CP 205 AHDB Horticulture Efficacy Trials 2022

Final Trial Report

Work package:	WP 17
Title:	New treatment programmes for control of apple canker
Crop	Apple (Malus domestica)
Target	European apple canker (*Neonectria ditissima*)
Lead researcher:	Dr Matevz Papp-Rupar
Organisation:	NIAB East Malling
Period:	2022-2-23
Report date:	20/7/23
Report authors:	Matevz Papp-Rupar
ORETO Number:	The trial was done under ORETO standard number 411.

I the undersigned, hereby declare that the work was performed according to the procedures herein described and that this report is an accurate and faithful record of the results obtained

Date 28.7.2023

Author's signature

Trial Summary

The aim of this trial was to test efficacy of biocontrol agents (BCA), plant extract products (PE) and novel chemical fungicides (CF) against apple canker pathogen (*Neonectria ditissima*). All the tested products were either already available on UK/EU markets in 2022, but not registered for apple or in final stages of registration.

The trial focused on leaf scar and wound protection after harvest and during the leaf fall period, when most canker infections occur in the UK. All products were compared to water control and standard treatment (captan / tebuconazole / captan at 20% / 50% / 80% leaf fall).

Current standard was overall the best treatment, significantly reducing canker in majority of tested conditions. One biocontrol product and one chemical fungicide effectively protected rasp wounds, but were most effective at low inoculum levels. A further 3 products showed partial efficacy.

Future research should focus on development of spray programmes combining effective products identified here, with the aim to achieve efficacy comparable, if not higher than the current standard.

Introduction

Over the last few years there have been reductions in the number of fungicide products available to the UK growers for control of apple canker at leaf fall. This calls for increased research in efficacy of novel control products.

Methods

The trial was conducted in commercial apple orchards on 10-year-old Braeburn trees planted at NIAB East Malling. All spray applications were done in autumn 2022 starting 3 days after harvest and finishing at 80% leaf fall. Eight new treatments were sprayed on the trees (at 500L/ha) 2 - 5 times during that time, depending on manufacturers instructions. Six plots of 3 trees were used per treatment.

On each tree we used a range of natural and artificial wounds (rasp wounds, pruning wounds, leaf/bud scars) in combination with different levels of inoculum pressure (natural, artificial-low, artificial-high) to establish different levels of disease (see Table 1). Canker inoculations were done at 20%-30% leaf fall in 2022 and assessed at flowering in 2023.

Results

As expected, water and standard treated plots had the highest and the lowest incidence of canker, respectively, on majority of wound-inoculum combinations (Table 1). BCA1 (AHDB9788) and CF2 (AHDB9862) treatments significantly decreased canker incidence on rasp wounds compared to water control. Their effect was most obvious at lower inoculum levels of naturally infected wounds. Products BCA3 (AHDB9712), PE2 (AHDB9852) and CF1 (AHDB9808) have decreased canker incidence to a lesser level. Their canker incidence was not significantly lower than in water control, but also not significantly higher than in the standard treatment. We recognise these products as partly effective

Table 1. Summary of canker incidence results across different inoculated wounds and inoculum levels. Mean incidences and standard errors (SE) are given. Water treated control is highlighted in grey. Products that were found effective and partially effective are highlighted in green and orange, respectively.

Treatment code	All rasp wounds		Naturally infected rasp wounds		Artificially infected rasp wounds		Leaf/bud scars		Pruning wounds	
	Canker incidence	SE	Canker incidence	SE	Canker incidence	SE	Canker incidence	SE	Canker incidence	SE
Water	**35.0%**	4.0%	**10.8%**	2.4%	**51.4%**	3.7%	**1.9%**	0.8%	**19.6%**	2.6%
Standard	**15.7%**	3.1%	**1.9%**	1.0%	**33.2%**	3.4%	**0.7%**	0.5%	**13.9%**	2.2%
BCA1 (AHDB9788)	**20.1%**	3.3%	**3.7%**	1.4%	**39.3%**	3.5%	**2.3%**	1.0%	**14.2%**	2.2%
BCA2 (AHDB9694)	**34.7%**	4.0%	**9.3%**	2.2%	**53.3%**	3.6%	**1.8%**	0.8%	**18.9%**	2.5%
BCA3 (AHDB9712)	**23.0%**	3.5%	**4.3%**	1.5%	**42.1%**	3.6%	**1.2%**	0.6%	**16.1%**	2.4%
PE1 (AHDB9792)	**27.9%**	3.6%	**9.3%**	2.2%	**41.8%**	3.6%	**1.9%**	0.8%	**16.0%**	2.3%
PE2 (AHDB9852)	**25.2%**	3.7%	**4.4%**	1.5%	**46.2%**	3.6%	**1.9%**	0.8%	**16.9%**	2.4%
CF1 (AHDB9808)	**27.4%**	3.7%	**8.4%**	2.1%	**42.5%**	3.7%	**1.5%**	0.7%	**18.7%**	2.6%
CF2 (AHDB9862)	**22.9%**	3.9%	**2.3%**	1.1%	**49.6%**	3.7%	**1.0%**	0.5%	**17.6%**	2.5%
CF3 (AHDB9710)	**32.0%**	3.8%	**11.7%**	2.5%	**45.2%**	3.5%	**2.0%**	0.9%	**20.9%**	2.7%

Take home messages:

None of the tested products alone could replace the current standard.

A biocontrol agent and a novel fungicide showed efficacy against apple canker, but mostly in in low inoculum pressure conditions.

All the possible effort should be made to decrease the inoculum levels in the commercial orchards to the levels where alternative products can be effective.

The future research efforts should focus on combining existing and novel products in spray programmes, with the aim to reach or supersede the control efficacy of the current standard.

SCIENCE SECTION

Objectives

Evaluate efficacy of the selected products to control apple canker, Neonectria ditissima, in orchard trial.

Efficacy of 8 treatments will be compared to water treated control and previous standard (tebuconazole and captan). Natural and artificial inoculation will be used to ensure high disease pressure. Spray application will be timed after harvest and during the leaf fall period.

Methods

Trial conduct

The following EPPO guidelines were followed:

Relevant EPPO guideline(s)		Variation from EPPO
PP1/135(4)	Phytotoxicity assessment	none
PP1/152(4)	Design and analysis of efficacy evaluation trials	none
PP1/181(5)	Conduct and reporting of efficacy evaluation trials, including good experimental practice	none
PP1/223(2)	Introduction to the efficacy evaluation of plant protection products	none
PP1/239(3)	Dose expression for plant protection products	none
PP1/296(1)	Principles of efficacy evaluation for low-risk plant protection products	none

Test site

Item	Details
Location address	NIAB East Malling, Middle Park 196 field,
Crop	Apple
Cultivar	Braeburn
Soil or substrate type	Soil. Soil properties not analysed.
Agronomic practice	Standard commercial pruning and treatment practice. Irrigated orchard.
Prior history of site	Site used for apple canker trials due to very high apple canker incidence.

Trial design

Item	Details
Trial design:	Randomised block design
Number of replicates:	six
Row spacing:	3 m between rows and 1.5 m between trees within row
Plot size: (w x l)	2 m x 5 m
Plot size: (m^2)	10 m
Number of plants per plot:	3
Leaf Wall Area calculations	Not calculated

Inoculation details

Wound type:	Inoculation type:	Inoculum load	Inoculation date	Number per tree
Rasp wound	Natural	\	\	3 wounds
Rasp wound	Artificial - low	50 conidia per inoc. point	2/11/22	3 wounds
Rasp wound	Artificial - high	500 conidia per inoc. point	9/11/22	3 wounds
Leaf/bud scar	Artificial - low	50 conidia per inoc. point	2/11/22	3 wounds
Leaf/bud scar	Artificial - low	500 conidia per inoc. point	9/11/22	3 wounds
Pruning wound	Natural	\	\	3 wounds
Natural wounds	Natural	\	\	3 shoots observed

Rasp wounds were made ca. 20 cm from the apex of the 1-year-old shoots. Specially designed tool was used to make rasp wounds of consistent size and depth (3-4 mm long, 2 mm wide and 2 mm deep). Leaf / bud scars were created by manually removing leaves and adjacent leaf buds from 1-year-old shoots.
Artificial inoculation was done by applying 5 µl of conidial suspension (in water) per wound. A mix of 5 *N. ditissima* isolates (Hg199, P112, R6/15, R45/16, PC12/21) was used.

Treatment details

AHDB Code	Active substance	Product name/ manufacturer code	Formulation batch number	Content of active substance in product	Formulation type	Adju-vant
Water	Water	/	/	/	/	
Standard	Tebuconazole or Captan	Folicur (Bayer) or Captan 80 WDG	TBG104031 Not available	Folicur- 250g/kg Captan 800g per kg	Wettable powder Water dispersible granule	None
BCA1 (AHDB9788)	N/A	N/A	N/A	N/A	Water dispersible granule	None
BCA2 (AHDB9694)	N/A	N/A	N/A	N/A	Wettable granule	None
BCA3 (AHDB9712)	N/A	N/A	N/A	N/A	Wettable granule	None
PE1 (AHDB9792)	N/A	N/A	N/A	N/A	Suspension concentrate	None
PE2 (AHDB9852)	N/A	N/A	N/A	N/A	Suspension concentrate	None
CF1 (AHDB9808)	N/A	N/A	N/A	N/A	Suspension concentrate	None
CF2 (AHDB9862)	N/A	N/A	N/A	N/A	Suspension concentrate	None
CF3 (AHDB9710)	N/A	N/A	N/A	N/A	Suspension concentrate	None

Application schedule

Each treatment was applied at the water rate of 500 L per Ha. Three L of spray solution was used for each treatment (six plots of 3 trees) at each application date

Treatment	Application rate in the tank (per L)	Rate of product (L or kg/ha) in 500 l/ha water volume	Application timing
Water	3 L	500 L	A, B, C, D, E
Standard	0.52 g tebuconazole 4 g captan	260 ml 3200 g	D C, E
BCA1 (AHDB9788)	0.4 g	200 g	D, E
BCA2 (AHDB9694)	3 g	1500 g	A, B, C, D, E
BCA3 (AHDB9712)	0.5 g	250 g	A, B, C, D, E
PE1 (AHDB9792)	6 ml	3000 ml	A, B, C, D, E
PE2 (AHDB9852)	6.4 ml	3200 ml	A, B, C, D, E
CF1 (AHDB9808)	9 ml	4500 ml	A, B, C, D, E
CF2 (AHDB9862)	4 ml	2000 ml	D, E
CF3 (AHDB9710)	10 ml	5000 ml	A, B, C, D, E

Application details

	Application A	Application B	Application C	Application D	Application E
Application date	18/10/2022	28/10/22	11/11/2022	18/11/2022	25/11/2022
Time of day	16:46 - 18:09	10:56 - 12:09	8:57 - 10:29	9:41 - 11:43	9:35 – 12:09
Crop growth stage (Max, min average BBCH)	2 days after harvest BBCH 89 + 3 days	12 days after harvest BBCH 89 + 14 days	20% leaf fall BBCH 93-95	50% leaf fall BBCH 95	80% leaf fall BBCH 95-97
Crop height (cm)	2000-2500	2000-2500	2000-2500	2000-2500	2000-2500
Crop coverage (%)	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Application Method	Foliar	Foliar	Foliar	Foliar	Foliar

Application Placement	Not relevant	Not relevant	Not relevant	Not relevant	Not relevant
Application equipment	Electric Birchmeier + Electric Blower EMR 2	Electric Birchmeier + Electric Blower EMR 2	Electric Birchmeier + Electric Blower EMR 2	Electric Birchmeier + Electric Blower EMR 2	Electric Birchmeier + Electric Blower EMR 2
Nozzle pressure	4 bar	4 bar	4 bar	4 bar	4 bar
Nozzle type	Orange Albuz ART 80	Orange Albuz ART 80	Orange Albuz ART 80	Orange Albuz ART 80	Orange Albuz ART 80
Application water volume/ha	500 L	500 L	500 L	500 L	500 L
Temperature of air - shade (°C)	14	17.5	12.5	9	8.5
Relative humidity (%)	Not available	Not available	Not available	Not available	Not available
Wind speed range (km/h)	0	0.7-2	0.5-1.5	1.3-3.7	0-1.2
Dew presence (Y/N)	N	N	N	N	N
Temperature of soil - 2-5 cm (°C)	Not available	Not available	Not available	Not available	Not available
Wetness of soil - 2-5 cm	Not available	Not available	Not available	Not available	Not available
Cloud cover (%)	0-20	80-100	0-20	40-60	0-20

Untreated levels of pests/pathogens at application and through the assessment period

Common name	Scientific Name	EPPO Code	Infestation level pre-application	Infestation level at start of assessment period	Infestation level at end of assessment period
Apple canker	*Neonectria ditissima*	NECTGA	Up to 0-5 mainstem and 3-10 peripheral cankers per tree	Up to 0-5 mainstem and 3-10 peripheral cankers per tree	Up to 0-5 mainstem and 3-10 peripheral cankers per tree

Assessment details

	Evaluation Timing (DA)*				
Evaluation date	After first conventional insecticides	After first bio-pesticides	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotoxicity)	Assessment
10/5/23	180	204	67-71	efficacy	Counting cankers on natural and artificial wounds with different inoculum levels.
15/5/23	185	209	67-71	efficacy	Counting cankers on natural and artificial wounds with different inoculum levels.
16/5/23	186	210	67-71	efficacy	Counting cankers on natural and artificial wounds with different inoculum levels.
17/5/23	187	211	67-71	efficacy	Counting cankers on natural and artificial wounds with different inoculum levels.

