Project Title:	Blackcurrants: Further detailed evaluation of new cultivars from the breeding programme for evenness of bud break and development
Project number:	SF 012 (GSK215)
Project leader:	John Atwood, ADAS UK Ltd
Report:	Final report, September 2007
Previous report	None
Key staff:	John Atwood, ADAS, Project leader Chris Nicholson, ADAS, Site Manager, Newent
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Key words:	Baldwin, Ben Alder, Ben Gairn, Ben Hope, Ben Klibrek, Ben Lomond, blackcurrant, breeding, bud break, bud development, cultivar, fruit colour, *Ribes nigrum* L., ripening, Tiben, winter chill

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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.

John Atwood
Senior Consultant
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Signature …..... Date ….....

Report authorised by:

Dr W E Parker
Horticulture Research & Consultancy Manager
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Signature …..... Date ….....

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GROWER SUMMARY

Headlines

- Following detailed analysis of bud development on cultivars at the two GSK observation sites a quantitative method for ranking evenness is proposed.

- Based on this method the new cultivars Ben Klibrek, Tiben, 91192-1 and 9134-7 could be ranked as “good” and the cultivars, 9199-4, 934-60, 934-74, 938-56, 9311-25, 9311-66, 9311-82 could be ranked as “poor” alongside Ben Alder and Ben Lomond. Others were intermediate.

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. The 2006/7 winter was unusually mild, resulting in shortfall in the chill requirement for many of the current commercial cultivars.

In order to provide more information on the performance of new cultivars following a winter with low levels of chilling, detailed records of bud development and fruit ripening were taken in 2007 at the two cultivar observation sites, at Newent, Glos. and Bradenham, Norfolk, to provide accurate information for evenness ranking. Such information will be important in deciding on the suitability of new cultivars in areas prone to mild winters.

Summary of the project and main conclusions

The two established cultivar observation sites were used for the evaluation.

The Bradenham site comprised ten 50 m single rows, each with one cultivar planted in spring 2002-03. The Newent site comprised twenty four 60-80 m single rows, each with one cultivar planted from spring 2000-03.

Whilst the bushes were still dormant (early March) 10 shoots were selected within each cultivar row and monitored weekly. As soon as some buds were at the B1 growth stage (see

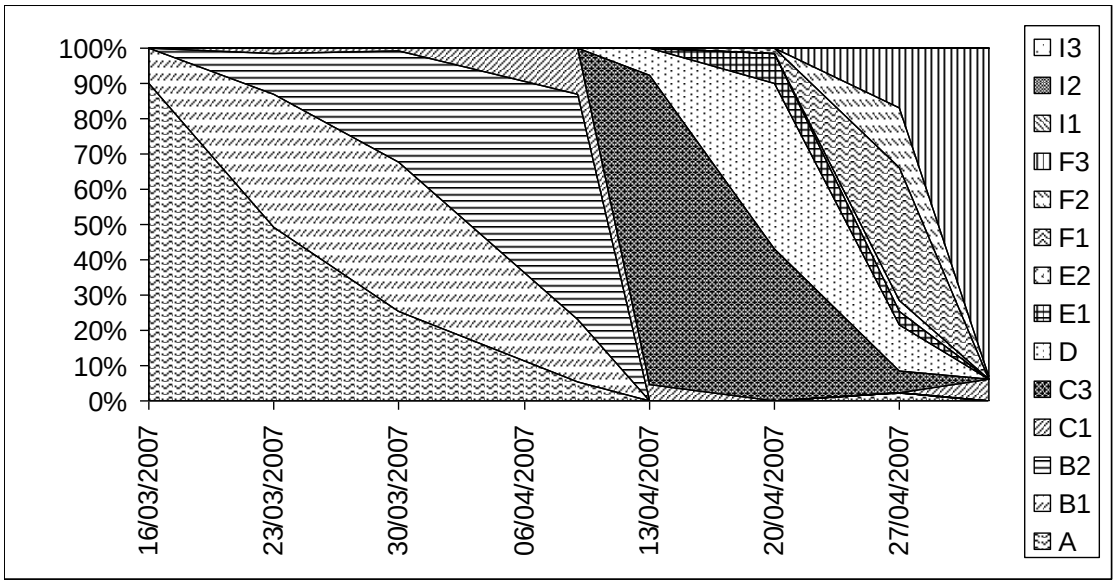
Glossary for a list of growth stage codes) the growth stage of each of the top 13 buds on each observed shoot was recorded weekly until the overall growth stage was assessed as F3 (100% flowers open). The final recordings were made at the end of May.

Seven days prior to harvest the numbers of black, red and green berries were recorded for each of the 13 bud nodes on the tagged shoots.

The earliest cultivars started to break bud on 8 March. The number of accumulated winter chill units (accumulated h < 7^{o}C) from 1 October 2006 to 8 March 2007 was 1434 h at Bradenham and 1212 h at Newent. The late cultivars broke bud on 10 April at Bradenham (1806 h) and on 30 March at Newent (1463 h). The average chill unit requirement for cultivars ranges from 1320 h up to 2366 h. So for many cultivars it is likely that the normal chill requirement would not have been fully met following the winter of 2006/07, the deficit being particularly acute at Newent.

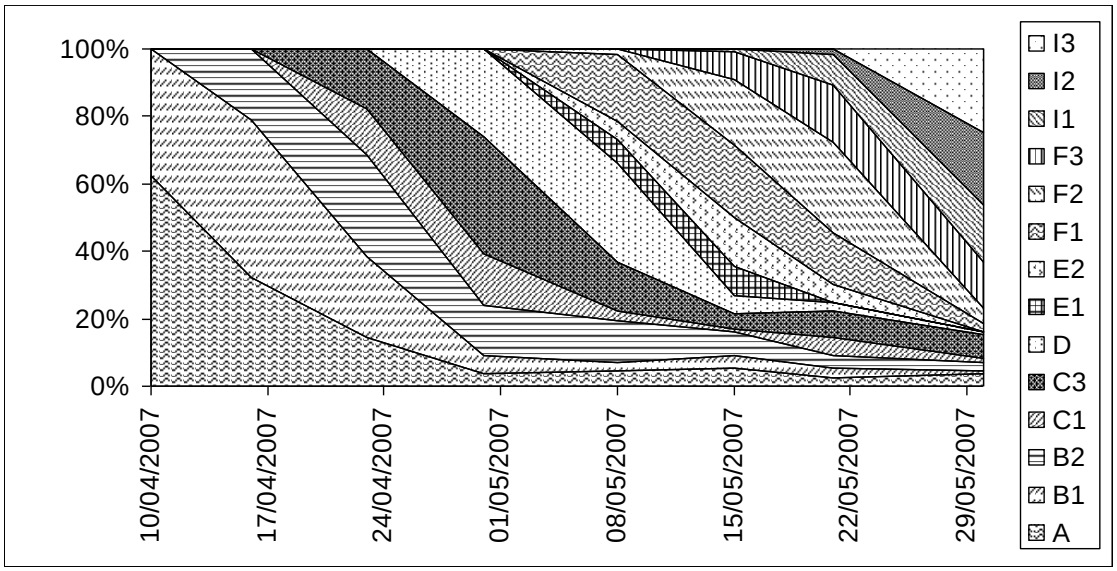
Cultivars varied considerably in the evenness of development, with some (e.g. Ben Klibrek) passing through growth stages uniformly (Figure 1).

Figure 1. Bud development Newent, for cv. Ben Klibrek: percentage of buds at each growth stage from mid-March to early-May.



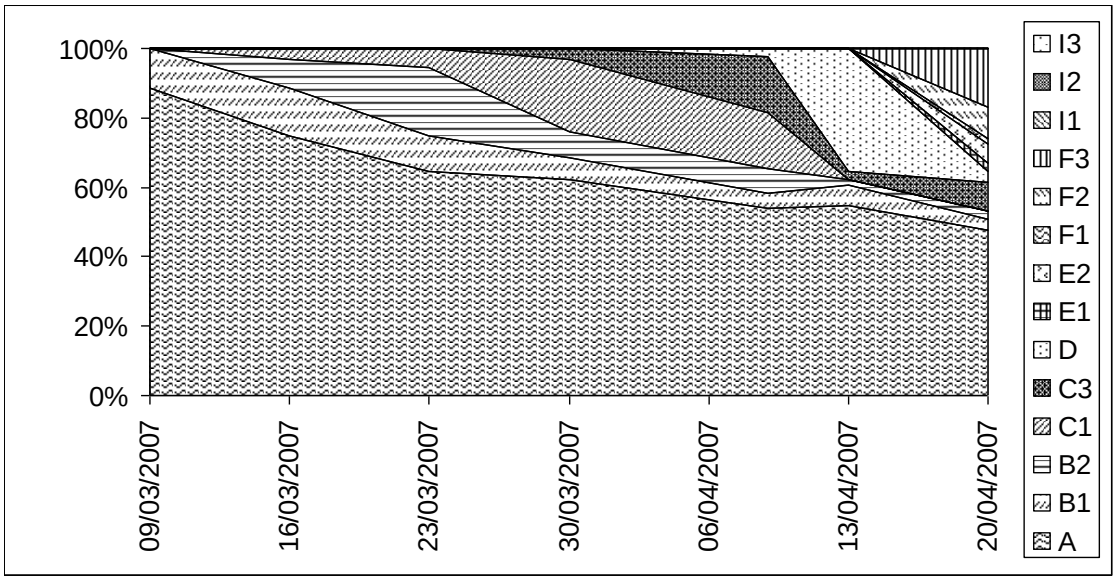
Others (e.g. Ben Alder) had buds at many different stages of development, particularly at flowering (Figure 2).

***Figure 2*.** Bud development Bradenham, for cv Ben Alder percentage of buds at each growth stage from mid-April to end-May.



Another characteristic of these unevenly developing cultivars was the presence of a significant percentage of dormant buds throughout the recording period. This was particularly evident at Newent where the level of winter chill was much less that at Bradenham. One of the worst cultivars for buds remaining dormant was 9311-66 with 50% of buds dormant at the end of the recording period (Figure 3).

Figure 3. Bud development Newent for cv 9311-66 percentage of buds at each growth stage from mid-March to end-April.



In order to quantify the uniformity of bud development, the data were further analysed by allocating a numeric value to each growth stage and calculating the standard deviation (a statistical measure of variability) of the values. This data were used to provide a ranking of uniformity for cultivars based on the mean of the standard deviation of growth stage scores at growth stages F1-F3 (Table 1).

Because Newent provides the most complete data set and the more challenging environment for winter chill, the cultivars are ranked in order of their performance at Newent. Bud development was noticeably more even at Bradenham with most cultivars with acceptable evenness. The two exceptions were S36-1-21 and Ben Alder, and both had relatively high variability at both sites. Surprisingly, S36-1-21 performed slightly better at Newent. There were some other inconsistencies between the rankings at the two sites. Baldwin and 91129-1 were more variable at Bradenham than at Newent and the evenness of 9199-4 was moderate at Bradenham but very poor at Newent largely due to 30% of buds remaining dormant throughout the recording period.

