Project title:	Winter chilling requirements of blackcurrants: An assessment of the chilling requirements for a range of cultivars at the Bradenham Hall trial site.
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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.

Principle worker

John G Atwood B.Sc. (Hons) (Hort), MRPPA (Hort) Author of report

Authentication

I declare that this work was undertaken either, directly by me, or under my personal supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

……. J Atwood
Signed

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GROWER SUMMARY

COMMERCIAL BENEFITS OF THE PROJECT

By assessing the chilling response of existing and potential cultivars in a formalised manner, it will be possible to predict their performance in seasons where low levels of chilling may be received. It is possible that with the onset of global warming, warmer winters could be more frequent and the selection of cultivars with a low winter chill requirement will be important.

BACKGROUND AND OBJECTIVES

There is increasing evidence that the amount of cold experienced by blackcurrant cultivars, in some regions, in some winters, is inadequate, leading to delayed and uneven bud break, with consequent adverse effects on yield and quality.

Following assessment of the chilling response, at the end of the trial it will be possible to rank all of the cultivars that are growing at the Bradenham Hall trial site, with respect to their winter chilling requirement. This information, taken together other parameters, will help growers to assess the suitability of a given cultivar for growing on a given site.

SUMMARY OF RESULTS AND CONCLUSIONS

Branches from each cultivar in the trial were cut twice weekly from January to March 2003, and kept at 20^{o}C for 21 days. Following assessment using 75% bud break as the criteria for the chill requirement having been met, the following provisional ranking of cultivars was derived.

Table 1: Cultivar Ranking

Row	Cultivar	Date sufficient chill received for 75% bud break	Chill Units	Heat Units	50% Flower	1st Grape
32	9032-1	16/1/03	1331	269.7	18/4	3/4
22	88111-4	20/1/03	1409	264.5	18/4	7/4
31	Ben Gairn	20/1/03	1409	264.5	18/4	9/4
21	Ben Hope	28/1/03	1577	268.2	20/4	14/4
23	8922-11	28/1/03	1577	246.0	18/4	7/4
9	S18-10-18	31/1/03	1647	298.1	23/4	16/4
12	8944-13	3/2/03	1719	298.1	23/4	16/4
18	8972-1	3/2/03	1719	244.7	18/4	7/4
5	903-1	13/2/03	1918	352.5	28/4	17/4
17	Baldwin	13/2/03	1918	191.9	15/4	2/4
36	8999-9	13/2/03	1918	253.6	20/4	14/4
27	Ben Dorain+	17/2/03	2014	-	-	-
30	896-4	17/2/03	2014	295.4	23/4	10/4
14	S18-25-20+	21/2/03	2104	-	-	-
15	S30-13-35	21/2/03	2104	295.4	23/4	18/4
24	Ben Lair+	21/2/03	2104	-	-	-
3	8814-2	24/2/03	2157	294.6	23/4	14/4
26	Ben Avon+	24/2/03	2157	-	-	-
28	894-2	24/2/03	2157	272.8	22/4	16/4
33	8949-15	24/2/03	2157	294.6	23/4	14/4
20	Ben Lomond	28/2/03	2221	282.2	23/4	16/4
2	8962-1	3/3/03	2250	448.8	8/5	30/4
35	8942-5	3/3/03	2250	266.4	23/4	16/4
37	8966-9	3/3/03	2250	255.2	22/4	16/4
4	871-5	7/3/03	2296	306.7	28/4	19/4
8	8982-6	7/3/03	2296	355.3	2/5	25/4
10	S18-3-70	7/3/03	2296	411.3	6/5	30/4
11	S18-2-23	7/3/03	2296	411.3	6/5	28/4
7	8986-13	10/3/03	2328	309.8	28/4	18/4
19	8955-2+	10/3/03	2328	-	-	-
38	Ben Tirran	14/3/03	2397	-	-	-
39	Ben Alder	24/3/03	2550	-	-	-

+ These cultivars were grubbed due to reversion before completion of the trial, at 10/3/03 insufficient chilling had been received on 8955-2.