* DA – days after application

Statistical analysis

The frequency of canker symptoms on each wound type and inoculum level was summarised on per plot basis in terms of number of cankers out of total wounds inoculated/exposed to natural inoculum. Generalized linear model with binomial distribution was used to analyse frequency of canker symptoms.

In the case of natural wounds inoculated by naturally present inoculum we summarised the total cankers on the 9 designated shoots in each plot and analysed using generalized linear model with Poisson's distribution.

Canker level observed in treatments were compared to water control and standard programme to ascertain their efficacy.

Products were considered effective if they significantly ($p<0.05$) reduced canker levels compared to water control.

Products were considered partly effective in situations where the standard significantly reduced canker levels compared to water control, the product did not reduce canker levels compared to water control but it was not significantly worse than standard either.

Results

Canker symptom incidence on all rasp wounds

Generalised mix model analysis of all rasp wounds across all inoculation levels indicated that block (p<0.001), inoculum level (p<0.001), product (p<0.001) and product by inoculum level interaction (p=0.03) all significantly affected the canker symptom incidence. The two effective treatments that significantly reduced incidence (probability) of canker symptoms compared to water control when all rasp wounds were analysed together were standard (p=0.003) and BCA1 (AHDB9788) (p=0.04) (Figure 1). The treatments that did not significantly reduce canker incidence compared to water control but at the same time not significantly increased canker incidence compared to standard were BCA3 (AHDB9712), PE1 (AHDB9792), PE2 (AHDB9852), CF1 (AHDB9808) and CF2 (AHDB9862). These can be considered a partially effective.

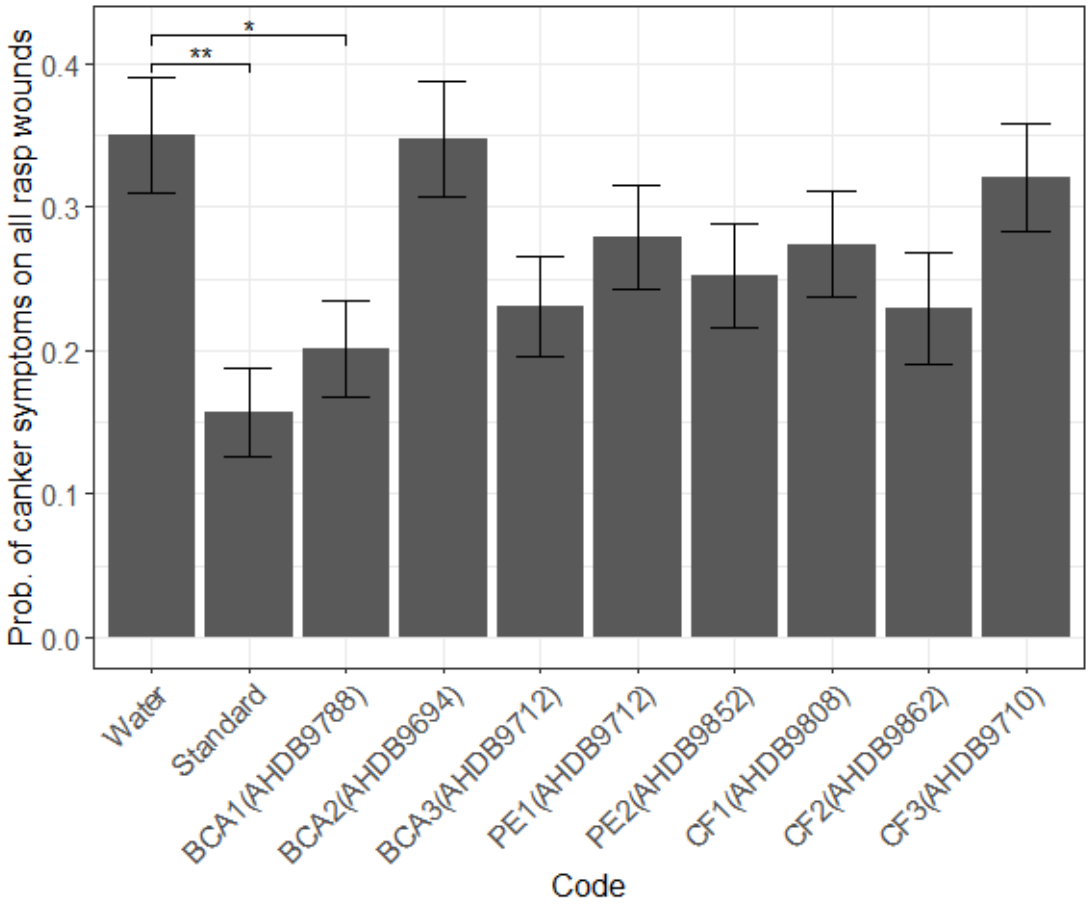


Figure 1[!]. Probability (incidence) of canker symptoms on rasp wounds across all inoculation levels (natural, artificial-low, artificial-high). * = 0.05 >p>0.01; ** = 0.01>p>0.001.

[!]Figure correction code PE1(AHDB9712) should be PE1(AHDB9792)

Significant interaction of product with inoculum level indicated that some products may be more or less effective depending on the inoculum level (Figure 2). Comparison of canker incidence across different inoculation levels indicated that naturally infected rasp wounds had significantly lower incidence than artificially inoculated rasp wounds (p<0.001). There was no difference in canker incidence between low and high level of

inoculum used in artificially inoculated rasp wounds. We have thus analysed naturally and artificially inoculated wounds separately.

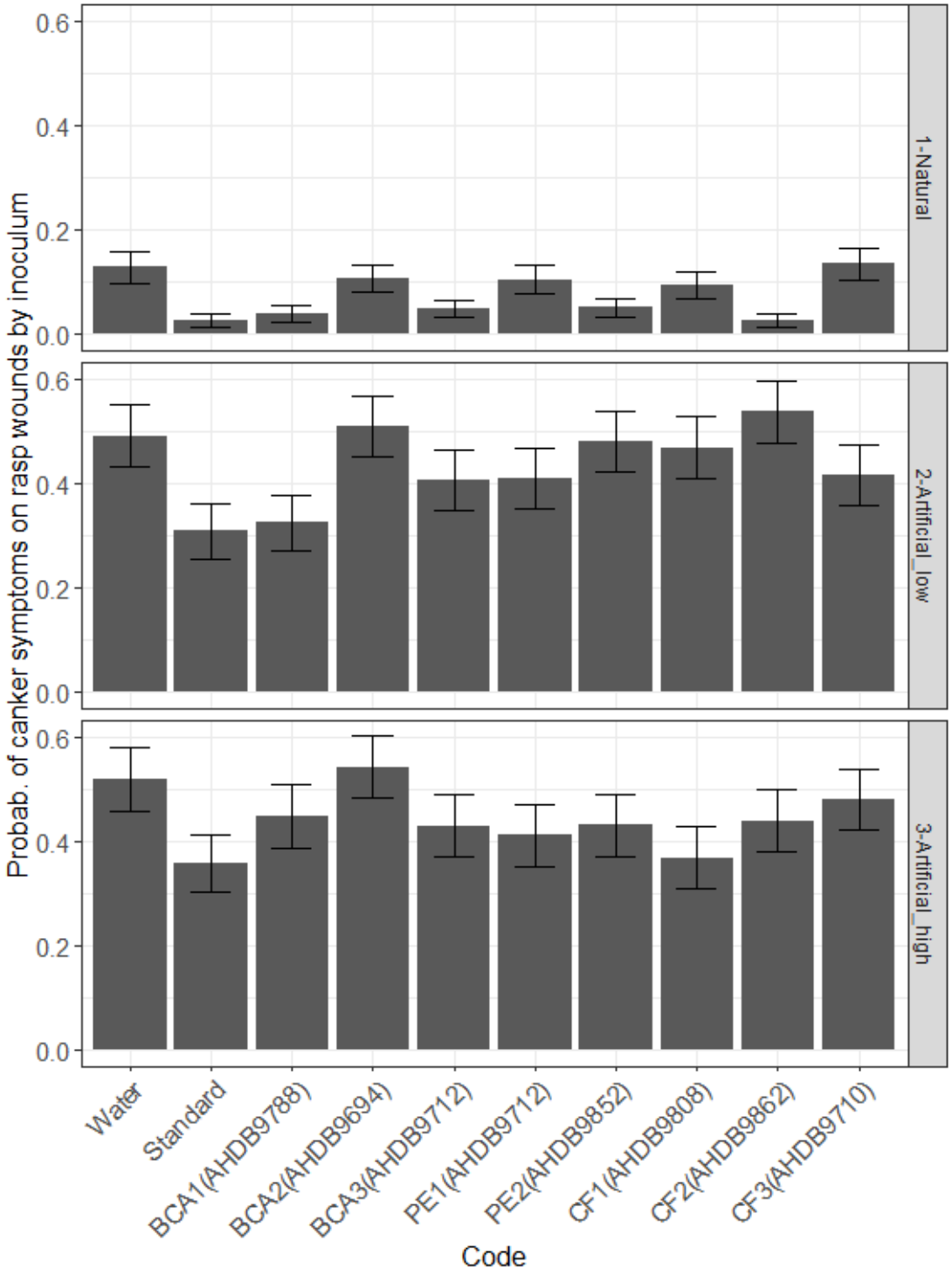


Figure 2[!]. Probability (incidence) of canker symptoms on rasp wounds by inoculation level.

[!]Figure correction code PE1(AHDB9712) should be PE1(AHDB9792)

Canker incidence on naturally infected rasp wounds

Standard (p=0.01) and CF2 (AHDB9862) (p=0.01) treatments significantly reduced canker incidence compared to water control when naturally infected rasp wounds were analysed separately. They both reduced the incidence from above than 10% in water control to ca. 2% (Figure 3) and are thus considered effective. The treatments BCA1 (AHDB9788) (AHDB9788), BCA3 (AHDB9712), PE2 (AHDB9852) and CF2 (AHDB9862) reduced canker incidence by more than 50%, from 10 % in water control to below 5%. Their incidence, however, was not significantly lower than in water control or significantly higher than in standard treatment. They are thus considered partly effective.

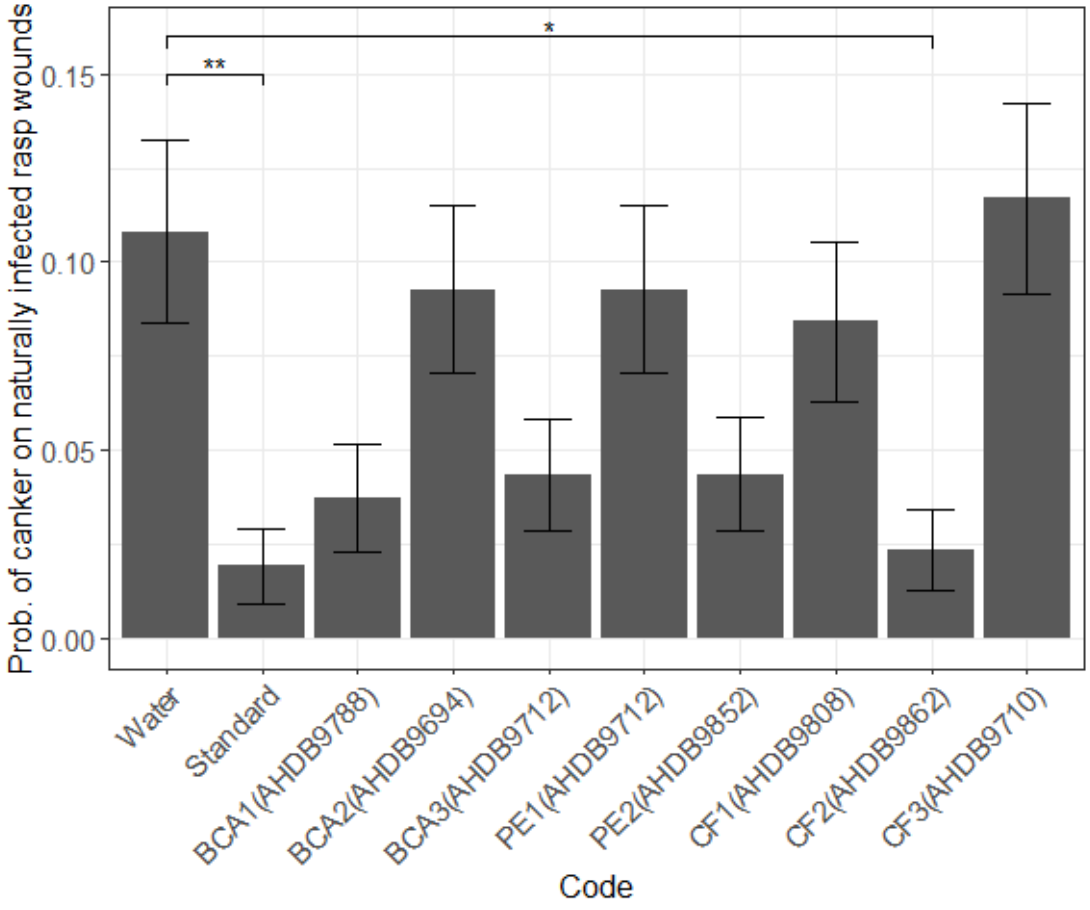


Figure 3[!]. Probability (incidence) of canker symptoms on naturally inoculated rasp wounds. * = 0.05> p>0.01; ** = 0.01>p >0.001.