Table 1: Mean standard deviation of growth stage scores at F1 – F3 growth stage, and uniformity rating

		Mean standard deviation of growth stage scores	
Cultivar	**Uniformity rating**	**Newent**	**Bradenham**
Ben Klibrek	Good	1.91	-
Tiben		2.37	0.73
91192-1		2.45	2.72
Baldwin		2.58	2.88
9134-7		2.77	0.59
9148-9	Moderate – Good	3.1	-
B. Hope		3.12	0.79
9154-3		3.21	1.15
Ben Gairn		3.24	-
9137-2	Moderate – Poor	3.43	-
9111-14		3.44	-
S36-1-21		3.47	3.71
91129-1		3.59	2.51
9198-1		3.59	-
934-58		3.67	-
934-60	Poor	4.05	-
Ben Alder		4.05	3.17
Ben Lomond		4.14	-
9311-66		4.16	-
9311-25		4.39	-
9199-4		4.44	2.09
9311-82		4.65	-
934-74		4.77	-
938-56		4.78	-

The cultivar Ben Klibrek has recently been named and is being multiplied up for release. At both sites where it has been grown in 2007 it has produced high yields, generally better than existing commercial cultivars. Cultivar 9134-7 has similarly performed well with good agronomic characteristics. Tiben is unlikely to be progressed due to processing considerations and 91129-1 is, unfortunately, very slow growing and the results at Bradenham were more variable. Cultivars 9148-9 and 9154-3 also showed some promise in uniformity characteristics. Cultivar 9148-9 in has good agronomic characteristics but 9154-3 has produced disappointingly poor fruit quality to date.

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Cultivars in the “moderate-poor” category should not be dismissed at this stage as the work so far is based on one season’s results and for some of the cultivars, results from only one site.

Records were also taken of fruit colour 7 days prior to harvest. Although the uniform development of fruit colour should be related to bud development uniformity, other factors come into play. These include; the bush habit and the relative exposure of the fruit, the loss of overripe fruit prior to harvest and the ability of the ripe fruit to "hang" whilst under-ripe fruit ripens.

The cultivars that had noticeably variable fruit colour (<96% black) included S36-1-21, 9137-2, 9148-9, 9198-1, Ben Alder and Ben Lomond. Of these Ben Alder was the most variable at both sites.

Financial benefits

The 2007 cropping season has shown that a lack of winter chilling can result in a yield loss of 50% for the worst affected cultivars, reducing yield from 10 tonnes/ha to 5 tonnes/ha. The cost could therefore amount to 5 tonnes/ha or £3200 per ha.

By the correct choice of cultivars for the site, growers may be able to achieve more consistent results in mild winters.

Action points for growers

- Ben Klibrek, Tiben, 91192-1 and 9134-7 showed very good uniformity characteristics in a season with low chill levels.
- Cultivars 9148-9 and 9154-3 showed some promise in uniformity characteristics.
- Ben Klibrek also has good agronomic characteristics and is already being bulked up for release to the industry. It appears to be suitable for planting in low chill situations.
- Cultivars 9134-7 and 9148-9 have some good agronomic characteristics and might be considered for fast track release to the industry for use in low chill situations. However 9148-9 is only suitable for sites with a low risk of gall mite and reversion.

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 (Atwood, 2004). The 2006/7 winter was unusually mild, resulting in shortfall in the chill requirement for many cultivars.

The protocol for evaluating new cultivars from the GSK breeding programme at the two observation sites does not include detailed quantitative recording of individual bud development for evenness ranking.

In order to provide more information on the performance of new cultivars following a winter with low levels of chilling, more detailed records were taken in 2007 at the two cultivar observation sites at Newent, Glos. and Bradenham, Norfolk, to provide accurate information for evenness ranking.

Materials and Methods

Site details

The two established cultivar observation sites (Bradenham, Norfolk and Newent, Glos.) were used for the evaluation. The Bradenham site comprised ten 50 m single rows, each with one cultivar planted at a spacing of 0.3 m x 3 m. A layout plan is shown in the Appendix 1. The site was planted spring 2002-03. The Newent site comprised twenty-four, 60-80 m single rows, each with one cultivar planted at a spacing of 0.3 m x 3 m. A layout plan is shown in Appendix 2. The site was planted spring 2000-03.

Assessments

Whilst the bushes were still dormant (early March) ten shoots were randomly selected within each cultivar row 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 previous year's pruning or laterals from the base of a branch were not selected.

Selected branches were tagged and numbered. Branches were then monitored weekly. As soon as some buds were at the B1 growth stage (early bud-burst, see Glossary for growth stage definitions) 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 made at the end of May.

At 7 days prior to harvest the number of black, red and green berries were recorded for each of the 13 bud nodes on the tagged shoots.

The number of winter chill units (accumulated h < 7^{o}C) was logged at each site using two weather stations, each situated within the experimental areas. Temperature data were accumulated from 1 October 2006.

Results and Discussion

The earliest cultivars started to break bud on 8 March. The number of accumulated winter chill units on 8 March was 1434 h at Bradenham and 1212 h at Newent. The late cultivars broke bud on 10 April at Bradenham (1806 h) and on 30 March at Newent (1463 h). The average chill unit requirement for cultivars ranges from 1320 h up to 2366 h (Atwood, 2004). So for many cultivars it is likely that the normal chill requirement would not have been fully met following the winter of 2006/07, the deficit being particularly acute at Newent.

Following assessment of bud development in the treated blocks, the records of bud growth development for both sites were converted to percentages and are listed in Appendix 3. Cultivars varied considerably in the evenness of development, with some (e.g. Ben Klibrek) passing through growth stages uniformly and others (e.g. Ben Alder) having buds at many different stages of development particularly at flowering. Another characteristic of these unevenly developing cultivars was the presence of a significant percentage of dormant (growth stage A) or near dormant (B1) buds throughout the recording period. This was particularly evident at Newent where the level of winter chill was much less that at Bradenham.

In order to better illustrate the developmental characteristics of the cultivars, the data in Appendix 3 have been presented in Figures 4 – 37 below. Cultivars that had good uniformity

through the growth stages have charts with vertical rather than horizontal blocks and low percentages of dormant buds. Examples of cultivars with these desirable characteristics include Baldwin, Ben Gairn, Ben Hope, Ben Klibrek, Tiben, 91192-1, 9134-7 and 9148-9. Cultivars with very uneven bud development include Ben Alder, S36-1-21, 9111-14, 9199-4, 9311-66 and 9311-88 resulting in horizontally blocked charts. Some cultivars at Newent, such as 9311-25, 9311-66, 9311-82, 934-74 and 938-56 had over 25% dormant buds at the end of flowering, and 9311-66 was the worst with 50% of buds dormant.

Figure 4. Bradenham, cv S36-1-21 percentage of buds at each growth stage from mid-April to end-May.

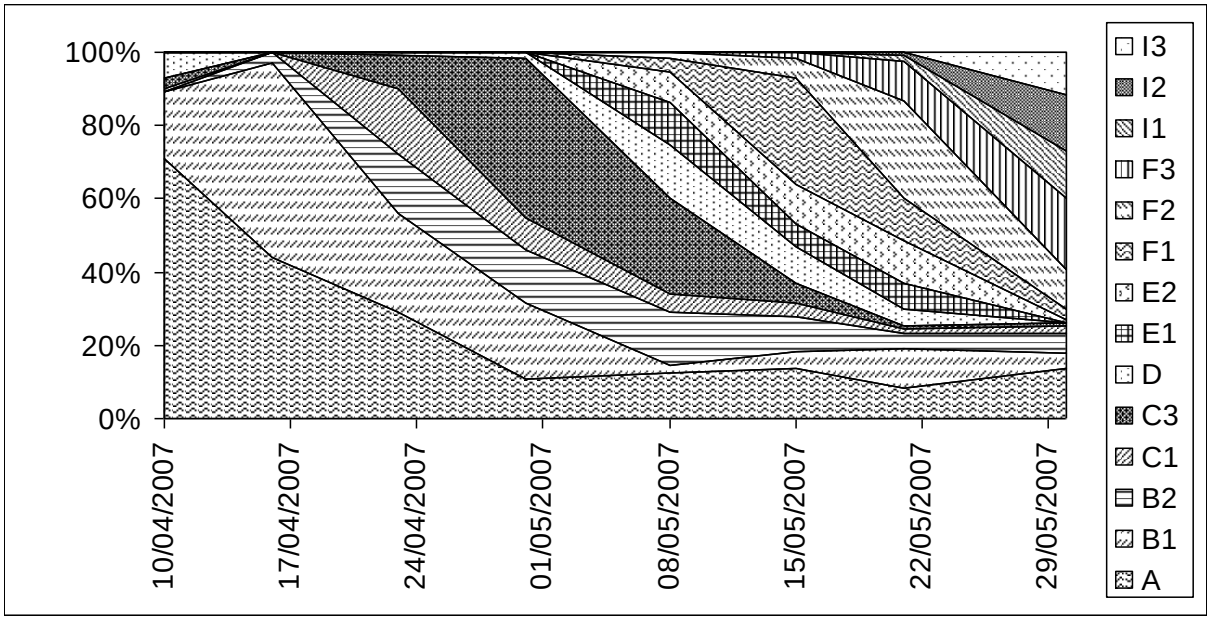


Figure 5. Bradenham cv 91129-1 percentage of buds at each growth stage from mid-March to end-April.

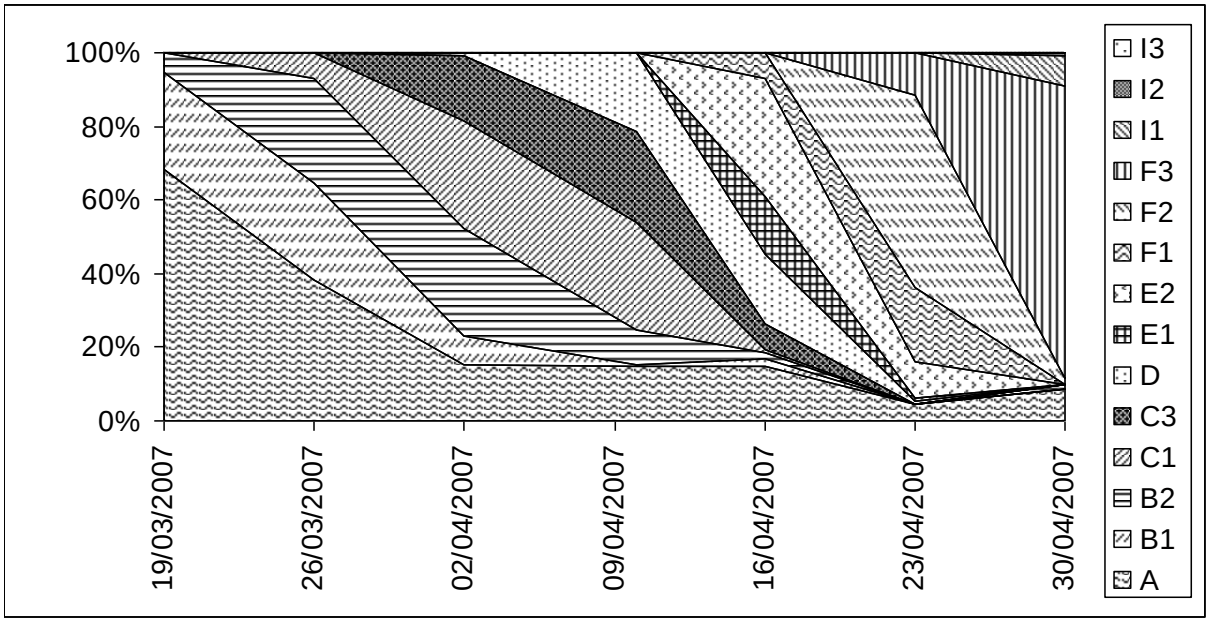


Figure 6. Bradenham cv 91192-1 percentage of buds at each growth stage from mid-March to early-May.

