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DISCLAIMER:

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

AUTHENTICATION

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

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GROWER SUMMARY

Headline

- Two adjuvants, Activator 90 and Silwett-L77, showed potential as alternatives to Erger G when applied with calcium nitrate as dormancy breaking treatments on Ben Tirran blackcurrant with a winter chill deficit of just under 1000 hours <7°C.

Background and expected deliverables

A number of commercial blackcurrant cultivars are known to have a significant winter chill requirement to enable even bud break and uniform ripening. With the prospect of warmer winters, this chill requirement may be increasingly difficult to achieve. Commercial trials have shown that Erger G + calcium nitrate, a proprietary nutrient/adjuvant combination, can promote earlier and more even bud break on cultivars that have not received sufficient winter chilling. As the 2006/07 winter was unusually mild, cultivars such as Ben Tirran and Ben Alder did not receive sufficient winter chilling for normal dormancy breaking. The 2007 season therefore provided an opportunity to make detailed observations on farm applied dormancy breaking treatments of Erger G + calcium nitrate.

However, Erger G is expensive, has not always proved effective in improving crop evenness and has limited availability. It is known that combinations of nutrients with other adjuvant sprays applied before bud burst can have a similar effect at potentially lower cost. In the work reported here a wide range of nutrient/adjuvant combinations were tested on cut shoots forced under controlled conditions using the techniques developed by Lantin (1973) for determining chill requirements for blackcurrant cultivars.

Summary of the project and main conclusions

A range of treatments (Table 1) were tested on cut bud sticks of dormant Ben Tirran that had not received sufficient winter chilling for normal bud development. The experiments were done under controlled conditions with the bud sticks forced for 21 days at 20°C before recording bud break.

Table 1: Experimental treatments applied to cut shoots

Treatment number	**Trade name**	**Active ingredient**	**Application rate**	**Approval status**
1	Untreated	-	-	-
2	Water dip	-	-	-
3	Calcium nitrate		125 mg/L	Nutrient
4	Calcium nitrate + Erger G	- Not disclosed	125 mg/L 50 mL/L	NutrienT Nutrient
5	Calcium nitrate + Silwett L-77	- 80% w/w polyalkylene oxide modified heptamethyltrisiloxane + < 20% w/w allyloxypolyethylene glycol methyl ether	125 mg/L 1.5 mL/L	Nutrient Adjuvant A0193
6**	Calcium nitrate + Silwett L-77	- 80% w/w polyalkylene oxide modified heptamethyltrisiloxane + < 20% w/w allyloxypolyethylene glycol methyl ether	125 mg/L 3 mL/L	Nutrient Adjuvant A0193
7	Calcium nitrate + Silwett L-77	- 80% w/w polyalkylene oxide modified heptamethyltrisiloxane + < 20% w/w allyloxypolyethylene glycol methyl ether	125 mg/L 15 mL/L	Nutrient Adjuvant A0193
8	Calcium nitrate + Newman's T-80	- 78% w/w polyoxyethylene tallow amine	125 mg/L 5 mL/L	Nutrient Adjuvant A0192
9	Calcium nitrate + Newman's T-80	- 78% w/w polyoxyethylene tallow amine	125 mg/L 50 mL/L	Nutrient Adjuvant A0192
10	Calcium nitrate + Torpedo-II	- 210 g/kg alkoxylated tallow amine, 380 g/kg alcohol ethoxylates, 75 g/L natural fatty acids + 210 g/kg polyalkylene glycol	125 mg/L 1 mL/L	Nutrient Adjuvant A0541
11	Calcium nitrate + Torpedo-II	- 210 g/kg alkoxylated tallow amine, 380 g/kg alcohol ethoxylates, 75 g/L natural fatty acids + 210 g/kg polyalkylene glycol	125 mg/L 10 mL/L	Nutrient Adjuvant A0541
12	Calcium nitrate + Activator 90	- *750 g/L alkylphenyl hydroxypolyoxyethylene + 150 g/L natural fatty acids ***750 g/L alcohol ethoxylates + 150 g/L natural fatty acids	125 mg/L 1 mL/L	Nutrient Adjuvant A0337 A0547
13	Calcium nitrate + Activator 90	- *750 g/L alkylphenyl hydroxypolyoxyethylene + 150 g/L natural fatty acids ***750 g/L alcohol ethoxylates + 150 g/L natural fatty acids	125 mg/L 10 mL/L or 10 mL/L	Nutrient Adjuvant A0337 A0547
14	Calcium nitrate + Maxicrop original	- Seaweed extracts	125 mg/L 10 mL/L	Nutrient Nutrient
15	Calcium nitrate + Route	- Zinc + nitrogen complexes + alkylpolyglycoside	125 mg/L 10 mL/L	Nutrient Nutrient

* used for 26/2/07 cutting date, ** used for 19/3/07 and 22/3/07 cutting dates, ***used for 22/3/07 cutting date

Two observational studies focusing on Erger G were also done on field-grown blackcurrant crops at Newent, Gloucestershire, (Ben Tirran) and Bradenham, Norfolk, (Ben Alder). Treatments are shown in Table 2.

Table 2: Experimental treatments applied to field crops

Treatment number	**Product**	**Active ingredient**	**Conc.**	**Application volume (L/ha)**	**Timing**	**Approval status**
F1	Untreated	-	-	-	-	-
F2	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	250[1] or 300[2]	12/3/07	Nutrient Nutrient
F3	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	500	12/3/07	Nutrient Nutrient
F4	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	250[1] or 300[2]	29/3/07	Nutrient Nutrient
F5	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	500	29/3/07	Nutrient Nutrient
F6[1]	Calcium nitrate Slither	- 80.0 % w/w polyalkylene oxide modified heptamethyl trisiloxane	50 mg/L 0.8 mL/L	500	29/3/07	Nutrient Approved Adjuvant A0458

[1] Newent site
[2] Bradenham site

All applications were made using a cross-flow-fan blackcurrant sprayer.

Results

The results of the experiments done on cut shoots are shown in Table 3. Calcium nitrate + Erger G, Silwett L-77 at all rates and Activator 90 original were all effective at the later cutting date when 1,535 h <7°C winter chill had been received. The 0.15% rate of Silwett L-77 treatment resulted in slightly less even bud break.