[!]Figure correction code PE1(AHDB9712) should be PE1(AHDB9792)

Canker incidence on artificially infected rasp wounds

No test product significantly reduced canker incidence on artificially inoculated rasp wounds. Standard treatment was effective, but only reduced incidence by ca 33% compared to water control (Figure 4).

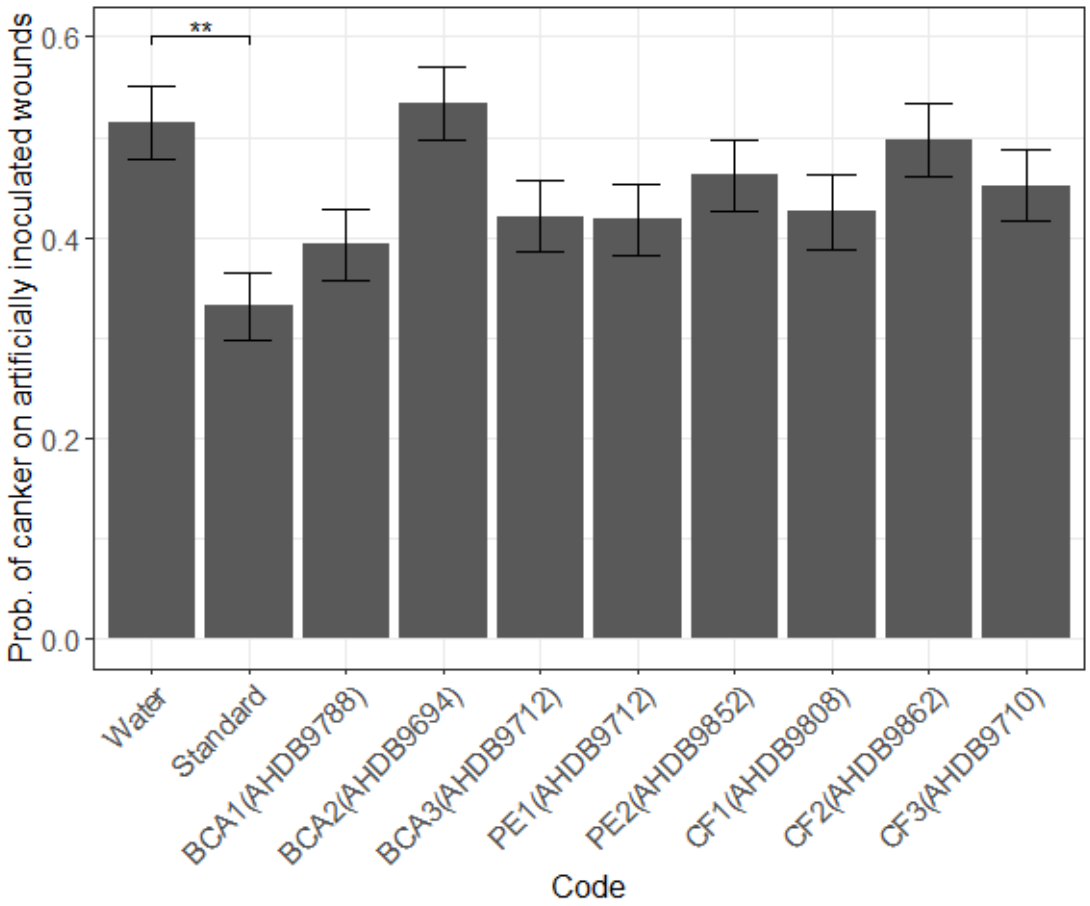


Figure 4[!]. Probability (incidence) of canker symptoms on artificially inoculated rasp wounds. * = 0.05> p>0.01; ** = 0.01>p >0.001.

[!]Figure correction code PE1(AHDB9712) should be PE1(AHDB9792)

Canker incidence on leaf/bud scars

Canker incidence on inoculated leaf/bud scars was relatively low, below 5% (Figure 5). Two different levels of artificial inoculation were used on leaf/bud scars. The incidence of canker symptoms on high inoculum level (mean ca. 3%) was significantly higher than on the low level (mean ca. 1%) (p=0.03), data not shown. None of the test products nor Standard treatment reduced the canker incidence on leaf/bud scars.

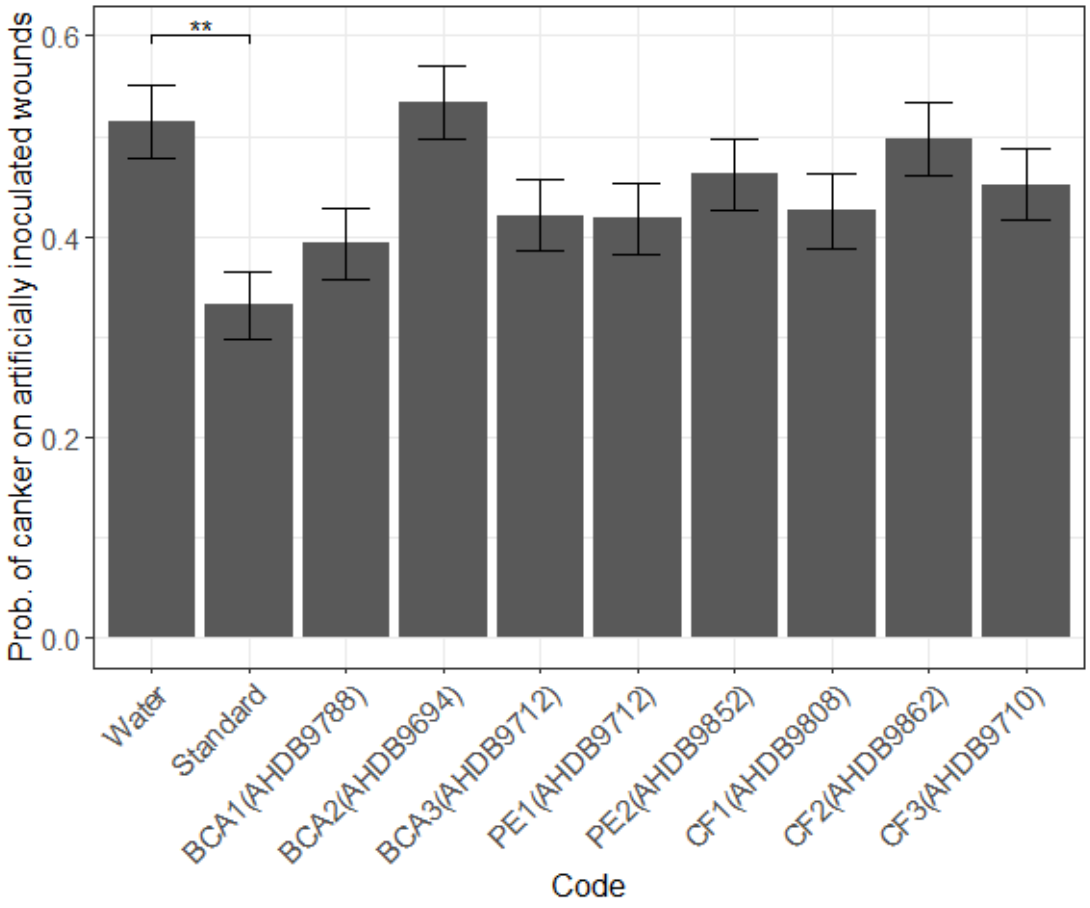


Figure 5[I]. Probability (incidence) of canker symptoms on artificially inoculated leaf/bud scars.

[I]Figure correction code PE1(AHDB9712) should be PE1(AHDB9792)

Canker incidence on naturally infected pruning wounds

Overall canker incidence on naturally infected pruning wounds was between 15% and 20%. None of the test products nor standard treatment reduced the canker incidence on naturally inoculated pruning wounds.

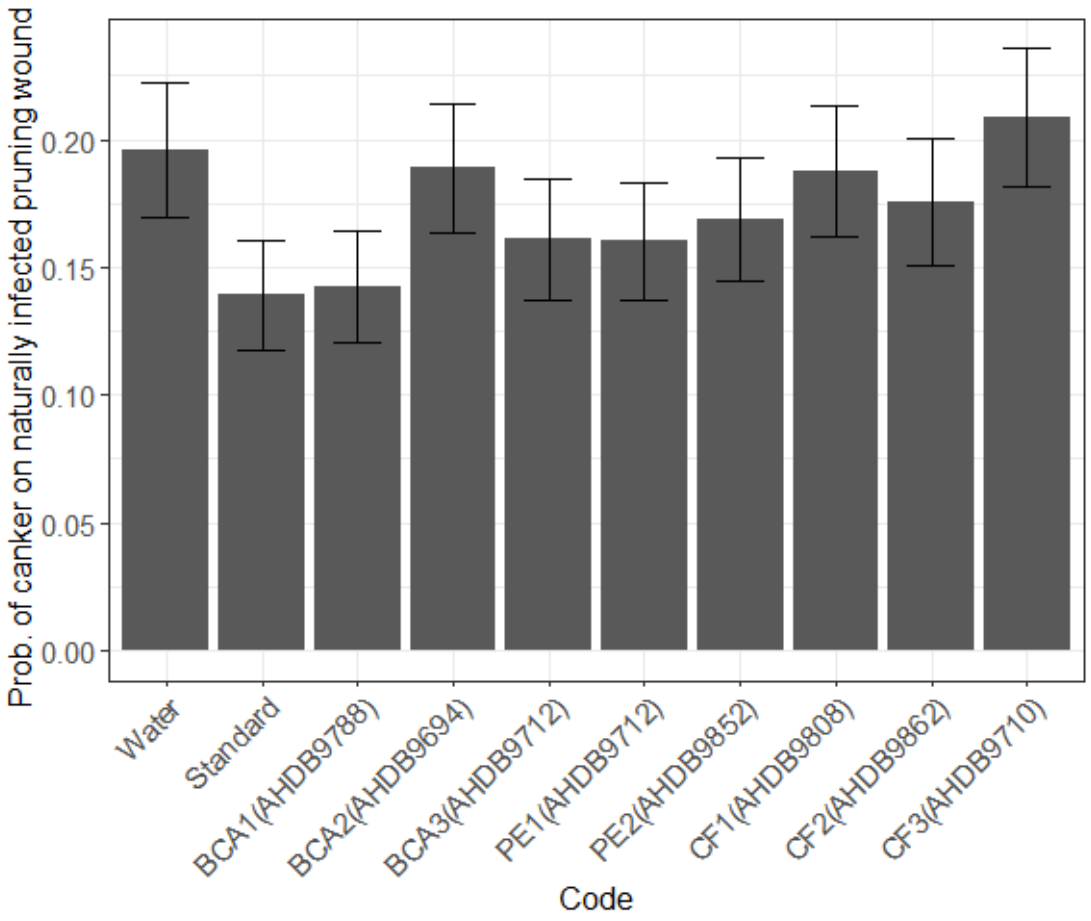


Figure 6[I]. Probability (incidence) of canker symptoms on naturally inoculated pruning wounds.

[I]Figure correction code PE1(AHDB9712) should be PE1(AHDB9792)

Number naturally occurring cankers

Number of cankers on naturally occurring wounds due to natural inoculum was very low (Figure 7). Less than 1 in 100 shoots that were observed had any naturally occurring cankers. The numbers were too low to conduct valid analysis.