Figure 7. Bradenham cv 9134-7 percentage of buds at each growth stage from early-April to early-May.

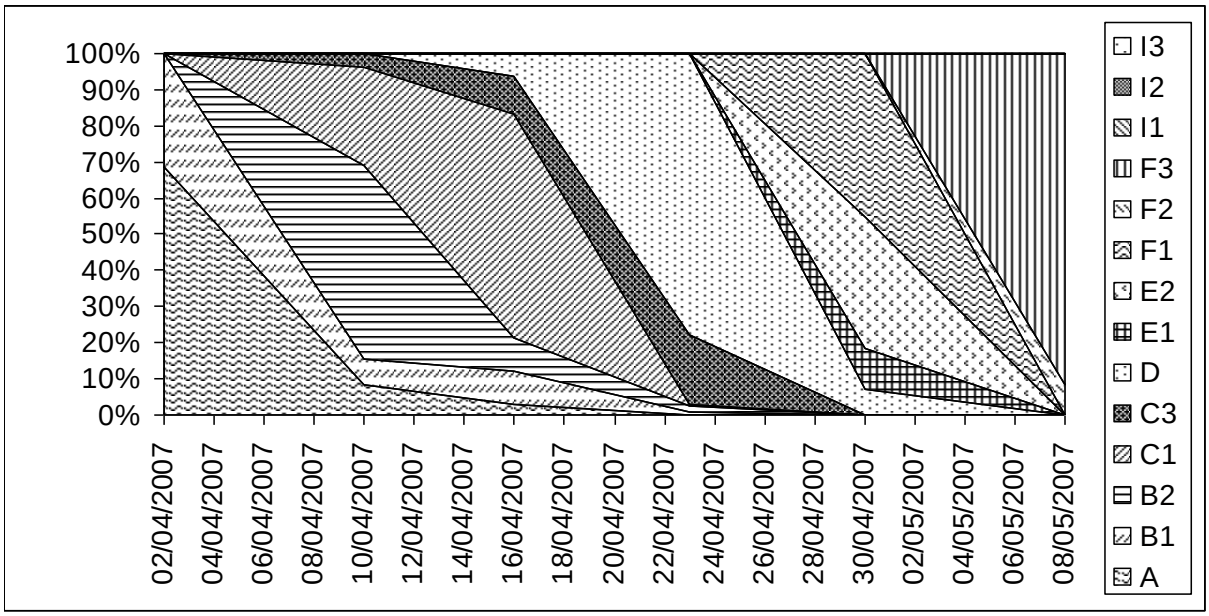


Figure 8. Bradenham cv 9154-3 percentage of buds at each growth stage from mid-March to early-May.

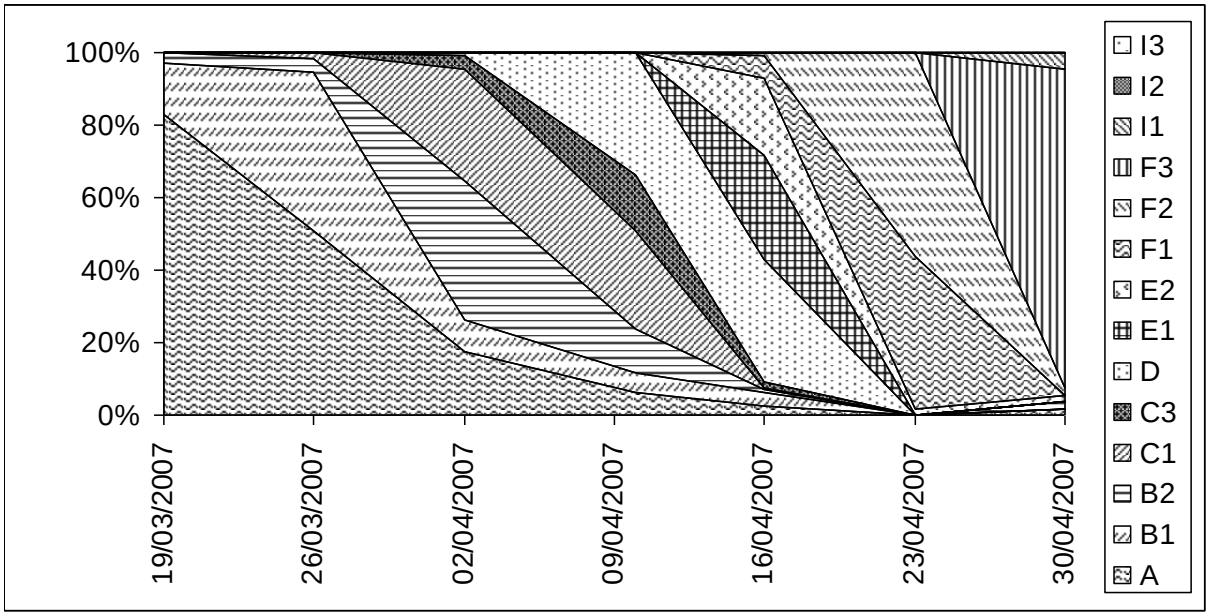


Figure 9. Bradenham cv 9199-4 percentage of buds at each growth stage from mid-March to early-May.

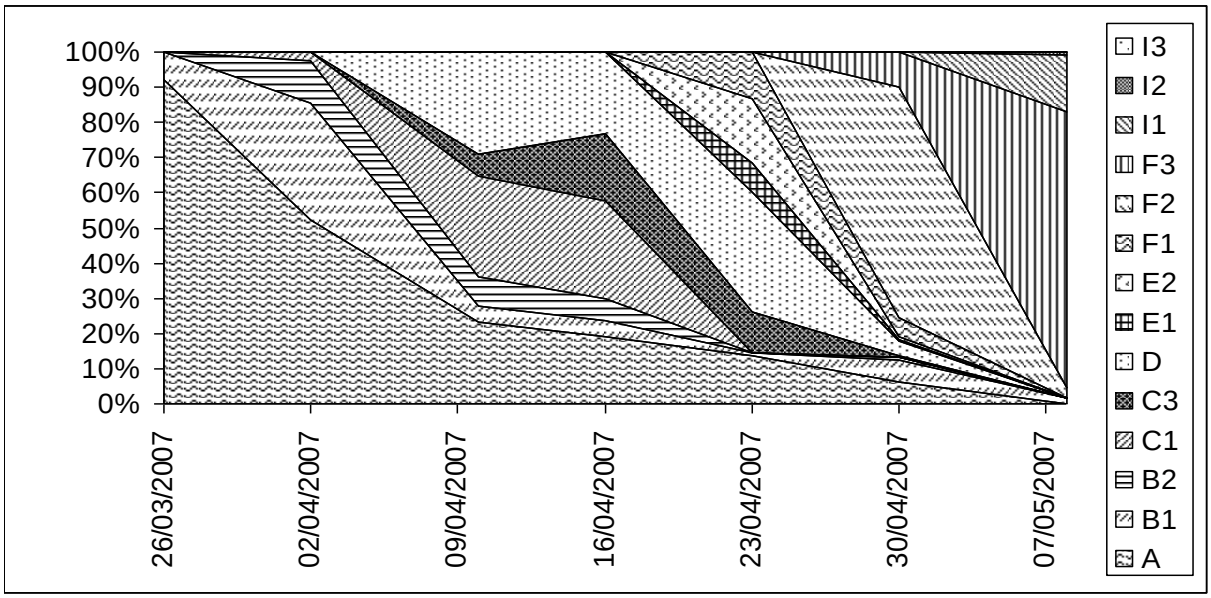


Figure 10. Bradenham cv Ben Alder percentage of buds at each growth stage from mid-April to early-May.

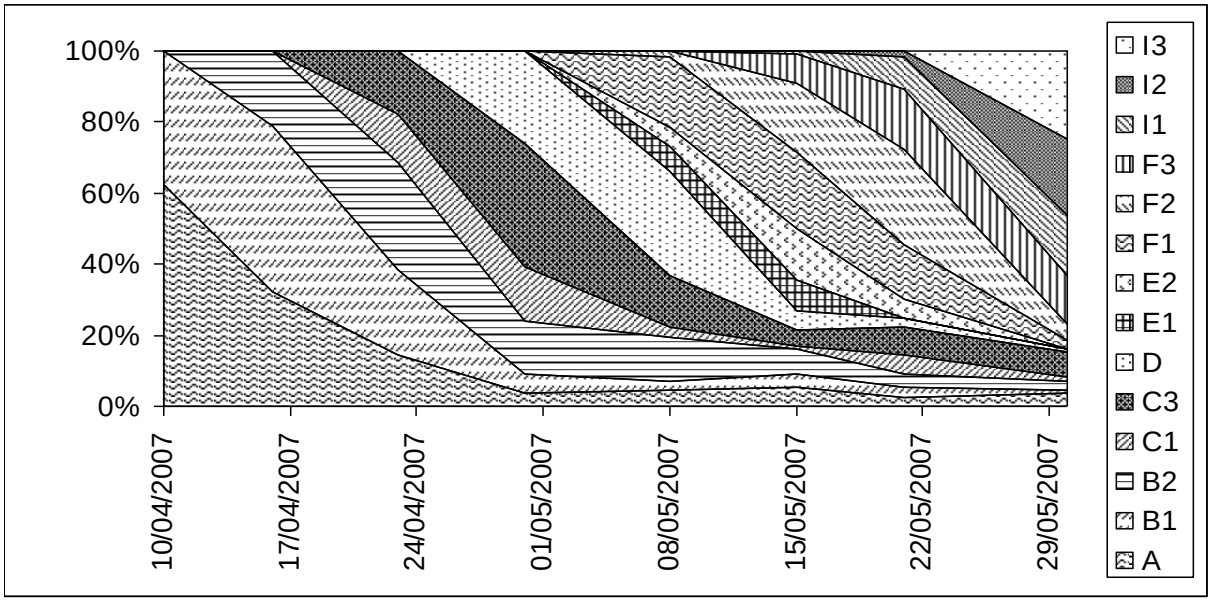


Figure 11. Bradenham cv Ben Hope percentage of buds at each growth stage from mid-March to early-May.

