Project title:	Extension of Innovate UK 102132. Winter chilling in blackcurrants: adapting to climate change, through new technologies for improved dormancy release
Project number:	SF 159a
Project leader:	Adrian Harris, NIAB EMR
Report:	Final Report 31 December 2021
Previous report:	n/a
Key staff:	Adrian Harris
Location of project:	
Industry Representative:	n/a
Date project commenced:	February 2020 to December 2020

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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.

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GROWER SUMMARY

Headline

Dormancy breaking in blackcurrant can be simply and effectively managed with the application of a dormancy breaking product at 3% green tip, either using a commercially available product:

- Brecaut LG 440 + Brecaut LG 441
- Bluprins + Bluact
- Erger + Active Erger

Or via a fertilizer mix of readily available products:

Treatment	Nitrogen source	Citric acid Conc.	Glucose Conc.	Wetter
Basal C	Ammonium nitrate (5 kg/hl)	2%	2%	Brecaut LG 441 (0.8%)
Basal A	Calcium nitrate (10 kg/hl)	2%	2%	Silwett L-77 (0.05%)
Basal C	Ammonium nitrate (5 kg/hl)	2%	2%	Silwett L-77 (0.05%)
Basal A	Calcium nitrate (10 kg/hl)	2%	2%	Wetcit (0.25%)
Basal C	Ammonium nitrate (5 kg/hl)	2%	2%	Wetcit (0.25%)

Background and expected deliverables

Blackcurrants require a prolonged chilling period to induce and synchronise flowering. With current fluctuations in the UK climate, blackcurrants are regularly failing to achieve the chilling required to allow buds to break evenly and fully, resulting in decreased yields and fruit quality. Under Innovate UK 102132 project “Winter chilling in blackcurrants: adapting to climate change, through new technologies for improved dormancy release”, new bud breaking products and combinations of nutrients were tested for their effect on bud breaking in blackcurrant. This project aims to unite the findings from work package 3 of the Innovate UK project and combine the most efficacious nutrients into a single treatment to validate findings, explore cheaper alternatives to the most expensive components of the mix and to test new commercially available products for bud breaking potential to protect the security of the supply of UK blackcurrants in a changing climate.

Summary of the project and main conclusions

Replicated small plot trials were undertaken in three blackcurrant plantations across Kent (Table 1).

Table 1. Replicated small plot trials in Kent

Site	Manager	Farm name	Address	Variety
1	John Hinchliff	Nackington Farm	Nackington Road Canterbury CT4 7BA	Ben Alder
2	Hugh Boucher	Newlands Farm	Teynham Sittingbourne ME9 9JQ	Ben Tirran
3	Graham Caspell	NIAB EMR	New Road East Malling ME19 6BJ	Ben Tirran

All three trials featured Erger + Active Erger as an industry standard and compared it to Basal A (Calcium nitrate) or Basal C (Ammonium nitrate). Erger + Active Erger was not always effective at inducing bud burst (nitrogen source trial on Ben Alder), suggesting that there are other factors involved in dormancy breaking than just the accumulation of chill hours and there may be other varietal effects involved.

In the two trials where significant results were obtained (wetting agent and industry alternatives), Basal A (Calcium nitrate) or Basal C (Ammonium nitrate) were never significantly different to each other, indicating that either Calcium nitrate or Ammonium nitrate, can be used as a nitrogen source for dormancy breaking.

The most startling result from the programme of work was how important the choice of wetting agent is in dormancy breaking, with the use of Silwett l-77 massively increasing the efficacy of both Basal A and C. This observation was borne from the use of the Brecaut LG 441 wetting agent with Basal C in the industry alternatives trial, as it significantly increased the efficacy of Basal C.

Stocks of Erger in the UK can often be limited so it would be beneficial to investigate the supply of Brecaut and Bluprins as both are equally effective at dormancy breaking in blackcurrant.

Main conclusions

- Both Calcium nitrate (Basal A) at 10 kg/hl or Ammonium nitrate (Basal C) at 5 kg/hl are equally effective as the nitrogen source in a dormancy breaking mix.
- Silwet L-77 increases the efficiency of both Basal A and C.
- Brecaut and Bluprins are the most effective of the three commercially available dormancy breaking products.
- The inclusion of the Brecaut LG 441 wetting agent with Basal C increases its efficiency as a dormancy breaker.

Financial benefits

According to Defra Horticultural Statistics (Provisional Figures for 2020), a total of 16.4 thousand tonnes of blackcurrants were produced in the UK and this was worth a value of £28.1 million. A reduction in yield of as little as 10% due to incomplete bud break following a mild winter could therefore result in a reduced income of £2.8 million for the blackcurrant industry and in many wild winters, losses are likely to rather more than this.

The use of effective dormancy breaking products, applied to blackcurrant bushes during the late winter period, therefore have the potential to make savings of several million pounds for the UK blackcurrant industry each season.

Action points for growers

- Where insufficient winter chilling has occurred in blackcurrants, use an effective dormancy breaking product in the late winter period at 3% green tip stage.

Use either a commercially available product:

- Brecaut LG 440 + Brecaut LG 441
- Bluprins + Bluact
- Erger + Active Erger

Or via a fertilizer mix of readily available products:

Treatment	Nitrogen source	Citric acid Conc.	Glucose Conc.	Wetter
Basal C	Ammonium nitrate (5 kg/hl)	2%	2%	Brecaut LG 441 (0.8%)
Basal A	Calcium nitrate (10 kg/hl)	2%	2%	Silwett L-77 (0.05%)
Basal C	Ammonium nitrate (5 kg/hl)	2%	2%	Silwett L-77 (0.05%)
Basal A	Calcium nitrate (10 kg/hl)	2%	2%	Wetcit (0.25%)
Basal C	Ammonium nitrate (5 kg/hl)	2%	2%	Wetcit (0.25%)

SCIENCE SECTION

Introduction

Blackcurrants require a prolonged chilling period to induce and synchronise flowering. With current fluctuations in the UK climate, blackcurrants are regularly failing to achieve the chilling required to allow buds to break evenly and fully, resulting in decreased yields and fruit quality. Under Innovate UK 102132 project “Winter chilling in blackcurrants: adapting to climate change, through new technologies for improved dormancy release”, new bud breaking products and combinations of nutrients were tested for their effect on bud breaking on blackcurrant. This project aims to unite the findings from Work Package 3 of the Innovate UK project and combine the most efficacious nutrients into a single treatment to validate findings, explore cheaper alternatives to the most expensive components of the mix and to test new commercially available products for bud breaking potential to protect the security of the supply of UK blackcurrants in a changing climate.

Objectives

Trial 1.

Evaluate the effect of varying nitrogen sources to compare Basal A with a new formulation Basal C in spray treatments on bud dormancy measured by bud break in Ben Alder at Nackington Farm, Canterbury.

Trial 2.

Evaluate the effect of varying wetter sources on the efficacy of Basal A compared with a new formulation Basal C in spray treatments on bud dormancy measured by bud break in Ben Tirran at Newlands Farm, Teynham.

Trial 3.

To evaluate the effects of commercially available dormancy breaking products in comparison with Basal A and Basal C on bud break in blackcurrant on the variety Ben Tirran at NIAB EMR.

Materials and methods

UK regulatory guidelines were followed but EPPO guidelines took precedence. The following EPPO guidelines were followed:

Relevant EPPO guideline(s)		**Variation from EPPO**
PP 1/152(3)	Design and analysis of efficacy evaluation trials	None
PP 1/135(3)	Phytotoxicity assessment	None
PP 1/181(3)	Conduct and reporting of efficacy evaluation trials including GEP	None

There were no deviations from EPPO guidance.

Trial 1.

Nitrogen source

Item	Details
Location address	Nackington Farm, Nackington Road, Canterbury, CT4 7BA (51.25240,1.08739)
Crop	Blackcurrant
Cultivar	Ben Alder
Soil or substrate type	Soilscape 5 Freely draining lime-rich loamy soils
Agronomic practice	LR Suntory advised
Prior history of site	Blackcurrant

Trial design

Item	Details
Trial design:	Randomised complete block design
Number of replicates:	4
Row spacing:	3m
Plot size: (w x l)	3.5m x 3m
Plot size: (m^2)	10.5m^2
Number of plants per plot:	7
Leaf Wall Area calculations	N/A

Treatment details

Treatment code	Active substance	Product name/ manufacturers code	Adjuvant
01	Untreated		
02	Erger + Active Erger	Erger + Active Erger	None
03	Calcium nitrate + 2% citric acid + 2% glucose	“Basal A”	Wetcit (0.25%)
04	Ammonium nitrate + 2% citric acid + 2% glucose	“Basal C”	Wetcit (0.25%)
05	Calcium nitrate	N/A	None
06	Ammonium nitrate	N/A	None
07	Citric acid	N/A	None
08	Glucose	N/A	None

N/A (Not applicable)

Application schedule

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application timing code
01	Untreated			08 April 2020
02	Erger + Active Erger	N/A	20 l/ha 30 l/ha	08 April 2020
03	“Basal A” Calcium nitrate + 2% citric acid + 2% glucose	40 kg/ha 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020
04	“Basal C” Ammonium nitrate + 2% citric acid + 2% glucose	20 kg/h 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020
05	Calcium nitrate	40 kg/ha	N/A	08 April 2020
06	Ammonium nitrate	20 kg/ha	N/A	08 April 2020
07	Citric acid	2% (8 kg/ha)	N/A	08 April 2020
08	Glucose	2% (8 kg/ha)	N/A	08 April 2020

Application details

	Application A
Application date	08/04/20
Time of day	10:50
Crop growth stage (Max, min average BBCH)	B1 (max), A(min), A(mean)
Crop height (cm)	75cm
Crop coverage (%)	N/A
Application Method	Mist blower
Application Placement	Crop
Application equipment	Euro-Pulve + Birchmeier Blower
Nozzle pressure	4 Bar
Nozzle type	Brown Albuz ATR 80
Nozzle size	
Application water volume l/ha	400
Temperature of air-shade (°C)	14.5
Relative humidity (%)	92
Wind speed range (m/s)	3.9-4.5
Dew presence (Y/N)	Y
Temperature of soil-2-5 cm (°C)	N/A
Wetness of soil-2-5 cm	N/A
Cloud cover (%)	N/A

Assessment Timing

Evaluation date	Evaluation Timing (Days After Application)	Crop Growth Stage (BBCH)	Evaluation type (efficacy, phytotox)	Assessment
17/04/20	9	A-B1	Growth	Visual Growth
24/04/20	16	A-B2	Growth	Visual Growth
01/05/20	23	A-B2	Growth	Visual Growth
08/05/20	30	A-B2	Growth	Visual Growth
23/05/20	44	A-B2	Growth	Visual Growth

Trial 2.

