungicide programme in reducing botrytis fruit rot. Without further trials data it is not possible to draw any firm conclusions.

Conclusions

- The weather was wet and favourable during flowering at both sites for infection and spread of botrytis
- Despite this no botrytis was seen in flowers and the incidence of botrytis in green fruit was very low
- The weather in June and July was hot and dry and not favourable for botrytis spread and development. Botrytis incidence in fruit pre-harvest and in post-harvest tests was also low at both sites
- At the Rosemary Farm site there was significantly less botrytis in fruit from AHDB9916 only treated plots compared to the standard fungicide plots. However, little importance can be placed on this result because of the low incidence of botrytis
- There was no effect of treatments on fruit set and fruit size at either site

- There were no obvious effects of treatments on yield
- Unfortunately, the low incidence of botrytis in the fruit at both sites makes it impossible to come to any firm conclusions on the effect of alternative treatments on botrytis fruit rot.

Knowledge and Technology Transfer

The results of the trials from 2017 and 2018 were reported to the AHDB Blackcurrant Research Committee in November 2017 and 2018.

Acknowledgements

Thanks to AHDB for funding the work, to Peter and Michael Reeves for providing a trial site and to the trials team, Tom Passey, Jennifer Kingsnorth, Sarah Cohen and Joyce Robinson at NIAB EMR for assistance with the trials