At the earlier cutting date, only 1,334 h <7°C winter chill had been received and only the high rates of Silwett L-77 and Activator 90 original were effective alongside Erger G at this stage.

A further experiment was done to investigate the newly-available formulation of Activator 90 (Table 4).

Table 3: Percentage bud break 21 days after 26/02/07 & 19/03/07 cutting dates

No.	Treatment	Application rate	Average % of buds at bud break (B1) after 21 days at 20°C	
			26/02/07 cut (1334 h <7°C)	19/03/07 cut (1535 h <7°C)
1	Untreated		2.3	3.8
2	Water dip		1.5	8.5
3	Calcium nitrate	125 mg/L	6.9	26.9
4	Calcium nitrate + Erger G	125 mg/L 50 mL/L	97.7	95.4
5	Calcium nitrate + Silwett L-77	125 mg/L 1.5 mL/L	46.2	87.7
6	Calcium nitrate + Silwett L-77	125 mg/L 3 mL/L	Treatment not included	98.5
7	Calcium nitrate + Silwett L-77	125 mg/L 15 mL/L	90.8	100.0
8	Calcium nitrate + Newman's T-80	125 mg/L 5 mL/L	13.1	34.6
9	Calcium nitrate + Newman's T-80	125 mg/L 50 mL/L	12.3	36.9
10	Calcium nitrate + Torpedo-II	125 mg/L 1 mL/L	9.2	35.4
11	Calcium nitrate + Torpedo-II	125 mg/L 10 mL/L	50.8	77.7
12	Calcium nitrate + Activator 90 original	125 mg/L 1 mL/L	9.2	43.1
13	Calcium nitrate + Activator 90 original	125 mg/L 10 mL/L	90.0	98.5
14	Calcium nitrate + Maxicrop original	125 mg/L 10 mL/L	3.1	24.6
15	Calcium nitrate + Route	125 mg/L 10 mL/L	0.8	23.1
		P (ANOVA*)	<0.001	<0.001
		df	126	135
		SED	6.04	6.77

* ANOVA = Analysis of Variance

Table 4: Percentage bud break 21 days after 22 March 2007 cutting date

No.	Treatment	Application rate	Average % of buds at bud break (B1) after 21 days at 20°C
			22.03.07 cut (1607 h <7°C)
1	Untreated		7.7
6	Calcium nitrate + Silwett L-77	125 mg/L 3 mL/L	88.5
12	Calcium nitrate + Activator 90 new	125 mg/L 1 mL/L	34.6
13	Calcium nitrate + Activator 90 new	125 mg/L 10 mL/L	87.5
		P (ANOVA)	<0.001
		df	36
		SED	5.83

The new formulation of Activator 90 proved to be effective at the higher rate only, as per the old formulation. Although it is not possible to compare the two sets of results directly, the results suggest that it may be slightly less effective than the older formulation. It is not possible to be sure whether it would be adequately effective at lower levels of winter chill.

It is clearly preferable to wait until the maximum amount of natural chilling has been received before applying dormancy breaking treatments. Better results can then be achieved with a broader range of chemicals and lower application rates.

For late treatments, where around 1,535 h <7°C had been accumulated, the effective treatments were calcium nitrate plus Erger G, Silwett L-77, Activator 90 (original and new formulations - but only at the high rate of 10 mL/L). Of these, the most cost effective treatments were Activator 90 or Silwett L-77 at an application rate of 1.5 mL/L. Increasing the rate of Silwett L-77 from 1.5 mL/L to 3 mL/L improved the evenness of bud break and increased the percentage of bud break from 87.7% to 98.5%. It is possible that the 3 mL/L rate will prove more robust under field conditions, although it is interesting that a useful result was achieved at Newent with Slither at the much lower rate of 0.8 mL/L.

Where much less winter chill has been accumulated the most effective alternative treatment was Activator 90 original. However whilst the original formulation was available during 2007 it will be replaced during 2008 with the new formulation which has not been tested at the same level of chill deficit.

It is recommended that the treatments to consider as alternatives to Erger G are Silwett L-77 (3 mL/L) or Activator 90 new formulation (10 mL/L).

Note that both of these application rates are higher than the current maximum label recommended rates for Silwett L-77 and Activator 90, at 1.5 mL/L and 1 mL/L respectively. These rates are within the concentration limit for reduced volume pesticide use, which is 10 times the maximum label recommended rate. However Activator 90 is rated as having a risk of serious damage to eyes. This would preclude use of Activator 90 at higher than label concentrations if it were applied with a pesticide. In this case no pesticides are being applied so higher concentration use is *legal* but clearly there is an enhanced risk in this situation and Silwett L-77 would be preferred for this reason.

The results of the field observations on effects of Erger G + calcium nitrate were less conclusive. At Newent there was a very substantial winter chill deficit for Ben Tirran (only 1,463 h accumulated at bud burst, but 2,328 h required) and the effect of the Erger G treatment was minimal, both in forcing bud break and crop evenness. At Bradenham there was a smaller winter chill deficit for Ben Alder (1806 h accumulated at bud burst, but 2157 h required) and the Erger G + calcium nitrate (higher rate, applied at the later date) forced earlier bud development, but again this was not carried through to a benefit in crop evenness. However, the farm treatment at Newent, a silicon based adjuvant (similar to Silwett L-77), Slither 0.8 mL/L + calcium nitrate proved more effective giving a 1.2 t/ha improvement in yield and a more even crop (Table 5). However the yield was still very low at 5.2 t/ha.

Table 5: Percentage fruit colour recorded 7 days pre-harvest (Newent site field observation – harvested 25/7/07).

	Fruit colour		
Treatment	**Black**	**Red**	**Green**
F1. Control	65	18	17
F6. 29/3 applied Slither 0.8 mL/L + Calcium Nitrate 50 mg/L (Farm treatment)	76	15	9

Main conclusions.

This work has identified potential alternative treatments for dormancy breaking in blackcurrant and has quantified the effects in a year when natural winter chill levels were lower than normal. However, the field observations on Erger G showed that it cannot be assumed that:

(a) treatments showing potential from bud stick tests will perform as well in the field
(b) that the initial forcing of bud break will necessarily result in a more even crop.

