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 17/008
Project leader:	Dr Angela M Berrie, NIAB EMR
Report:	Annual report, March 2018
Previous report:	None
Key staff:	Dr A M 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

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[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

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Professor Xiangming Xu

Head of Department, Pest & Pathogen Ecology

NIAB EMR

Signature .... Date ....

CONTENTS

GROWER SUMMARY

Headline

Several biostimulants have been assessed for their efficacy in controlling *Botrytis cinerea* in blackcurrant.

Background and expected deliverables

Blackcurrant production in the UK occupies an area of around 2,538 ha, producing a total tonnage of around 12,700 tonnes, which in 2014 had a value of £14.9 million (Defra Horticulture Statistics 2014). The majority of the crop is grown on contract for processing. Botrytis fruit rot (*Botrytis cinerea*) is by far the most important disease problem and 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 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 (biostimulant), 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 the product coded 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. 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 a replicated small plot trial the effect of several biostimulants on the botrytis incidence in flowers and fruit on cvs. Ben Hope and Ben Tirran, was compared to that in a standard fungicide programme and an untreated control in a blackcurrant plantation, located at NIAB EMR. AHDB9916, with or without the addition of the wetter Wetcit, was applied from pre-flowering at 3-4 week intervals, a total of three sprays. AHDB9915 was applied from pre-flowering at 2-week intervals, a total of six sprays and AHDB9957 was applied from pre-flowering at 7-10 day intervals, a total of six sprays. The standard fungicide treatment was applied from first flower at 7-10 day intervals, a total of three sprays. 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.

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. The trial will be repeated in 2018.

Financial benefits

Botrytis cinerea not only leads to fruit rot, but can infect blackcurrants during the flowering period, leading to 'run-off' or premature fruit drop. If severe infection is allowed to occur, up to 50% of the fruit can drop off the bushes. The total value of UK produced blackcurrants in 2014 was recorded at £14.9 million (Defra Horticultural Statistics 2014), so 50% crop loss would result in over £7 million of financial loss.

Any measures which can be developed to reduce the influence of Botrytis infection would therefore offer considerable financial benefits to the industry.

Action points for growers

- There are no actions resulting from this trial at this stage.

SCIENCE SECTION

Introduction

Blackcurrant production in the UK occupies an area of around 2,300 ha, producing a total tonnage of around 14,000 t, 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 and 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. Further trials are needed to properly assess the effect of AHDB9916 on fruit rots and other crop parameters and particularly consistency of performance and this was the purpose of the work reported here.

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 321)

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), 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 six 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. 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 Stihl SR 450 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 A2-A4 in the appendix.

Experimental design

Each plot consisted of six bushes. Treatments were replicated five 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 adjacent to the trial block at East Malling Research (Table A1 in the 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 five branches in each plot and counting the number of flowers present (10 May Ben Hope, 12 June Ben Tirran) followed by number of green fruit in June (15 June Ben Hope, 29 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 (13 June Ben Hope, 5 July 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 five 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 (20 July Ben Hope, 1 August 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^{o}C) to encourage development of botrytis rot if present. Numbers of botrytis-rotted fruit were recorded after 7 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 2017

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 + 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
5	AHDB9915	Blend of several organic compounds	2.5% concentration	First spray at grape stage 5 Sprays
6	AHDB9957	N/D	1 L	First spray at grape stage. 7-10 day intervals

Table 2. Treatment application dates in 2017 – Ben Hope

Treatment Number	Treatment	Product / Timing/Growth stage						
		18 April BBCH56/57	**26 April BBCH60/61**	**10 May BBCH65/67**	**16 May BBCH67**	**24 May BBCH71/72**	**6 June BBCH73/74**	**23 June BBCH79**
1	-	-	-	-	-	-	-	-
2	Fungicides	-	Signum	Switch		Teldor		
3	AHDB9916	AHDB9916			AHDB9916		AHDB9916	
4	AHDB9916 + Wetcit	AHDB9916 + Wetcit			AHDB9916 + Wetcit		AHDB9916 + Wetcit	
5	AHDB9915	AHDB9915		AHDB9915		AHDB9915	AHDB9915	AHDB9915
6	AHDB9957	AHDB9957		AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957