Chill Units – Total number of hours below 7^{o}C recorded from 1st October 2002 to the date on which sufficient chilling had been received for >75% bud break after 21 days at 20^{o}C

Heat Units – Total number of day degrees (base temperature 4^{o}C) accumulated from the date of sufficient chill to the date of 50% flower open in the field.

ACTION POINTS FOR GROWERS

- Cultivars Ben Gairn, Ben Hope, 9032-1, 88111-4, 8922-1, S18-10-18, 8944-13, and 8972-1 could be classified as having a low winter chill requirement and would be suitable for use in areas of minimal winter chill.
- Cultivars Baldwin, Ben Dorain, Ben Lair, Ben Avon, 903-1, 8999-9, 896-4, S18-25-20, S30-13-35, 8814-2, 894-2, and 8949-15 could be classified as having a moderate winter chill requirement
- Cultivars Ben Lomond, Ben Tirran, Ben Alder, 8962-1, 8942-5, 8966-9, 871-5, 8982-6, S18-3-70, S18-2-23, 8986-13 and 8955-2 could be classified as having a high winter chill requirement and would be likely to under perform in areas where minimal winter chilling is likely to be received.

ANTICIPATED PRACTICAL AND FINANCIAL BENEFITS

The winter chill ranking could be used to decide suitability of existing and potential new cultivars for planting in areas with different winter climates. Planting unsuitable cultivars can result in uneven bud break, uneven ripening and poor yields.

SCIENCE SECTION

INTRODUCTION

The need for plants to experience a period of cold is well established. There is increasing evidence that the amount of cold experienced by blackcurrant cultivars, in some regions, in some winters, is inadequate, leading to delayed and uneven bud break, with consequent adverse effects on yield and quality.

The GSK growers association is investigating the problem in a number of ways, and one branch of the research is aimed at assessing the chilling response of existing and potential cultivars in a formalised manner.

OBJECTIVES

At the end of the trial it will be possible to rank all of the cultivars that are growing at the Bradenham Hall trial site, with respect to their winter chilling requirement. This information, taken together other parameters, will help growers to assess the suitability of a given cultivar for growing on a given site.

MATERIAL AND METHODS

Method

The procedure adopted is similar to that employed by Lantin (1973). From early January, twice weekly, one or two branches were cut from a bush of each cultivar in the Bradenham Hall Cultivars trial. Care was taken to ensure that branches were selected with both two year old and one year old extension growth. The extension growth being selected to have at least 13 buds. Branches arising from previous years pruning or laterals from the base of a branch were not used. As far as possible, bushes a similar distance from the windbreak were used on each occasion. Where there was sufficient bushes and growth, two branches were taken, where the rows were short or the growth poor, only out branch was selected.

Following cutting, branches were labelled with date and code and placed in a warm (20˚C) insulated building in a plastic flower buckets with sufficient water to cover the base of the shoot.

Assessments

After 21 (+ or - 1) days branches were examined and the top 3 and following 10 buds were recorded as broken or not. The definition of bud break being growth stage B1 (a distinctive appearance of green that can clearly be identified as something that will develop into a leaf). The total number of buds broken was recorded.

As a guide to the speed of development, branches were observed for a further 3 weeks and another similar record taken at 42 (+ or - 1) days.

A record was also taken of root development on 28/2/03 in which a score of 0-5 was used to record the volume of root growth.

Experiment design

The cultivar trial consists of single non-replicated rows of individual cultivars. Because of the non-replicated nature of the trial, assessments were not statistically analysed. Material for Ben Tirran and Ben Alder was taken from another plantation on the farm as these cultivars were not in the cultivar trial. These cultivars were allocated notional row numbers 38 and 39 respectively.

RESULTS AND DISCUSSION

Budbreak

The full records of bud break after 21 and 42 days are shown in Appendix 1, Tables 1 and 2 respectively.

Using this data a ranking has been drawn up for all cultivars in the trial to show the first cutting date for which sufficient chilling had been received to give either 8 out of 10 buds breaking after 21 days (buds 4-13) or 9 out of 13 buds breaking after 21 days (all buds, 1-13). (Table 1) below.