Financial benefits

Table 6: Cost of treatments assuming application at 400 L/ha

No.	Treatment	Application rate	Cost £/ha
1	Untreated		0
2	Water dip		0
3	Calcium nitrate (£10/kg)	125 mg/L	20
4	Calcium nitrate + Erger G (£5.5/L)	125 mg/L 50 mL/L	135
5	**Calcium nitrate + Silwett L-77 (£36/L)**	**125 mg/L 1.5 mL/L**	**42**
6	**Calcium nitrate + Silwett L-77**	**125 mg/L 3 mL/L**	**63**
7	**Calcium nitrate + Silwett L-77**	**125 mg/L 15 mL/L**	**226**
8	Calcium nitrate + Newman's T-80 (£3/L)	125 mg/L 5 mL/L	26
9	Calcium nitrate + Newman's T-80	125 mg/L 50 mL/L	80
10	Calcium nitrate + Torpedo-II (£25/L)	125 mg/L 1 mL/L	30
11	Calcium nitrate + Torpedo-II	125 mg/L 10 mL/L	120
12	Calcium nitrate + Activator 90 (£4/L)	125 mg/L 1 mL/L	22
13	**Calcium nitrate + Activator 90**	**125 mg/L 10 mL/L**	**36**
14	Calcium nitrate + Maxicrop original (£25/L)	125 mg/L 10 mL/L	45
15	Calcium nitrate + Route (£10/L)	125 mg/L 10 mL/L	60

The most effective alternative treatments to Erger G are listed in bold. Of these, the cheapest treatment is calcium nitrate + Activator 90 @ 10 mL/L, at £36/ha. The cost of the high rates of Silwett L-77 and Torpedo-II rule them out of consideration.

If no treatment is applied when there is a chill deficit it can be assumed that 33% of a typical 9 t/ha crop of Ben Tirran might be lost due to bare wood, and/or uneven ripening causing berry drop prior to harvest.

The financial loss would be £650 x 3 t/ha = £1,950/ha which could be partially offset by treatments costing from £36/ha. Even if the yield response was only 1.2 t/ha as reported at Newent, there would still be a substantial cost benefit.

Action points for growers

- Where there is a significant chill deficit for a cultivar, a dormancy breaking treatment should be considered.
- The treatment should be made as late as possible prior to bud burst to maximize natural winter chill units.
- At 1,535 h <7°C for Ben Tirran, calcium nitrate applied with either Erger G, Silwett L-77 or Activator 90 (both formulations, 1% rate) was effective in forcing an even bud break in cut shoot tests.
- Where there was less winter chill received, at 1,334 h <7^{o}°C, calcium nitrate applied with either Erger G, Silwett L-77 (15 mL/L rate) or Activator 90 (original, 10 mL/L rate) was effective in cut shoot tests.
- The most cost effective treatment was calcium nitrate + Activator 90 at a 10 mL/L rate, however extreme caution is required for the use of Activator 90 at this rate because of the hazard rating “risk of serious damage to eyes”.
- The new formulation of Activator 90 was effective at 1,607 h <7^{o}°C for Ben Tirran but has not been tested where less winter chill units had been received.
- For very low winter chill situations it would be worth experimenting with either Silwett L-77 (1.5-3 mL/L) or Slither (0.8-1.5 mL/L).

- Although Erger G performed well in cut shoot tests, field performance was disappointing with limited bud forcing and little effect on crop evenness.

- Although cut shoot tests indicate treatments with potential it cannot be assumed that they will perform as well under field conditions, or that the effect on crop yield and evenness will be significant.

- The use of dormancy breaking treatments is likely to advance bud break and potentially advance harvest slightly. This could be used to advantage where a greater spread of harvest dates is required from one cultivar.

SCIENCE SECTION

Introduction

A number of commercial blackcurrant cultivars are known to have a significant winter chill requirement to enable even bud break and uniform ripening. With the prospect of warmer winters, this chill requirement may be increasingly difficult to achieve. Limited commercial trials (R. Saunders, personal communication) have shown that Erger G, a proprietary nutrient/adjuvant combination can promote earlier and more even bud break. It is normally applied with calcium nitrate before bud burst to cultivars that have not received sufficient winter chilling.

As the 2006/07 winter was unusually mild, cultivars such as Ben Tirran and Ben Alder did not receive sufficient winter chilling for normal dormancy breaking. The 2007 season therefore provided an opportunity to make detailed observations on farm–applied, dormancy breaking treatments of Erger G + calcium nitrate at two application rates and two timings to blocks of field grown blackcurrants at two sites.

Erger G is, however, expensive and has limited availability. It is known that combinations of nutrients with other adjuvant sprays applied before bud burst can have a similar effect at potentially lower cost. Fraser (2005) investigated a limited number of nutrient and adjuvant combinations for dormancy breaking as part of a broader project. Following recent restrictions on the use of alkyl phenyl compounds, adjuvant formulations are being changed and there is a need to test other products. In order to test a wide range of nutrient/adjuvant combinations without extensive field trials these experiments were carried out on cut shoots forced under controlled conditions using the techniques developed by Lantin (1973) for determining chill requirements for cultivars.

Materials and Methods

Evaluation of dormancy breaking treatments (alternatives to Erger G)

The experiments were conducted on Ben Tirran, a cultivar with a high chill requirement (2,328 h <7 ^{o}C) (Atwood, 2004).

Dormant Ben Tirran shoots were selected and cut from a local plantation (Goregate Ltd, Dereham, Hall 2 Field) using the following criteria:

1. Uniformity of growth with both two-year-old and one-year-old extension growth.
2. The extension growth being selected to have at least 13 buds.
3. Branches arising from the previous year's pruning or laterals from the base of a branch were not selected.

Shoots were sprayed to the point of run-off with the treatment solutions (Table 7) using a hand mini-sprayer, then allowed to surface dry before placing in flower buckets with sufficient water to cover the base of the shoot. The buckets were placed in a warm (20˚C) insulated building with natural lighting for 21 days. Bud break (B1 – see Glossary, Table 15 for a list of growth stages) on the top 13 buds was assessed after 21 days.

The first experiment was done on shoots cut on 26 February 2007 and the experiment was repeated with shoots cut on 19 March 2007.

Following the results of the earlier cutting trial it was decided to include an additional treatment (15) for the 19 March cutting date, using Silwett at an intermediate rate of 3 mL/L.