Table 3. Treatment application dates in 2017 – Ben Tirran

Treatment Number	Treatment	Product / Timing						
		9 May BBCH56/57	**16 May BBCH60/61**	**30 May BBCH65**	**7 June BBCH67**	**16 June BBCH72**	**28 June BBCH80/81**	**17 July BBCH82**
1	-	-	-	-	-	-	-	-
2	Fungicides	-	Signum	Switch		Teldor		
3	AHDB9916	AHDB9916			AHDB9916		AHDB9916	
4	AHDB9916 + Wetcit	AHDB9916 + Wetcit			AHDB9916 + Wetcit		AHDB9916 + Wetcit	
5	AHDB9915	AHDB9915		AHDB9915		AHDB9915	AHDB9915	AHDB9915
6	AHDB9957	AHDB9957		AHDB9957	AHDB9957	AHDB9957	AHDB9957	AHDB9957

Results

Treatment and weather

Rainfall for the 7 days before treatment and the 14 days following are shown in Tables 4 and 5. The flowering period is highlighted in yellow. 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.

Of greater significance was frost which occurred on 20 April, 25 April, 27 April and 10 May (Appendix Table A1), the latter three during the flowering period of Ben Hope. Consequently a proportion of the Ben Hope flowers were frosted and failed to set a crop, which accounts for the low fruit set (Table 6) recorded for Ben Hope compared to Ben Tirran.

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 6. Fruit set in Ben Tirran was twice that in Ben Hope, most likely due to the frost which occurred during the flowering period of Ben Hope. There were no significant effects of treatments on fruit set.

Table 4. Rainfall and rain days recorded before and after the treatment periods in 2017 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
18 April	0	0	3.4	6
26 April	1.2	3	6.0	4
10 May	4.0	2	50.0	7
16 May	6.2	4	44.2	4
22 May	44.4	4	18.4	3
6 June	2.6	1	28.8	4
23 June	0	0	5.2	3

Table 5. Rainfall and rain days recorded before and after the treatment periods in 2017 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
9 May	4.0	2	50.0	7
16 May	6.2	4	44.2	5
30 May	0.4	1	31.4	5
7 June	18.0	2	13.4	3
16 June	9.2	2	5.2	3
28 June	0.6	1	35.6	3
12 July	0	0	63.0	8

Table 6. % 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	29.2 (23.8)	45.0 (50.0)
2	Signum Switch Teldor	27.1 (20.7)	48.9 (56.9)
3	AHDB9916	28.6 (22.9)	44.1 (48.4)
4	AHDB9916 + Wetcit	26.5 (19.9)	40.8 (42.7)
5	AHDB9915	25.7 (18.8)	47.9 (55.1)
6	AHDB9957	27.9 (21.9)	48.3 (55.8)
	F Prob	0.805	0.114
	SED (20)	2.801	3.098
	LSD (p=0.05)	5.843	6.463

Yield and fruit size

Yield was not recorded due to the frost damage. Fruit size (Table 7), measured as weight of 300 fruit, was greater for Ben Tirran than Ben Hope. Reasons for the larger fruit size in Ben Tirran are not clear, but may be related to frost damage. 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 8 and 9. Botrytis was recorded in 24-37% of the Ben Hope green fruit in the plate tests, but only at low incidence (5% or less) 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 the plate tests and in post-harvest tests was low with no significant effects of treatments (Table 8). The incidence of botrytis in Ben Tirran green fruit was much higher (60-80%) with significantly less recorded in fruit from fungicide-treated plots (Table 9). In the post-harvest tests, significantly less botrytis rot was recorded in Treatment 2 (fungicide only) and Treatment 3 (AHDB9916) than in the untreated control. However, this result must be treated with caution as the incidence of botrytis was very low (1-5%). The incidence of penicillium rot was also low in both the plate tests and post-harvest tests with no significant effect of treatments.