Observations of the branches over the period showed that:

- The 1st terminal bud broke readily, typically requiring one months' less chilling than other buds.
- Buds 2 and 3 were more variable, tending to break much later than the terminal. These buds were often relatively small and it could be difficult to detect bud break. If bud 3 was particularly small, it sometimes did not break until most of the other buds had broken.
- There was a tendency for a few buds to break ahead of the 75% bud break stage.
- The 75% target bud break date was for most varieties clear cut with later cutting dates giving similar or more bud break.
- Where 2 branches were taken from a cultivar, there were slight differences in response even though branches were apparently similar.

However these differences were often limited to + or - 2 buds breaking and did not affect interpretation of the general trend.

- Observation from 21-42 days showed that for cultivars that had not received sufficient chilling, a few more buds would develop slowly by 42 days.
- In most cases, recording bud break after 42 days would not have given a different 'chill achieved' date from 21 days.
- For a few low chill requirement varieties 8 (8982-6), 12 (8944-13) and 36 (8999-9) buds continued to develop after 21 days and an even earlier 'chill achieved' date would have been recorded by allowing 42 days for development.

Table 1: Cultivar Ranking

Row	Cultivar	Date sufficient chill received for 75% bud break	Chill Units	Heat Units	50% Flower	1st Grape
32	9032-1	16/1/03	1331	269.7	18/4	3/4
22	88111-4	20/1/03	1409	264.5	18/4	7/4
31	Ben Gairn	20/1/03	1409	264.5	18/4	9/4
21	Ben Hope	28/1/03	1577	268.2	20/4	14/4
23	8922-11	28/1/03	1577	246.0	18/4	7/4
9	S18-10-18	31/1/03	1647	298.1	23/4	16/4
12	8944-13	3/2/03	1719	298.1	23/4	16/4
18	8972-1	3/2/03	1719	244.7	18/4	7/4
5	903-1	13/2/03	1918	352.5	28/4	17/4
17	Baldwin	13/2/03	1918	191.9	15/4	2/4
36	8999-9	13/2/03	1918	253.6	20/4	14/4
27	Ben Dorain+	17/2/03	2014	-	-	-
30	896-4	17/2/03	2014	295.4	23/4	10/4
14	S18-25-20+	21/2/03	2104	-	-	-
15	S30-13-35	21/2/03	2104	295.4	23/4	18/4
24	Ben Lair+	21/2/03	2104	-	-	-
3	8814-2	24/2/03	2157	294.6	23/4	14/4
26	Ben Avon+	24/2/03	2157	-	-	-
28	894-2	24/2/03	2157	272.8	22/4	16/4
33	8949-15	24/2/03	2157	294.6	23/4	14/4
20	Ben Lomond	28/2/03	2221	282.2	23/4	16/4
2	8962-1	3/3/03	2250	448.8	8/5	30/4
35	8942-5	3/3/03	2250	266.4	23/4	16/4
37	8966-9	3/3/03	2250	255.2	22/4	16/4
4	871-5	7/3/03	2296	306.7	28/4	19/4
8	8982-6	7/3/03	2296	355.3	2/5	25/4
10	S18-3-70	7/3/03	2296	411.3	6/5	30/4
11	S18-2-23	7/3/03	2296	411.3	6/5	28/4
7	8986-13	10/3/03	2328	309.8	28/4	18/4
19	8955-2+	10/3/03	2328	-	-	-
38	Ben Tirran	14/3/03	2397	398.8	7/5	28/4
39	Ben Alder	24/3/03	2550	382.7	7/5	28/4

+ These cultivars were grubbed due to reversion before completion of the trial, at 10/3/03 insufficient chilling had been received on 8955-2.

Chill Units – Total number of hours below 7^{o}C recorded from 1st October 2002 to the date on which sufficient chilling had been received for >75% bud break after 21 days at 20^{o}C

Heat Units – Total number of day degrees (base temperature 4^{o}C) accumulated from the date of sufficient chill to the date of 50% flower open.