Wetting agents

Item	Details
Location address	Newlands Farm, Teynham, Sittingbourne Kent, ME9 9JQ (51.33897,0.786945)
Crop	Blackcurrant
Cultivar	Ben Tirran
Soil or substrate type	Soilscape 6 Freely draining slightly acid loamy soils
Agronomic practice	LR Suntory advised
Prior history of site	Blackcurrant

Trial design

Item	Details
Trial design	Randomised complete block design
Number of replicates	4
Row spacing	3m
Plot size: (w x l)	3.5m x 3m
Plot size: (m^2)	10.5m^2
Number of plants per plot:	7
Leaf wall area calculations	N/A

Treatment details

Treatment code	Active substance	Product name/ manufacturers code	Adjuvant
01	Untreated		
02	Erger + Active Erger	Erger + Active Erger	None
03	Calcium nitrate + 2% citric acid + 2% glucose	"Basal A"	Wetcit (0.25%)
04	Calcium nitrate + 2% citric acid + 2% glucose	"Basal A"	Codacide (0.25%)
05	Calcium nitrate + 2% citric acid + 2% glucose	"Basal A"	Silwett L-77 (0.05%)
06	Ammonium nitrate + 2% citric acid + 2% glucose	"Basal C"	Wetcit (0.25%)
07	Ammonium nitrate + 2% citric acid + 2% glucose	"Basal C"	Codacide (0.25%)
08	Ammonium nitrate + 2% citric acid + 2% glucose	"Basal C"	Silwett L-77 (0.05%)

Application schedule

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application timing
01	Untreated			08 April 2020
02	Erger + Active Erger	N/A	20 l/ha 30 l/ha	08 April 2020
03	"Basal A" Calcium nitrate + 2% citric acid + 2% glucose	40 kg/ha 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020
04	"Basal A" Calcium nitrate + 2% citric acid + 2% glucose	40 kg/ha 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020
05	"Basal A" Calcium nitrate + 2% citric acid + 2% glucose	40 kg/ha 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020
06	"Basal C" Ammonium nitrate + 2% citric acid + 2% glucose	20 kg/ha 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020
07	"Basal C" Ammonium nitrate + 2% citric acid + 2% glucose	20 kg/ha 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020
08	"Basal C" Ammonium nitrate + 2% citric acid + 2% glucose	20 kg/ha 2% (8 kg/ha) 2% (8 kg/ha)	N/A	08 April 2020

Application details

	Application A
Application date	08/04/20
Time of day	08:00
Crop growth stage (Max, min average BBCH)	A-B1
Crop height (cm)	100 cm
Crop coverage (%)	N/A
Application Method	Mist blower
Application Placement	Crop
Application equipment	Euro-Pulve + Birchmeier Blower
Nozzle pressure	4 Bar
Nozzle type	Brown Albuz
Nozzle size	ATR 80
Application water volume l/ha	400
Temperature of air-shade (°C)	10
Relative humidity (%)	94
Wind speed range (m/s)	0
Dew presence (Y/N)	Y
Temperature of soil-2-5 cm (°C)	N/A
Wetness of soil-2-5 cm	N/A
Cloud cover (%)	N/A

Evaluation date	Evaluation Timing (Days After Application)	Crop Growth Stage (BBCH)	Evaluation type	Assessment
10/04/20	2	A-B1	Growth	Visual Growth
17/04/20	9	A-C3	Growth	Visual Growth
26/04/20	18	A-D	Growth	Visual Growth
01/05/20	23	A-E2	Growth	Visual Growth
08/05/20	30	A-F2	Growth	Visual Growth
15/05/20	37	A-F3	Growth	Visual Growth
22/05/20	44	A I2	Growth	Visual Growth
30/05/20	52	A-I3	Growth	Visual Growth
06/06/20	59	A-I3	Growth	Visual Growth

Trial 3.

Commercial alternatives to Erger

Item	Details
Location address	NIAB EMR New Road East Malling, Kent, ME19 6BJ (51.288782, 0448483)
Crop	Blackcurrant
Cultivar	Ben Tirran
Soil or substrate type	Soilscape 6 Freely draining slightly acid loamy soils
Agronomic practice	LR Suntory advised
Prior history of site	Blackcurrant

Trial design

Item	Details
Trial design:	Randomised complete block design
Number of replicates:	4
Row spacing:	3m
Plot size: (w x l)	2.5m x 3m
Plot size: (m^2)	7.5m^2
Number of plants per plot:	8
Leaf wall area calculations	N/A

Treatment details

Treatment code	Active substance	Product name/ manufacturers code	Adjuvant
01	Untreated		
02	Erger + Active Erger	Erger + Active Erger	None
03	Calcium nitrate + 2% citric acid + 2% glucose	"Basal A"	Wetcit (0.25%)
04	Ammonium nitrate + 2% citric acid + 2% glucose	"Basal C"	Wetcit (0.25%)
05	Dormex		
06	Brecaut LG 440		Brecaut LG 441
07	Bluprins		Bluact
08	Ammonium nitrate + 2% citric acid + 2% glucose	"Basal C"	Brecaut LG 441

Application schedule

Treatment number	Treatment: product name or AHDB code	Rate of active substance (ml or g a.s./ha)	Rate of product (l or kg/ha)	Application timing code
01	Untreated			08 April 2020
02	Erger + Active Erger	N/A	20 l/ha 30 l/ha	08 April 2020
03	"Basal A" Calcium nitrate + 2% citric acid + 2% glucose	40 kg/ha 8 kg/ha 8 kg/ha	N/A	08 April 2020
04	"Basal C" Ammonium nitrate + 2% citric acid + 2% glucose	20 kg/ha 8 kg/ha 8 kg/ha	N/A	08 April 2020
05	Dormex	N/A	16 l/ha	08 April 2020
06	Brecaut LG 440 + Brecaut LG 441	N/A	40 l/ha 3.2l/ha	08 April 2020
07	Bluprins + Bluact	N/A	16l/ha 60-80l/ha	08 April 2020
08	"Basal C" Ammonium nitrate + 2% citric acid + 2% glucose + Brecaut LG 441	N/A	20 kg/ha 8 kg/ha 8 kg/ha 3.2l/ha	08 April 2020

Application details

	Application A
Application date	09/04/20
Time of day	09:30
Crop growth stage (Max, min average BBCH)	A-B1
Crop height (cm)	75cm
Crop coverage (%)	N/A
Application Method	Mist blower
Application Placement	Crop
Application equipment	Euro-Pulve + Birchmeier Blower
Nozzle pressure	4 Bar
Nozzle type	Brown Albuz
Nozzle size	ATR 80
Application water volume l/ha	400
Temperature of air-shade (°C)	13
Relative humidity (%)	90
Wind speed range (m/s)	15 - 2.1
Dew presence (Y/N)	Y
Temperature of soil-2-5 cm (°C)	N/A
Wetness of soil-2-5 cm	N/A
Cloud cover (%)	N/A

Evaluation date	Evaluation Timing (Days After Application)	Crop Growth Stage (BBCH)	Evaluation type	Assessment
06/04/20	-3	A	Growth	Visual Growth
14/04/20	5	A	Growth	Visual Growth
20/04/20	11	A – B1	Growth	Visual Growth
27/04/20	18	A – B1	Growth	Visual Growth
04/05/20	25	A – C1	Growth	Visual Growth
11/05/20	32	A – C3	Growth	Visual Growth
18/05/20	39	A – F1	Growth	Visual Growth
25/05/20	46	A – F3	Growth	Visual Growth
01/06/20	53	A – I1	Growth	Visual Growth
08/06/20	60	A – I2	Growth	Visual Growth
15/06/20	67	A - I3	Growth	Visual Growth

Assessment details

Weather

Chilling hours (<°7C) and growing degree days were calculated using weather station data. Sites 1 and 2 were monitored by Agrovista weather stations, which recorded: air temperature (°C), relative humidity (RH) and soil temperature (°C). Site 3 was monitored by a Met office weather station.

Bud break

Bud break was defined as the point at which green leaf material was visible on the buds. Bud break assessments were carried out weekly by the site manager's staff from Week 11. All bud break assessments were carried out on five tagged shoots per plot until all buds have reached B2 stage. Assessments were carried out on the topmost 13 buds. Shoots were labelled:

1. Number each bud from the top of the main shoot to the base (see Figure 1)
2. Record growth stage of buds using Lantin's growth stage key for blackcurrant (Figure 2) and the descriptor table from Atwood, 2007 (Table 6)
3. Calculate % bud break and % of buds at different growth stages. Buds 4-13

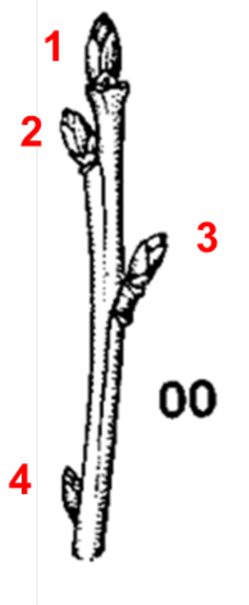


Figure 1. Blackcurrant bud order of numbering on shoots

Table 1. Descriptors for Lantin's blackcurrant growth stage key

Stage	Description
A	Dormant, no green showing
B1	Burst, tips of buds showing green
B2	Burst, folded leaves as long as the bud scales

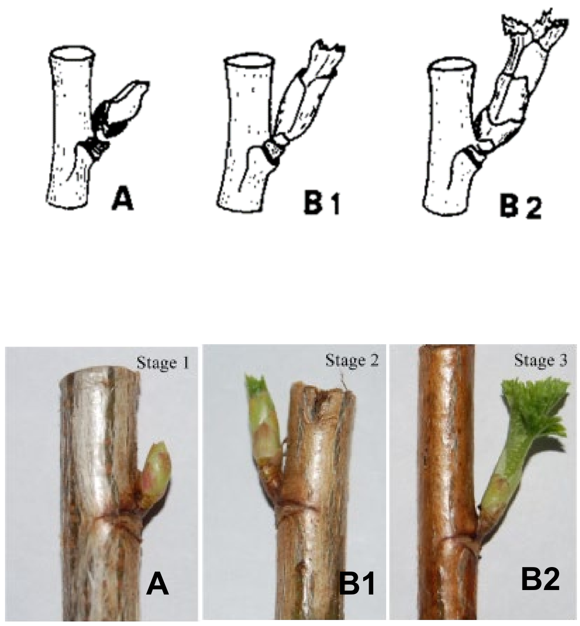


Figure 2. Growth stages of blackcurrant taken from Lantin (1973). Photographic images taken from A. Sønsteby & O.M. Heide (2014) *Scientia Horticulturae* 179: 256–265

Results

Nitrogen source

The winter of 2019-2020 was exceptionally mild at Nackington Farm, Nackington Road, Canterbury, CT4 7BA (Figure 3). Ben Alder blackcurrants require 2157 hours of chill below 7°C between 1 October and 31 March to trigger bud burst. In the winter of 2019-20, only 1576 hours were obtained at Nackington Farm (Figure 4). If we look at the proposed new method chill calculation of CCD5, calculated as: (5-(mean of daily maximum and minimum temperatures (where any negative values are set equal to 0)) then only 28 hours were obtained (Figure 5). This calculation allows us to predict the date of bud burst for several varieties, but not Ben Alder. Ben Tirran is the closest related variety to Ben Alder in terms of winter chill requirement.

Predicted bud burst was: 16 May (+/- 5 days), which is close to the 75% bud burst date for the untreated control of 5 May (Table 2).