Table 7. 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	224.8
2	Signum Switch Teldor	147	230.2
3	AHDB9916	140	217.6
4	AHDB9916 + Wetcit	158	220.0
5	AHDB9915	144	218.8
6	AHDB9957	129	232.4
	F Prob	0.157	0.829
	SED (20)	11.306	13.571
	LSD (p=0.05)	23.585	28.308

Table 8. % 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	Post-harvest % Botrytis	Post-harvest % Penicillium
1	Untreated	34.2 (31.7)	11.4 (3.9)	6.8 (1.4)
2	Signum Switch Teldor	30.0 (25.0)	13.0 (5.1)	7.5 (1.7)
3	AHDB9916	37.2 (36.5)	13.6 (5.5)	7.7 (1.8)
4	AHDB9916 + Wetcit	32.5 (28.8)	13.7 (5.6)	6.3 (1.2)
5	AHDB9915	30.2 (25.3)	13.2 (5.2)	6.3 (1.2)
6	AHDB9957	29.4 (24.2)	11.3 (3.8)	10.8 (3.5)
	F Prob	0.914	0.955	0.387
	SED (20)	7.948	3.331	2.260
	LSD (p=0.05)	16.580	6.948	4.714

Table 9. % 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	Post-harvest % Botrytis	Post-harvest % Penicillium
1	Untreated	62.4 (78.5) b	12.2 (4.5) c	13.6 (5.5)
2	Signum Switch Teldor	51.5 (61.2) a	5.7 (1.0) a	13.6 (5.5)
3	AHDB9916	59.9 (74.8) b	5.5 (0.9) a	12.9 (5.0)
4	AHDB9916 + Wetcit	59.5 (74.2) b	10.1 (3.1) bc	19.2 (10.8)
5	AHDB9915	63.1 (79.6) b	7.0 (1.5) ab	16.5 (8.0)
6	AHDB9957	60.5 (75.8) b	10.4 (3.3) bc	14.9 (6.6)
	F Prob	0.011	0.007	0.587
	SED (20)	2.952	1.856	3.839
	LSD (p=0.05)	6.157	3.871	8.008

Figures with different letters are significantly different

Discussion

There were several practical issues with this trial such as problems with weed control and no spring fertiliser application which had an impact on the performance of the bushes in the trial plots. However, the greatest issues were the late frosts in April and May during the flowering period of Ben Hope which considerably reduced fruit set and the lack of winter chill which affected the performance of the Ben Tirran. Despite the favourable weather during flowering and fruit development for botrytis infection and spread, the actual incidence of botrytis fruit rot, especially in the post-harvest tests was low which made the results, particulary in Ben Tirran, difficult to interpret. In the latter both the fungicide programme (Treatment 2) and AHDB9916 (Treatment 3) significantly reduced botrytis in post-harvest tests compared to that in fruit from untreated plots. However, the incidence of botrytis in Treatment 4 (AHDB9916 + Wetcit) was double that in Treatment 3 where the same product was used. The post-harvest tests for Ben Tirran were also affected by an infestation of spotted wing Drosophila. This had an effect of causing fruit collapse with excessive juice production which resulted in poor expression of botrytis due to the excessive moisture present. The results from this trial should there be treated with caution. The trial will be repeated in 2018.

Conclusions

For the reasons given in the discussion, it is difficult to draw any meaningful conclusions from this trial.

Knowledge and Technology Transfer

The project is at an early stage and no technology transfer has been undertaken.

References

Jorg, E., Harzer, U. & Ollig, W. 2003: Control of *Botrytis* grey mould on raspberry and red currant. IOBC-WPRS Bull. 26(2): 153-160.