Table 2: Rooting 6 February 2003, 21 days after cutting

Row	Cultivar	Rooting Score 0-5 0= Nil, 5= Best
2	8962-1	2
3	8814-2	5
4	871-5	3
5	903-1	5
7	8986-13	3
9	S18-10-18	0
10	S18-3-70	5
11	S18-2-23	1
12	8944-13	1
14	S18-25-20	0
15	S30-13-35	0
17	Baldwin	0
18	8972-1	5
19	8955-2	1
20	Ben Lomond	0
21	Ben Hope	5
22	88111-4	4
23	8922-11	0
24	Ben Lair	3
26	Ben Avon	2
27	Ben Dorain	5
28	894-2	0
30	896-4	0
31	Ben Gairn	1
32	9032-1	0
33	8949-15	2
35	8942-5	5
36	8999-9	4
37	8966-9	0
38	Ben Tirran	2
39	Ben Alder	5

The cultivars that were still dormant at this stage tended to produce more root growth. The cultivars that were breaking bud had fewer tendencies to produce root.

CONCLUSIONS

The results obtained from the 2003 season have enabled a provisional ranking of cultivars to be drawn up for winter chilling requirement. In many cases the point where sufficient winter chill was received was clear cut, with a transition from a low percentage bud burst to over 75% on subsequent cutting dates.

There were a few cultivars where results from one or two cutting dates were anomalous and did not fit with a uniform trend. Where an otherwise normal trend was observed, the anomalous results were ignored in deciding the winter chill ranking. By repeating the experiment for another season it is hoped to refine the date and make the results more robust for these cultivars in particular.

Observation of the cuttings for the full 42 days indicated that 21 days at 20 ^{o}C was an appropriate period for observing bud burst. There was little advantage in observing over the longer period.

The performance of the top three buds was often different from the next 10 buds. The terminal bud showed a more ready tendency to burst after relatively little chilling, however the 2nd and 3rd buds were sometimes very small and sometimes did not burst even after the normal chilling requirement was achieved. It is possible that the criteria for achievement of bud burst could be assessed purely on the next 10 buds after the first 3.

From the provisional ranking, it was noted that cultivars with a low chill requirement also tended to have a relatively low heat unit requirement for subsequent development and were consequently relatively early to flower. There was however some variation; Ben Hope, S18-10-18 and 8944-13 were mid season flowering cultivars with relatively low chill requirements – a desirable combination, conversely 8966-9, 8942-5 and Ben Lomond were also mid season flowering cultivars but with a much higher chill requirement.

It is not known if the method of calculation for heat units with a 4 ^{o}C base temperature is appropriate for blackcurrants, however this method was chosen as it is typical for growth models of temperate crops. For proper validation, crop growth and temperature records would need to be taken for a number of seasons.

Records of root development were taken on one occasion. It was noted that root development may have been influenced by relative dormancy of the cuttings, with those cuttings at bud burst being less liable to develop roots. For a more accurate assessment of rooting potential of each cultivar it would therefore be necessary to take records on several occasions throughout the experiment.

REFERENCES

Lantin, B. (1973). Annales de l'Amelioration des Plantes. Institut National De La Recherche Agronomique

ACKNOWLEDGEMENTS

The assistance of M Thurley and C Allhussen of Bradenham Hall Farm, Norfolk, is gratefully acknowledged.

APPENDICES

Fig 1: Ben Gairn 11/2/03, 3 weeks after cutting, one of the earliest cultivars to achieve sufficient winter chill

Fig 2: Ben Hope 11/2/03, 3 weeks after cutting, almost had sufficient chill, top buds breaking

Fig 3: 8962-1 11/2/03, 3 weeks after cutting, tight bud, this cultivar required maximum winter chill