In order to test the new formulation of Activator 90 that was approved but not yet on the market, a further small experiment was done with shoots cut on 22 March 2007, using the new formulation at two rates compared with Silwett and a control.

Ten shoots were used per treatment in a fully randomized design.

Table 7: Experimental treatments used on cut shoots

Treatment number	Trade name	Active ingredient	Application rate	Approval status
1	Untreated	-	-	-
2	Water dip	-	-	-
3	Calcium nitrate		125 mg/L	Nutrient
4	Calcium nitrate + Erger G	- Not disclosed	125 mg/L 50 mL/L	NutrienT Nutrient
5	Calcium nitrate + Silwett L-77	- 80% w/w polyalkylene oxide modified heptamethyltrisiloxane + < 20% w/w allyloxypolyethylene glycol methyl ether	125 mg/L 1.5 mL/L	Nutrient Adjuvant A0193
6**	Calcium nitrate + Silwett L-77	- 80% w/w polyalkylene oxide modified heptamethyltrisiloxane + < 20% w/w allyloxypolyethylene glycol methyl ether	125 mg/L 3 mL/L	Nutrient Adjuvant A0193
7	Calcium nitrate + Silwett L-77	- 80% w/w polyalkylene oxide modified heptamethyltrisiloxane + < 20% w/w allyloxypolyethylene glycol methyl ether	125 mg/L 15 mL/L	Nutrient Adjuvant A0193
8	Calcium nitrate + Newman's T-80	- 78% w/w polyoxyethylene tallow amine	125 mg/L 5 mL/L	Nutrient Adjuvant A0192
9	Calcium nitrate + Newman's T-80	- 78% w/w polyoxyethylene tallow amine	125 mg/L 50 mL/L	Nutrient Adjuvant A0192
10	Calcium nitrate + Torpedo-II	- 210 g/kg alkoxylated tallow amine, 380 g/kg alcohol ethoxylates, 75 g/L natural fatty acids + 210 g/kg polyalkylene glycol	125 mg/L 1 mL/L	Nutrient Adjuvant A0541
11	Calcium nitrate + Torpedo-II	- 210 g/kg alkoxylated tallow amine, 380 g/kg alcohol ethoxylates, 75 g/L natural fatty acids + 210 g/kg polyalkylene glycol	125 mg/L 10 mL/L	Nutrient Adjuvant A0541
12	Calcium nitrate + Activator 90	- *750 g/L alkylphenyl hydroxypolyoxyethylene + 150 g/L natural fatty acids ***750 g/L alcohol ethoxylates + 150 g/L natural fatty acids	125 mg/L 1 mL/L	Nutrient Adjuvant A0337 A0547
13	Calcium nitrate + Activator 90	- *750 g/L alkylphenyl hydroxypolyoxyethylene + 150 g/L natural fatty acids ***750 g/L alcohol ethoxylates + 150 g/L natural fatty acids	125 mg/L 10 mL/L or 10 mL/L	Nutrient Adjuvant A0337 A0547
14	Calcium nitrate + Maxicrop original	- Seaweed extracts	125 mg/L 10 mL/L	Nutrient Nutrient
15	Calcium nitrate + Route	- Zinc + nitrogen complexes + alkylpolyglycoside	125 mg/L 10 mL/L	Nutrient Nutrient

* used for 26/2/07 cutting date, ** used for 19/3/07 and 22/3/07 cutting dates, ***used for 22/3/07 cutting date

Field evaluation of Erger G

Two observational studies were done.

Study 1: Newent

Location:	The Moat, Anthony's Cross, Newent, Glos, GL18 1JG
Culitvar:	Ben Tirran
Age of bush	11 years
Spacing	0.3 m x 3.0 m

Study 2: Bradenham

Location:	Bradenham Hall Farm, Bradenham, Dereham, Norfolk, IP25 7QR
Cultivar:	Ben Alder
Age of bush	14 years
Spacing	0.3 m x 3.0 m

Treatments (Table 8) were applied to unreplicated blocks consisting of three rows (Bradenham) or six rows (Newent) per block. Rows were approximately 500 m long. At Newent only, a "farm" treatment (F6) was applied to the remainder of the field. All applications were made using a cross-flow-fan blackcurrant sprayer.

Assessments

Prior to treatment, 10 shoots were randomly selected within each treatment block using the following criteria:

1. Uniformity of growth with both two year old and one year old extension growth
2. The extension growth being selected to have at least 13 buds
3. Branches arising from the previous year's pruning or laterals from the base of a branch were not selected.

Selected branches were tagged and numbered. Branches were monitored from time of treatment and as soon as some buds were at the B1 growth stage (Newent, 30 March; Bradenham, 10 April), the growth stage of each of the top 13 buds on each tagged shoot was recorded weekly until the overall growth stage was assessed as F3 (100% flowers open). The final recordings were on 24 May at Newent, and 30 May at Bradenham.

At seven days prior to harvest the number of black, red and green berries were recorded for the 13 bud nodes on the tagged shoots.

Table 8: Experimental treatments, field application of Erger G

Treatment number	Product	Active ingredient	Conc.	Application volume (L/ha)	Timing	Approval status
F1	Untreated	-	-	-	-	-
F2	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	250[1] or 300[2]	12/3/07	Nutrient Nutrient
F3	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	500	12/3/07	Nutrient Nutrient
F4	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	250[1] or 300[2]	29/3/07	Nutrient Nutrient
F5	Calcium nitrate Erger G	- Not disclosed	125 mg/L 50 mL/L	500	29/3/07	Nutrient Nutrient
F6[1]	Calcium nitrate Slither	- 80.0 % w/w polyalkylene oxide modified heptamethyl trisiloxane	50 mg/L 0.8 mL/L	500	29/3/07	Nutrient Approved Adjuvant A0458

[1] Newent site
[2] Bradenham site

Results and discussion

Evaluation of dormancy breaking treatments (alternatives to Erger G)

For the treatment of shoots cut at the earlier cutting date, only 1,334 h <7 °C chill units had been received, so the bushes were 994 h short of the normal 2,328 h requirement for Ben Tirran. Under these conditions treatment with calcium nitrate plus either Erger G, Silwett at the higher 15 mL/L rate, or Activator 90 original at the higher 10 mL/L rate, all gave satisfactory results, forcing a uniform bud break on at least 90% of the buds (Table 9).