Bud burst = -0.18150*CDD5+201.968 = 197 days after 31 Oct = 16 May (+/- 5 days)

Therefore, we can surmise that the winter of 2019-20 was not sufficiently cold enough to supply adequate chilling to trigger bud break in the test variety Ben Alder.

The treatments were applied on 8 April 2020 when the buds were just starting to show green (3% green tip). The assessment of % bud burst shows increase in % bud burst weekly from application until 25 May when the final assessment was conducted.

Statistical analysis of the data using a binomial model (based on the probability of a bud being either dormant or burst) and subsequent Dunnetts comparison tests between the untreated and each treatment showed that the data was highly variable with no detectable significant differences between the treatments (Table 3).

When the mean percentage bud burst against time is plotted (Figure 4), it shows that all the treatments cluster closely together. The untreated control (green line) is our reference, and any curve to the left of the untreated control had earlier bud burst and the steeper the gradient of the curve the faster and therefore more synchronized the bud burst. Both the positive control (Erger + Active Erger treatment 2) and Basal A (Treatment 3) had quicker, and more synchronised bud burst than the untreated control. The new blend “Basal C” (Treatment 4), which uses Ammonium nitrate rather than Calcium nitrate as a nitrogen source, was not different to the untreated control or the two nitrogen sources alone (Treatments 5 and 6), but none of these differences in developmental rates were significantly different to the untreated control.

Anything to the right of the untreated control were later to burst bud and a shallower slope indicates a less uniform bud break. Treatments 7 (Citric acid) and 8 (Glucose) were both slower to break bud and less synchronised than the untreated control.

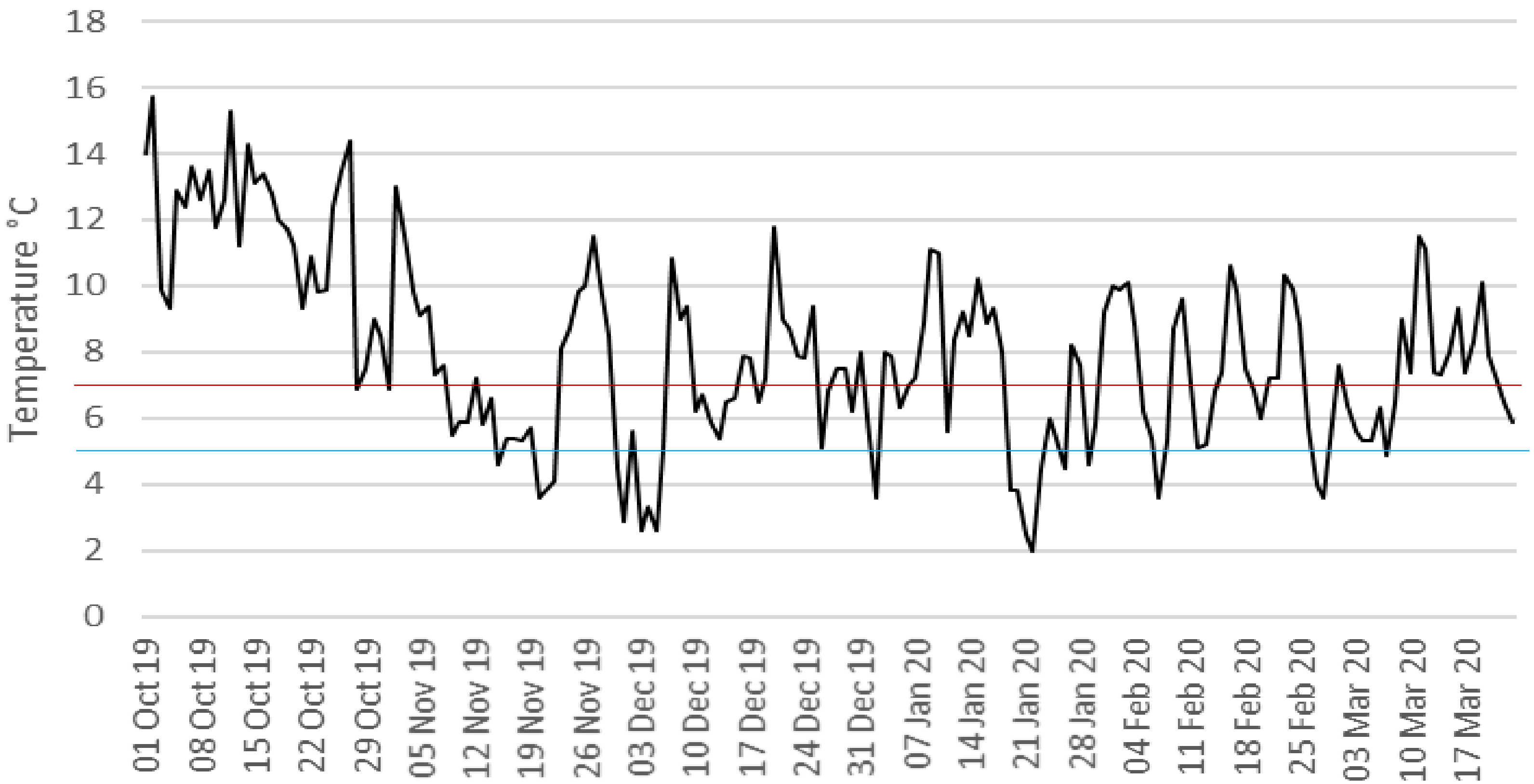


Figure 3. Mean daily temperature at Nackington farm from 01 October 2019 – 23 March 2020. Red line indicates 7°C, blue line indicates 5°C.

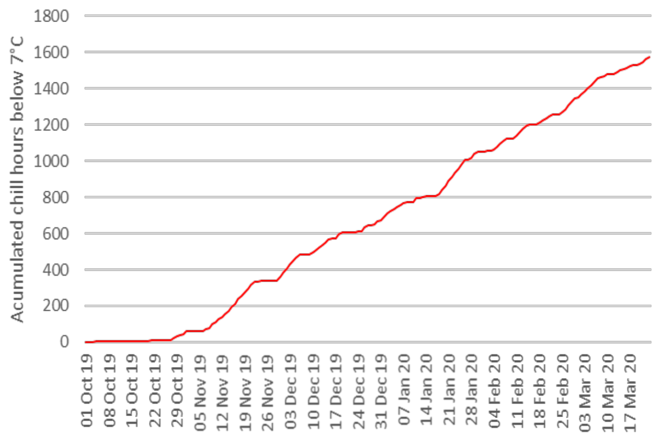


Figure 4. Accumulated chill day degrees below 7°C from 1 October 2019 – 23 March 2020

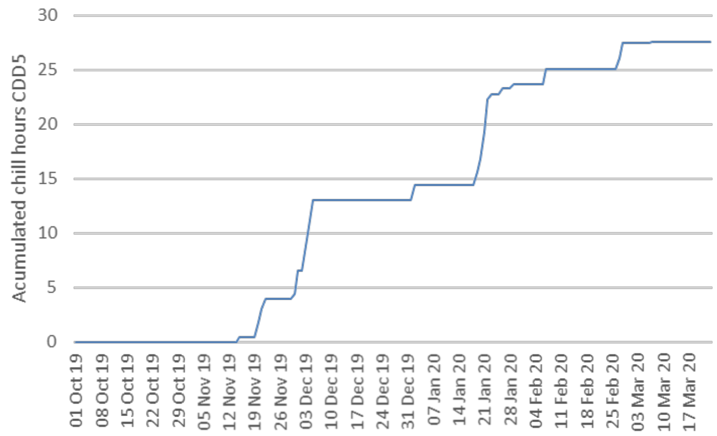


Figure 5. Accumulated chill Day degrees below 5°C from 1 October 2019 – 23 March 2020

Table 2. Date of 50%, 75% and maximum bud burst for each treatment, treatments applied on 8 April 2020

Treatment		Date 50% bud burst exceeded	Date 75% Bud burst exceeded	Maximum % bud burst	Buds labelled	Buds survived
01	Untreated	26 Apr	05 May	88	260	259
02	Erger + Active Erger	23 Apr	30 Apr	86	260	256
03	Basal A	23 Apr	01 May	88	260	259
04	Basal C	26 Apr	04 May	91	260	255
05	Calcium nitrate	26 Apr	07 May	83	260	257
06	Ammonium nitrate	26 Apr	04 May	86	260	256
07	Citric acid	28 Apr	18 May	78	260	247
08	Glucose	28 Apr	21 May	76	260	234

Table 3. Mixed model binomial regression of the numbers of dormant and burst buds. Dunnett test for significant difference was used to investigate if the probability of buds being dormant or burst between the treatments and the untreated control was significant

Treatment		17 Apr	24 Apr	01 May	08 May	23 May
01	Untreated					
02	Erger + Active Erger	0.9997	0.6619	0.3219	0.9952	0.9836
03	Basal A	0.9705	0.8766	0.8386	0.9375	0.9995
04	Basal C	0.7164	1.0000	1.0000	0.9319	0.9370
05	Calcium nitrate	0.9823	0.9969	0.9818	0.9800	0.9504
06	Ammonium nitrate	0.9852	0.9968	0.9848	0.9996	0.9979
07	Citric acid	1.0000	0.9469	0.7426	0.3575	0.3677
08	Glucose	0.9292	0.8714	0.6778	0.6570	0.3269
	F prob (p)	N/S	N/S	N/S	N/S	N/S