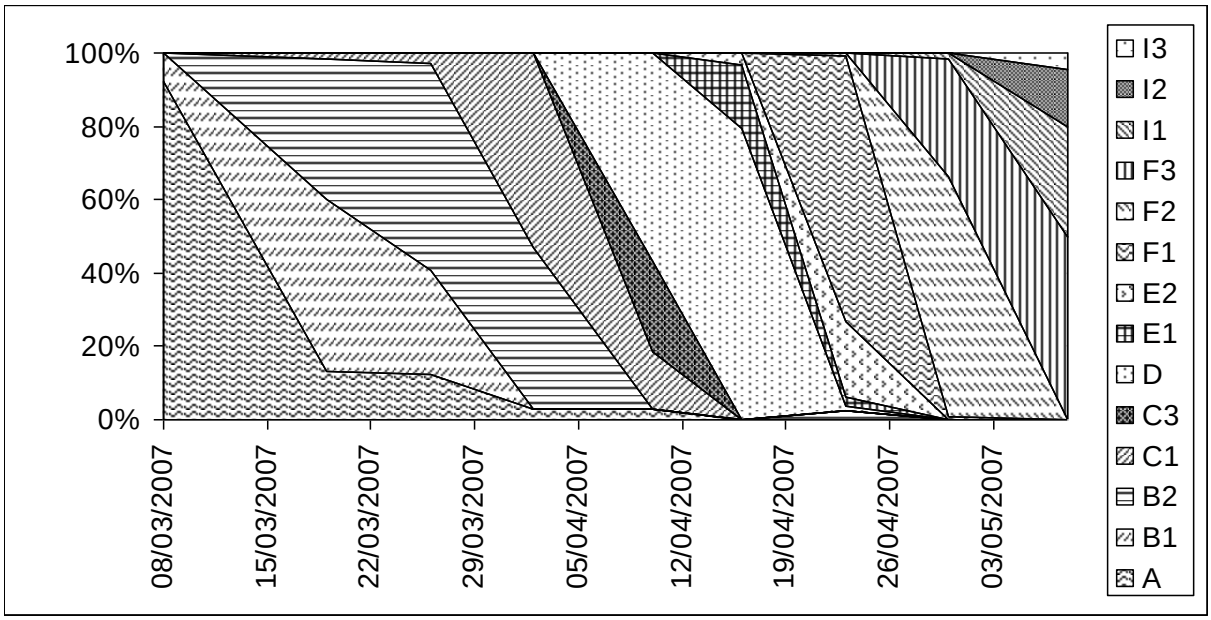


Figure 12. Bradenham cv Baldwin percentage of buds at each growth stage from mid-March to end-April.

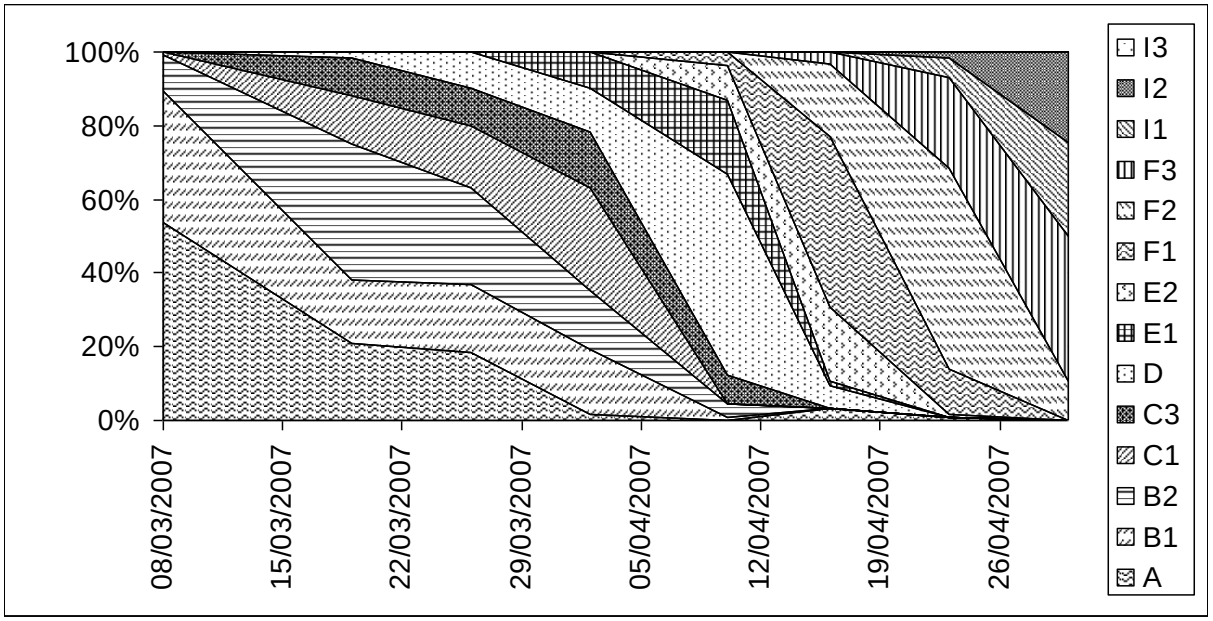


Figure 13. Newent cv Tiben percentage of buds at each growth stage from mid-March to end-April.

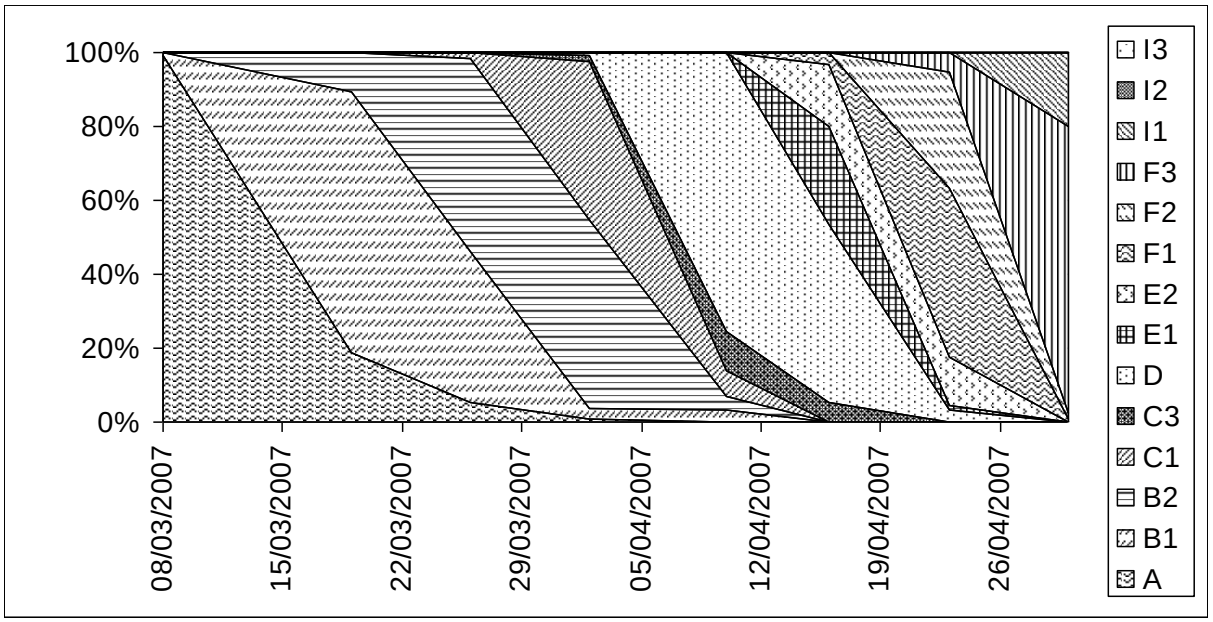


Figure 14. Newent cv 9111-14 percentage of buds at each growth stage from mid-April to mid-May.

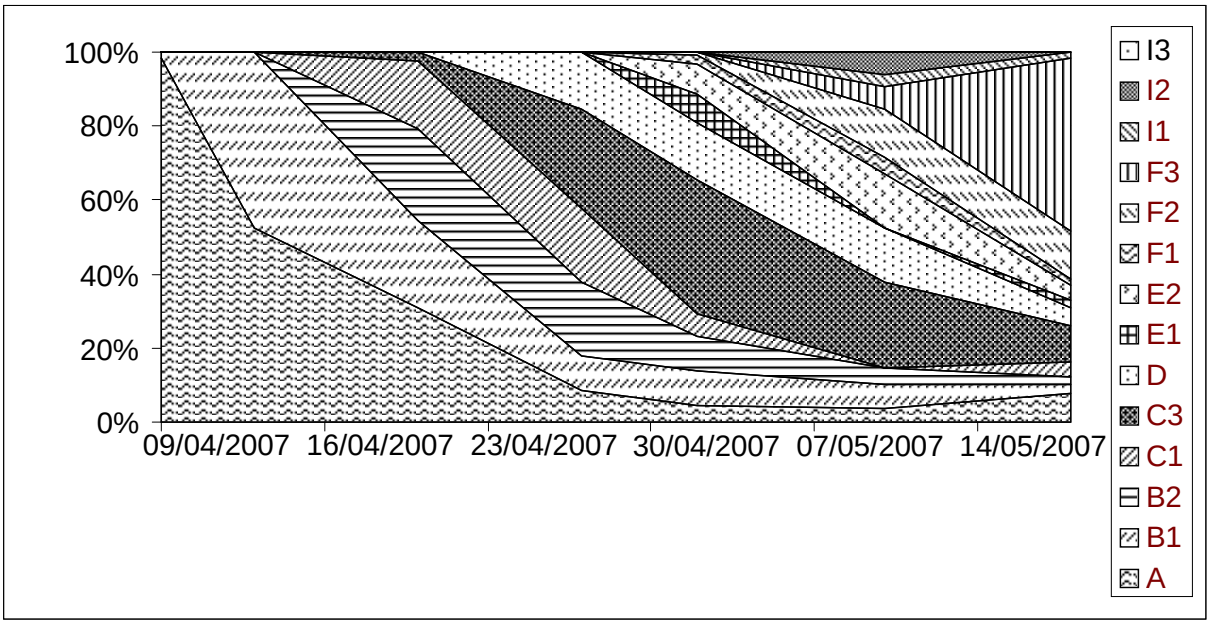


Figure 15. Newent cv 91129-1 percentage of buds at each growth stage from mid-March to end-April.

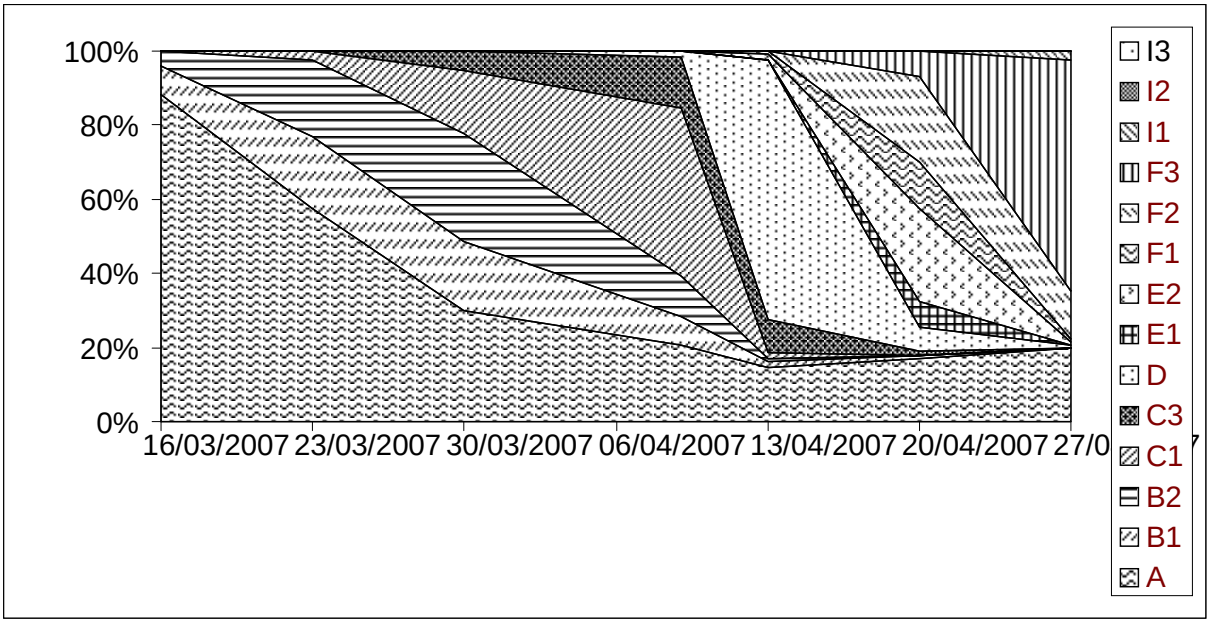


Figure 16. Newent cv 91192-1 percentage of buds at each growth stage from mid-March to end-April.