Table 9: Percentage bud break 21 days after 26 February 2007 cutting date

No.	Treatment	Application rate	% of shoots with chill requirement satisfied (>9 of 13 buds at B1 after 21 days at 20°C)	Average % of buds at B1 after 21 days at 20°C
1	Untreated	-	0	2.3
2	Water dip	-	0	1.5
3	Calcium nitrate	125 mg/L	0	6.9
4	Calcium nitrate + Erger G	125 mg/L 50 mL/L	100	97.7
5	Calcium nitrate + Silwett L-77	125 mg/L 1.5 mL/L	10	46.2
6	Calcium nitrate + Silwett L-77	125 mg/L 3 mL/L	Not included in this trial	
7	Calcium nitrate + Silwett L-77	125 mg/L 15 mL/L	80	90.8
8	Calcium nitrate + Newman's T-80	125 mg/L 5 mL/L	0	13.1
9	Calcium nitrate + Newman's T-80	125 mg/L 50 mL/L	0	12.3
10	Calcium nitrate + Torpedo-II	125 mg/L 1 mL/L	0	9.2
11	Calcium nitrate + Torpedo-II	125 mg/L 10 mL/L	20	50.8
12	Calcium nitrate + Activator 90 original	125 mg/L 1 mL/L	0	9.2
13	Calcium nitrate + Activator 90 original	125 mg/L 10 mL/L	100	90.0
14	Calcium nitrate + Maxicrop original	125 mg/L 10 mL/L	0	3.1
15	Calcium nitrate + Route	125 mg/L 10 mL/L	0	0.8
		P (ANOVA*)	<0.001	<0.001
		df	126	126
		SED	8.07	6.04

* ANOVA = Analysis of variance

Table 10: Percentage bud break 21 days after 19 March 2007 cutting date

No.	Treatment	Application rate	% of shoots with chill requirement satisfied (>10 of 13 buds at B1 after 21 days at 20°C)	Average % of buds at B1 after 21 days at 20°C
1	Untreated	-	0	3.8
2	Water dip	-	0	8.5
3	Calcium nitrate	125 mg/L	10	26.9
4	Calcium nitrate + Erger G	125 mg/L 50 mL/L	100	95.4
5	Calcium nitrate + Silwett L-77	125 mg/L 1.5 mL/L	100	87.7
6	Calcium nitrate + Silwett L-77	125 mg/L 3 mL/L	100	98.5
7	Calcium nitrate + Silwett L-77	125 mg/L 15 mL/L	100	100.0
8	Calcium nitrate + Newman's T-80	125 mg/L 5 mL/L	10	34.6
9	Calcium nitrate + Newman's T-80	125 mg/L 50 mL/L	0	36.9
10	Calcium nitrate + Torpedo-II	125 mg/L 1 mL/L	10	35.4
11	Calcium nitrate + Torpedo-II	125 mg/L 10 mL/L	70	77.7
12	Calcium nitrate + Activator 90 original	125 mg/L 1 mL/L	0	43.1
13	Calcium nitrate + Activator 90 original	125 mg/L 10 mL/L	100	98.5
14	Calcium nitrate + Maxicrop original	125 mg/L 10 mL/L	0	24.6
15	Calcium nitrate + Route	125 mg/L 10 mL/L	0	23.1
		P (ANOVA)	<0.001	<0.001
		df	135	135
		SED	8.43	6.77

The bud break from Erger G treatment was particularly rapid and this was marginally the most effective treatment. None of the other treatments were effective, although the lower rate of Silwett (1.5 mL/L) did have some effect, causing 46% of the buds to break, suggesting that a rate intermediate between 1.5 mL/L and 15 mL/L might be worth testing.

At this later cutting date, 1,535 h <7°C chill units had been received, so the bushes were closer to but still short of the normal 2,328 h requirement for Ben Tirran. At this stage, having had more natural chilling, the bushes were easier to force into growth. Under these conditions treatment with calcium nitrate plus either Erger G, Silwett at both rates, or Activator 90 original at the higher 10 mL/L rate all gave satisfactory results, forcing adequate bud break on 100% of the shoots. The bud break from the Silwett lowest rate (1.5 mL/L was slightly less uniform than that from the other treatments. Torpedo-II at the higher (10 mL/L) rate had a lesser but useful effect, forcing 77% of buds to break. The other treatments were not adequately effective, although most had some effect causing 20-45% of buds to break

Table 11: Percentage bud break 21 days after 22 March 2007 cutting date

No.	Treatment	Application rate	% of shoots with chill requirement satisfied (>(9 of 13 buds at B1 after 21 days at 20°C)	Average % of buds at B1 after 21 days at 20°C
1	Untreated	-	0	7.7
6	Calcium nitrate + Silwett L-77	125 mg/L 3 mL/L	80	88.5
12	Calcium nitrate + Activator 90 new	125 mg/L 1 mL/L	0	34.6
13	Calcium nitrate + Activator 90 new	125 mg/L 10 mL/L	80	87.5
		P (ANOVA)	<0.001	<0.001
		df	36	36
		SED	13.33	5.83

In order to test the new formulation of Activator 90 that was not commercially available in 2007, a further small test was carried out. At this stage 1,607 h <7°C chill units had been received. Results suggest that the new formulation is sufficiently effective when used at the higher 10 mL/L rate at this level of chill deficit. However, from these results it is not possible to say whether it would be as effective as the original formulation at higher levels of chill deficit.

Field evaluation of Erger G

At the time of first bud movement (30 March), the Newent site had received 1,463 h <7°C, a shortfall of 865 h winter chill for Ben Tirran. For the Bradenham site, first bud movement occurred on 10 April when the site had received 1,806 h <7°C, a smaller shortfall of 351 h for Ben Alder.

Following assessment of bud development in the treated blocks, the records of bud growth development for both sites and are listed in the Appendix (Tables 16 & 17). In general, differences between treatments were relatively small.

To aid interpretation of the bud records the data were further analysed by allocating a numeric value to each growth stage e.g. A=1, B1=2, B2=3 etc. on the basis that under normal temperature conditions the time taken to pass each growth stage is roughly equal, being around five days. This enabled a mean growth stage score to be calculated for each treatment at each recording date, and a standard deviation to be calculated to see if any of the treatments resulted in less variability in development stage. The modal growth stage (excluding dormant buds) is shown as this relates most closely to the visual assessment of growth stage. Occasionally, however, the high number of semi-dormant buds at growth stage B1 led to an unexpected low modal growth stage.