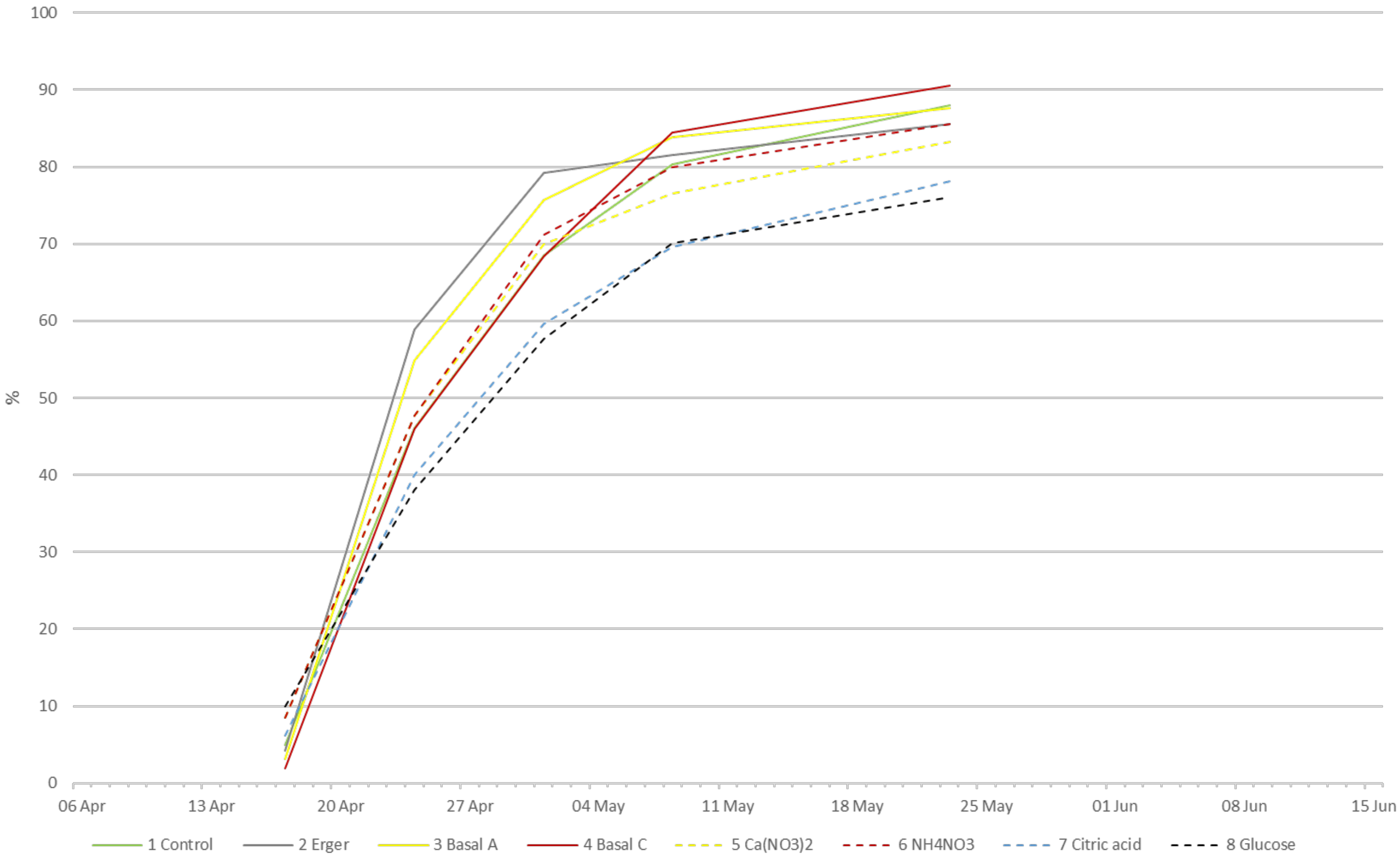


Figure 6. Mean percentage bud burst for each assessment date for each treatment applied in the nitrogen source experiment based at Nackington Farm

Wetting Agent

The winter of 2019-20 was exceptionally mild at Newlands Farm, Teynham, Sittingbourne, Kent, ME9 9JQ (Figure 7). Ben Tirran blackcurrants require 2328 hours of chill below 7°C between 1 October and 31 March to trigger bud burst. In the winter of 2019-20, only 1652 hours were obtained at Newlands Farm (Figure 8). If we look at the proposed new chill calculation method of CCD5, calculated as: (5-(mean of daily maximum and minimum temperatures (where any negative values are set equal to 0)) then only 38 hours were obtained (Figure 9). This calculation allows us to predict the date of bud burst for several Ben Tirran as:

Bud burst = -0.18150*CDD5+201.968 = 195 days after 31 Oct = May 13 (+/- 5 days)

Predicted bud burst was: May 13 (+/- 5 days), which is close to the 50% bud burst date for the untreated control of 09 May (Table 4), Ben Tirran at Newlands farm only achieved a maximum bud burst of 52% in the untreated control.

Therefore, we can surmise that the winter of 2019-20 was not sufficiently cold enough to supply adequate chilling to trigger bud break in the test variety Ben Tirran.

The treatments were applied on 8 April 2020, when the buds were just starting to show green (3% green tip). The assessment of % bud burst shows increase in % bud burst weekly from application until 11 May, assessments continued until June due to the lack of bud burst observed in the untreated control.

Statistical analysis of the data using a binomial model (based on the probability of a bud being either dormant or burst) and subsequent Dunnetts comparison tests between the untreated and each treatment showed significant treatment effects (Table 5).

The untreated control (green line) is our reference (Figure 10) any curve to the left of the untreated control is earlier bud burst and the steeper the gradient of the curve the more synchronized the bud burst. All the treatments except Treatment 4 ("Basal A + Codacide") irrespective of the wetting agent used triggered significantly increased quantity and speed of bud burst in the blackcurrant variety Ben Tirran.

The fastest and highest bud burst was seen in the treatments using the wetting agent "Silwett L-77", as both Basal A and Basal C with Silwett L-77 (Treatments 5 and 8), showed significantly earlier burst bud (26 April) than the other treatments.

Erger the current industry standard (Treatment 2), Basal A and Basal C with Wetsit (Treatments 3 and 6), and Basal C with Codacide (Treatment 7) all triggered significantly more and faster bud break than the untreated control, but these differences were seven days later than Basal A and Basal C with Silwett L-77 (Treatments 5 and 8).

Basal A and Basal C with Wetsit (Treatments 3 and 6) and Basal C with Codacide (Treatment 7) could not sustain significantly faster and increased bud break for as long as Basal A and Basal C with Silwett L-77 could (Treatments 5 and 8), with only 3 weeks and 2 weeks of increased development (respectively) compared to the 5 weeks of sustained bud development for Basal A and Basal C with Silwett L-77 (Treatments 5 and 8).

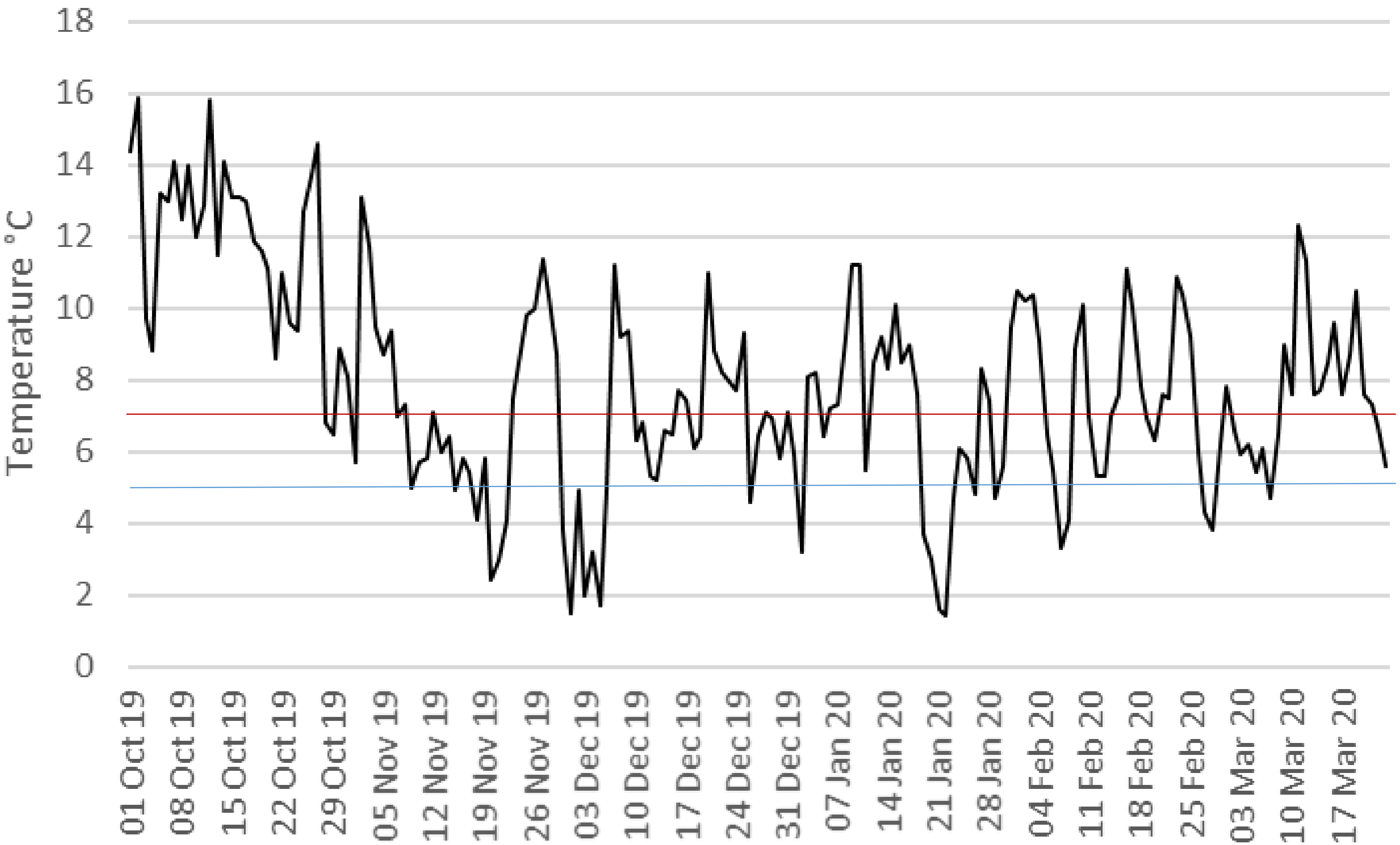


Figure 7. Mean daily temperature at Newlands Farm from 1 October 2019 – 23 March 2020. Red line indicates 7°C, blue line indicates 5°C.

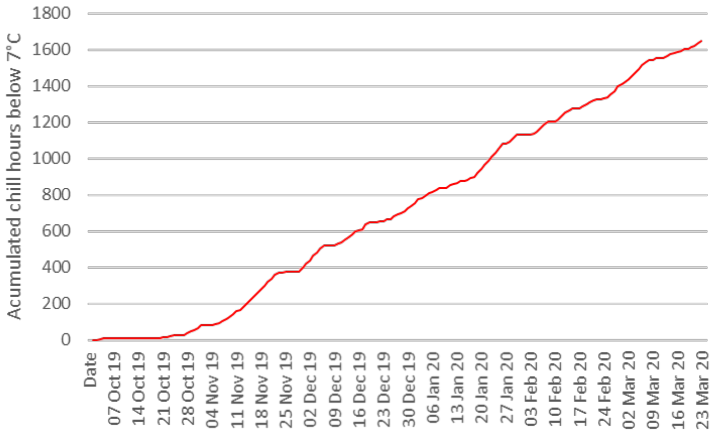


Figure 8. Accumulated chill day degrees below 7°C from 1 October 2019 – 23 March 2020

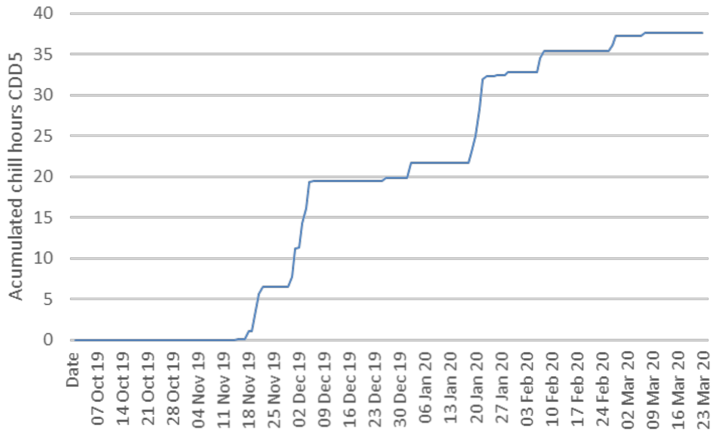


Figure 9. Accumulated chill day degrees below 5°C from 1 October 2019 – 23 March 2020