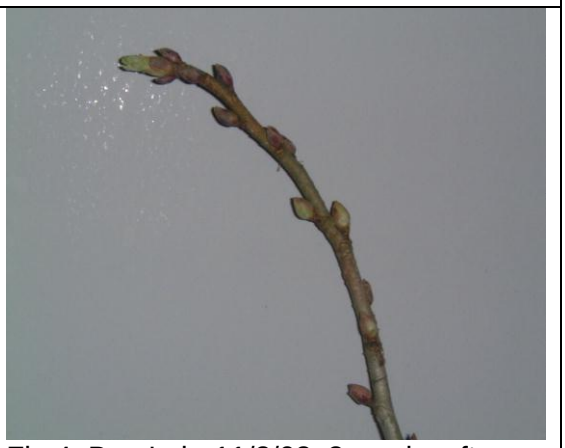

Fig 4: Ben Lair, 11/2/03, 3 weeks after cutting, tip buds only breaking, not sufficient winter chill

Fig 5: Baldwin, 11/2/03, 3 weeks after cutting, tip buds only breaking, not sufficient winter chill

Fig 6: 8972-1, 11/2/03, 3 weeks after cutting, more than 75% bud break

Fig 7: Ben Gairn, 7/3/03, 6 weeks after cutting, all buds burst

Fig 8: Ben Alder 7/3/03, 6 weeks after cutting, buds still tight

Fig 9: 9032-1 17/2/03, 3 weeks after cutting, this cultivar required the least winter chilling

Fig 10: 8962-1, 27/3/03, 3 weeks after cutting, still not breaking

Fig 11: 8972-1, 27/3/03, 3 weeks after cutting, fully open

Fig 12: 871-5, 27/3/03, 3 weeks after cutting, tip buds open only

Appendix 1 Table 1 Bud Break after 21 Days

Date Cut

Row	Variety	6/1	10/1	13/1	16/1	20/1	24/1	28/1	31/1	3/2	6/2	11/2	13/2	17/2	21/2	24/2	28/2	3/3	7/3	10/3	14/3	17/3	20/3	24/3	27/3
2	8962-1	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	2 0 0 0 0	0 0 0 0 0	0 0 0 0 0	1 0 2 0	2 4 3 6	1 9 2 9	- -	- -	- -	- -	- -	- -	- -
3	8814-2	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	1 5 0 0	0 0 0 0 0	0 0 0 0 0	3 0 1 1	0 0 0 0	0 1 1 0	1 0 1 1	2 4 2 4	3 8 3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -
4	871-5	0 0	1 1	0 0	0 0	0 3	0 6	0 0	0 0	0 0	0 1	0 0	1 0	3 6	2 1	3 2	3 5	2 1	3 6	3 3	1 6	- -	- -	- -	- -
5	903-1	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 1	0 0	0 0	2 7	3 8	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
7	8986-13	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	1 4 0 0	0 0 0 0	1 4 1 0	0 0 0 0	0 0 0 0	0 0 0 0	1 2 0 0	1 0 1 1	3 7 * *	1 0 * *	1 7 1 2	1 0 1 0	1 1 0 6	1 2 2 5	1 6 1 6	1 8 1 7	- -	- -	- -	- -	- -
8	8982-6	0 0	0 0	0 0	0 0	1 1 1 5	0 0 0 0	0 0 0 0	0 0 0 0	1 2 0 0	1 3 1 0	0 7 1 6	0 0 1 7	1 2 * *	1 4 1 0	1 2 0 0	1 5 1 0	1 3 1 2	1 6 1 9	1 6 0 8	2 4 2 5	2 7 2 7	3 9 2 6	- -	- -
9	518-10-18	0 0	1 0	1 1	0 0	0 0	1 0	1 3	2 7	2 3	0 2	2 3	3 7	2 9	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
10	518-3-70	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 1	1 0	0 0	1 0	0 0	3 2	3 4	1 0	3 8	0 2	1 2	1 3	1 5	2 9	2 7
11	518-2-23	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 1	0 1 1 0	0 0 1 0	2 2 1 0	0 4 1 2	2 4 0 3	1 5 3 4	0 3 3 6	2 7 1 10	1 1 1 2	3 6 2 6	2 2 2 1	2 5 2 6	2 6 3 10	2 7 3 7