McNicol, R. J. & Williamson, B. 1989: Systemic infection of black currant flowers by *Botrytis cinerea* and its possible involvement in premature abscission of fruits. Annals Applied Biology 114: 243-254.

Meier, U. 2001: Growth stages of mono and dicotyledonous plants. BBCH Monograph. Edited by Uwe Meier, Federal Biological Research Centre for Agriculture.

Walter, M., Obanor, F. O., Smith, J., Ford, C., Boyd-Wilson, K., Harris-Virgin, P. & Langford, G. I. 2007: Timing of fungicide application for *Botrytis cinerea* control in blackcurrant (*Ribes nigrum*). New Zealand Plant Protection 60: 114-122.

Xu, X.-M., Robinson, J. D. & Berrie, A. M. 2009: Infection of blackcurrant flowers and fruits by *Botrytis cinerea* in relation to weather conditions and fruit age. Crop Protection 28: 407-413.

Appendix

Table A1. Weather data East Malling Research 1 March to 31 October 2017

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL	RH_PERCENT
04/03/2017	10.1	6.4	1.6	89
05/03/2017	11.1	4.9	1.8	77
06/03/2017	10.6	3	5.4	83
07/03/2017	10.6	5.2	0	74
08/03/2017	11.7	4.8	1.4	79
09/03/2017	14.1	9.1	0.4	87
10/03/2017	16.3	2.3	0	72
11/03/2017	11	4.4	0	91
12/03/2017	16.3	5.9	0	84
13/03/2017	13.2	7.2	0	78
14/03/2017	14.8	4.2	0	73
16/03/2017	18	3.3	0	80
17/03/2017	16.1	4.5	0	74
18/03/2017	12.4	7.8	0	73
19/03/2017	15.2	11.5	0	78
20/03/2017	15.5	10.3	0.6	80
21/03/2017	13.4	4.3	1.2	83
22/03/2017	11.5	4.4	0	65
23/03/2017	8.3	5.6	20.6	90
24/03/2017	9.9	7.8	0	82
25/03/2017	9.8	4.9	0	86
26/03/2017	11.9	6	0	69
27/03/2017	12.9	6.4	0	83
28/03/2017	12.3	3.5	0	89
29/03/2017	17.4	9.9	0.2	78
30/03/2017	15.8	10.1	0	79
31/03/2017	20.9	7.2	0	68
01/04/2017	16	7.1	0	77
02/04/2017	15.7	5	1.4	82
03/04/2017	16.3	3.1	0	82
04/04/2017	16.5	6.3	0.4	82
05/04/2017	15.1	6	0.2	79
06/04/2017	14.4	3.4	0	67
07/04/2017	17.1	2.6	0	72
08/04/2017	17.7	4.2	0	79
09/04/2017	18.8	4.2	0	78
10/04/2017	23.4	8.7	0	60
11/04/2017	14.5	3.8	0	60
12/04/2017	15.5	3.7	0	69