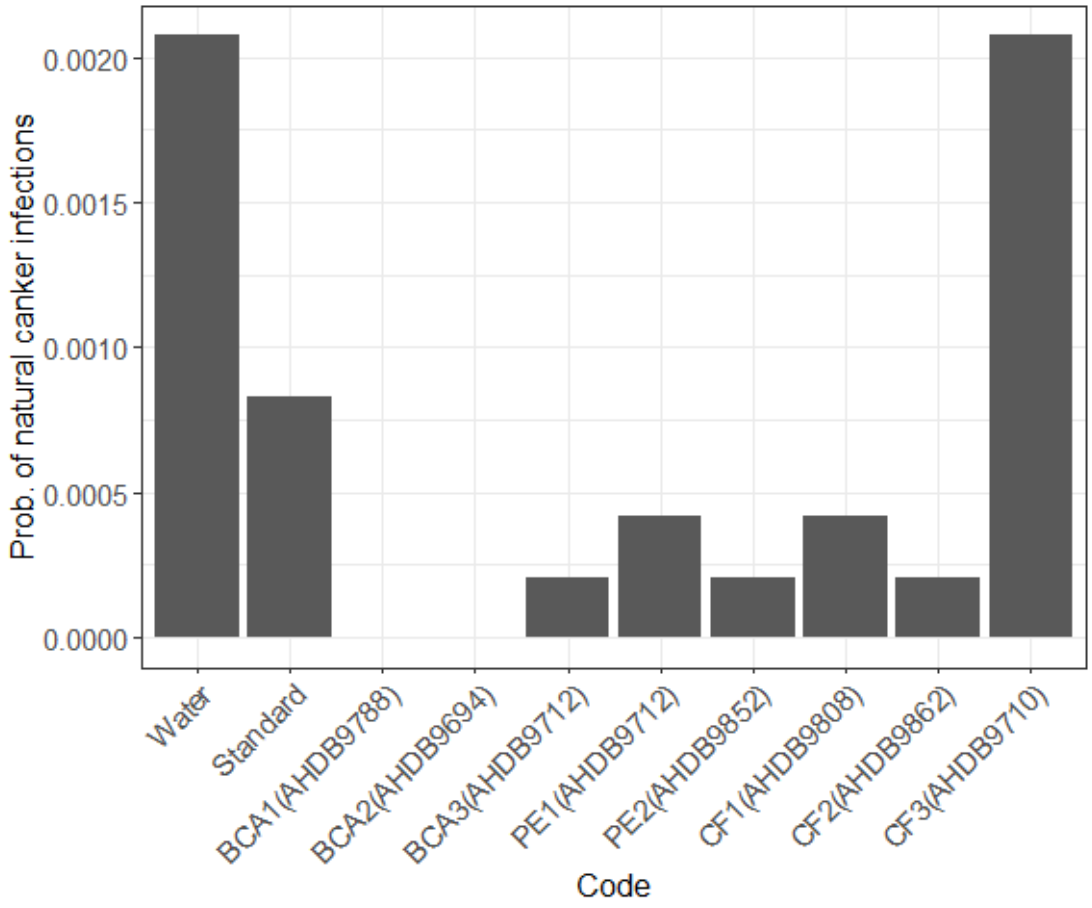


Figure 7[I]. Canker infections on natural wounds due to natural inoculum.

[I]Figure correction code PE1(AHDB9712) should be PE1(AHDB9792)

Discussion

Overall the experiments have been conducted successfully. The water control plots had the highest or second highest level canker while standard treated plots had the lowest levels of canker across all observed wounds and inoculation levels. From this experiment it is clear that the current standard practice, i.e. captan, tebuconazole, captan at 20%, 50% and 80% leaf fall, respectively, is effective at reducing canker infections of rasp wounds under high natural and artificial inoculum pressure (Table 2). No treatment reduced the relatively high canker incidence (ca 20%) on pruning wounds made post harvest. This indicates pruning wounds can not be protected and pruning between harvest and bud break should be avoided.

The canker incidence in naturally and artificially inoculated rasp wounds, naturally infected pruning wounds and naturally occurring wounds were as expected. Canker incidence in inoculated leaf/bud scar wounds (ca. 1-2%) were lower than the expected (about 30%), which could be due to the warm and dry conditions during and after inoculation favouring plant defences and wound healing. It is also possible that the prolonged cold and wet spring that delayed apple flowering also delayed canker symptom expression. It is known that canker infection can remain symptomless for up to few years post inoculation (McCracken *et al.*, 2003). The incidence of canker symptoms on naturally occurring wounds inoculated by naturally present inoculum was too low to warrant any firm conclusions.

Out of eight new products tested, two stood out as effective in at least one of the wound - inoculation level combinations tested. The most promising product was biocontrol agent BCA1 (AHDB9788) which showed the highest reductions in canker incidence across the tested conditions (Table 2), second only to the standard. This was to be expected since the active ingredient (organism) has previously shown to significantly reduce grapevine trunk diseases (Berbegal *et al.*, 2020) which shares similar epidemiology to apple canker. The second promising product was chemical fungicide 2 (CF2 (AHDB9862)) which worked well, but only in the low inoculum pressure scenario of naturally infected rasp wounds.

The three further products with partial efficacy were (in order of efficacy from higher to lower) biocontrol agent 3 (BCA3 (AHDB9712)), plant extract 2 (PE2 (AHDB9852)) and chemical fungicide 1 (CF1 (AHDB9808)). Although these products did not significantly reduce canker levels compared to water control, they have reduced canker levels by ca 20-60% depending on the inoculum pressure (Table 2) and these canker levels were not significantly different from the standard treatment. The most promising were BCA3 (AHDB9712) and PE2 (AHDB9852) which in natural inoculum conditions reduced canker levels by ca. 60% compared to water. Interestingly, the species of microbe which is the active ingredient in BC3 have been recently found to be effective against apple canker in detached shoots experiments (Elena *et al.*, 2022)

It is clear that canker is difficult to control using the existing standard practice. None of the products tested could replace captan or tebuconazole which are currently used as standard. Future research should focus on investigating the effect of combinations of the several promising products identified here. The best example would be the combination of CF2 (AHDB9862) at 20% leaf, followed by BCA1 (AHDB9788) at 50% and 80% leaf fall. Future experiments should include i) spray programmes with the number of sprays that reflect grower capabilities. The five applications conducted here with BCA2 (AHDB9694), BCA3 (AHDB9712), PE1 (AHDB9792), PE2 (AHDB9852),

CF1 (AHDB9808) and CF3 (AHDB9710) may not be possible in commercial practice. ii) Inoculum levels should be reduced to natural inoculum or very low artificial inoculum (ca 5-10 conidia per wound) and may better simulate commercial conditions.

Finally iii), the most important measure to combat canker with the current and future control products is thorough and frequent removal of inoculum from the orchard.

Table 2: Percent canker incidence reduction compared of each product compared to water control in conditions where significant reductions were detected. Products that were found effective and partially effective in each analysis are highlighted in green and orange, respectively. Canker incidences in water control were: 35 % in all rasp wounds, 10.8% in naturally infected rasp wounds and 51.4% in artificially infected rasp wounds.

Treatment code	All rasp wounds	Naturally infected rasp wounds	Artificially infected rasp wounds
Standard	55.2%	82.3%	35.4%
BCA1 (AHDB9788)	42.6%	65.4%	23.5%
BCA2 (AHDB9694)	0.8%	14.3%	0.0%
BCA3 (AHDB9712)	34.2%	60.0%	18.1%
PE1 (AHDB9792)	20.2%	14.3%	18.7%
PE2 (AHDB9852)	27.9%	59.7%	10.1%
CF1 (AHDB9808)	21.7%	22.1%	17.2%
CF2 (AHDB9862)	34.4%	78.3%	3.3%
CF3 (AHDB9710)	8.5%	0.0%	12.1%

Conclusions

None of the tested products alone could replace the current standard.

A biocontrol agent and a novel fungicide showed efficacy against apple canker, but mostly in in low inoculum pressure conditions.

All the possible effort should be made to decrease the inoculum levels in the commercial orchards to the levels where alternative products can be effective.

The future research efforts should focus on combining existing and novel products in spray programmes, with the aim to reach or supersede the control efficacy of the current standard.

Acknowledgements

The study was funded by AHDB CP-205 initiative. The products were selected with the guidance of Carlos Duarte and Adam Doxford (AHDB) and application details provided by representatives of plant protection product producers. All experiments were conducted by trained and trusted pathology team of Pest and Pathogen Ecology Department, NIAB East Malling. We thank all the people involved for their effort.

References

Berbegal, M. *et al.* (2020) ‘Evaluation of long-term protection from nursery to vineyard provided by Trichoderma atroviride SC1 against fungal grapevine trunk pathogens’, *Pest Management Science*, 76(3), pp. 967–977. doi: 10.1002/PS.5605.

Elena, G. *et al.* (2022) ‘Systematic stepwise screening of new microbial antagonists for biological control of European canker’, *Biological Control*, 174(July). doi: 10.1016/j.biocontrol.2022.105009.

McCracken, A. R. *et al.* (2003) ‘Relative significance of nursery infections and orchard inoculum in the development and spread of apple canker (Nectria galligena) in young orchards’, *Plant Pathology*, 52(5), pp. 553–566. doi: 10.1046/j.1365-3059.2003.00924.x.

Appendix

A) Trial diary

Date	Notes
4/10/23	Trial plots marked.
18/10/2022	Product application A
28/10/22	Product application B
2/11/22	Low inoculum branches marked with blue tape, and rasp wounds made. Low level *N. ditissima* spore inoculation completed on blocks 1-3 (at 1 x 104 spores/ml).
2/11/22	Low level inoculations done on blocks 4-6.
7/11/22	Branches marked with red tape (high inoculum level), and rasp wounds made on blocks 1-4.
9/11/22	Blocks 5-6 marked up with red tape (high inoculum level), and rasp wounds made. All blocks inoculated with *N. ditissima* mix at 1 x 105 spores/ml, leaf scar/bud wounds being made at the time of inoculation (red tape). Yellow markers (natural inoculation) put on blocks 2 and 3, and cut and rasp wounds made.
10/11/22	Yellow makers and cuts/wounds completed on blocks 1, 4, 5, 6.
11/11/2022	Product application C
18/11/2022	Product application D
25/11/2022	Product application E
10/5/23	Canker assessed block 1
15/5/23	Canker assessed block 2
16/5/23	Canker assessed blocks 3 & 4
17/5/23	Canker assessed blocks 5 & 6
29/5/23	Data transferred from assessment sheets to Excel.

2/6/23 JK MPR	Data validation
19-23/6/23 MPR	Statistical analysis

B) Trial Photographs

Two examples of inoculated rasp wounds. Images taken on 14/3/23 when the first indications of canker lesions were started to show on small subset of rasp wounds.