12	8944-13	0 0	0 0	0 0	0 0	0 0	2 5	1 0	0 0	2 7	1 7	1 1	1 8	2 8	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
14	518-25-20	0 0	0 0	0 0	1 0 2 1	0 0 0 0	2 0 1 0	2 1 0 0	1 2 0 0	1 0 3 0	1 4 0 0	2 4 2 5	1 0 1 0	1 0 1 2	* * * *	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
15	530-18-35	0 0	0 0	0 0	0 0	0 0	0 0	0 3	1 2	0 0	0 0	1 0	1 7	2 4	2 7	1 3	3 6	* *	1 7	- -	- -	- -	- -	- -	- -
17	Baldwin	0 0	0 0	0 0	0 0	1 1	2 9	1 1	3 2	3 1	2 1	2 5	3 10	3 8	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
18	8972-1	0 0	0 0	0 0	0 0	1 4 1 2	2 1 1 0	1 0 1 5	2 6 2 7	2 7 2 9	3 10 3 10	3 10 3 10	3 8 3 7	3 8 3 7	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
19	8955-2	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 0 0 0	0 0 0 0	1 0 0 0	1 0 0 0	2 0 3 2	1 0 2 3	1 0 3 4	1 0 1 1	* *	* *	* *	* *	* *
20	BLomond	0 0	0 0	1 0	0 0	0 0	2 2	0 0	3 2	0 0	2 0	1 0	1 0	1 1	1 1	3 2	2 7	2 9	- -	- -	- -	- -	- -	- -	- -
21	B. Hope	0 0	3 1	0 1	1 4	0 6	3 4	2 7	* *	3 7	3 4	3 6	3 4	3 4	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Row	Variety	6/1	10/1	13/1	16/1	20/1	24/1	28/1	31/1	3/2	6/2	11/2	13/2	17/2	21/2	24/2	28/2	3/3	7/3	10/3	14/3	17/3	20/3	24/3	27/3
22	88111-4	0 0	0 1	1 0	1 1	1 9	3 9	3 9	2 8	2 10	2 9	3 10	3 10	3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
23	8992-11	1 0	0 0	1 0	1 1	1 0	1 1	1 9	2 5	1 0	2 4	3 3	1 6	1 3	2 8	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

24	B. Lair	0 0	1 2	0 1	1 2	1 0	1 4	1 1	3 5	1 2	2 5	2 2	1 2	2 2	2 9	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
26	B. Avon	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	0 0	0 0	0 0	3 9	2 4	- -	3 9	- -	- -	- -	- -	- -	- -
27	B. Dorain	0 0	0 0	0 0	0 0	1 0	0 0	1 2	2 2	2 4	1 2	1 1	0 0	2 7	2 10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
28	894 -3	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	1 3	1 1	0 0	0 0	1 0	1 4	3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -
30	896 - 4	0 0	0 0	0 0	1 0	0 0	0 0	1 0	1 2	1 0	1 0	2 5	1 1	2 6	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
31	B. Gairn	3 0 2 5	* * *	1 8 1 3	1 6 2 6	2 10 * *	1 6 3 6	3 2 3 1	0 4 3 9	3 10 1 9	3 10 2 5	3 9 1 9	3 10 3 9	2 1 2 6	- - - -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
32	9032 - 1	0 0	0 0	2 4	3 9	2 3	3 9	3 10	0 0	2 9	3 10	3 10	3 3	3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
33	8949 - 15	0 0 0 0 0	0 0 0 0 0	2 1 2 0	1 0 1 0	2 1 0 0	0 0 0 0 0	1 0 1 0	1 0 1 6	1 0 1 1	1 1 2 0	2 2 2 0	1 0 1 3	* * * *	1 0 1 2	2 6 3 9	1 6 2 9	3 9 3 10	- -	- -	- -	- -	- -	- -	- -
35	8942 - 5	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	1 0 2 4	0 3 * *	0 0 1 2	1 0 1 5	1 0	1 2 1 4	1 2 1 4	2 6 * *	3 6 * *	3 10 * *	3 5 3 6	- -	- -	- -	- -	- -
36	8999 - 9	0 0	0 0	0 3	0 0	0 0	1 5	1 2	1 7	1 1	1 4	1 5	3 8	3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
37	8966 - 9	0 0	0 0	0 0	0 0	0 0	0 0	1 0	0 0	1 1	1 2	2 0	1 0	1 0	1 1	3 4	1 3	3 9	- -	- -	- -	- -	- -	- -	- -
38	B. Tirran	0 0	0 0	0 0	0 0	3 5	0 0	0 0	1 0	1 1	3 1	1 0	3 0	3 10	3 2	3 3	1 4	3 6	1 4	2 2	2 9 3 5	3 6 3 5	2 9	1 8	- -