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL	RH_PERCENT
13/04/2017	16.8	5.7	0	63
14/04/2017	14.4	3.8	0	62
15/04/2017	14.9	9.9	0	67
16/04/2017	14.4	5.8	0	56
17/04/2017	14.4	7.6	0	67
18/04/2017	12.2	0.2	0.2	71
19/04/2017	12.5	0	0	66
20/04/2017	11.8	-1.1	0	67
21/04/2017	14.8	3.1	0	72
22/04/2017	16	8.6	0.2	66
23/04/2017	14.2	7.1	0.8	70
24/04/2017	14.3	3.4	0	79
25/04/2017	14.6	0.2	0.2	63
26/04/2017	10.6	2.2	0	63
27/04/2017	9.3	-0.8	1.4	81
28/04/2017	11.1	5.6	0.6	74
29/04/2017	13.3	4.3	0	72
30/04/2017	15	10.1	0	55
01/05/2017	16	8.3	0	72
02/05/2017	13	4.8	0	83
03/05/2017	16.7	6.8	1	77
04/05/2017	11	8.4	3	89
05/05/2017	13	9.4	0	80
06/05/2017	12.8	9.2	0	79
07/05/2017	14.3	5.8	0	82
08/05/2017	15.3	7.3	0	71
09/05/2017	12.3	5.9	0	74
10/05/2017	11.9	-0.9	0	77
11/05/2017	15.7	3.7	0	77
12/05/2017	21.9	11.9	2.8	76
13/05/2017	17.6	10.2	1.2	84
14/05/2017	17.7	7	1.6	74
15/05/2017	19	5.5	0.6	75
16/05/2017	19.8	12.5	0	77
17/05/2017	23.8	15	14.4	80
18/05/2017	20.5	10.4	12.6	87
19/05/2017	16.5	9.4	16.8	86
20/05/2017	14.7	5.3	0	81
21/05/2017	16.8	6.3	0	77
22/05/2017	19.1	6.4	0	72
23/05/2017	23.2	11.6	0	64
24/05/2017	20.8	10.2	0	79
25/05/2017	24.6	10.3	0	74
26/05/2017	23.2	10	0	72
27/05/2017	25.4	10.5	0.4	71

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL	RH_PERCENT
28/05/2017	22.9	8.6	0	81
30/05/2017	23.1	14.7	0	82
31/05/2017	20	10.4	0	80
01/06/2017	21.9	9.2	0	82
02/06/2017	23.8	8.8	0	73
03/06/2017	25.3	14.5	2.6	79
04/06/2017	20.9	9.8	0	63
05/06/2017	18.9	9.3	0	71
06/06/2017	18.2	9.5	15.4	82
07/06/2017	16.3	9.8	4.2	72
08/06/2017	19.4	13.1	0	70
09/06/2017	18.9	12.5	8.2	81
10/06/2017	20	12.2	1	77
11/06/2017	21.8	12.2	0	75
12/06/2017	21.9	10.4	0	73
13/06/2017	19.2	8.5	0	72
14/06/2017	23	8.3	0	72
16/06/2017	24.3	11.6	0	63
17/06/2017	23.1	13.8	0	71
18/06/2017	28	14.6	0	71
19/06/2017	29.7	13.8	0	71
20/06/2017	28.2	12.9	0	75
21/06/2017	27.6	14.9	0	77
22/06/2017	31.4	17.3	0	68
23/06/2017	24.8	12.6	0.6	74
24/06/2017	23.2	15.5	0	72
25/06/2017	21.6	14.9	0	80
26/06/2017	22.1	12	0	68
29/06/2017	18.2	12.2	4.2	84
30/06/2017	18.9	11.9	0	81
01/07/2017	21.5	13.3	0.4	74
02/07/2017	21	15.2	0	70
03/07/2017	23	13.1	0	71
04/07/2017	22.7	11.2	0	78
05/07/2017	23.7	11.8	0	73
06/07/2017	25.4	13.8	0	68
07/07/2017	28.1	16.2	0	72
08/07/2017	27.9	17.6	0	63
09/07/2017	25.7	13.3	0	74
10/07/2017	26	12.8	0	68
11/07/2017	25.6	13.9	0	64
12/07/2017	20.6	13.9	31	87
13/07/2017	21	7.3	0.4	78
14/07/2017	21	13.1	0	67
15/07/2017	20.5	10.5	0	71