Table 4. Date of 50%, 75% and maximum bud burst for each treatment, treatments applied on 8 April 2020

Treatment		Date 50% bud burst exceeded	Date 75% Bud burst exceeded	Maximum % bud burst	Buds labelled	Buds survived
01	Untreated	09 May	-	52	260	260
02	Erger + Active Erger	22 Apr	-	72	260	247
03	Basal A + Wetsit	22 Apr	-	73	260	247
04	Basal A + Codacide	26 Apr	-	65	260	260
05	Basal A + Silwett L77	19 Apr	30 Apr	81	260	252
06	Basal C + Wetsit	23 Apr	18 May	76	260	259
07	Basal C + Codacide	26 Apr	13 May	77	260	228
08	Basal C + Silwett L77	20 Apr	30 Apr	79	260	255

Table 5. Mixed model binomial regression of the numbers of dormant and burst buds. Dunnett test for significant difference was used to investigate if the probability of buds being dormant or burst between the treatments and the untreated control was significant

Treatment:		10 Apr	17 Apr	26 Apr	01 May	08 May	15 May	22 May	30 May	06 Jun
01	Untreated									
02	Erger + Active Erger	0.9074	0.3365	0.1139	0.0041*	0.0469*	0.0285*	0.0007*	0.0610	0.0464
03	Basal A + Wetsit	0.99974	0.7848	0.1783	0.0575*	0.2161	0.1431	<0.0001*	0.1643	0.1636
04	Basal A + Codacide	0.8468	0.9491	0.7250	0.4565	0.4642	0.2953	0.1195	0.4719	0.4727
05	Basal A + Silwett L-77	0.6745	0.0579	0.0013*	0.0027*	0.0096*	0.0069*	<0.0001*	0.0197	0.0200
06	Basal C + Wetsit	0.9927	0.8895	0.2642	0.0764*	0.2210	0.0843*	0.0092*	0.1272	0.1138
07	Basal C + Codacide	0.9892	1.000	0.6680	0.0761*	0.1218	0.378*	0.0034*	0.1072	0.2260
08	Basal C + Silwett L-77	0.9955	0.1965	0.0239*	0.0024*	0.0106*	0.0021*	<0.0001*	0.0089	0.0092
	F prob (p)	N/S	N/S	0.02234	0.01275	0.04117	0.05255	0.07102	N/S	N/S

** = significantly different to the untreated control for that assessment date*

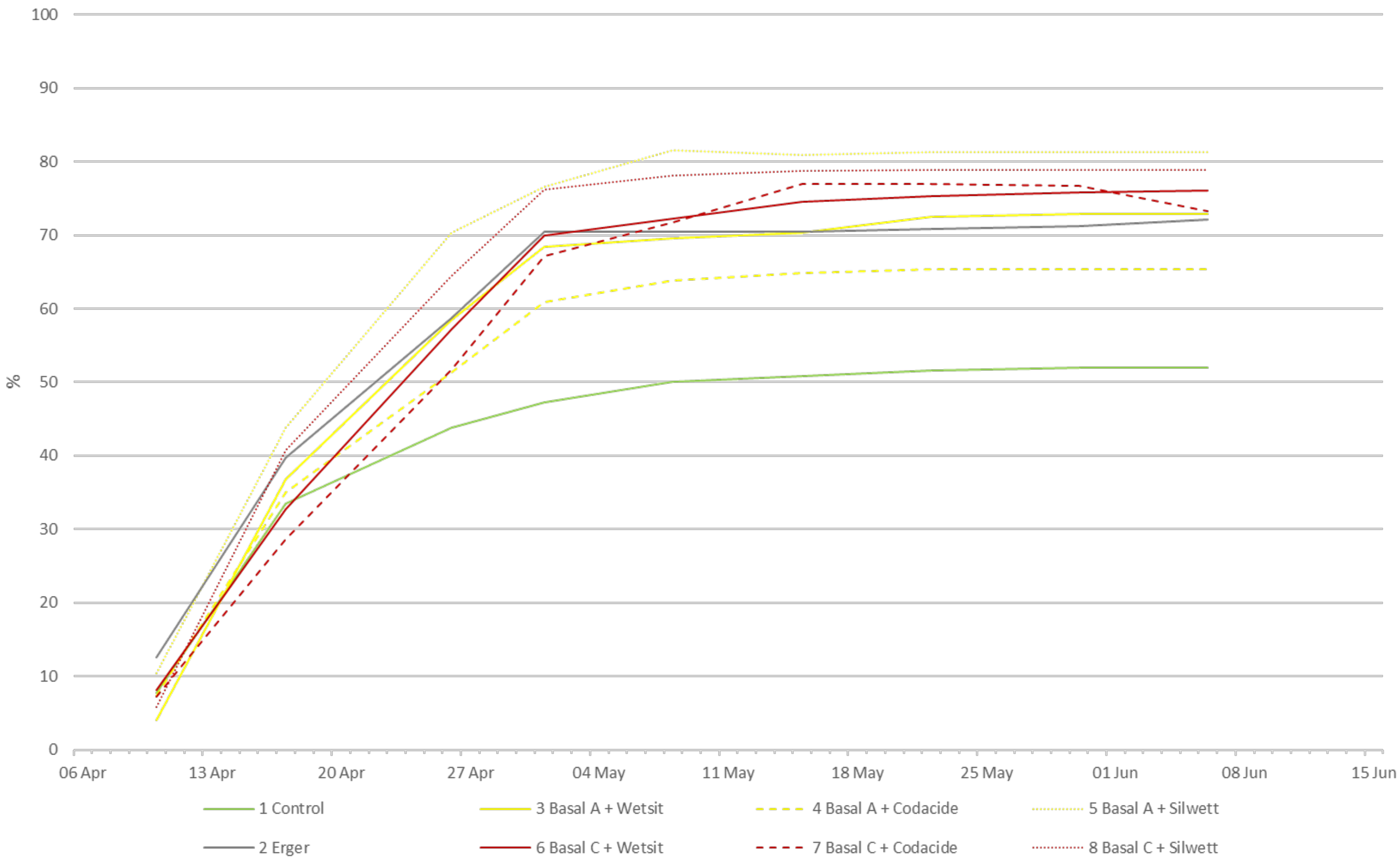


Figure 10. Mean percentage bud burst for each assessment date for each treatment applied in the wetting agent experiment based at Newlands Farm

Industry alternatives

The winter of 2019-20 was exceptionally mild at NIAB EMR, East Malling, Kent, ME19 6BJ (Figure 11). Ben Tirran blackcurrant requires 2328 hours of chill below 7°C between 1 October and 31 March to trigger bud burst. In the winter of 2019-20, only 1857 hours were obtained at NIAB EMR (Figure 12). If we look at the proposed new chill calculation method of CCD5, calculated as: (5-(mean of daily maximum and minimum temperatures (where any negative values are set equal to 0) then only 58 hours were obtained (Figure 13). This calculation allows us to predict the date of bud burst of Ben Tirran as:

Bud burst = -0.18150*CDD5+201.968 = 191 days after 31 Oct = 09 May (+/-5 days)

Predicted bud burst was 9 May (+/-5 days). Ben Tirran at NIAB EMR only achieved a maximum bud burst of 40% in the untreated control (Table 6).

Therefore, we can surmise that the winter of 2019-20 was not sufficiently cold enough to supply adequate chilling to trigger bud break in the test variety Ben Tirran.

The treatments were applied on 8 April 2020 when the buds were just starting to show green (3% green tip). The assessment of percentage bud burst shows increase in bud burst (%) weekly from application until 11 May, assessments continued into June due to the lack of bud burst in the untreated control.

Statistical analysis of the data using a binomial model (based on the probability of a bud being either dormant or burst) and subsequent Dunnetts comparison tests between the untreated and each treatment showed significant treatment effects (Table 7).

The untreated control (green line) is our reference (Figure 14) any curve to the left of the untreated control is earlier bud burst and the steeper the gradient of the curve the more synchronized the bud burst. All the treatments caused significantly increased bud burst on at least one date (Table 7).

Four of the treatments tested gave significantly increased bud burst over multiple dates, Erger + Active Erger (Treatment 2), Brecaut (Treatment 6), Bluprins (Treatment 7) and Basal C + Brecaut LG 441 (Treatment 8) compared to the untreated control. Treatment 8 was a last-minute addition to the trial to use a space in the trial left by product being withdrawn and consisted of the normal Basal C mix but using the wetter Brecaut LG 441 rather than Wetsit.

Basal A (Treatment 3), Basal C (Treatment 4) and Dormex (Treatment 5) all significantly increased bud break but only on one assessment date.

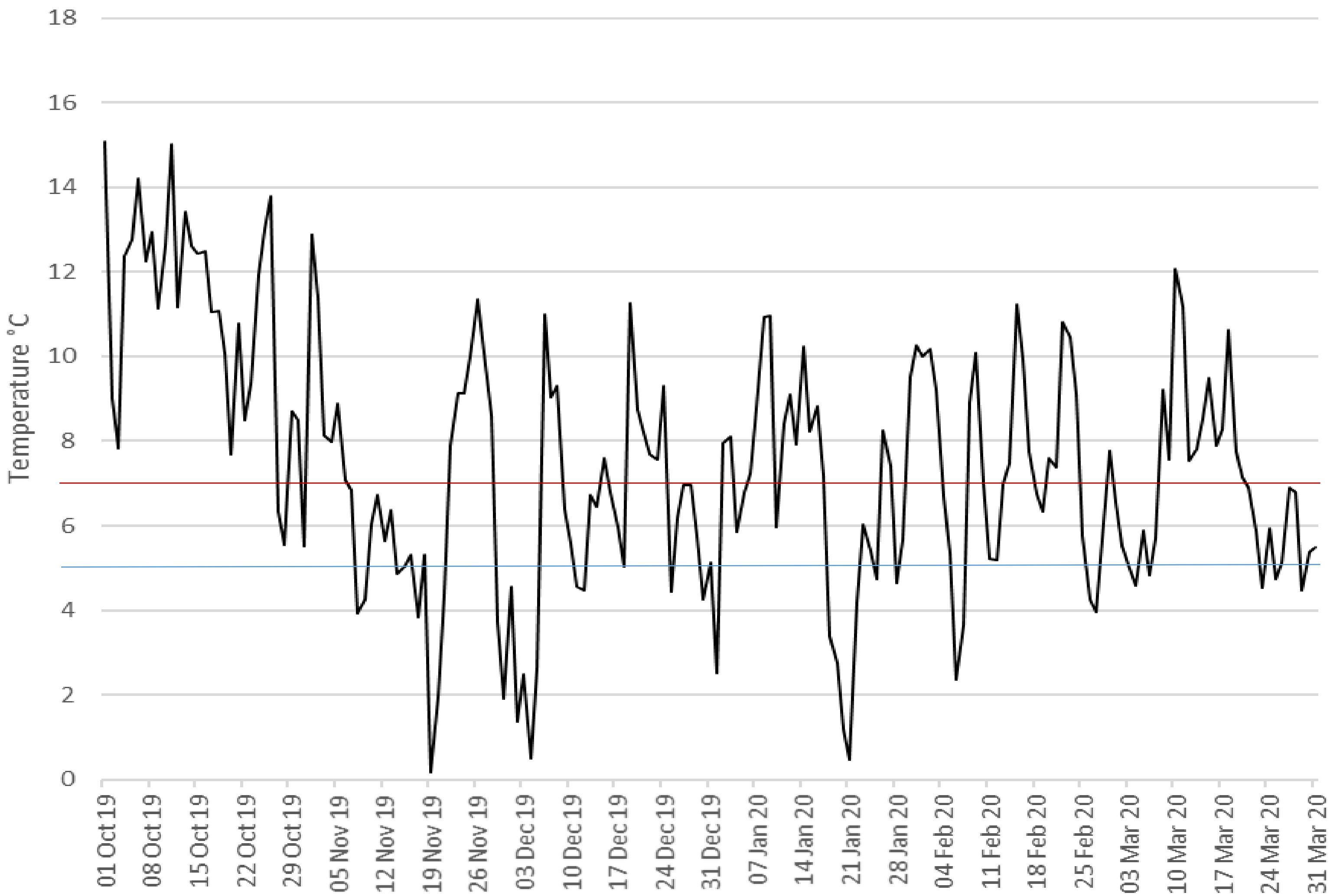


Figure 11. Mean daily temperature at NIAB EMR from 1 October 2019 – 31 March 2020. Red line indicates 7°C, blue line indicates 5°C.