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Appendix

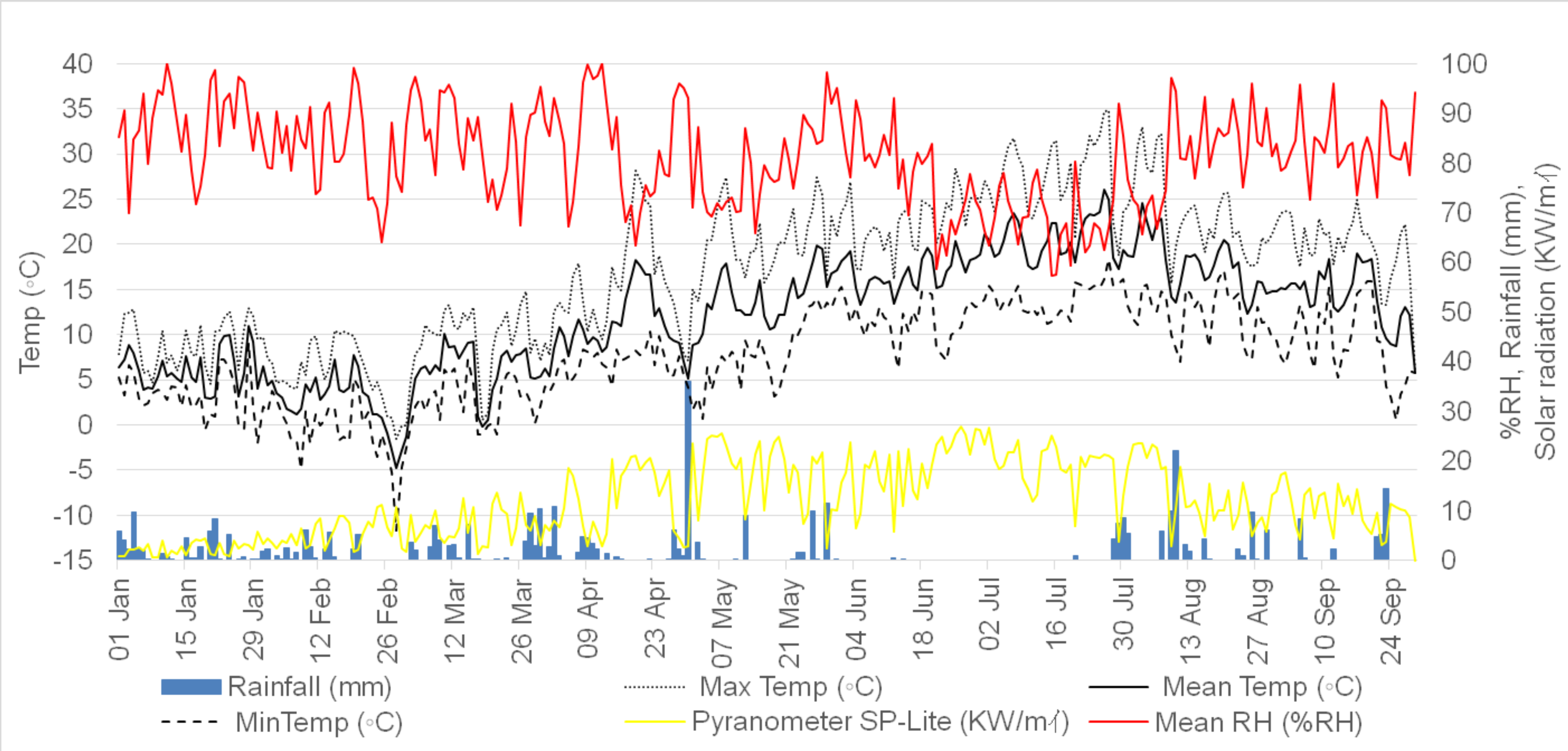

Fig. A1 Weather data 1 January – 30 September NIAB EMR 2018

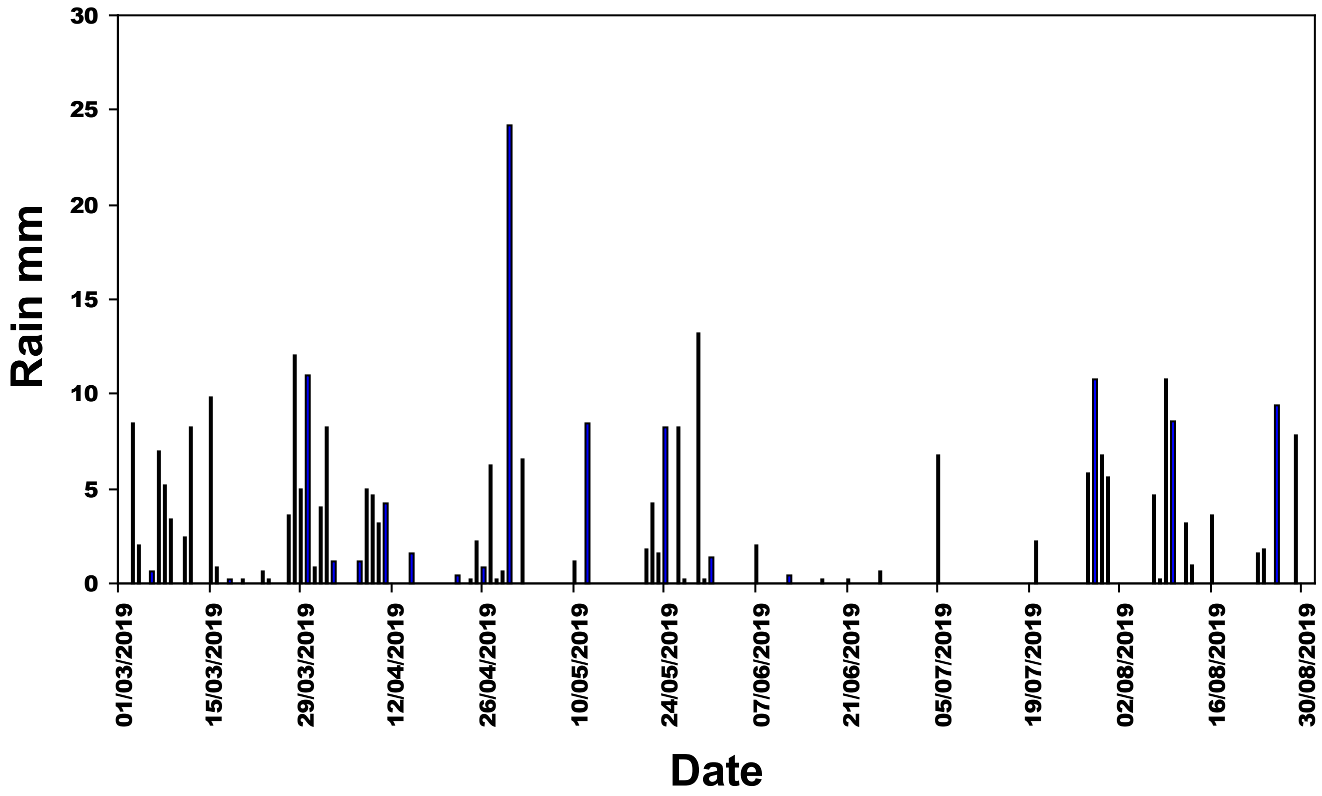

Fig. A2 Rainfall mm for Lamberhurst, Kent March-August 2018

AHDB Blackcurrant Botrytis Ben Hope 2018 ORETO 18/007 NIAB EMR

Plot	Block	Treatment	% Fruit Set	Wt 300 Fruit g	Green fruit % Bot	% Healthy	% Botrytis Post harv	% Pen Post harv
15	1	3	7.4	113.35	0	42	0	2
16	1	5	39.2	122.62	2	18	0	0.33
17	1	1	20.8	112.27	6	28	0	5.7
18	1	6	33.9	128.55	0	40	0	8.3
19	1	2	20.5	116.47	4	34	0	0.33
20	1	4	22.6	127.35	0	32	0	3.3
21	1	7	13.5	139.07	2	28	0	4.7
22	2	1	31.1	130.48	0	48	3	3.7
23	2	4	29	140.57	0	30	0.67	2
24	2	7	30	133.29	0	26	0.33	3
25	2	3	6.8	116.33	0	34	0	22.3
26	2	6	23.1	160.89	0	22	0	12.3
27	2	5	11.3	149.92	0	32	0	8
28	2	2	47.2	146.22	4	24	0	1.3
29	3	1	46	127.73	2	30	0	0.67
30	3	5	53.8	140.57	6	32	1	4.7
31	3	3	27.9	125.54	2	16	1.3	1.7
32	3	4	31.8	154.09	2	44	0	1.3
33	3	6	14.4	111.52	4	24	0	0.33
34	3	7	45.1	126.96	0	76	0	10.7
35	3	2	17.4	128.25	0	36	0	5
57	4	2	22.7	151.42	2	24	0	1.3
58	4	4	55.4	165.28	0	36	0.33	4
59	4	7	17.2	159.69	2	34	2	1.7
60	4	1	5.1	144.02	2	32	1.3	0.67
61	4	3	13.1	159.98	2	30	0	1.7
62	4	6	7.6	139.19	2	26	0	7.3
63	4	5	38.8	162.29	6	16	0	0.33
64	5	7	23.4	130.84	2	18	0	3
65	5	1	22.6	141.18	6	24	0.67	0.33
66	5	4	15.6	143.08	2	24	0.33	8.3
67	5	6	21	137.95	2	24	0.33	1.3
68	5	3	8.5	134.42	2	36	0.33	1
69	5	5	5.2	126.25	0	34	0	3.3
70	5	2	19.4	151.02	0	44	1	3.3

AHDB Blackcurrant Botrytis Ben Tirran 2018 ORETO 18/007 NIAB EMR

Plot	Block	Treatment	% Fruit Set	Wt 300 Fruit g	Green fruit % Bot	% Healthy	% Botrytis Post harv	% Pen Post harv