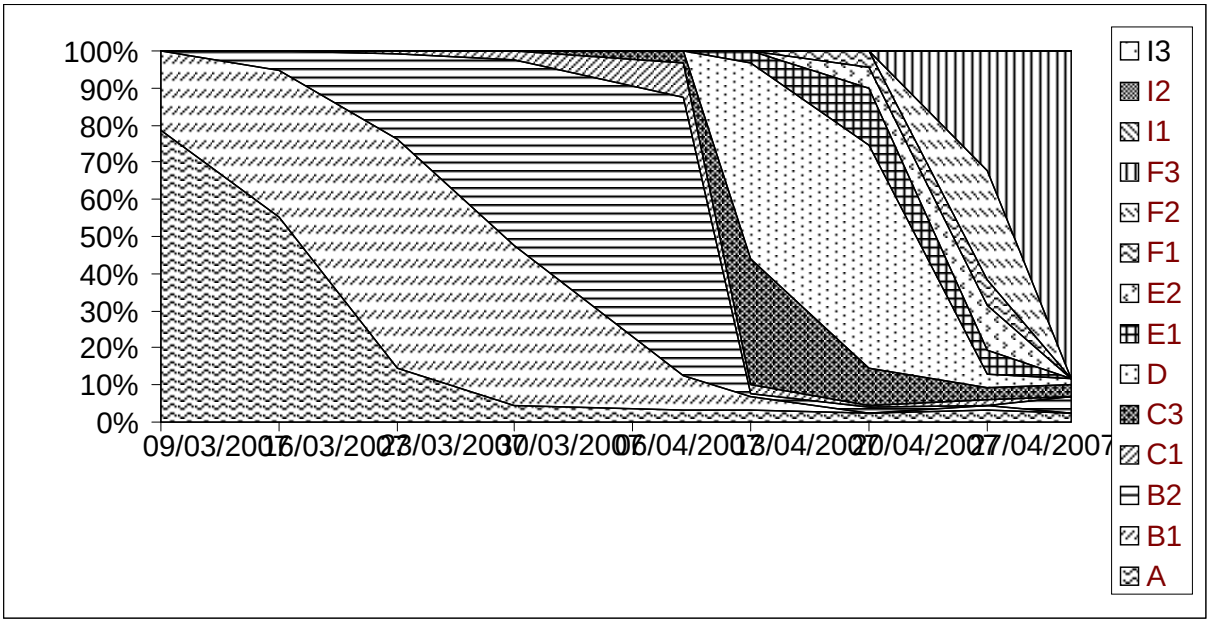


Figure 17. Newent cv 9134-7 percentage of buds at each growth stage from end-March to early-May.

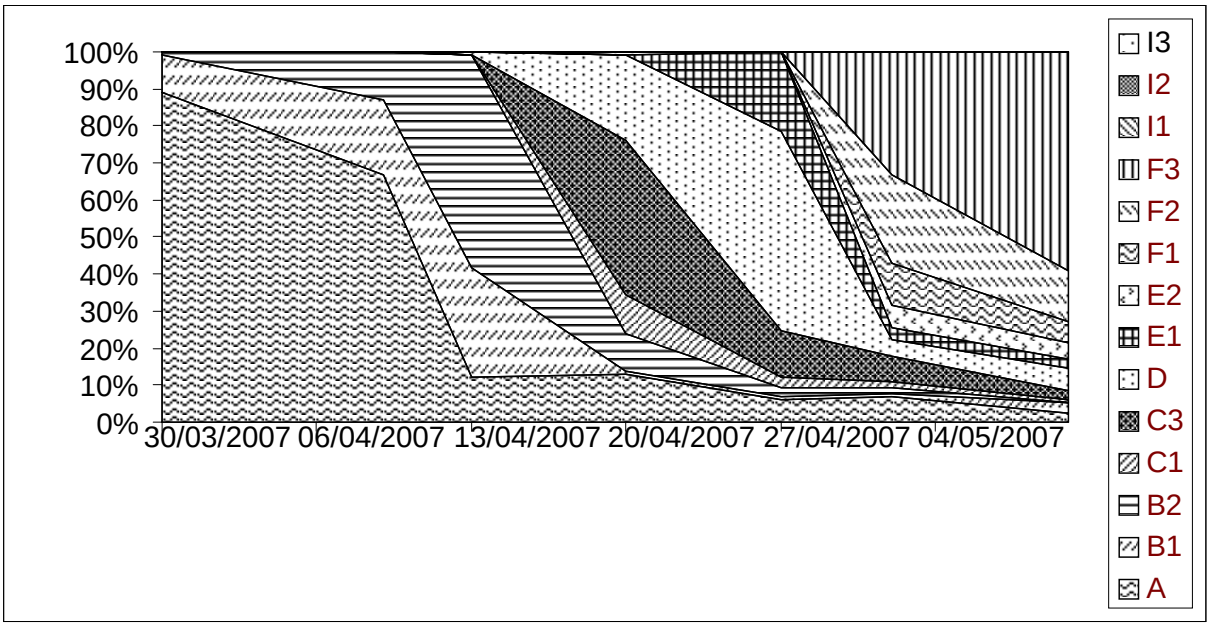


Figure 18. Newent cv 9137-2 percentage of buds at each growth stage from mid-March to early-May.

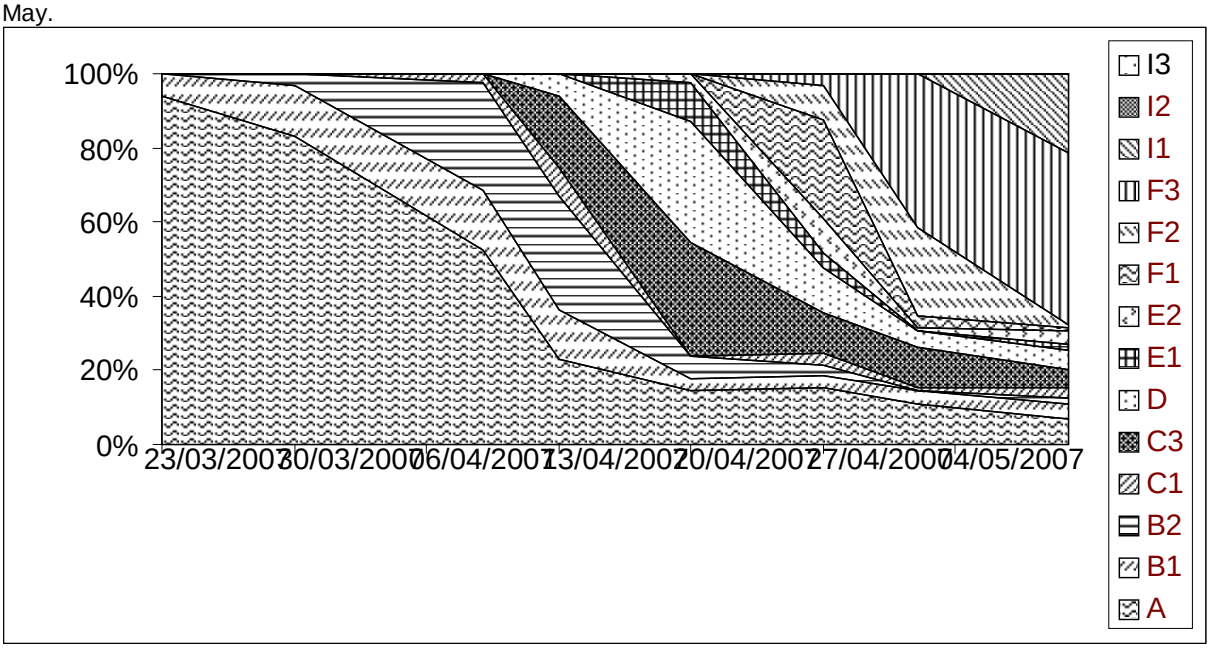


Figure 19. Newent cv 9148-9 percentage of buds at each growth stage from mid-March to end-April.

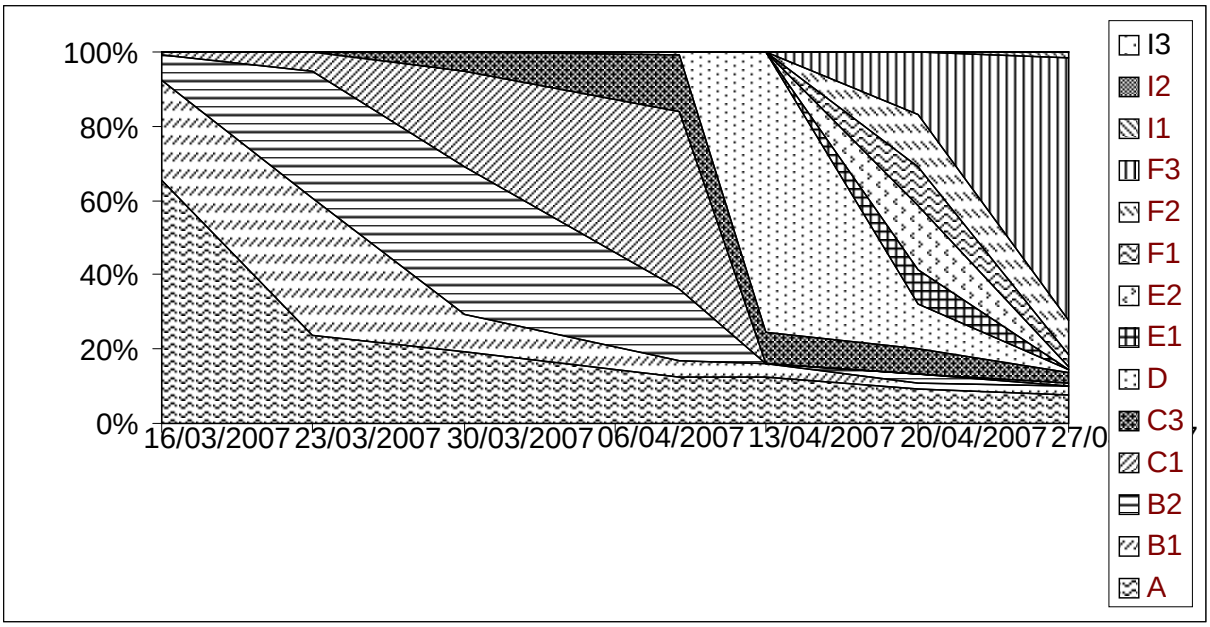


Figure 20. Newent cv 9154-3 percentage of buds at each growth stage from mid-March to end-April.