		00	00	00	00	24	00	00	00	22	00	00	10	32	00	14	28	05	22	37			35	27	
39	B. Alder	0000	0000	1001	1000	3252	0000	0000	0100	0010	0011	0000	1000	2000	1202	1202	1212	2318	2015	1536	3914	3524	3914	1819	--

* = missing data

Table 2 Bud Break after 42 Days

Date Cut

Row	Variety	6/1	10/1	13/1	16/1	20/1	24/1	28/1	31/1	3/2	6/2	11/2	13/2	17/2	21/2	24/2	28/2	3/3	7/3	10/3	14/3	17/3	20/3	24/3	27/3
2	8962-1	0000	0000	0000	0000	0000	0000	0001	0211	3100	0300	0303	2133	1306	1323	1335	- -	- -	- -	- -	- -	- -	- -	- -	- -
3	8814-2	0000	0000	0020	0000	1101	1001	1025	1000	1000	3210	1012	1210	1112	2113	2336	- -	- -	- -	- -	- -	- -	- -	- -	- -
4	871-5	00	36	25	00	04	34	00	0213	12	21	12	10	34	21	31	36	21	35	32	3 6	- -	- -	- -	- -
5	903-1	00	01	01	00	33	12	10	22	11	11	23	27	38	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
7	8986-13	0000	0001	0000	1114	11	2311	1121	12	1000	1222	1011	3701	10	2612	1023	1008	1128	1516	- -	- -	- -	- -	- -	- -
8	8982-6	00	22	30	21	26	00	23	210	21	18	07	27	11	13	13	11	16	13	- -	2826	2821	- -	- -	- -

		0 0	2 2	2 0	2 5	2 3	0 0	2 4	1 5		1 7	2 7	0 0	1 3	1 0	1 3	2 6	2 7	1 7						
9	518-10-18	0 0	2 0	2 6	2 1	0 0	2 2	1 5	2 7	3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
10	518-3-70	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	2 1	1 2	0 0	* *	2 0	1 0	1 3	3 4	2 6	3 6	0 2	0 4	2 5	- -	- -	- -
11	518-2-23	0 0 0 0	0 1 1 1	0 0 0 0	0 0 0 0	3 2	1 1 0 1	0 0	0 3 0 0	3 3 0 3	3 4 0 4	0 2 1 4	3 1 1 1	3 5 1 0	2 1 0 5	3 3 2 5	1 5 2 3	3 8 0 4	2 5 1 7	0 1 2 4	2 8 2 6	3 3 2 2	- -	- -	- -
12	8944-13	0 0	1 6	2 7	2 6	1 5	2 7	1 8	3 3	3 7	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
14	518-25-20	1 0 0 0	2 7 1 0	3 2 1 1	1 0 2 2	1 1 1 3	2 1 1 0	2 1 2 0	1 0 1 1	2 0 3 2	1 3 1 0	1 4 1 5	1 0 1 1	1 0 1 2	3 6 3 5	1 0 2 1	- -	- -	- -	- -	- -	- -	- -	- -	- -
15	530-18-35	0 0	0 0	2 0	2 3	1 2	3 1	2 9	3 4	1 3	1 2	1 0	1 7	1 5	2 5 2 5	2 5	- -	- -	- -	- -	- -	- -	- -	- -	- -
17	Baldwin	3 0	3 3	0 0	3 2	1 1	3 9	3 3	3 1	1 0	3 0	3 4	3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
18	8972-1	0 1	3 6 0 2	1 0 2 0	3 6 2 5	2 5 2 4	1 1 1 1	2 1 1 1	1 2 1 1	3 8 3 5	3 8 3 10	3 10 3 10	3 10 3 10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
19	8955-2	0 0 0 0	0 0 0 0	0 0 0 0	0 0 0 0	1 0 1 0	1 0 0 0	1 0 0 0	1 0 2 0	0 0 3 2	1 0 0 1	2 1 1 0	1 0 1 0	2 0 3 0	2 1 0 0	1 0 1 0	2 4 2 1	1 0 2 5	3 6 2 1	2 4 1 0	* *	* *	- -	- -	- -
20	Blomond	0 0	2 2	3 2	1 3	0 0	3 3	2 0	2 1	* *	2 0	1 0	1 1	2 1	1 3 2 1	3 4	2 7	- -	- -	- -	- -	- -	- -	- -	- -