The results are shown in Table 12 for the Bradenham site and in Table 13 for the Newent site.

At Bradenham (Table 12) there was an indication that treatment 5, the higher rate of Erger G applied at the later timing, had the effect of advancing the growth stage. For example on 8 May, the modal growth stage was F2, score 7.2 for treatment 5 compared with B1, score 3.9 for treatment 1 control. There was no obvious effect in reducing variability as measured by the standard deviation. Throughout all recording dates the lowest number of dormant buds was recorded in treatment 5 (Appendix Table 17).

At Newent (Table 13) there was no obvious effect from any of the treatments either in advancing growth or reducing variability in bud development. The winter chill deficit was just over 500 h more for Ben Tirran at Newent, compared with Ben Alder at Bradenham.

Table 12: Bradenham site, variability of growth stage (standard deviation)

Treatment (date and low or high application rate)	Assessment date	Mean growth stage score	Modal growth stage	Standard deviation
1. Control	10-Apr	1.0	B1	0.17
2. 12/3 Low		1.4	B1	0.49
3. 12/3 High		1.5	B1	0.50
4. 29/3 Low		1.1	B1	0.31
5. 29/3 High		1.5	B1	0.50
1. Control	23-Apr	1.0	B1	0.17
2. 12/3 Low		1.4	B1	0.49
3. 12/3 High		1.5	B1	0.50
4. 29/3 Low		1.1	B1	0.31
5. 29/3 High		1.5	B1	0.50
1. Control	30-Apr	2.9	B1	1.76
2. 12/3 Low		4.1	C1	2.27
3. 12/3 High		3.6	B1	2.25
4. 29/3 Low		3.2	B1	1.64
5. 29/3 High		4.8	D	1.45
1. Control	8-May	3.9	B1	2.68
2. 12/3 Low		5.7	D	3.06
3. 12/3 High		4.5	B1	2.83
4. 29/3 Low		4.9	D	2.87
5. 29/3 High		7.2	F2	3.00
1. Control	15-May	4.9	B1	3.43
2. 12/3 Low		7.0	F2	3.34
3. 12/3 High		5.8	B2	3.54
4. 29/3 Low		5.7	F1	3.34
5. 29/3 High		8.5	F2	2.67
1. Control	21-May	6.0	F2	3.94
2. 12/3 Low		8.3	F3	3.64
3. 12/3 High		6.9	F2	3.94
4. 29/3 Low		7.1	F3	3.75
5. 29/3 High		9.9	F3	2.68
1. Control	30-May	6.9	F3	4.56
2. 12/3 Low		9.6	I3	4.73
3. 12/3 High		8.1	B2	4.59
4. 29/3 Low		8.7	F3	4.38
5. 29/3 High		Not recorded as already at F3 previous week		

Table 13: Newent site, variability of growth stage (standard deviation)

Treatment (date and low or high application rate)	Assessment date	Mean growth stage score	Modal growth stage	Standard deviation
1. Control	30-Mar	1.0	A	0
2. 12/3 Low		1.0	B1	0.09
3. 12/3 High		1.0	A	0
4. 29/3 Low		1.0	B1	0.12
5. 29/3 High		1.0	B1	0
6. 29/3 Farm		1.0	B1	0.15
1. Control	9-Apr	1.0	A	0
2. 12/3 Low		1.0	B1	0.12
3. 12/3 High		1.0	B1	0.12
4. 29/3 Low		1.0	B1	0.17
5. 29/3 High		1.0	B1	0.09
6. 29/3 Farm		1.0	B1	0.15
1. Control	13-Apr	1.5	A	0.74
2. 12/3 Low		1.3	B1	0.53
3. 12/3 High		1.2	B1	0.41
4. 29/3 Low		1.3	B1	0.53
5. 29/3 High		1.2	B1	0.39
6. 29/3 Farm		1.2	B1	0.36
1. Control	20-Apr	2.9	C1	1.56
2. 12/3 Low		2.0	B1	1.26
3. 12/3 High		2.2	B2	1.28
4. 29/3 Low		2.1	B1	1.32
5. 29/3 High		2.1	B1	1.17
6. 29/3 Farm		2.0	B1	1.17
1. Control	27-Apr	4.2	C3	1.54
2. 12/3 Low		3.0	C3	1.68
3. 12/3 High		4.0	C3	1.42
4. 29/3 Low		3.4	C3	1.69
5. 29/3 High		3.3	C3	1.52
6. 29/3 Farm		3.2	C3	1.61
1. Control	2-May	5.4	C3	2.07
2. 12/3 Low		4.8	C3	1.69
3. 12/3 High		4.2	C3	1.92
4. 29/3 Low		4.3	C3	2.2
5. 29/3 High		4.4	C3	1.86
6. 29/3 Farm		4.1	C3	1.93

Table 13: (continued).

Treatment (date and low or high application rate)	Assessment date	Mean growth stage score	Modal growth stage	Standard deviation
1. Control	10-May	7.3	F2	3.06
2. 12/3 Low		6.8	D	2.56
3. 12/3 High		5.5	D	2.76
4. 29/3 Low		6.0	D	3.11
5. 29/3 High		6.1	D	2.74
6. 29/3 Farm		5.6	D	1.96
1. Control	18-May	8.7	F3	3.12
2. 12/3 Low		7.2	F3	3.66
3. 12/3 High		8.7	F3	2.43
4. 29/3 Low		7.4	F3	3.69
5. 29/3 High		7.9	F3	3.43
6. 29/3 Farm		7.3	F3	3.75
1. Control	24-May	9.8	F3	3.9
2. 12/3 Low		8.2	F3	4.11
3. 12/3 High		10.0	F3	2.89
4. 29/3 Low		8.6	F3	4.47
5. 29/3 High		8.7	F3	3.94
6. 29/3 Farm		8.8	F3	3.68

The percentages of black, red and green fruit were recorded for the marked bud nodes and the results are shown in Table 14. At both Bradenham and Newent there was very little difference in the evenness of fruit ripening between the Erger G treatments and the control.