WEATHER_DATE	TEMP_MAX	TEMP_MIN	RAINFALL	RH_PERCENT
16/07/2017	21.1	17.1	0	79
17/07/2017	25.1	15	0	73
18/07/2017	24.6	12.2	0	69
20/07/2017	22.9	16.8	4.6	86
21/07/2017	20.4	9.5	4.6	77
22/07/2017	21.1	13.9	6.4	73
23/07/2017	19.8	9.2	6.8	84
24/07/2017	18.8	12.9	7.2	84
25/07/2017	17.4	13.8	2	88
26/07/2017	22.5	11.2	0	78
27/07/2017	20.5	13.4	0.4	83
28/07/2017	20.7	13.3	0.6	79
29/07/2017	19.9	15.9	1	83
30/07/2017	20.5	15.8	5.6	85
31/07/2017	20.6	12	0	77

Table A2. Air temperature and humidity conditions at the time of spray applications – Ben Hope

Date	At start of spray applications					At end of spray applications					Weather conditions
	Time	Temp °C			Windspeed (kmph) Direction	Time	Temp °C			Windspeed (kmph) Direction	
		Dry bulb	Wet bulb	RH%			Dry bulb	Wet bulb	RH%		
18 April	14.45	16.0	10.0	45.2	8.9 N	15.03	14.5	10.0	55.9	10.9 N	Sunny spells, breezy
26 April	14.45	13.0	11.0	78.6	6.1 N	15.03	13.0	10.0	68.4	9.9 N	Sunny spells, breezy
10 May	07.45	10.0	9.0	88.0	0	09.17	10.0	10.0	100	3.9 NW	Overcast
16 May	14.15	29.0	19.0	37.8	6.4 W	15.11	26.0	20.0	57.3	2.8	Sunny spells, breezy
22 May	11.00	24.0	19.0	62.2	0	11.25	24.0	19.0	62.2	0.7 SW	Sunny
6 June	10.00	17.0	14.5	76.4	7.6 W	11.10	15.0	12.0	70.3	12.3 W	Sunny breezy
23 June	10.18	23.5	20.0	72.5	7.6 W	10.39	25.0	19.0	56.4	10.1 W	Sunny spells

Table A3. 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 °C			Windspeed (kmph) Direction	Time	Temp °C			Windspeed (kmph) Direction	
		Dry bulb	Wet bulb	RH%			Dry bulb	Wet bulb	RH%		
9 May	07.45	10.0	9.0	88.0	0	09.17	10.0	10.0	100	3.9 NW	Overcast
16 May	14.15	29.0	19.0	37.8	6.4 W	14.30	26.0	20.0	57.3	2.8 W	Sunny spells, breezy
30 May	13.40	26.0	22.0	70.5	0	14.18	28.0	21.5	56.0	0	Sunny spells
7 June	10.00	17.5	14.5	72.4	7.6 W	11.00	15.0	12.0	70.3	12.3	Sunny breezy
16 June	11.55	22.0	17.5	64.0	0	12.29	24.0	20.0	69.2	0	Sunny spells
28 June	13.35	24.0	20.0	69.2	3.6 W	14.24	24.0	18.0	55.4	8.8 W	Overcast
12 July	13.47	25.0	20.0	63.0	0	14.06	27.0	23.0	71.1	0	Sunny

Table A4. % accuracy of spray applications (volume applied / volume required expressed as a percentage) – Ben Hope and Ben Tirran

Spray date	Treatment number				
	2	**3**	**4**	**5**	**6**
Ben Hope					
18 April		88	102	71	88
26 April	91				
10 May	106			88	105
16 May		88	95		113
22 May	95			93	91
6 June		104	104	97	102
23 June				102	93
Ben Tirran					
9 May		102	100	88	105
16 May	88				
30 May	80			135	106
7 June		88	102		102
16 June	102			213	102
28 June		108	111	111	106
12 July				97	106