1	1	1	69.8	188	0	30	4.3	9
2	1	4	50.4	181	0	38	1.3	10
3	1	3	43.9	180	2	44	0.33	6
4	1	5	26.1	223	4	34	0	5.3
5	1	7	50.7	174	4	12	1.67	9.3
6	1	2	45.6	164	2	26	1.67	6.67
7	1	6	34.5	196	2	14	1	1.67
8	2	2	39.5	143	2	36	0.67	3
9	2	6	72.7	164	0	46	1.67	3.3
10	2	7	50	223	4	36	1.67	0.33
11	2	4	42.8	215	2	28	1	6.33
12	2	3	20.6	200	0	32	2	1.67
13	2	5	20.7	206	2	44	0.67	2
14	2	1	41.5	*	2	30	*	*
36	3	6	49.3	159	0	18	1	1.5
37	3	7	62	226	6	14	0.67	6
38	3	3	55.3	226	4	34	0	7.33
39	3	1	50.8	244	2	22	4.67	2.33
40	3	4	28.4	176	4	14	0	1.33
41	3	5	64	219	0	52	0.67	1.67
42	3	2	67.9	198	6	10	8	17.3
43	4	7	72.7	218	2	50	2	0.67
44	4	4	53.9	244	4	64	1	9
45	4	5	60.4	227	6	16	4	14.3
46	4	6	31.8	154	0	56	1	3
47	4	3	53.7	234	0	30	1.67	3
48	4	1	35	207	4	34	2.33	5
49	4	2	26.6	211	4	36	5.67	3.67
50	5	4	51.2	242	0	44	8.33	15
51	5	7	53.4	228	4	34	4	1.67
52	5	5	54.8	238	0	36	7.67	4.67
53	5	2	60.4	204	0	52	0.67	4
54	5	1	36.9	218	0	48	1.67	1.33
55	5	3	41.2	214	4	36	1.33	0.67
56	5	6	43.4	250	4	24	5.67	3

AHDB Blackcurrant Botrytis Ben Tirran 2018 Rosemary Farm trial ORETO 18/008

					Green fruit		Post-Harvest	
			% Fruit	Wt 300	% Bot	% Healthy	% Botry	% Pen
Plot	Block	Treatment	Set	Fruit g				
1	1	3	67.5	276.83	2	38	0	6.7
2	1	2	70.9	271.28	2	42	2.3	5
3	1	1	43.6	190.83	8	48	1.3	1.7
4	1	4	74.2	246	4	84	2.3	13.3
5	2	2	64.2	256.48	2	62	1.3	14
6	2	4	58.8	262.76	0	68	1.3	21
7	2	3	73.8	243.88	0	42	0.67	9.7
8	2	1	65.8	234.89	0	76	0.67	15
9	3	1	61.3	188.99	4	74	1	17.7
10	3	3	72.3	259.55	0	74	0	19.3
11	3	4	68.8	263.76	0	90	2.3	10.3
12	3	2	60.9	258.25	2	68	2.7	14
13	4	4	67.7	235.41	0	56	3.7	5.7
14	4	1	64.5	275.72	0	62	0	1.3
15	4	3	63.5	237.42	0	56	0	12.3
16	4	2	67.2	253.28	2	60	14.7	7