Observations were made at harvest by the harvesting teams at both sites. There were no visual differences between the Erger G treatments and the control and either site. However at Newent, treatment F6 (farm standard) was reported to have resulted in a more even sample and a yield improvement of 1.2 t/ha compared with the control and the Erger G treatments.

Table 14: Percentage fruit colour 7 days pre harvest

	Newent (25/7/07)			Bradenham (30/7/07)		
Treatment	**Black**	**Red**	**Green**	**Black**	**Red**	**Green**
1. Control	65	18	17	79	12	9
2. 12/3 Low	55	21	24	84	11	5
3. 12/3 High	55	21	24	78	17	5
4. 29/3 Low	51	26	23	83	12	5
5. 29/3 High	37	31	32	93	7	0
6. 29/3 Farm	76	15	9	-	-	-

Conclusions

On comparing results from the small-scale testing of treatments on cut shoots with treatment in the field it is clear that whilst the former tests are very useful in indicating treatments with potential, it is necessary to go further with field testing to check whether treatments are effective in forcing bud break on a field scale and whether the effects can be translated into a more even crop at harvest.

Results from the testing of dormancy-breaking treatments on cut shoots, and in-field observations, suggest that it is preferable to wait until the maximum amount of natural chilling has been received before applying dormancy breaking treatments. Better results can then be achieved with a broader range of chemicals and lower rates.

For late treatments, when 1,535-1,607 h <7°C had been accumulated, the effective treatments were calcium nitrate plus Erger G, Silwett L-77, or Activator 90 (original and new formulations - but only at the high 10 mL/L rate). Of these, the most cost-effective treatments would be Activator 90 or Silwett L-77 (1.5 mL/L). Increasing the rate of Silwett L-77 from 1.5 mL/L to 3 mL/L improved the evenness of bud break and increased the percentage of bud break from 87.7% to 98.5%. It is likely that this increased rate will prove more robust under field conditions. In the field observation the use of a similar, silicon-based adjuvant, Slither, at a relatively low rate of 0.8 mL/L with calcium nitrate appeared to give a 1.2 t/ha yield increase and improvement in crop evenness under field conditions for Ben Tirran, where only 1,463 h <7°C were accumulated, a deficit of 865 h for this cultivar.

Where much less winter chill had been accumulated, Erger G appeared to be effective. However this is the most expensive treatment and the results from the field observations were less clear-cut. The most effective alternative treatment was Activator 90 original. However whilst the original formulation was available during 2007 it will be replaced during 2008 with the new formulation which has not been tested at the same level of chill deficit.

Note that both of these application rates are higher than the current maximum label recommended rates for Silwett L-77 and Activator 90, at 1.5 mL/L and 1 mL/L respectively. These rates are within the concentration limit for reduced volume pesticide use, which is 10 times the maximum label recommended rate. However Activator 90 is rated as having a risk of serious damage to eyes. This would preclude use of Activator 90 at higher than label concentrations if it were applied with a pesticide. In this case no pesticides are being applied so higher concentration use is *legal* but clearly there is an enhanced risk in this situation and Silwett L-77 would be preferred for this reason.

Technology transfer

No formal technology transfer activities have taken place during this project. However preliminary results were used in preparing advice for growers through GSK crop notes. The results will also be presented to growers through GSK grower meetings. Further publicity will also be discussed with GSK as required including the use of press articles and grower information sheets.

Glossary

Table 15: Blackcurrant growth stages

A	Dormant, no green showing
B1	Burst, tips of buds showing green
B2	Burst, folded leaves as long as the bud scales
C1	First leaves fan open
C3	Three leaves open
D	Grape stage, flower buds visible as a compact dome
E1	Grape stage, first bud separated
E2	Grape stage, all buds separated
F1	First Flowers open
F2	50% flowers open
F3	100% flowers open
I1	First fruit set
I2	50% fruit set
I3	100% fruit set

References

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Lantin, B. (1973). Les exigences en froid des bourgeons du Cassis (*Ribes nigrum L.*) et de quelques Groseilliers (*Ribes* sp.). Annales de l'Amelioration des Plantes. Institut National De La Recherche Agronomique.

Appendices

Appendix 1: Newent site, percentage of buds at each growth stage

Treatment	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
1. Control	30-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
2. 12/3 Low		99	1	0	0	0	0	0	0	0	0	0	0	0	0
3. 12/3 High		100	0	0	0	0	0	0	0	0	0	0	0	0	0
4. 29/3 Low		98	2	0	0	0	0	0	0	0	0	0	0	0	0
5. 29/3 High		100	0	0	0	0	0	0	0	0	0	0	0	0	0
6. 29/3 Farm		98	2	0	0	0	0	0	0	0	0	0	0	0	0
1. Control	9-Apr	100	0	0	0	0	0	0	0	0	0	0	0	0	0
2. 12/3 Low		98	2	0	0	0	0	0	0	0	0	0	0	0	0
3. 12/3 High		98	2	0	0	0	0	0	0	0	0	0	0	0	0
4. 29/3 Low		97	3	0	0	0	0	0	0	0	0	0	0	0	0
5. 29/3 High		99	1	0	0	0	0	0	0	0	0	0	0	0	0
6. 29/3 Farm		98	2	0	0	0	0	0	0	0	0	0	0	0	0
1. Control	13-Apr	67	23	8	2	0	0	0	0	0	0	0	0	0	0
2. 12/3 Low		75	22	4	0	0	0	0	0	0	0	0	0	0	0
3. 12/3 High		82	17	1	0	0	0	0	0	0	0	0	0	0	0
4. 29/3 Low		72	25	3	0	0	0	0	0	0	0	0	0	0	0
5. 29/3 High		85	15	1	0	0	0	0	0	0	0	0	0	0	0
6. 29/3 Farm		85	15	0	0	0	0	0	0	0	0	0	0	0	0
1. Control	20-Apr	31	14	11	25	20	0	0	0	0	0	0	0	0	0
2. 12/3 Low		52	17	15	11	5	0	0	0	0	0	0	0	0	0
3. 12/3 High		46	17	17	15	5	0	0	0	0	0	0	0	0	0
4. 29/3 Low		49	18	12	16	5	0	0	0	0	0	0	0	0	0
5. 29/3 High		43	24	15	16	2	0	0	0	0	0	0	0	0	0
6. 29/3 Farm		48	19	17	15	2	0	0	0	0	0	0	0	0	0
1. Control	27-Apr	12	6	7	13	51	10	2	0	0	0	0	0	0	0
2. 12/3 Low		28	17	12	15	26	2	1	0	0	0	0	0	0	0
3. 12/3 High		11	5	12	22	43	8	0	0	0	0	0	0	0	0
4. 29/3 Low		24	7	17	17	28	8	0	0	0	0	0	0	0	0
5. 29/3 High		21	14	9	28	28	0	0	0	0	0	0	0	0	0