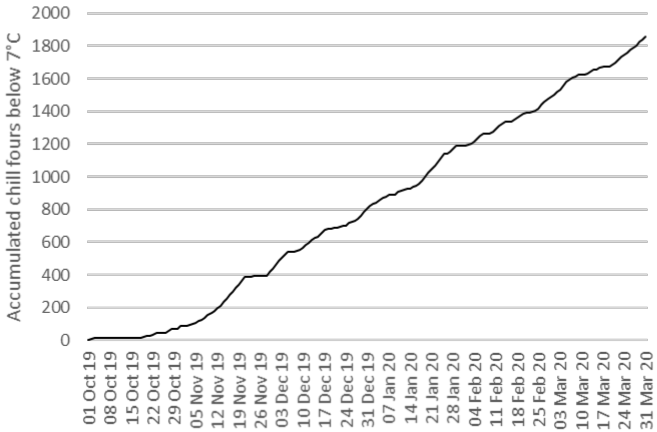


Figure 12. Accumulated chill day degrees below 7°C from 1 October 2019 – 23 March 2020

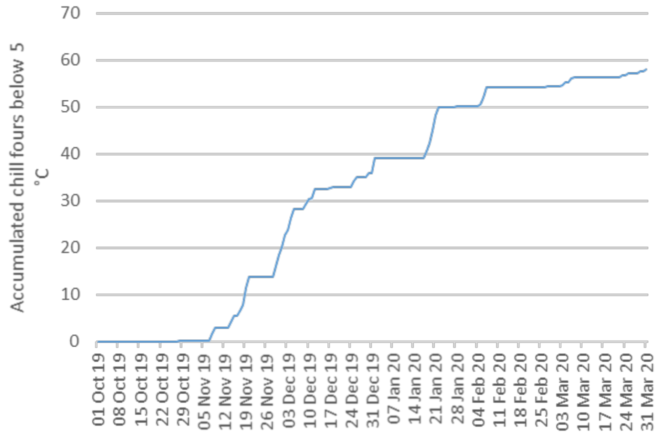


Figure 13. Accumulated chill day degrees below 5°C from 1 October 2019 – 23 March 2020

Table 6. Date of 50%, 75% and maximum bud burst for each treatment, treatments applied on 8 April 2020

Treatment		Date 50% bud burst exceeded	Date 75% Bud burst exceeded	Maximum % bud burst	Buds labelled	Buds survived
01	1 Control	-	-	40	260	142
02	2 Erger + Active Erger	18 May	-	64	260	135
03	3 Basal A	05 Jun	-	51	260	143
04	4 Basal C	02 Jun	-	52	260	169
05	5 Dormex	-	-	50	260	155
06	6 Brecaut	08 May	-	74	260	159
07	7 Bluprins	18 May	-	61	260	148
08	8 Basal C + Brecaut	08 May	08 Jun	75	260	144

Table 7. Mixed model binomial regression of the numbers of dormant and burst buds. Dunnett test for significant difference was used to investigate if the probability of buds being dormant or burst between the treatments and the untreated control was significant

Treatment		14 Apr	20 Apr	27 Apr	04 May	11 May	18 May	25 May	01 June	08 June
01	1 Control									
02	2 Erger + Active Erger	0.9863	<0.0001*	<0.0001*	<0.0001*	0.0149*	0.1558	0.1661	0.0378*	0.0351*
03	3 Basal A	0.9356	0.0777*	0.7040	0.5783	0.8922	0.7234	0.7319	0.1651	0.4542
04	4 Basal C	#	0.0371*	0.9206	0.1857	0.4408	0.4308	0.7288	0.7765	0.4939
05	5 Dormex	0.9150	0.2563	0.0150*	0.9142	0.8276	0.9383	0.8887	0.9997	0.9754
06	6 Brecaut	0.6715	0.9446	<0.0001*	<0.0001*	0.0099*	0.0009*	0.0004*	0.0001*	<0.0001*
07	7 Bluprins	0.7995	1.000	<0.0001*	0.0008*	0.1015*	0.0555*	0.0423*	0.0483*	0.0237*
08	8 Basal C + Brecaut	0.9954	0.3957	<0.0001*	<0.0001*	0.0054*	0.0028*	0.0008*	0.0003*	<0.0001*
	F Prob (p)	N/S	<0.0001	<0.0001	<0.0001	<0.0001*	<0.0001	<0.0001	<0.0001	<0.0001

* = significantly different to the untreated control for that assessment date
# = all buds in each replicate were at the same growth stage, this made the data unanalysable (called complete separation)

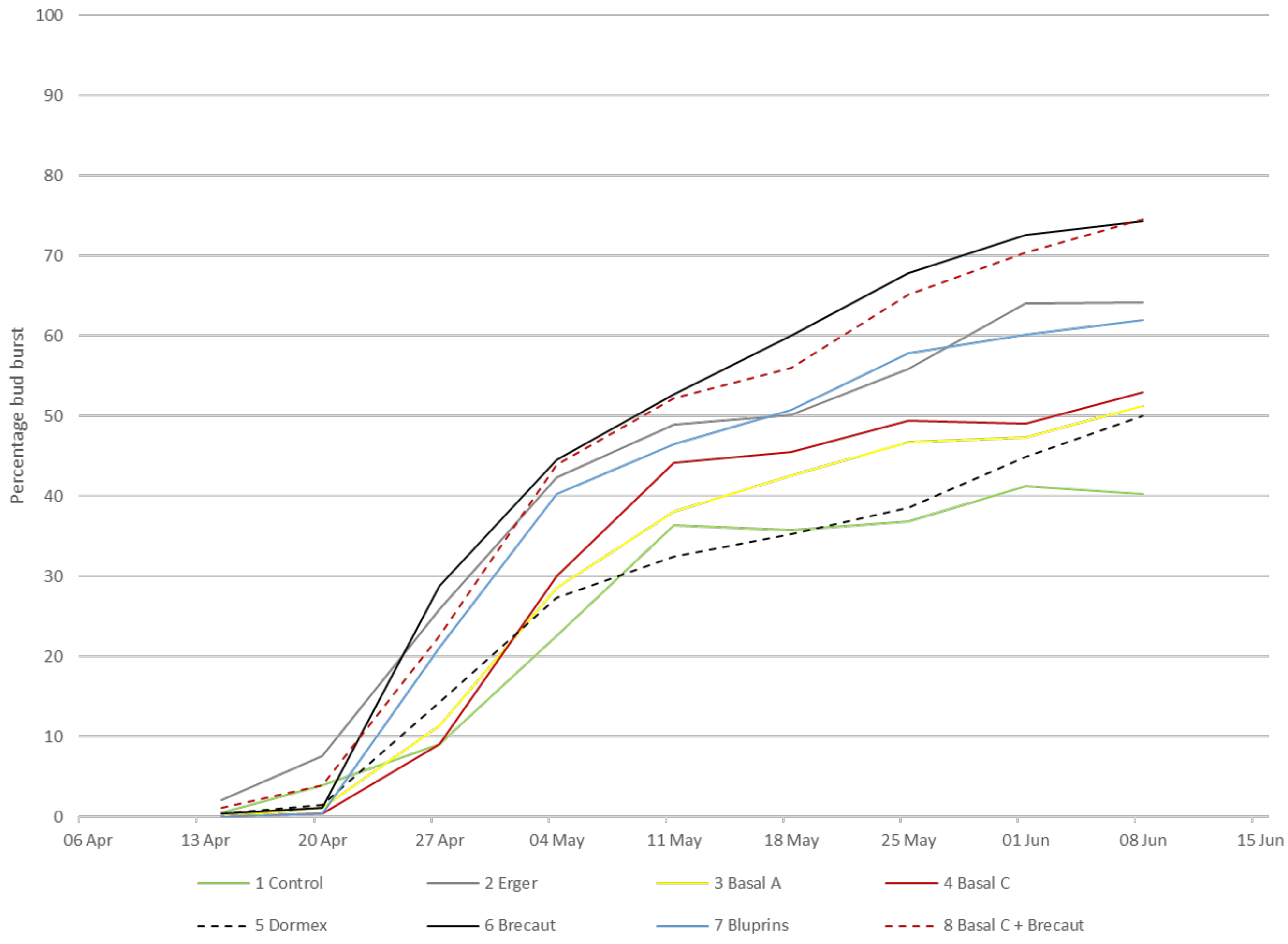


Figure 14. Mean percentage bud burst for each assessment date for each treatment applied in the wetting agent experiment based at Newlands Farm

Discussion

All three trials featured Erger + Active Erger as an industry standard and compared it to Basal A (Calcium nitrate) or Basal C (Ammonium nitrate). Erger + Active Erger were not always effective at inducing bud burst (nitrogen source trial on Ben Alder), suggesting that there are other factors involved in dormancy breaking than just the accumulation of chill hours, and there may be other varietal affects involved.

In the two trials (wetting agent and industry alternatives) where Basal A (Calcium nitrate) and Basal C (Ammonium nitrate) gave significantly faster and more synchronised bud burst than the untreated control, the two treatments were never significantly different to each other, indicating that either Calcium nitrate or Ammonium nitrate, can be used as a nitrogen source for dormancy breaking.

The most startling result from the programme of work was how important the choice of wetting agent is in dormancy breaking, with the use of Silwett I-77 massively increasing the efficacy of both Basal A and C. This observation was borne from the use of the Brecaut LG 441 wetting agent with Basal C in the industry alternatives trial as it significantly increased the efficacy of Basal C.