C) Trial design

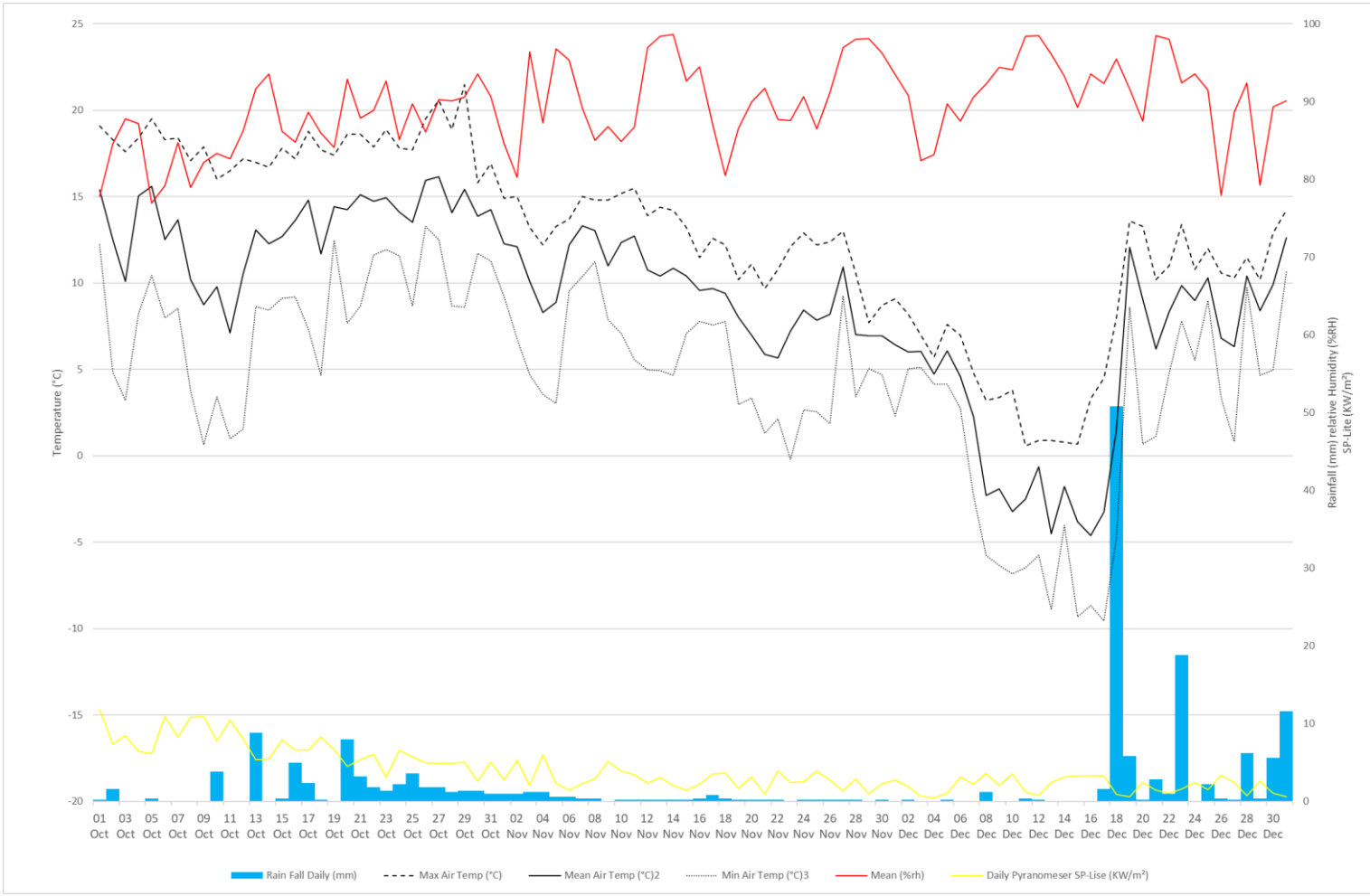
Treatment code	Field code	Colour	Number of replicates (plots)	Trees per replicate
Water	T9	grey	6	3
Standard	T10	black	6	3
BCA1 (AHDB9788)	T4	yellow	6	3
BCA2 (AHDB9694)	T7	blue-yellow	6	3
BCA3 (AHDB9712)	T5	stripy	6	3
PE1 (AHDB9792)	T6	blue-green	6	3
PE2 (AHDB9852)	T3	green	6	3
CF1 (AHDB9808)	T2	red	6	3
CF2 (AHDB9862)	T1	blue	6	3
CF3 (AHDB9710)	T8	blue-stripy	6	3

Plot plan

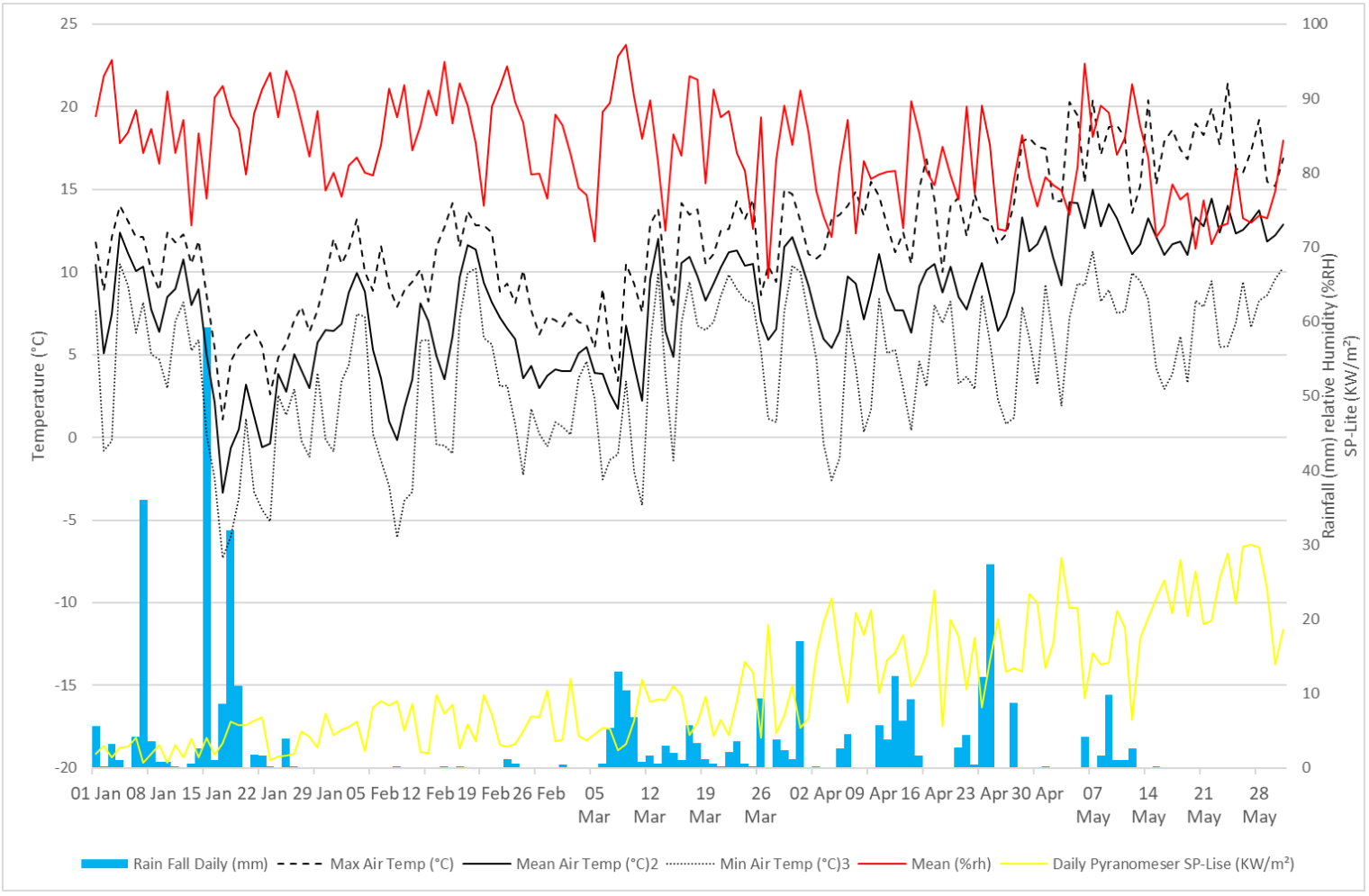
Tree no.	plot no.	treat.	colour	plot no.	treat.	colour	plot no.	treat.	colour	plot no.	treat.	colour	plot no.	treat.	colour	plot no.	treat.	colour
tree 50	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 49	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 48	110	T6	blue-green	210	T3	green	310	T2	red	410	T9	grey	510	T5	stripy	610	T4	yellow
tree 47	110	T6	blue-green	210	T3	green	310	T2	red	410	T9	grey	510	T5	stripy	610	T4	yellow
tree 46	110	T6	blue-green	210	T3	green	310	T2	red	410	T9	grey	510	T5	stripy	610	T4	yellow
tree 45	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 44	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 43	109	T7	blue-yellow	209	T10	black	309	T10	black	409	T7	blue-yellow	509	T9	grey	609	T7	blue-yellow
tree 42	109	T7	blue-yellow	209	T10	black	309	T10	black	409	T7	blue-yellow	509	T9	grey	609	T7	blue-yellow
tree 41	109	T7	blue-yellow	209	T10	black	309	T10	black	409	T7	blue-yellow	509	T9	grey	609	T7	blue-yellow
tree 40	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 39	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 38	108	T9	grey	208	T2	red	308	T5	stripy	408	T10	black	508	T1	blue	608	T5	stripy
tree 37	108	T9	grey	208	T2	red	308	T5	stripy	408	T10	black	508	T1	blue	608	T5	stripy
tree 36	108	T9	grey	208	T2	red	308	T5	stripy	408	T10	black	508	T1	blue	608	T5	stripy
tree 35	107	T8	blue-stripy	207	T9	grey	307	T1	blue	407	T5	stripy	507	T4	yellow	607	T1	blue
tree 34	107	T8	blue-stripy	207	T9	grey	307	T1	blue	407	T5	stripy	507	T4	yellow	607	T1	blue
tree 33	107	T8	blue-stripy	207	T9	grey	307	T1	blue	407	T5	stripy	507	T4	yellow	607	T1	blue
tree 32	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 31	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 30	106	T1	blue	206	T6	blue-green	306	T4	yellow	406	T8	blue-stripy	506	T8	blue-stripy	606	T10	black
tree 29	106	T1	blue	206	T6	blue-green	306	T4	yellow	406	T8	blue-stripy	506	T8	blue-stripy	606	T10	black
tree 28	106	T1	blue	206	T6	blue-green	306	T4	yellow	406	T8	blue-stripy	506	T8	blue-stripy	606	T10	black
tree 27	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 26	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 25	105	T5	stripy	205	T1	blue	305	T6	blue-green	405	T3	green	505	T3	green	605	T2	red
tree 24	105	T5	stripy	205	T1	blue	305	T6	blue-green	405	T3	green	505	T3	green	605	T2	red
tree 23	105	T5	stripy	205	T1	blue	305	T6	blue-green	405	T3	green	505	T3	green	605	T2	red
tree 22	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 21	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 20	104	T10	black	204	T8	blue-stripy	304	T7	blue-yellow	404	T2	red	504	T7	blue-yellow	604	T8	blue-stripy
tree 19	104	T10	black	204	T8	blue-stripy	304	T7	blue-yellow	404	T2	red	504	T7	blue-yellow	604	T8	blue-stripy
tree 18	104	T10	black	204	T8	blue-stripy	304	T7	blue-yellow	404	T2	red	504	T7	blue-yellow	604	T8	blue-stripy
tree 17	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 16	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 15	103	T3	green	203	T5	stripy	303	T3	green	403	T1	blue	503	T6	blue-green	603	T9	grey
tree 14	103	T3	green	203	T5	stripy	303	T3	green	403	T1	blue	503	T6	blue-green	603	T9	grey
tree 13	103	T3	green	203	T5	stripy	303	T3	green	403	T1	blue	503	T6	blue-green	603	T9	grey
tree 12	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 11	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 10	102	T4	yellow	202	T7	blue-yellow	302	T8	blue-stripy	402	T6	blue-green	502	T2	red	602	T6	blue-green
tree 9	102	T4	yellow	202	T7	blue-yellow	302	T8	blue-stripy	402	T6	blue-green	502	T2	red	602	T6	blue-green
tree 8	102	T4	yellow	202	T7	blue-yellow	302	T8	blue-stripy	402	T6	blue-green	502	T2	red	602	T6	blue-green
tree 7	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 6	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 5	101	T2	red	201	T4	yellow	301	T9	grey	401	T4	yellow	501	T10	black	601	T3	green
tree 4	101	T2	red	201	T4	yellow	301	T9	grey	401	T4	yellow	501	T10	black	601	T3	green
tree 3	101	T2	red	201	T4	yellow	301	T9	grey	401	T4	yellow	501	T10	black	601	T3	green
tree 2	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
tree 1	Guard tree			Guard tree			Guard tree			Guard tree			Guard tree			Guard tree		
Guard row	block 1		Guard row	block 2		Guard row	block 3		Guard row	block 4		Guard row	block5		Guard row	block6		Guard row