Control of Botrytis in Blackcurrants cv. Ben Hope ORETO
17/08 2017

Plot	Block	Treat-ment	% Fruit set	Green Fruit % Botrytis	Green Fruit % Penicil	Weight kg 300 fruit	Post harvest rots % Botrytis	Post harvest rots % Penicil
13	1	3	20.4	30.6	18.4	125	6	1.7
14	1	5	25	77.6	2	150	4.3	2.7
15	1	6	25	27.1	8.3	150	4.7	5.3
16	1	4	11.8	30	54	175	9.3	1
17	1	1	18.7	64.6	0	150	0	0
18	1	2	27.2	6	8	145	1.3	0.7
19	2	4	29.6	26.5	40.8	150	10.3	1
20	2	2	22.6	34	0	160	11.3	3.3
21	2	1	24.1	32.7	11.5	120	3.3	2
22	2	3	23.4	51	0	110	10	0.7
23	2	6	20.3	39.2	2	110	4.3	1.3
24	2	5	17.9	16.3	4.1	110	4	1.7
25	3	5	18.3	15.7	0	150	2.7	1
26	3	4	29.1	37.3	3.9	150	0.7	3.7
27	3	3	24.8	12.2	32.7	155	6.7	8.7
28	3	6	17.3	12	8	155	3.7	4.3
29	3	1	23	30	20	125	8.7	2.7
30	3	2	10.8	48.1	0	145	5.7	6
49	4	1	19.2	14	18	150	9.7	3.3
50	4	2	25.9	13.7	7.8	160	6.3	2
51	4	4	17.5	19.2	1.9	165	9.3	2.3
52	4	5	13.9	25.5	3.9	150	7	1
53	4	3	15.6	28	38	150	1	1
54	4	6	21.6	7.8	15.7	100	7.7	2.7
55	5	6	25.6	42.3	5.8	130	0.7	4.7
56	5	1	35.3	21.6	31.4	110	3.7	1
57	5	5	19.4	4.1	14.3	160	9	0.3
58	5	2	18.8	32	0	125	3.3	0
59	5	4	13.9	32	10	150	2.7	0
60	5	3	31.4	66	0	160	6.3	0.3

Control of Botrytis in Blackcurrants cv. Ben Tirran ORETO
17/08 2017

Plot	Block	Treat-ment	% Fruit set	Green Fruit % Botrytis	Green Fruit % Penicil	Weight kg 300 fruit	Post harvest rots % Botrytis	Post harvest rots % Penicil
1	1	3	39.6	70.8	2.1	204	0	5.3
2	1	5	48.5	84	6	206	0.7	4.3
3	1	6	48.4	62	0	247	0.7	1
4	1	4	45.3	70	0	240	0.7	5.3
5	1	1	54.7	75	0	212	5.3	5
6	1	2	58.5	62.5	2.1	223	0.7	5
7	2	4	27.8	76.5	0	152	3.3	18.3
8	2	2	50.9	50	0	183	1	18.7
9	2	1	44.9	71.4	22.4	243	1.7	4.7
10	2	3	48.2	75.5	0	192	0	0
11	2	6	58.4	77.6	0	201	4.3	9.3
12	2	5	63.6	79.5	0	185	1	14.3
31	3	5	56.5	78	0	253	4	20
32	3	4	51	82	8	260	12.3	29.7
33	3	3	46.7	78	2	248	4	14.7
34	3	6	76	77.6	0	249	11.3	19.3
35	3	1	45.6	87.5	2.1	194	10.7	18.3
36	3	2	56.2	51	0	269	6.7	9
37	4	1	56.4	80	0	246	2	6
38	4	2	50.2	60.8	2	245	0	2.3
39	4	4	47.3	72	4	229	0.7	5
40	4	5	56.1	68.6	0	235	1.3	3
41	4	3	52.3	74	0	238	1.3	2.7
42	4	6	50.2	76	4	240	1.7	3.7
43	5	6	44.8	84	0	225	2	5.7
44	5	1	48.2	77.1	0	229	5	0.3
45	5	5	50.8	86.3	0	215	1.3	4
46	5	2	68.1	80	8	231	0.3	0.3
47	5	4	43	70	0	219	3	4
48	5	3	55.3	75.5	0	206	2.7	11