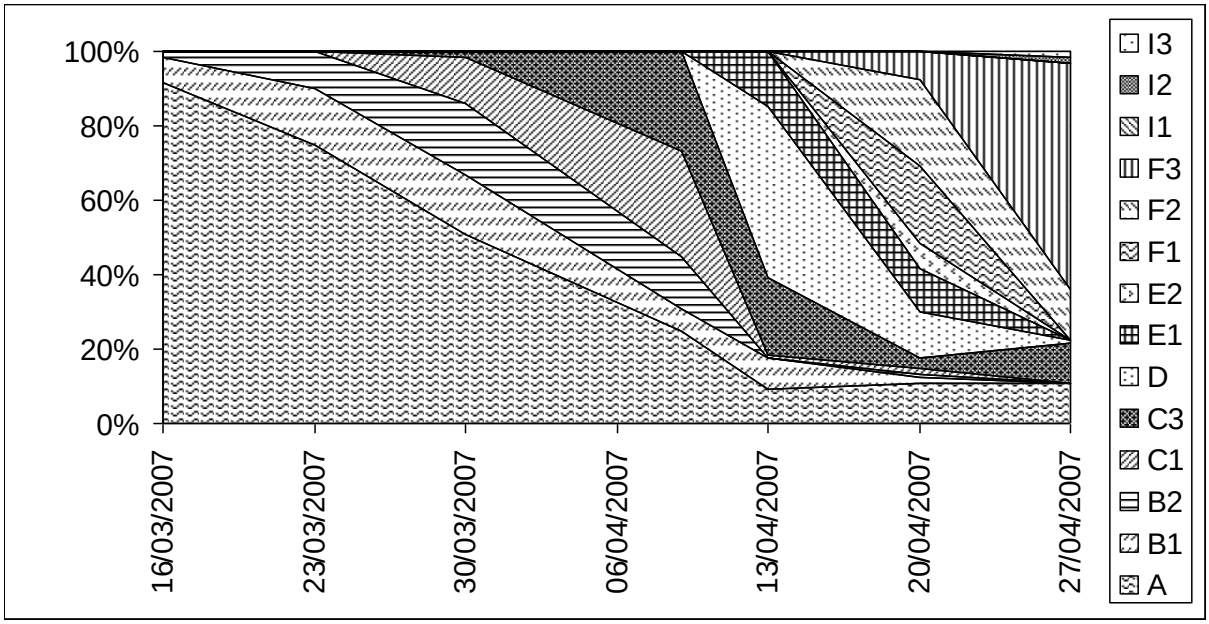


Figure 21. Newent cv 9198-1 percentage of buds at each growth stage from end-March to early-May.

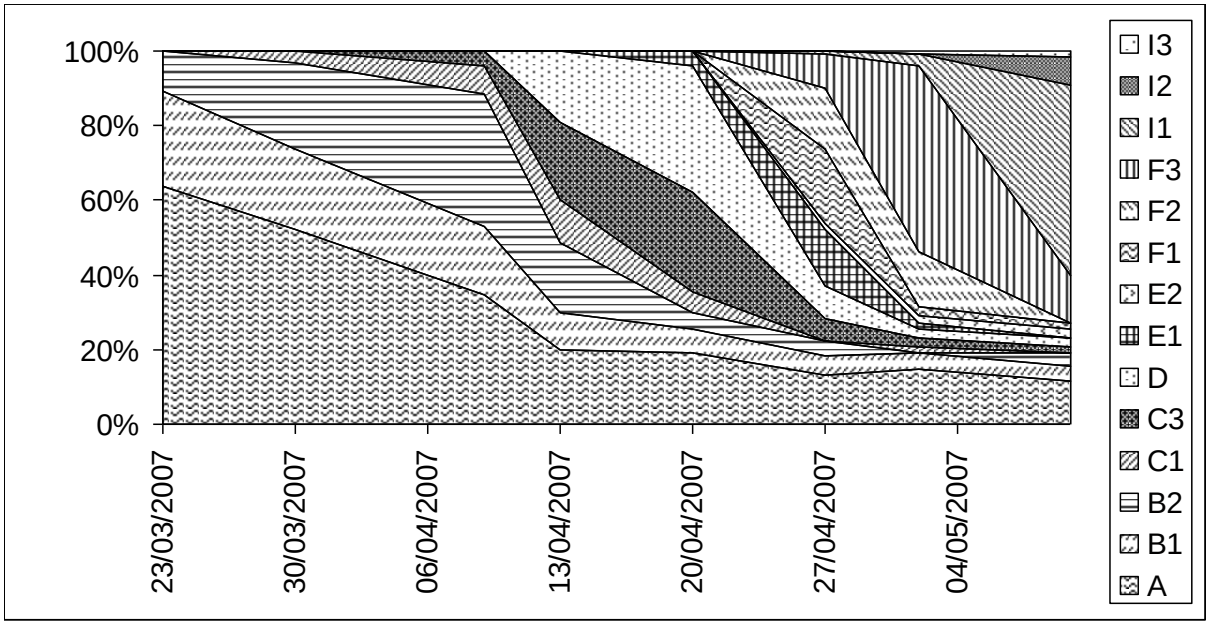


Figure 22. Newent cv 9199-4 percentage of buds at each growth stage from end-March to early-May.

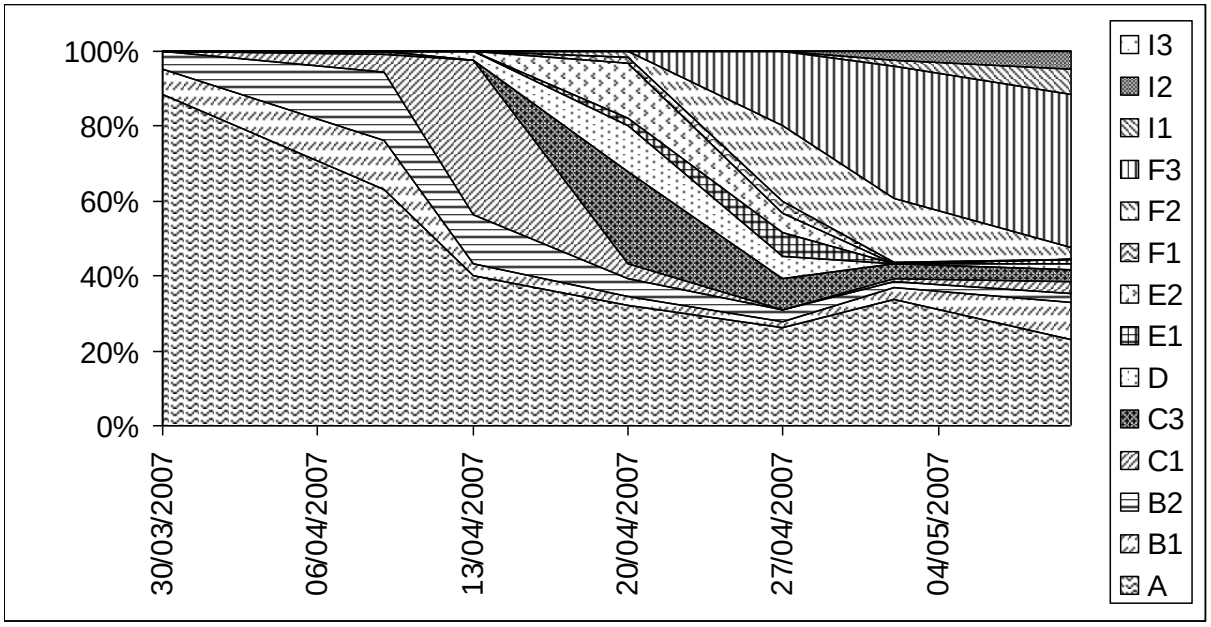


Figure 23. Newent cv 9311-25 percentage of buds at each growth stage from mid-March to end-April.

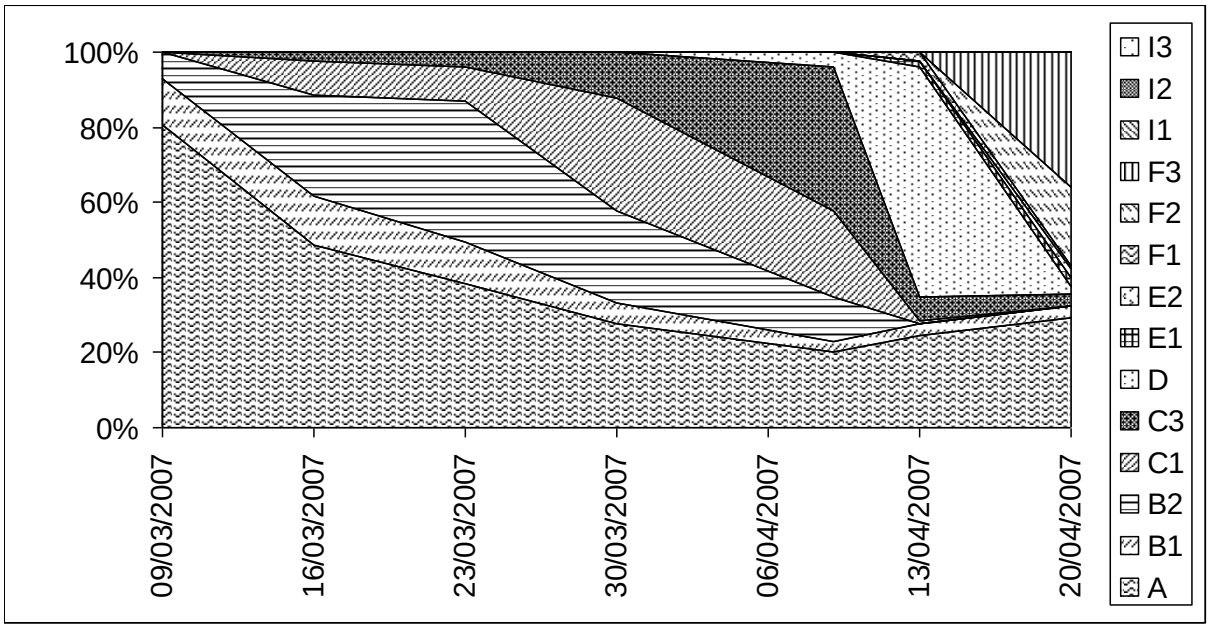


Figure 24. Newent cv 9311-66 percentage of buds at each growth stage from mid-March to mid-April.