D) Weather Data

Oct 2022- Dec 2022



Jan 2023 – May 2023



E) Raw data

Rasp wounds

Block	Plot	Code	Inoculum_level	Total_rasp_w	Canker_rasp_w
block 1	101	CF1 (AHDB9808)	2-Artificial_low	16	3
block 1	101	CF1 (AHDB9808)	3-Artificial_high	18	0
block 1	101	CF1 (AHDB9808)	1-Natural	27	1
block 1	102	BCA1 (AHDB9788)	2-Artificial_low	18	8
block 1	102	BCA1 (AHDB9788)	3-Artificial_high	18	4
block 1	102	BCA1 (AHDB9788)	1-Natural	24	0
block 1	103	PE2 (AHDB9852)	2-Artificial_low	18	7
block 1	103	PE2 (AHDB9852)	3-Artificial_high	18	4
block 1	103	PE2 (AHDB9852)	1-Natural	24	4
block 1	104	Standard	2-Artificial_low	18	8
block 1	104	Standard	3-Artificial_high	18	3
block 1	104	Standard	1-Natural	27	0
block 1	105	BCA3 (AHDB9712)	2-Artificial_low	18	8
block 1	105	BCA3 (AHDB9712)	3-Artificial_high	18	6
block 1	105	BCA3 (AHDB9712)	1-Natural	27	4
block 1	106	CF2 (AHDB9862)	2-Artificial_low	18	10
block 1	106	CF2 (AHDB9862)	3-Artificial_high	18	4
block 1	106	CF2 (AHDB9862)	1-Natural	27	1
block 1	107	CF3 (AHDB9710)	2-Artificial_low	18	10
block 1	107	CF3 (AHDB9710)	3-Artificial_high	18	5
block 1	107	CF3 (AHDB9710)	1-Natural	27	11
block 1	108	Water	2-Artificial_low	18	10
block 1	108	Water	3-Artificial_high	18	9
block 1	108	Water	1-Natural	27	8
block 1	109	BCA2 (AHDB9694)	2-Artificial_low	18	12
block 1	109	BCA2 (AHDB9694)	3-Artificial_high	18	8
block 1	109	BCA2 (AHDB9694)	1-Natural	27	6
block 1	110	PE1 (AHDB9792)	2-Artificial_low	18	11
block 1	110	PE1 (AHDB9792)	3-Artificial_high	18	2
block 1	110	PE1 (AHDB9792)	1-Natural	27	7
block 2	201	BCA1 (AHDB9788)	2-Artificial_low	18	9
block 2	201	BCA1 (AHDB9788)	3-Artificial_high	18	7
block 2	201	BCA1 (AHDB9788)	1-Natural	27	3
block 2	202	BCA2 (AHDB9694)	2-Artificial_low	16	11
block 2	202	BCA2 (AHDB9694)	3-Artificial_high	18	8
block 2	202	BCA2 (AHDB9694)	1-Natural	24	2
block 2	203	BCA3 (AHDB9712)	2-Artificial_low	17	10
block 2	203	BCA3 (AHDB9712)	3-Artificial_high	18	3
block 2	203	BCA3 (AHDB9712)	1-Natural	27	0
block 2	204	CF3 (AHDB9710)	2-Artificial_low	18	7
block 2	204	CF3 (AHDB9710)	3-Artificial_high	18	2

block 2	204	CF3 (AHDB9710)	1-Natural	27	0
block 2	205	CF2 (AHDB9862)	2-Artificial_low	18	9
block 2	205	CF2 (AHDB9862)	3-Artificial_high	16	4
block 2	205	CF2 (AHDB9862)	1-Natural	24	0
block 2	206	PE1 (AHDB9792)	2-Artificial_low	18	7
block 2	206	PE1 (AHDB9792)	3-Artificial_high	18	4
block 2	206	PE1 (AHDB9792)	1-Natural	24	5
block 2	207	Water	2-Artificial_low	15	11
block 2	207	Water	3-Artificial_high	18	5
block 2	207	Water	1-Natural	27	1
block 2	208	CF1 (AHDB9808)	2-Artificial_low	16	11
block 2	208	CF1 (AHDB9808)	3-Artificial_high	14	6
block 2	208	CF1 (AHDB9808)	1-Natural	27	2
block 2	209	Standard	2-Artificial_low	18	7
block 2	209	Standard	3-Artificial_high	18	1
block 2	209	Standard	1-Natural	21	0
block 2	210	PE2 (AHDB9852)	2-Artificial_low	18	12
block 2	210	PE2 (AHDB9852)	3-Artificial_high	18	2
block 2	210	PE2 (AHDB9852)	1-Natural	24	2
block 3	301	Water	2-Artificial_low	18	5
block 3	301	Water	3-Artificial_high	18	7
block 3	301	Water	1-Natural	27	11
block 3	302	CF3 (AHDB9710)	2-Artificial_low	18	8
block 3	302	CF3 (AHDB9710)	3-Artificial_high	18	8
block 3	302	CF3 (AHDB9710)	1-Natural	27	7
block 3	303	PE2 (AHDB9852)	2-Artificial_low	18	8
block 3	303	PE2 (AHDB9852)	3-Artificial_high	18	4
block 3	303	PE2 (AHDB9852)	1-Natural	27	1
block 3	304	BCA2 (AHDB9694)	2-Artificial_low	18	8
block 3	304	BCA2 (AHDB9694)	3-Artificial_high	18	7
block 3	304	BCA2 (AHDB9694)	1-Natural	27	3
block 3	305	PE1 (AHDB9792)	2-Artificial_low	18	5
block 3	305	PE1 (AHDB9792)	3-Artificial_high	16	3
block 3	305	PE1 (AHDB9792)	1-Natural	27	1
block 3	306	BCA1 (AHDB9788)	2-Artificial_low	18	1
block 3	306	BCA1 (AHDB9788)	3-Artificial_high	14	1
block 3	306	BCA1 (AHDB9788)	1-Natural	18	1
block 3	307	CF2 (AHDB9862)	2-Artificial_low	18	9
block 3	307	CF2 (AHDB9862)	3-Artificial_high	18	3
block 3	307	CF2 (AHDB9862)	1-Natural	24	2
block 3	308	BCA3 (AHDB9712)	2-Artificial_low	18	7
block 3	308	BCA3 (AHDB9712)	3-Artificial_high	18	5
block 3	308	BCA3 (AHDB9712)	1-Natural	25	1
block 3	309	Standard	2-Artificial_low	16	5
block 3	309	Standard	3-Artificial_high	16	5

block 3	309	Standard	1-Natural	24	0
block 3	310	CF1 (AHDB9808)	2-Artificial_low	18	5
block 3	310	CF1 (AHDB9808)	3-Artificial_high	18	3
block 3	310	CF1 (AHDB9808)	1-Natural	27	0
block 4	401	BCA1 (AHDB9788)	2-Artificial_low	18	5
block 4	401	BCA1 (AHDB9788)	3-Artificial_high	18	1
block 4	401	BCA1 (AHDB9788)	1-Natural	24	0
block 4	402	PE1 (AHDB9792)	2-Artificial_low	18	8
block 4	402	PE1 (AHDB9792)	3-Artificial_high	18	5
block 4	402	PE1 (AHDB9792)	1-Natural	27	1
block 4	403	CF2 (AHDB9862)	2-Artificial_low	18	16
block 4	403	CF2 (AHDB9862)	3-Artificial_high	18	4
block 4	403	CF2 (AHDB9862)	1-Natural	24	0
block 4	404	CF1 (AHDB9808)	2-Artificial_low	18	11
block 4	404	CF1 (AHDB9808)	3-Artificial_high	18	5
block 4	404	CF1 (AHDB9808)	1-Natural	27	2
block 4	405	PE2 (AHDB9852)	2-Artificial_low	18	10
block 4	405	PE2 (AHDB9852)	3-Artificial_high	18	5
block 4	405	PE2 (AHDB9852)	1-Natural	27	1
block 4	406	CF3 (AHDB9710)	2-Artificial_low	18	10
block 4	406	CF3 (AHDB9710)	3-Artificial_high	18	4
block 4	406	CF3 (AHDB9710)	1-Natural	26	0
block 4	407	BCA3 (AHDB9712)	2-Artificial_low	18	6
block 4	407	BCA3 (AHDB9712)	3-Artificial_high	18	4
block 4	407	BCA3 (AHDB9712)	1-Natural	15	0
block 4	408	Standard	2-Artificial_low	18	5
block 4	408	Standard	3-Artificial_high	18	4
block 4	408	Standard	1-Natural	25	1
block 4	409	BCA2 (AHDB9694)	2-Artificial_low	18	7
block 4	409	BCA2 (AHDB9694)	3-Artificial_high	18	3
block 4	409	BCA2 (AHDB9694)	1-Natural	27	3
block 4	410	Water	2-Artificial_low	18	5
block 4	410	Water	3-Artificial_high	18	3
block 4	410	Water	1-Natural	27	0
block 5	501	Standard	2-Artificial_low	18	6
block 5	501	Standard	3-Artificial_high	18	11
block 5	501	Standard	1-Natural	27	3
block 5	502	CF1 (AHDB9808)	2-Artificial_low	18	11
block 5	502	CF1 (AHDB9808)	3-Artificial_high	18	14
block 5	502	CF1 (AHDB9808)	1-Natural	24	11
block 5	503	PE1 (AHDB9792)	2-Artificial_low	18	9
block 5	503	PE1 (AHDB9792)	3-Artificial_high	18	18
block 5	503	PE1 (AHDB9792)	1-Natural	27	5
block 5	504	BCA2 (AHDB9694)	2-Artificial_low	18	12
block 5	504	BCA2 (AHDB9694)	3-Artificial_high	18	18

block 5	504	BCA2 (AHDB9694)	1-Natural	27	3
block 5	505	PE2 (AHDB9852)	2-Artificial_low	18	9
block 5	505	PE2 (AHDB9852)	3-Artificial_high	18	18
block 5	505	PE2 (AHDB9852)	1-Natural	27	1
block 5	506	CF3 (AHDB9710)	2-Artificial_low	17	5
block 5	506	CF3 (AHDB9710)	3-Artificial_high	18	16
block 5	506	CF3 (AHDB9710)	1-Natural	24	5
block 5	507	BCA1 (AHDB9788)	2-Artificial_low	18	7
block 5	507	BCA1 (AHDB9788)	3-Artificial_high	18	17
block 5	507	BCA1 (AHDB9788)	1-Natural	24	2
block 5	508	CF2 (AHDB9862)	2-Artificial_low	16	5
block 5	508	CF2 (AHDB9862)	3-Artificial_high	18	18
block 5	508	CF2 (AHDB9862)	1-Natural	27	2
block 5	509	Water	2-Artificial_low	18	11
block 5	509	Water	3-Artificial_high	16	16
block 5	509	Water	1-Natural	27	2
block 5	510	BCA3 (AHDB9712)	2-Artificial_low	18	13
block 5	510	BCA3 (AHDB9712)	3-Artificial_high	18	15
block 5	510	BCA3 (AHDB9712)	1-Natural	27	4
block 6	601	PE2 (AHDB9852)	2-Artificial_low	18	6
block 6	601	PE2 (AHDB9852)	3-Artificial_high	10	10
block 6	601	PE2 (AHDB9852)	1-Natural	24	0
block 6	602	PE1 (AHDB9792)	2-Artificial_low	16	4
block 6	602	PE1 (AHDB9792)	3-Artificial_high	10	9
block 6	602	PE1 (AHDB9792)	1-Natural	27	0
block 6	603	Water	2-Artificial_low	18	10
block 6	603	Water	3-Artificial_high	10	10
block 6	603	Water	1-Natural	21	0
block 6	604	CF3 (AHDB9710)	2-Artificial_low	18	5
block 6	604	CF3 (AHDB9710)	3-Artificial_high	18	17
block 6	604	CF3 (AHDB9710)	1-Natural	27	0
block 6	605	CF1 (AHDB9808)	2-Artificial_low	16	7
block 6	605	CF1 (AHDB9808)	3-Artificial_high	10	8
block 6	605	CF1 (AHDB9808)	1-Natural	24	1
block 6	606	Standard	2-Artificial_low	18	3
block 6	606	Standard	3-Artificial_high	18	15
block 6	606	Standard	1-Natural	15	0
block 6	607	CF2 (AHDB9862)	2-Artificial_low	16	6
block 6	607	CF2 (AHDB9862)	3-Artificial_high	10	10
block 6	607	CF2 (AHDB9862)	1-Natural	27	0
block 6	608	BCA3 (AHDB9712)	2-Artificial_low	18	0
block 6	608	BCA3 (AHDB9712)	3-Artificial_high	14	12
block 6	608	BCA3 (AHDB9712)	1-Natural	24	0
block 6	609	BCA2 (AHDB9694)	2-Artificial_low	18	4
block 6	609	BCA2 (AHDB9694)	3-Artificial_high	12	11

block 6	609	BCA2 (AHDB9694)	1-Natural	27	2
block 6	610	BCA1 (AHDB9788)	2-Artificial_low	18	7
block 6	610	BCA1 (AHDB9788)	3-Artificial_high	18	18
block 6	610	BCA1 (AHDB9788)	1-Natural	24	1