Stocks of Erger in the UK can often be limited, it would therefore be beneficial investigating the supply of Brecaut and Bluprins as both are equally effective at dormancy breaking in blackcurrant.

Conclusions

- Both Calcium nitrate at 10 kg/hl or Ammonium nitrate at 5 kg/hl are equally as effective as the nitrogen source in a dormancy breaking mix
- Silwet L-77 increases the efficiency of both Basal A and C
- Brecaut and Bluprins are the most effective of the three commercially available dormancy breaking products
- The inclusion of the Brecaut LG 441 wetting agent with Basal C increases its efficiency as a dormancy breaker

Acknowledgements

We would like to thank AHDB Horticulture for funding and supporting this project.

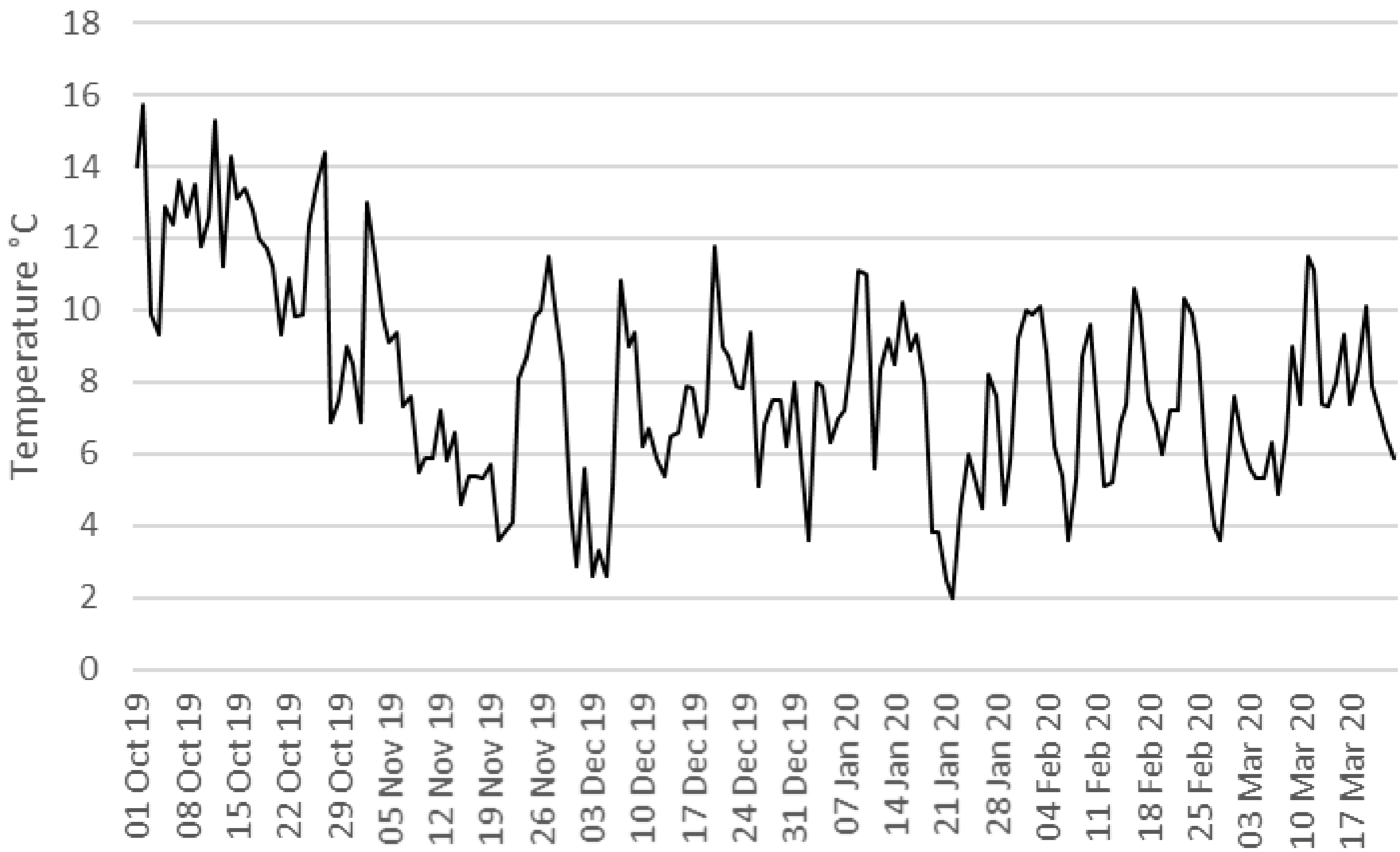
We would also like to thank John Hinchliff, Hugh Boucher, Harriet Prosser, Rob Saunders and LR Suntory for their advice and support.

Appendices

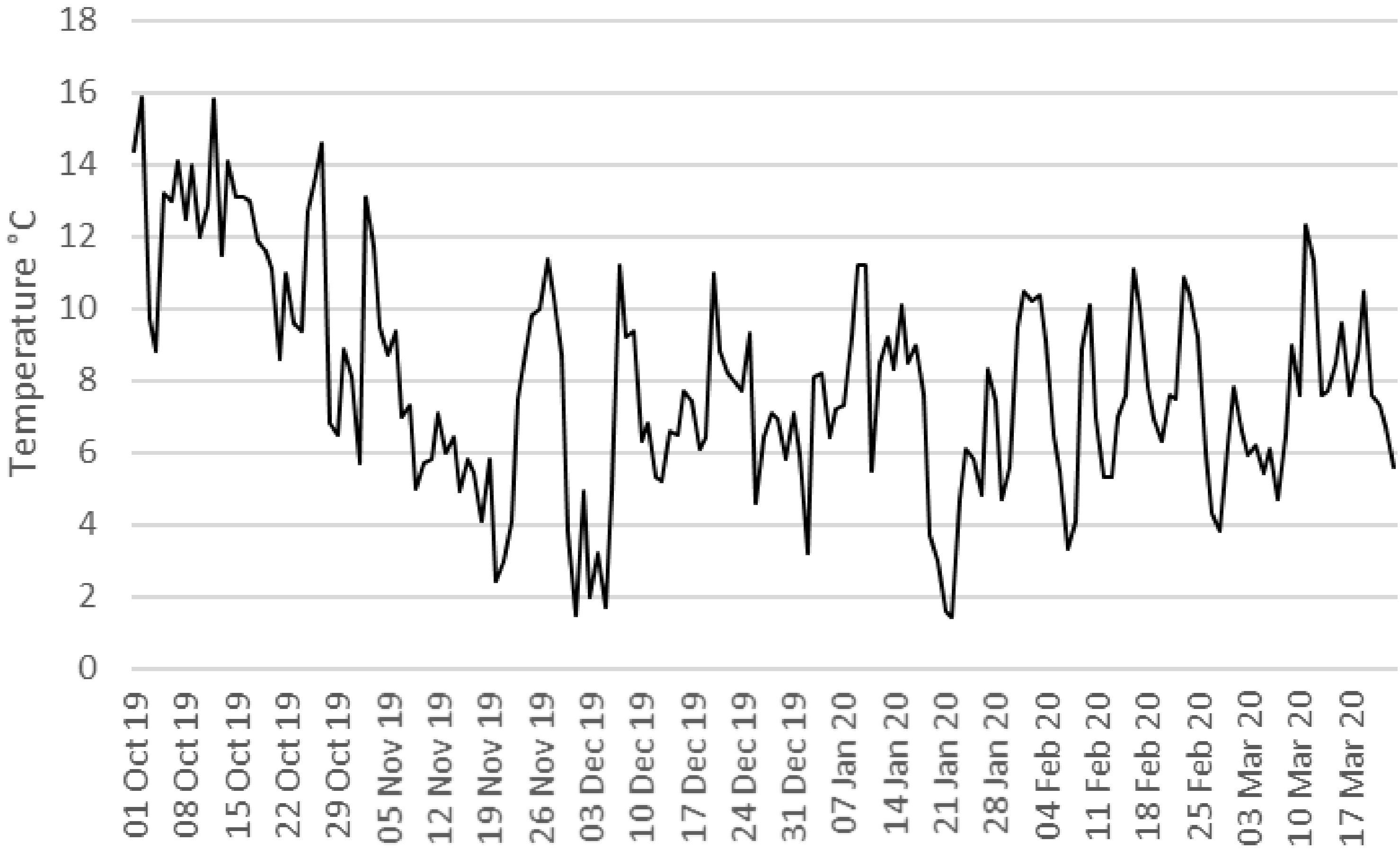
a. Crop diary – events related to growing crop are not applicable

Date and name		Record of work done, observations made or reference to lab or field book entry (give book and page numbers – not applicable)
06/04/2020	IH	Visual Growth assessment industry alternatives trial
08/04/2020	LB IH	Treatment application N2 trial and wetting agent Trial
09/04/2020	LB IH	Treatment application industry alternatives
10/04/2020	GB	Visual Growth assessment wetting agent trial
14/04/2020	IH	Visual Growth assessment industry alternatives trial
17/04/2020	JH	Visual Growth assessment N2 source trial
17/04/2020	GB	Visual Growth assessment wetting agent trial
20/04/2020	IH	Visual Growth assessment industry alternatives trial
24/04/2020	JH	Visual Growth assessment N2 source trial
26/04/2020	GB	Visual Growth assessment wetting agent trial
27/04/2020	IH	Visual Growth assessment industry alternatives trial
01/05/2020	JH	Visual Growth assessment N2 source trial
01/05/2020	GB	Visual Growth assessment wetting agent trial
04/05/2020	IH	Visual Growth assessment industry alternatives trial
08/05/2020	JH	Visual Growth assessment N2 source trial
08/05/2020	GB	Visual Growth assessment wetting agent trial
11/05/2020	IH	Visual Growth assessment industry alternatives trial
15/05/2020	GB	Visual Growth assessment wetting agent trial
18/05/2020	IH	Visual Growth assessment industry alternatives trial
22/05/2020	GB	Visual Growth assessment wetting agent trial
23/05/2020	JH	Visual Growth assessment N2 source trial
25/05/2020	IH	Visual Growth assessment industry alternatives trial
30/05/2020	GB	Visual Growth assessment wetting agent trial
01/06/2020	IH	Visual Growth assessment industry alternatives trial
06/06/2020	GB	Visual Growth assessment wetting agent trial
08/06/2020	IH	Visual Growth assessment industry alternatives trial
15/06/2020	IH	Visual Growth assessment industry alternatives trial