Appendix 1: (continued)

Treatment	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
6. 29/3 Farm		24	13	12	19	31	2	0	0	0	0	0	0	0	0
1. Control	2-May	10	4	1	2	35	23	12	8	5	0	1	0	0	0
2. 12/3 Low		7	7	4	6	50	18	3	2	3	0	0	0	0	0
3. 12/3 High		20	6	1	5	50	17	0	0	1	1	0	0	0	0
4. 29/3 Low		22	4	6	1	40	18	5	0	5	0	0	0	0	0
5. 29/3 High		14	8	5	0	45	25	0	2	0	1	0	0	0	0
6. 29/3 Farm		16	15	2	6	36	22	1	1	1	0	0	0	0	0
1. Control	10-May	6	5	2	0	8	25	5	2	2	32	12	0	0	0
2. 12/3 Low		6	2	1	1	9	39	3	11	8	12	8	0	0	0
3. 12/3 High		15	5	3	1	18	27	9	6	4	11	1	0	0	0
4. 29/3 Low		12	10	2	1	12	27	4	5	2	24	2	0	0	0
5. 29/3 High		8	9	5	4	7	24	11	13	8	11	2	0	0	0
6. 29/3 Farm		11	14	5	2	15	15	12	6	5	15	0	0	0	0
1. Control	18-May	2	7	4	0	4	5	4	6	12	8	45	3	0	0
2. 12/3 Low		10	9	6	1	5	8	4	10	8	9	29	1	0	0
3. 12/3 High		3	1	2	0	5	5	8	16	9	25	27	0	0	0
4. 29/3 Low		12	5	11	0	3	3	2	15	4	20	25	1	0	0
5. 29/3 High		7	5	5	5	7	3	5	5	5	24	30	1	0	0
6. 29/3 Farm		10	14	2	0	5	8	5	6	2	20	28	0	0	0
1. Control	24-May	5	8	0	5	2	0	0	0	3	10	32	12	12	11
2. 12/3 Low		18	2	0	4	5	2	1	2	2	12	45	6	2	0
3. 12/3 High		3	4	0	0	5	1	0	2	4	12	47	17	2	2
4. 29/3 Low		15	8	1	2	2	1	2	2	2	9	32	10	7	8
5. 29/3 High		11	8	0	1	6	2	0	2	2	9	43	15	2	0
6. 29/3 Farm		5	8	7	0	1	3	3	4	5	6	44	11	2	1

Appendix 2: Bradenham site, percentage of buds at each growth stage

Treatment	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
1. Control	10-Apr	97	3	0	0	0	0	0	0	0	0	0	0	0	0
2. 12/3 Low		59	41	0	0	0	0	0	0	0	0	0	0	0	0
3. 12/3 High		53	47	0	0	0	0	0	0	0	0	0	0	0	0
4. 29/3 Low		89	11	0	0	0	0	0	0	0	0	0	0	0	0
5. 29/3 High		47	53	0	0	0	0	0	0	0	0	0	0	0	0
1. Control	23-Apr	97	3	0	0	0	0	0	0	0	0	0	0	0	0
2. 12/3 Low		59	41	0	0	0	0	0	0	0	0	0	0	0	0
3. 12/3 High		53	47	0	0	0	0	0	0	0	0	0	0	0	0
4. 29/3 Low		89	11	0	0	0	0	0	0	0	0	0	0	0	0
5. 29/3 High		47	53	0	0	0	0	0	0	0	0	0	0	0	0
1. Control	30-Apr	33	17	12	15	14	8	1	0	0	0	0	0	0	0
2. 12/3 Low		11	18	15	20	18	5	2	3	9	0	0	0	0	0
3. 12/3 High		18	22	16	16	9	12	0	0	7	1	0	0	0	0
4. 29/3 Low		18	25	14	14	22	8	0	0	0	0	0	0	0	0
5. 29/3 High		5	7	8	3	35	42	0	0	0	0	0	0	0	0
1. Control	8-May	27	18	8	8	5	12	7	12	3	0	0	0	0	0
2. 12/3 Low		11	14	6	4	5	24	2	6	17	11	1	0	0	0
3. 12/3 High		13	22	13	4	11	14	2	8	7	5	1	0	0	0
4. 29/3 Low		18	10	9	6	10	19	5	8	8	6	0	0	0	0
5. 29/3 High		2	8	9	6	8	4	2	9	18	33	1	0	0	0
1. Control	15-May	21	22	5	2	6	7	4	5	17	10	1	0	0	0
2. 12/3 Low		8	12	5	2	5	3	2	11	23	24	5	0	0	0
3. 12/3 High		12	12	18	2	5	5	4	8	15	9	11	0	0	0
4. 29/3 Low		18	8	10	2	8	8	5	8	22	12	1	0	0	0
5. 29/3 High		2	1	8	2	5	2	2	2	7	68	2	0	0	0
1. Control	21-May	20	12	7	4	3	5	8	3	3	21	10	4	0	0
2. 12/3 Low		5	2	12	5	5	2	2	5	5	15	25	17	0	0
3. 12/3 High		8	12	11	4	9	4	1	3	8	16	11	14	0	0
4. 29/3 Low		16	2	8	2	9	7	2	7	7	16	25	1	0	0
5. 29/3 High		2	3	2	0	2	3	1	2	1	7	70	7	0	0

Appendix 2: (continued)

Treatment	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
1. Control	30-May	21	12	3	4	5	2	1	3	8	5	19	7	8	2
2. 12/3 Low		9	5	10	0	1	2	2	0	0	8	13	10	15	25
3. 12/3 High		10	1	22	0	2	6	2	3	3	5	13	13	8	12
4. 29/3 Low		14	3	7	1	0	4	2	8	2	5	23	15	12	5