Leaf/bud scar wounds

Block	Plot	Code	Inoculum_level	Total_leaf_buds	Cankers_leaf_buds
block 1	101	CF1 (AHDB9808)	2-Artificial_low	24	0
block 1	101	CF1 (AHDB9808)	3-Artificial_high	27	0
block 1	102	BCA1 (AHDB9788)	2-Artificial_low	27	0
block 1	102	BCA1 (AHDB9788)	3-Artificial_high	27	1
block 1	103	PE2 (AHDB9852)	2-Artificial_low	27	0
block 1	103	PE2 (AHDB9852)	3-Artificial_high	27	0
block 1	104	Standard	2-Artificial_low	27	0
block 1	104	Standard	3-Artificial_high	27	0
block 1	105	BCA3 (AHDB9712)	2-Artificial_low	27	0
block 1	105	BCA3 (AHDB9712)	3-Artificial_high	27	0
block 1	106	CF2 (AHDB9862)	2-Artificial_low	27	0
block 1	106	CF2 (AHDB9862)	3-Artificial_high	27	0
block 1	107	CF3 (AHDB9710)	2-Artificial_low	27	0
block 1	107	CF3 (AHDB9710)	3-Artificial_high	27	6
block 1	108	Water	2-Artificial_low	27	0
block 1	108	Water	3-Artificial_high	27	2
block 1	109	BCA2 (AHDB9694)	2-Artificial_low	27	0
block 1	109	BCA2 (AHDB9694)	3-Artificial_high	27	3
block 1	110	PE1 (AHDB9792)	2-Artificial_low	27	3
block 1	110	PE1 (AHDB9792)	3-Artificial_high	27	1
block 2	201	BCA1 (AHDB9788)	2-Artificial_low	27	0
block 2	201	BCA1 (AHDB9788)	3-Artificial_high	27	5
block 2	202	BCA2 (AHDB9694)	2-Artificial_low	24	2
block 2	202	BCA2 (AHDB9694)	3-Artificial_high	27	2
block 2	203	BCA3 (AHDB9712)	2-Artificial_low	27	2
block 2	203	BCA3 (AHDB9712)	3-Artificial_high	27	1
block 2	204	CF3 (AHDB9710)	2-Artificial_low	27	2
block 2	204	CF3 (AHDB9710)	3-Artificial_high	27	1
block 2	205	CF2 (AHDB9862)	2-Artificial_low	27	3
block 2	205	CF2 (AHDB9862)	3-Artificial_high	24	0
block 2	206	PE1 (AHDB9792)	2-Artificial_low	27	2
block 2	206	PE1 (AHDB9792)	3-Artificial_high	27	4
block 2	207	Water	2-Artificial_low	24	3
block 2	207	Water	3-Artificial_high	27	4
block 2	208	CF1 (AHDB9808)	2-Artificial_low	24	3
block 2	208	CF1 (AHDB9808)	3-Artificial_high	21	4
block 2	209	Standard	2-Artificial_low	27	0
block 2	209	Standard	3-Artificial_high	27	2
block 2	210	PE2 (AHDB9852)	2-Artificial_low	27	6

block 2	210	PE2 (AHDB9852)	3-Artificial_high	27	3
block 3	301	Water	2-Artificial_low	27	0
block 3	301	Water	3-Artificial_high	27	0
block 3	302	CF3 (AHDB9710)	2-Artificial_low	27	0
block 3	302	CF3 (AHDB9710)	3-Artificial_high	27	1
block 3	303	PE2 (AHDB9852)	2-Artificial_low	27	0
block 3	303	PE2 (AHDB9852)	3-Artificial_high	27	0
block 3	304	BCA2 (AHDB9694)	2-Artificial_low	27	0
block 3	304	BCA2 (AHDB9694)	3-Artificial_high	27	0
block 3	305	PE1 (AHDB9792)	2-Artificial_low	27	0
block 3	305	PE1 (AHDB9792)	3-Artificial_high	24	0
block 3	306	BCA1 (AHDB9788)	2-Artificial_low	27	0
block 3	306	BCA1 (AHDB9788)	3-Artificial_high	24	0
block 3	307	CF2 (AHDB9862)	2-Artificial_low	27	0
block 3	307	CF2 (AHDB9862)	3-Artificial_high	27	0
block 3	308	BCA3 (AHDB9712)	2-Artificial_low	27	0
block 3	308	BCA3 (AHDB9712)	3-Artificial_high	27	0
block 3	309	Standard	2-Artificial_low	24	1
block 3	309	Standard	3-Artificial_high	24	1
block 3	310	CF1 (AHDB9808)	2-Artificial_low	27	0
block 3	310	CF1 (AHDB9808)	3-Artificial_high	27	0
block 4	401	BCA1 (AHDB9788)	2-Artificial_low	27	0
block 4	401	BCA1 (AHDB9788)	3-Artificial_high	27	0
block 4	402	PE1 (AHDB9792)	2-Artificial_low	27	1
block 4	402	PE1 (AHDB9792)	3-Artificial_high	27	0
block 4	403	CF2 (AHDB9862)	2-Artificial_low	27	0
block 4	403	CF2 (AHDB9862)	3-Artificial_high	27	0
block 4	404	CF1 (AHDB9808)	2-Artificial_low	27	0
block 4	404	CF1 (AHDB9808)	3-Artificial_high	27	0
block 4	405	PE2 (AHDB9852)	2-Artificial_low	27	0
block 4	405	PE2 (AHDB9852)	3-Artificial_high	27	0
block 4	406	CF3 (AHDB9710)	2-Artificial_low	27	0
block 4	406	CF3 (AHDB9710)	3-Artificial_high	27	1
block 4	407	BCA3 (AHDB9712)	2-Artificial_low	27	0
block 4	407	BCA3 (AHDB9712)	3-Artificial_high	27	1
block 4	408	Standard	2-Artificial_low	27	0
block 4	408	Standard	3-Artificial_high	27	0
block 4	409	BCA2 (AHDB9694)	2-Artificial_low	27	0
block 4	409	BCA2 (AHDB9694)	3-Artificial_high	27	0
block 4	410	Water	2-Artificial_low	27	0
block 4	410	Water	3-Artificial_high	27	0
block 5	501	Standard	2-Artificial_low	27	0
block 5	501	Standard	3-Artificial_high	27	1
block 5	502	CF1 (AHDB9808)	2-Artificial_low	27	1
block 5	502	CF1 (AHDB9808)	3-Artificial_high	27	1

block 5	503	PE1 (AHDB9792)	2-Artificial_low	27	0
block 5	503	PE1 (AHDB9792)	3-Artificial_high	27	0
block 5	504	BCA2 (AHDB9694)	2-Artificial_low	27	3
block 5	504	BCA2 (AHDB9694)	3-Artificial_high	27	0
block 5	505	PE2 (AHDB9852)	2-Artificial_low	27	0
block 5	505	PE2 (AHDB9852)	3-Artificial_high	27	2
block 5	506	CF3 (AHDB9710)	2-Artificial_low	27	1
block 5	506	CF3 (AHDB9710)	3-Artificial_high	27	0
block 5	507	BCA1 (AHDB9788)	2-Artificial_low	27	2
block 5	507	BCA1 (AHDB9788)	3-Artificial_high	27	1
block 5	508	CF2 (AHDB9862)	2-Artificial_low	24	1
block 5	508	CF2 (AHDB9862)	3-Artificial_high	27	2
block 5	509	Water	2-Artificial_low	27	0
block 5	509	Water	3-Artificial_high	24	1
block 5	510	BCA3 (AHDB9712)	2-Artificial_low	27	0
block 5	510	BCA3 (AHDB9712)	3-Artificial_high	27	4
block 6	601	PE2 (AHDB9852)	2-Artificial_low	27	0
block 6	601	PE2 (AHDB9852)	3-Artificial_high	15	1
block 6	602	PE1 (AHDB9792)	2-Artificial_low	24	0
block 6	602	PE1 (AHDB9792)	3-Artificial_high	15	0
block 6	603	Water	2-Artificial_low	27	1
block 6	603	Water	3-Artificial_high	15	0
block 6	604	CF3 (AHDB9710)	2-Artificial_low	27	0
block 6	604	CF3 (AHDB9710)	3-Artificial_high	27	0
block 6	605	CF1 (AHDB9808)	2-Artificial_low	24	0
block 6	605	CF1 (AHDB9808)	3-Artificial_high	15	0
block 6	606	Standard	2-Artificial_low	27	0
block 6	606	Standard	3-Artificial_high	27	0
block 6	607	CF2 (AHDB9862)	2-Artificial_low	24	0
block 6	607	CF2 (AHDB9862)	3-Artificial_high	15	0
block 6	608	BCA3 (AHDB9712)	2-Artificial_low	27	0
block 6	608	BCA3 (AHDB9712)	3-Artificial_high	21	0
block 6	609	BCA2 (AHDB9694)	2-Artificial_low	27	0
block 6	609	BCA2 (AHDB9694)	3-Artificial_high	18	0
block 6	610	BCA1 (AHDB9788)	2-Artificial_low	27	1
block 6	610	BCA1 (AHDB9788)	3-Artificial_high	27	5

Naturally infected pruning wounds

Block	Plot	Code	Inoculum_level	Total_pruning_w	Canker_pruning_w
block 1	102	BCA1 (AHDB9788)	1-Natural	8	0
block 2	201	BCA1 (AHDB9788)	1-Natural	9	0
block 3	306	BCA1 (AHDB9788)	1-Natural	6	1
block 4	401	BCA1 (AHDB9788)	1-Natural	8	0
block 5	507	BCA1 (AHDB9788)	1-Natural	8	0

block 6	610	BCA1 (AHDB9788)	1-Natural	8	0
block 3	306	BCA1 (AHDB9788)	2-Artificial_low	18	1
block 3	306	BCA1 (AHDB9788)	3-Artificial_high	14	1
block 3	306	BCA1 (AHDB9788)	1-Natural	18	1
block 4	401	BCA1 (AHDB9788)	2-Artificial_low	18	5
block 4	401	BCA1 (AHDB9788)	3-Artificial_high	18	1
block 4	401	BCA1 (AHDB9788)	1-Natural	24	0
block 5	507	BCA1 (AHDB9788)	2-Artificial_low	18	7
block 5	507	BCA1 (AHDB9788)	3-Artificial_high	18	17
block 5	507	BCA1 (AHDB9788)	1-Natural	24	2
block 6	610	BCA1 (AHDB9788)	2-Artificial_low	18	7
block 6	610	BCA1 (AHDB9788)	3-Artificial_high	18	18
block 6	610	BCA1 (AHDB9788)	1-Natural	24	1
block 1	109	BCA2 (AHDB9694)	1-Natural	9	1
block 2	202	BCA2 (AHDB9694)	1-Natural	8	1
block 3	304	BCA2 (AHDB9694)	1-Natural	9	0
block 4	409	BCA2 (AHDB9694)	1-Natural	9	0
block 5	504	BCA2 (AHDB9694)	1-Natural	9	1
block 6	609	BCA2 (AHDB9694)	1-Natural	8	0
block 3	304	BCA2 (AHDB9694)	2-Artificial_low	18	8
block 3	304	BCA2 (AHDB9694)	3-Artificial_high	18	7
block 3	304	BCA2 (AHDB9694)	1-Natural	27	3
block 4	409	BCA2 (AHDB9694)	2-Artificial_low	18	7
block 4	409	BCA2 (AHDB9694)	3-Artificial_high	18	3
block 4	409	BCA2 (AHDB9694)	1-Natural	27	3
block 5	504	BCA2 (AHDB9694)	2-Artificial_low	18	12
block 5	504	BCA2 (AHDB9694)	3-Artificial_high	18	18
block 5	504	BCA2 (AHDB9694)	1-Natural	27	3
block 6	609	BCA2 (AHDB9694)	2-Artificial_low	18	4
block 6	609	BCA2 (AHDB9694)	3-Artificial_high	12	11
block 6	609	BCA2 (AHDB9694)	1-Natural	27	2
block 1	105	BCA3 (AHDB9712)	1-Natural	9	0
block 2	203	BCA3 (AHDB9712)	1-Natural	9	0
block 3	308	BCA3 (AHDB9712)	1-Natural	9	0
block 4	407	BCA3 (AHDB9712)	1-Natural	5	0
block 5	510	BCA3 (AHDB9712)	1-Natural	9	3
block 6	608	BCA3 (AHDB9712)	1-Natural	8	0
block 3	308	BCA3 (AHDB9712)	2-Artificial_low	18	7
block 3	308	BCA3 (AHDB9712)	3-Artificial_high	18	5
block 3	308	BCA3 (AHDB9712)	1-Natural	25	1
block 4	407	BCA3 (AHDB9712)	2-Artificial_low	18	6
block 4	407	BCA3 (AHDB9712)	3-Artificial_high	18	4
block 4	407	BCA3 (AHDB9712)	1-Natural	15	0
block 5	510	BCA3 (AHDB9712)	2-Artificial_low	18	13
block 5	510	BCA3 (AHDB9712)	3-Artificial_high	18	15