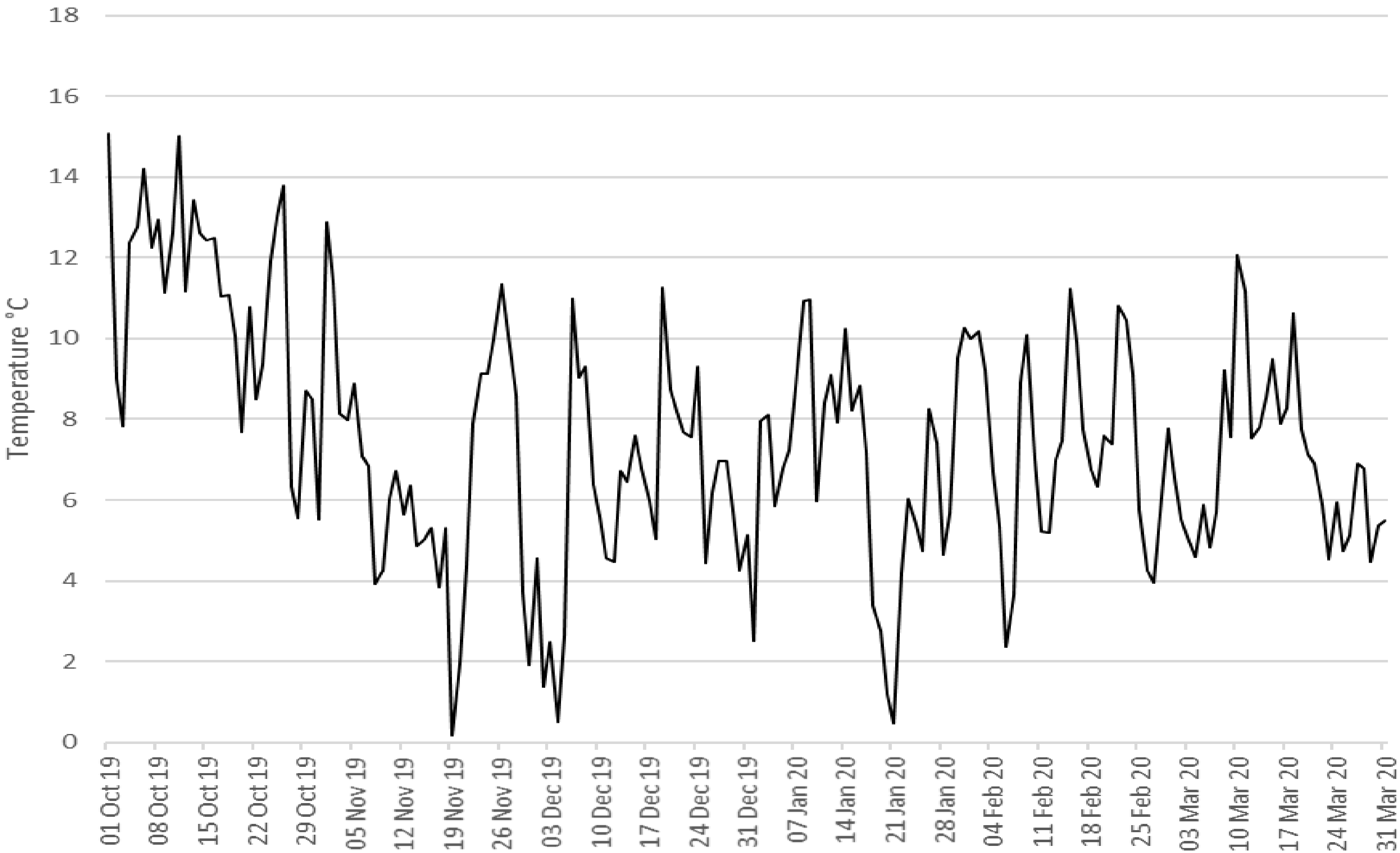
b. **Climatological data from the weather station at Nackington Farm**



c. **Climatological data from the weather station at Newlands Farm**



d. Climatological data from the weather station at NIAB EMR



e. Raw mean data from nitrogen source trial assessments, mean per plot of 13 buds on 5 shoots (65 buds per plot per assessment 2080 buds per assessment)

Label	Block	Plot	Treat	Colour	17/04/2020	24/04/2020	01/05/2020	08/05/2020	23/05/2020
101	1	1	1	G	0	1	1	1	2
102	1	2	5	BLK	1	1	1	1	2
103	1	3	2	R	0	1	1	2	2
104	1	4	4	B	0	1	2	2	2
105	1	5	3	Y	0	2	2	2	2
106	1	6	7	Y Y	0	1	1	1	1
107	1	7	8	R R	0	1	1	1	2
108	1	8	6	GRY	0	1	2	2	2
201	2	1	8	R R	0	1	1	2	2
202	2	2	5	BLK	0	1	1	2	2
203	2	3	4	B	0	1	2	2	2
204	2	4	3	Y	0	1	1	2	2
205	2	5	6	GRY	0	1	1	1	2

206	2	6	2	R	1	2	2	2	2
207	2	7	7	Y Y	0	1	1	1	2
208	2	8	1	G	0	1	1	2	2
301	3	1	2	R	1	1	2	2	2
302	3	2	3	Y	0	1	1	2	2
303	3	3	8	R R	0	1	1	1	2
304	3	4	4	B	0	1	2	2	2
305	3	5	1	G	0	1	2	2	2
306	3	6	6	GRY	1	1	2	2	2
307	3	7	7	Y Y	1	1	2	2	2
308	3	8	5	BLK	1	1	1	2	2
401	4	1	7	Y Y	0	1	1	2	2
402	4	2	6	GRY	1	1	2	2	2
403	4	3	5	BLK	1	2	2	2	2
404	4	4	3	Y	1	2	2	2	2
405	4	5	8	R R	1	1	1	2	2

406	4	6	4	B	0	1	1	2	2
407	4	7	1	G	1	2	2	2	2
408	4	8	2	R	0	1	2	2	2

f. Raw mean data from wetting agent trial assessments (* denotes missing value), mean per plot of 13 buds on 5 shoots (65 buds per plot per assessment 2080 buds per assessment)

Label	Block	Plot	Treat	Colour	10/04/20	17/04/20	26/04/20	01/05/20	08/05/20	15/05/20	22/05/20	30/05/20	06/06/20
101	1	1	3	Y	0	0	1	1	1	1	1	1	1
102	1	2	4	Y B	0	1	1	1	1	1	1	1	1
103	1	3	1	G	0	1	1	1	1	1	1	1	1
104	1	4	7	R B	0	0	1	2	2	2	2	2	2
105	1	5	8	R BLK	0	1	1	1	1	1	1	1	1
106	1	6	2	GRY	0	0	1	1	1	1	1	1	1
107	1	7	6	R	0	1	1	1	1	1	1	1	1
108	1	8	5	Y BLK	0	1	1	1	1	1	1	1	1
201	2	1	4	Y B	0	0	0	0	1	1	1	1	1

202	2	2	3	Y	0	1	1	1	1	1	1	1	1
203	2	3	6	R	0	0	1	1	1	1	1	1	1
204	2	4	7	R B	0	0	1	1	1	1	1	1	1
205	2	5	5	Y BLK	0	1	1	1	2	2	2	2	2
206	2	6	1	G	0	1	1	1	1	1	1	1	1
207	2	7	2	GRY	0	1	1	1	1	1	1	1	1
208	2	8	8	R BLK	0	1	1	2	2	2	2	2	2
301	3	1	6	R	1	1	2	2	2	2	2	2	2
302	3	2	2	GRY	1	1	2	2	2	2	2	2	2
303	3	3	7	R B	0	1	1	1	1	1	1	1	1
304	3	4	4	Y B	0	1	2	2	2	2	2	2	2
305	3	5	5	Y BLK	0	1	2	2	2	2	2	2	2
306	3	6	1	G	0	1	1	1	1	1	1	1	1
307	3	7	3	Y	0	1	2	2	2	2	2	2	2
308	3	8	8	R BLK	1	2	2	2	2	2	2	2	2
401	4	1	4	Y B	1	2	2	2	2	2	2	2	2

402	4	2	3	Y	1	1	2	2	2	2	2	2	2
403	4	3	6	R	0	1	2	2	2	2	2	2	2
404	4	4	7	R B	1	1	2	2	2	2	2	2	2
405	4	5	5	Y BLK	1	1	2	2	2	2	2	2	2
406	4	6	8	R BLK	0	1	2	2	2	2	2	2	2
407	4	7	2	GRY	1	2	2	2	2	2	2	2	2
408	4	8	1	G	0	1	1	2	2	2	2	2	2

g. Raw mean data from industry alternatives trial assessments, mean per plot of 13 buds on 5 shoots (65 buds per plot per assessment 2080 buds per assessment)

Label	Block	Plot	Treat	Colour	06/04/20	14/04/20	20/04/20	27/04/20	04/05/20	11/05/20	18/05/20	25/05/20	01/06/20	08/06/20	15/06/20
101	1	1	5	B	0	0	0	0	0	1	1	1	1	1	2
102	1	2	6	BLK	0	0	0	1	1	1	1	1	1	1	2
103	1	3	2	Gry	0	0	1	1	1	1	1	1	2	2	2
104	1	4	8	R R	0	0	0	1	1	1	1	1	1	1	2

105	1	5	4	R	0	0	0	0	1	1	1	1	1	1	2
106	1	6	7	Y Y	0	0	0	0	1	1	1	1	1	1	2
107	1	7	1	G	0	0	0	0	1	1	1	1	1	1	2
108	1	8	3	Y	0	0	0	0	1	1	1	1	1	1	2
201	2	1	8	R R	0	0	0	0	1	1	1	1	1	1	2
202	2	2	7	Y Y	0	0	0	0	1	1	1	1	1	1	2
203	2	3	3	Y	0	0	0	0	1	1	1	1	1	1	2
204	2	4	5	B	0	0	0	0	0	1	1	1	1	1	2
205	2	5	4	R	0	0	0	0	0	1	1	1	1	1	1
206	2	6	1	G	0	0	0	0	0	1	1	1	1	1	2
207	2	7	6	BLK	0	0	0	0	1	1	1	1	1	1	2
208	2	8	2	Gry	0	0	0	1	1	1	1	1	1	1	2
301	3	1	3	Y	0	0	0	0	1	1	1	1	1	1	2
302	3	2	4	R	0	0	0	0	1	1	1	1	1	1	2
303	3	3	6	BLK	0	0	0	1	1	1	1	2	2	2	2
304	3	4	5	B	0	0	0	1	1	1	1	1	1	2	2

305	3	5	7	Y Y	0	0	0	1	1	1	1	1	2	2	2
306	3	6	1	G	0	0	0	0	0	1	1	1	1	1	2
307	3	7	2	Gry	0	0	0	0	1	1	1	1	1	1	2
308	3	8	8	R R	0	0	0	1	1	2	2	2	2	2	2
401	4	1	4	R	0	0	0	0	1	1	1	1	1	1	2
402	4	2	7	Y Y	0	0	0	1	1	1	1	2	2	2	2
403	4	3	8	R R	0	0	0	0	1	1	1	1	1	1	2
404	4	4	3	Y	0	0	0	0	1	1	1	1	1	1	2
405	4	5	2	Gry	0	0	0	1	1	1	1	1	1	1	2
406	4	6	1	G	0	0	0	0	1	1	1	1	0	0	1
407	4	7	5	B	0	0	0	0	0	1	1	0	0	0	2
408	4	8	6	BLK	0	0	0	1	1	1	1	1	2	2	2

h. 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 W. Mellor
Authorised signatory

Certification Number
ORETO 411

HSE
Chemicals Regulation Division

Department of
Agriculture and Rural Development

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