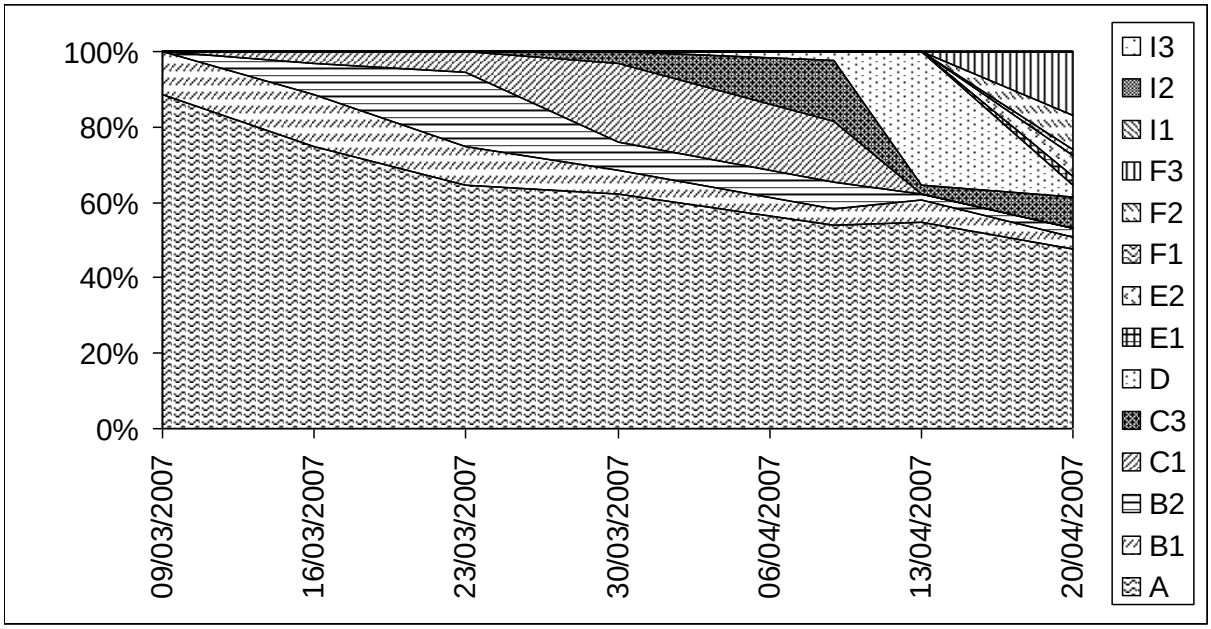


Figure 25. Newent cv 9311-82 percentage of buds at each growth stage from mid-March to mid-April.

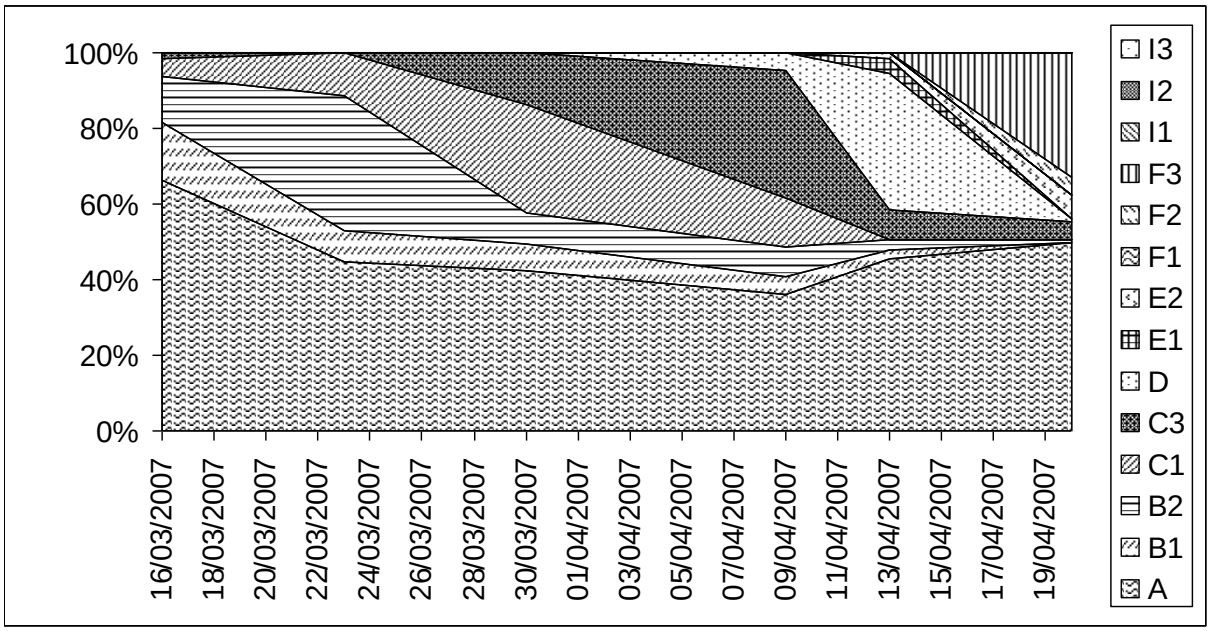


Figure 26. Newent cv 934-58 percentage of buds at each growth stage from mid-March to mid-April.

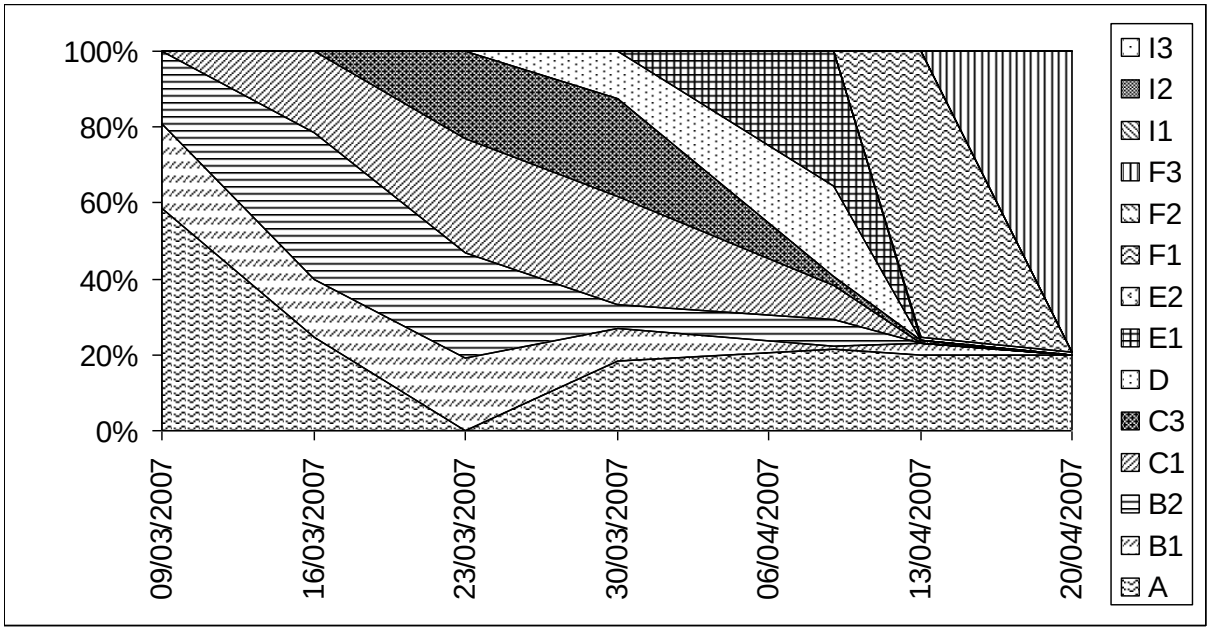


Figure 27. Newent cv 934-60 percentage of buds at each growth stage from mid-March to mid-April.

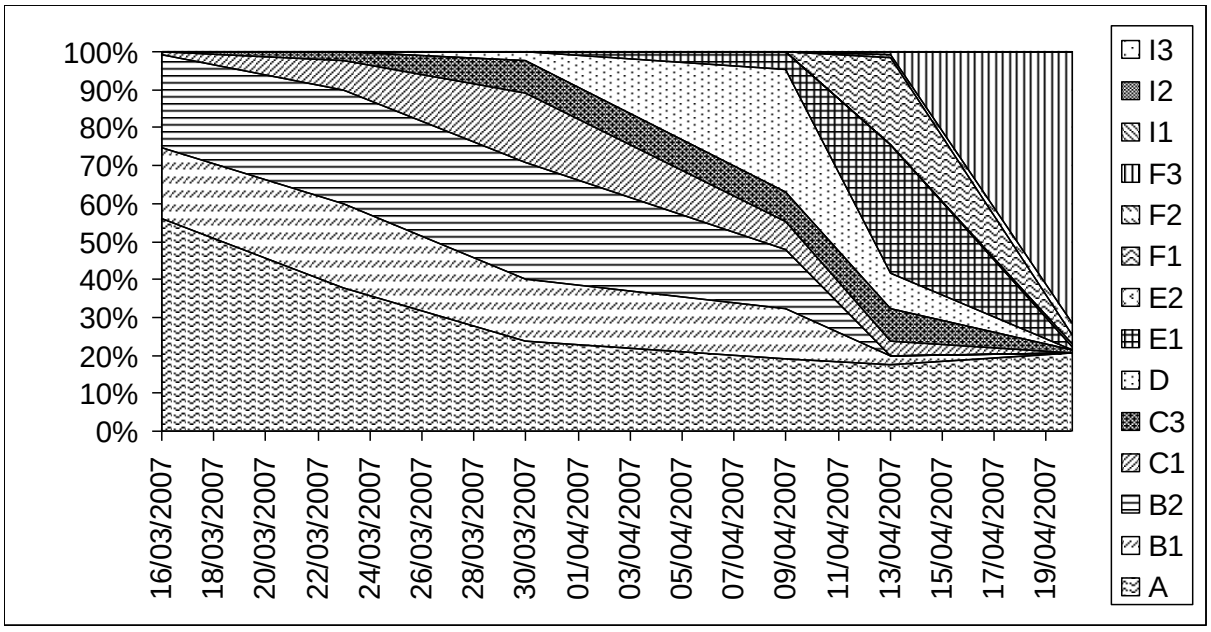


Figure 28. Newent cv 934-74 percentage of buds at each growth stage from mid-March to end-April.

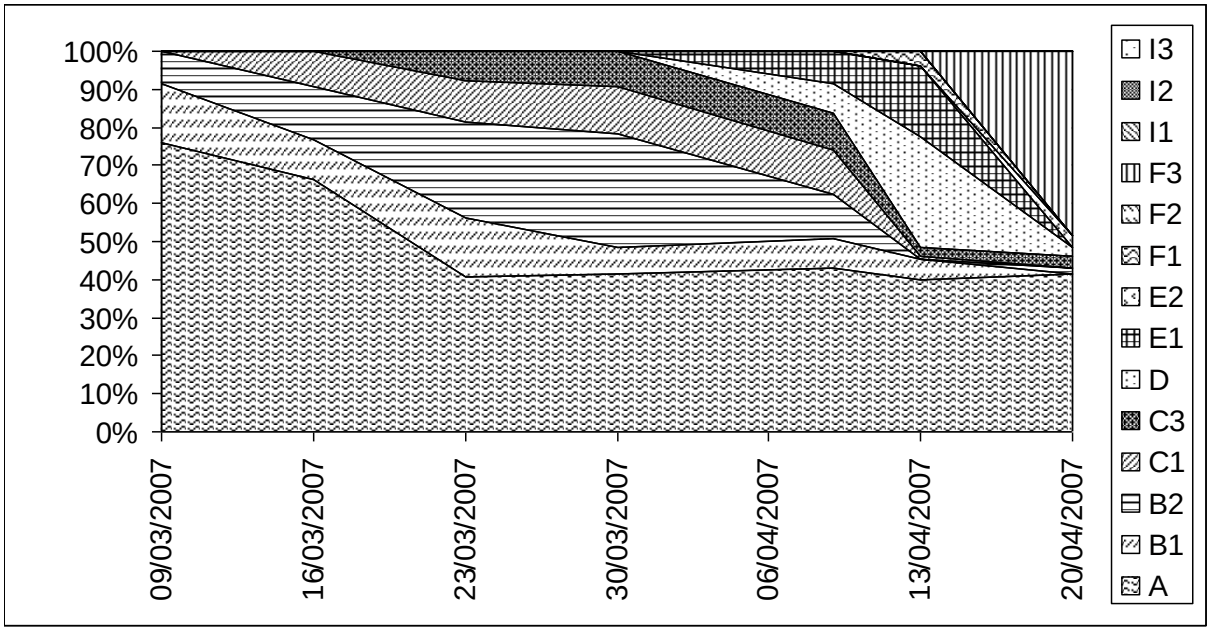


Figure 29. Newent cv 938-56 percentage of buds at each growth stage from mid-March to mid-April.