21	B. Hope	10	33	27	14	17	36	34	28	**	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

Row	Variety	6/1	10/1	13/1	16/1	20/1	24/1	28/1	31/1	3/2	6/2	11/2	13/2	17/2	21/2	24/2	28/2	3/3	7/3	10/3	14/3	17/3	20/3	24/3	27/3
22	88111-4	1010	11	35	15	110	310	310	28	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
23	8992-11	10	14	22	24	23	12	23	28	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
24	B. Lair	00	23	13	22	11	00	11	34	12	24	15	12	13	23	35	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
26	B. Avon	00	31	13	00	00	10	00	00	13	10	11	00	00	22	36	14	- -	- -	- -	- -	- -	- -	- -	- -	- -
27	B. Dorain	00	00	07	00	10	00	12	21	32	11	11	**	310	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
28	894 -3	00	00	00	11	02	00	05	00	22	22	10	01	10	23	37	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
30	896 - 4	00	00	34	21	22	11	10	34	21	10	17	11	28	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
31	B. Gairn	3328	***	2257	1525	210	3516	35331	3904	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
32	9032 - 1	32	13	310	310	39	39	31030	11	29	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -

33	8949 - 15	0 0 0 0	2 2 2 1	3 2 2 2	1 0 1 2	2 1	1 0	1 0 1 6	1 0 1 7	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
35	8942 - 5	0 0	0 0	0 1	0 2 0 0	0 0 0 3	1 3 1 0	3 2 1 2	0 2 0 0	0 5 2 4	0 2 0 2	1 0 1 2	0 0 1 5	1 1	1 5 1 3	1 3	1 0 1 5	1 2 3 6	3 2 1 7	3 10 3 10	- -	- -	- -	- -	- -
36	8999 - 9	0 0	1 0	1 7	0 7	3 5	2 9	2 3	2 8	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
37	8966 - 9	0 0	2 1	3 1	1 1	1 0	2 0	3 2	1 0	3 2	1 2	2 1	* *	1 3	2 0	3 3 3 5	2 3	- -	- -	- -	- -	- -	- -	- -
38	B. Tirran	0 0 0 0	2 0 5 0	2 5 0 1	2 1 0 0	2 6 1 3	1 1 1 1	1 0 0 0	3 0 0 2	2 2 2 2	1 2 2 3	0 1 0 0	0 2 1 3	3 4 3 10	3 7 0 1	2 6 2 3	2 4 2 8	2 6 0 4	3 4 1 3	3 9 2 6	3 7 2 7	- -	- -	- -
39	B. Alder	0 0 0 0	* * * *	1 1 * *	1 0 2 0	3 7 2 3	0 1 0 2	1 5 1 1	3 2 1 2	1 1 1 1	1 1 1 1	1 0 2 0	1 0 0 1	1 4 1 0	0 5 1 3	1 0 1 1	1 0 0 1	1 8 2 6	2 3 1 2	3 5 1 7	1 1 1 2	- -	- -	- -

Note – in a few cases there are fewer bud recorded as burst after 42 days compared with 21 days, this was due to a number of very small buds which appeared to be developing after 21 days but which subsequently failed to develop.