block 5	510	BCA3 (AHDB9712)	1-Natural	27	4
block 6	608	BCA3 (AHDB9712)	2-Artificial_low	18	0
block 6	608	BCA3 (AHDB9712)	3-Artificial_high	14	12
block 6	608	BCA3 (AHDB9712)	1-Natural	24	0
block 1	101	CF1 (AHDB9808)	1-Natural	9	0
block 2	208	CF1 (AHDB9808)	1-Natural	8	1
block 3	310	CF1 (AHDB9808)	1-Natural	9	0
block 4	404	CF1 (AHDB9808)	1-Natural	9	0
block 5	502	CF1 (AHDB9808)	1-Natural	9	1
block 6	605	CF1 (AHDB9808)	1-Natural	8	0
block 3	310	CF1 (AHDB9808)	2-Artificial_low	18	5
block 3	310	CF1 (AHDB9808)	3-Artificial_high	18	3
block 3	310	CF1 (AHDB9808)	1-Natural	27	0
block 4	404	CF1 (AHDB9808)	2-Artificial_low	18	11
block 4	404	CF1 (AHDB9808)	3-Artificial_high	18	5
block 4	404	CF1 (AHDB9808)	1-Natural	27	2
block 5	502	CF1 (AHDB9808)	2-Artificial_low	18	11
block 5	502	CF1 (AHDB9808)	3-Artificial_high	18	14
block 5	502	CF1 (AHDB9808)	1-Natural	24	11
block 6	605	CF1 (AHDB9808)	2-Artificial_low	16	7
block 6	605	CF1 (AHDB9808)	3-Artificial_high	10	8
block 6	605	CF1 (AHDB9808)	1-Natural	24	1
block 1	106	CF2 (AHDB9862)	1-Natural	9	0
block 2	205	CF2 (AHDB9862)	1-Natural	8	0
block 3	307	CF2 (AHDB9862)	1-Natural	9	0
block 4	403	CF2 (AHDB9862)	1-Natural	8	1
block 5	508	CF2 (AHDB9862)	1-Natural	9	0
block 6	607	CF2 (AHDB9862)	1-Natural	9	0
block 3	307	CF2 (AHDB9862)	2-Artificial_low	18	9
block 3	307	CF2 (AHDB9862)	3-Artificial_high	18	3
block 3	307	CF2 (AHDB9862)	1-Natural	24	2
block 4	403	CF2 (AHDB9862)	2-Artificial_low	18	16
block 4	403	CF2 (AHDB9862)	3-Artificial_high	18	4
block 4	403	CF2 (AHDB9862)	1-Natural	24	0
block 5	508	CF2 (AHDB9862)	2-Artificial_low	16	5
block 5	508	CF2 (AHDB9862)	3-Artificial_high	18	18
block 5	508	CF2 (AHDB9862)	1-Natural	27	2
block 6	607	CF2 (AHDB9862)	2-Artificial_low	16	6
block 6	607	CF2 (AHDB9862)	3-Artificial_high	10	10
block 6	607	CF2 (AHDB9862)	1-Natural	27	0
block 1	107	CF3 (AHDB9710)	1-Natural	9	3
block 2	204	CF3 (AHDB9710)	1-Natural	9	2
block 3	302	CF3 (AHDB9710)	1-Natural	9	0
block 4	406	CF3 (AHDB9710)	1-Natural	9	0
block 5	506	CF3 (AHDB9710)	1-Natural	8	1

block 6	604	CF3 (AHDB9710)	1-Natural	9	0
block 3	302	CF3 (AHDB9710)	2-Artificial_low	18	8
block 3	302	CF3 (AHDB9710)	3-Artificial_high	18	8
block 3	302	CF3 (AHDB9710)	1-Natural	27	7
block 4	406	CF3 (AHDB9710)	2-Artificial_low	18	10
block 4	406	CF3 (AHDB9710)	3-Artificial_high	18	4
block 4	406	CF3 (AHDB9710)	1-Natural	26	0
block 5	506	CF3 (AHDB9710)	2-Artificial_low	17	5
block 5	506	CF3 (AHDB9710)	3-Artificial_high	18	16
block 5	506	CF3 (AHDB9710)	1-Natural	24	5
block 6	604	CF3 (AHDB9710)	2-Artificial_low	18	5
block 6	604	CF3 (AHDB9710)	3-Artificial_high	18	17
block 6	604	CF3 (AHDB9710)	1-Natural	27	0
block 1	110	PE1 (AHDB9792)	1-Natural	9	1
block 2	206	PE1 (AHDB9792)	1-Natural	9	0
block 3	305	PE1 (AHDB9792)	1-Natural	9	0
block 4	402	PE1 (AHDB9792)	1-Natural	9	2
block 5	503	PE1 (AHDB9792)	1-Natural	9	1
block 6	602	PE1 (AHDB9792)	1-Natural	9	0
block 3	305	PE1 (AHDB9792)	2-Artificial_low	18	5
block 3	305	PE1 (AHDB9792)	3-Artificial_high	16	3
block 3	305	PE1 (AHDB9792)	1-Natural	27	1
block 4	402	PE1 (AHDB9792)	2-Artificial_low	18	8
block 4	402	PE1 (AHDB9792)	3-Artificial_high	18	5
block 4	402	PE1 (AHDB9792)	1-Natural	27	1
block 5	503	PE1 (AHDB9792)	2-Artificial_low	18	9
block 5	503	PE1 (AHDB9792)	3-Artificial_high	18	18
block 5	503	PE1 (AHDB9792)	1-Natural	27	5
block 6	602	PE1 (AHDB9792)	2-Artificial_low	16	4
block 6	602	PE1 (AHDB9792)	3-Artificial_high	10	9
block 6	602	PE1 (AHDB9792)	1-Natural	27	0
block 1	103	PE2 (AHDB9852)	1-Natural	8	0
block 2	210	PE2 (AHDB9852)	1-Natural	8	0
block 3	303	PE2 (AHDB9852)	1-Natural	9	2
block 4	405	PE2 (AHDB9852)	1-Natural	9	0
block 5	505	PE2 (AHDB9852)	1-Natural	9	0
block 6	601	PE2 (AHDB9852)	1-Natural	8	0
block 3	303	PE2 (AHDB9852)	2-Artificial_low	18	8
block 3	303	PE2 (AHDB9852)	3-Artificial_high	18	4
block 3	303	PE2 (AHDB9852)	1-Natural	27	1
block 4	405	PE2 (AHDB9852)	2-Artificial_low	18	10
block 4	405	PE2 (AHDB9852)	3-Artificial_high	18	5
block 4	405	PE2 (AHDB9852)	1-Natural	27	1
block 5	505	PE2 (AHDB9852)	2-Artificial_low	18	9
block 5	505	PE2 (AHDB9852)	3-Artificial_high	18	18

block 5	505	PE2 (AHDB9852)	1-Natural	27	1
block 6	601	PE2 (AHDB9852)	2-Artificial_low	18	6
block 6	601	PE2 (AHDB9852)	3-Artificial_high	10	10
block 6	601	PE2 (AHDB9852)	1-Natural	24	0
block 1	104	Standard	1-Natural	9	1
block 2	209	Standard	1-Natural	7	0
block 3	309	Standard	1-Natural	8	0
block 4	408	Standard	1-Natural	9	0
block 5	501	Standard	1-Natural	9	0
block 6	606	Standard	1-Natural	5	2
block 3	309	Standard	2-Artificial_low	16	5
block 3	309	Standard	3-Artificial_high	16	5
block 3	309	Standard	1-Natural	24	0
block 4	408	Standard	2-Artificial_low	18	5
block 4	408	Standard	3-Artificial_high	18	4
block 4	408	Standard	1-Natural	25	1
block 5	501	Standard	2-Artificial_low	18	6
block 5	501	Standard	3-Artificial_high	18	11
block 5	501	Standard	1-Natural	27	3
block 6	606	Standard	2-Artificial_low	18	3
block 6	606	Standard	3-Artificial_high	18	15
block 6	606	Standard	1-Natural	15	0
block 1	108	Water	1-Natural	9	2
block 2	207	Water	1-Natural	9	0
block 3	301	Water	1-Natural	9	0
block 4	410	Water	1-Natural	9	0
block 5	509	Water	1-Natural	9	1
block 6	603	Water	1-Natural	7	0
block 3	301	Water	2-Artificial_low	18	5
block 3	301	Water	3-Artificial_high	18	7
block 3	301	Water	1-Natural	27	11
block 4	410	Water	2-Artificial_low	18	5
block 4	410	Water	3-Artificial_high	18	3
block 4	410	Water	1-Natural	27	0
block 5	509	Water	2-Artificial_low	18	11
block 5	509	Water	3-Artificial_high	16	16
block 5	509	Water	1-Natural	27	2
block 6	603	Water	2-Artificial_low	18	10
block 6	603	Water	3-Artificial_high	10	10
block 6	603	Water	1-Natural	21	0

Naturally infected natural wounds

Block	Plot	Code	Inoculum_level	Total_infectios
block 1	101	CF1 (AHDB9808)	1-Natural	0
block 1	102	BCA1 (AHDB9788)	1-Natural	0
block 1	103	PE2 (AHDB9852)	1-Natural	0
block 1	104	Standard	1-Natural	0
block 1	105	BCA3 (AHDB9712)	1-Natural	0
block 1	106	CF2 (AHDB9862)	1-Natural	0
block 1	107	CF3 (AHDB9710)	1-Natural	0
block 1	108	Water	1-Natural	0
block 1	109	BCA2 (AHDB9694)	1-Natural	0
block 1	110	PE1 (AHDB9792)	1-Natural	0
block 2	201	BCA1 (AHDB9788)	1-Natural	0
block 2	202	BCA2 (AHDB9694)	1-Natural	0
block 2	203	BCA3 (AHDB9712)	1-Natural	0
block 2	204	CF3 (AHDB9710)	1-Natural	0
block 2	205	CF2 (AHDB9862)	1-Natural	0
block 2	206	PE1 (AHDB9792)	1-Natural	0
block 2	207	Water	1-Natural	5
block 2	208	CF1 (AHDB9808)	1-Natural	0
block 2	209	Standard	1-Natural	0
block 2	210	PE2 (AHDB9852)	1-Natural	1
block 3	301	Water	1-Natural	0
block 3	302	CF3 (AHDB9710)	1-Natural	0
block 3	303	PE2 (AHDB9852)	1-Natural	0
block 3	304	BCA2 (AHDB9694)	1-Natural	0
block 3	305	PE1 (AHDB9792)	1-Natural	0
block 3	306	BCA1 (AHDB9788)	1-Natural	0
block 3	307	CF2 (AHDB9862)	1-Natural	0
block 3	308	BCA3 (AHDB9712)	1-Natural	0
block 3	309	Standard	1-Natural	0
block 3	310	CF1 (AHDB9808)	1-Natural	0
block 4	401	BCA1 (AHDB9788)	1-Natural	0
block 4	402	PE1 (AHDB9792)	1-Natural	2
block 4	403	CF2 (AHDB9862)	1-Natural	1
block 4	404	CF1 (AHDB9808)	1-Natural	0
block 4	405	PE2 (AHDB9852)	1-Natural	0
block 4	406	CF3 (AHDB9710)	1-Natural	2
block 4	407	BCA3 (AHDB9712)	1-Natural	0

block 4	408	Standard	1-Natural	2
block 4	409	BCA2 (AHDB9694)	1-Natural	0
block 4	410	Water	1-Natural	1
block 5	501	Standard	1-Natural	2
block 5	502	CF1 (AHDB9808)	1-Natural	2
block 5	503	PE1 (AHDB9792)	1-Natural	0
block 5	504	BCA2 (AHDB9694)	1-Natural	0
block 5	505	PE2 (AHDB9852)	1-Natural	0
block 5	506	CF3 (AHDB9710)	1-Natural	7
block 5	507	BCA1 (AHDB9788)	1-Natural	0
block 5	508	CF2 (AHDB9862)	1-Natural	0
block 5	509	Water	1-Natural	4
block 5	510	BCA3 (AHDB9712)	1-Natural	1
block 6	601	PE2 (AHDB9852)	1-Natural	0
block 6	602	PE1 (AHDB9792)	1-Natural	0
block 6	603	Water	1-Natural	0
block 6	604	CF3 (AHDB9710)	1-Natural	1
block 6	605	CF1 (AHDB9808)	1-Natural	0
block 6	606	Standard	1-Natural	0
block 6	607	CF2 (AHDB9862)	1-Natural	0
block 6	608	BCA3 (AHDB9712)	1-Natural	0
block 6	609	BCA2 (AHDB9694)	1-Natural	0
block 6	610	BCA1 (AHDB9788)	1-Natural	0

F) ORETO certificate

Certificate of

Official Recognition of Efficacy Testing Facilities or Organisations in the United Kingdom

This certifies that

NIAB EMR

complies with the minimum standards laid down in Regulation (EC) 1107/2009 for efficacy testing.

The above Facility/Organisation has been officially recognised as being competent to carry out efficacy trials/tests in the United Kingdom in the following categories:

Agriculture/Horticulture
Biologicals and Semiochemicals
Stored Crops

Date of issue: 12 July 2018
Effective date: 1 January 2018
Expiry date: 31 December 2022

Signature _____
Authorised signatory

Certification Number
ORETO 411

HSE
Chemicals Regulation Division

Department of
Agriculture and
Rural Development