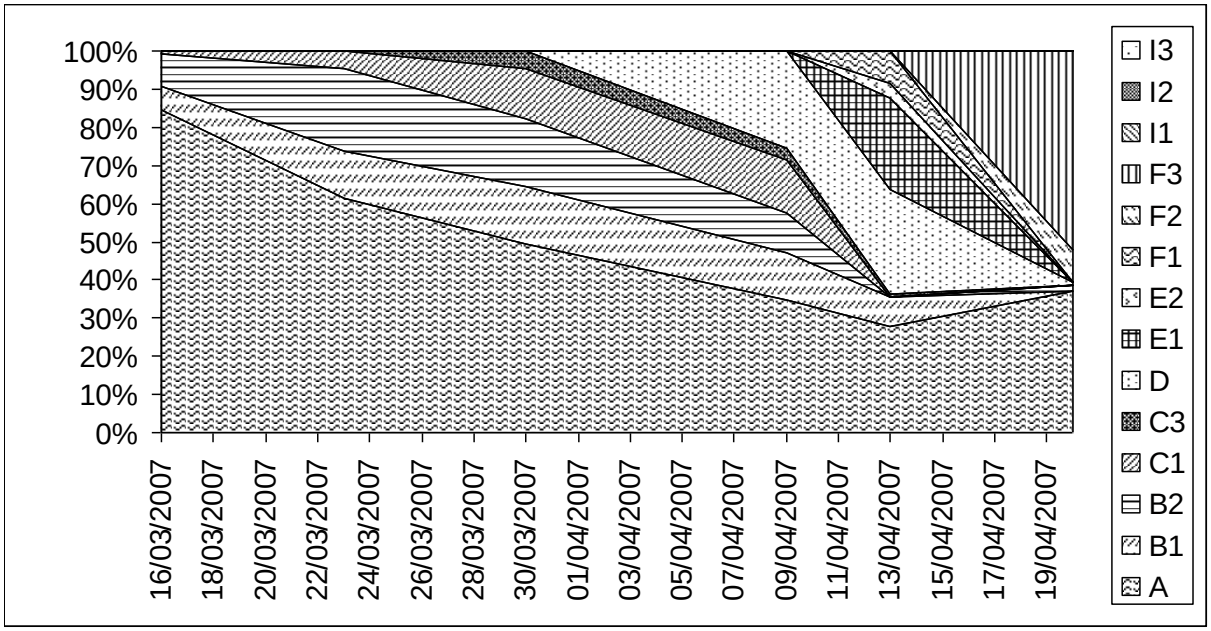


Figure 30. Newent cv Ben Klibrek percentage of buds at each growth stage from mid-March to end-April.

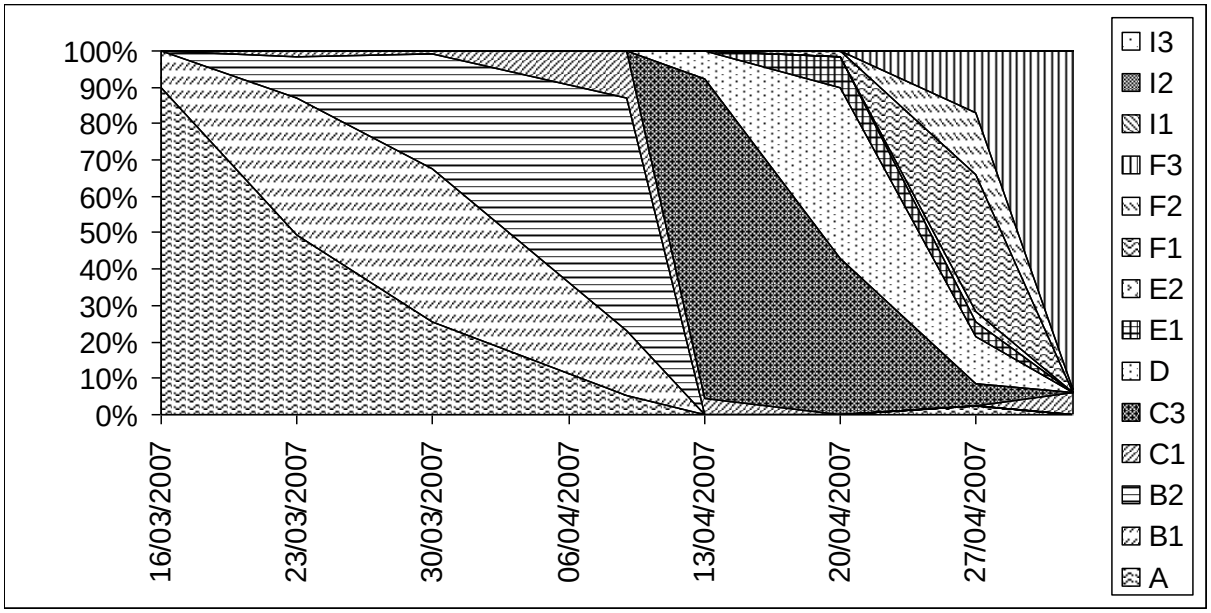


Figure 31. Newent cv Ben Lomond percentage of buds at each growth stage from mid-March to end-April.

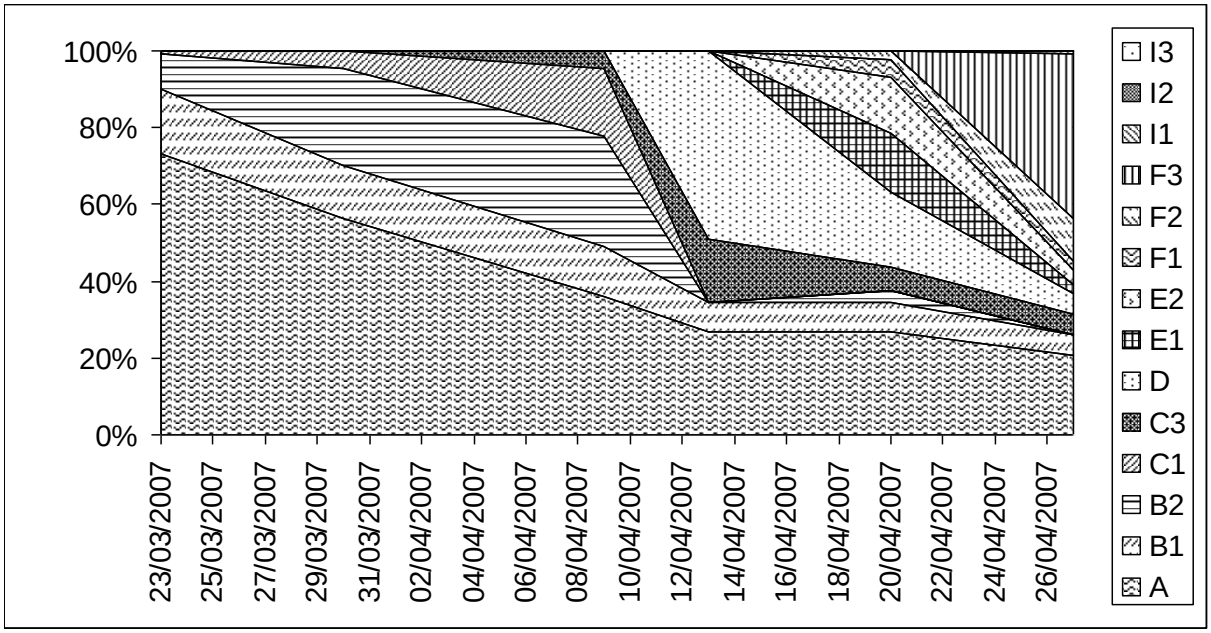


Figure 32. Newent cv Baldwin percentage of buds at each growth stage from mid-March to end-April.

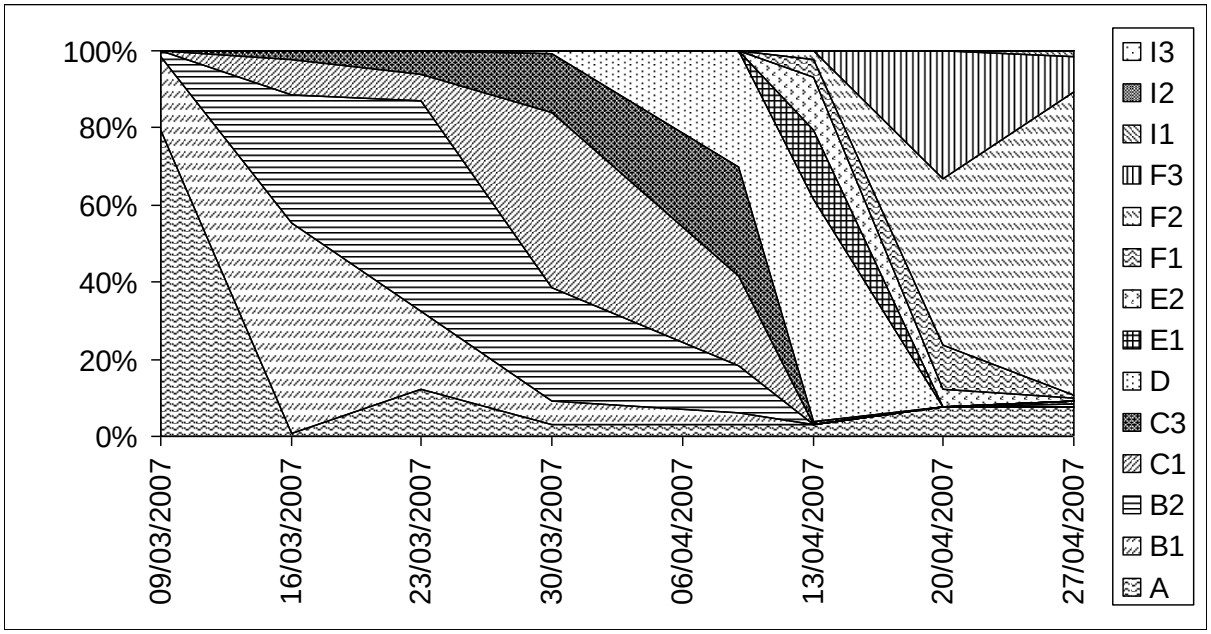


Figure 33. Newent cv Ben Alder percentage of buds at each growth stage from end-March to end-May.

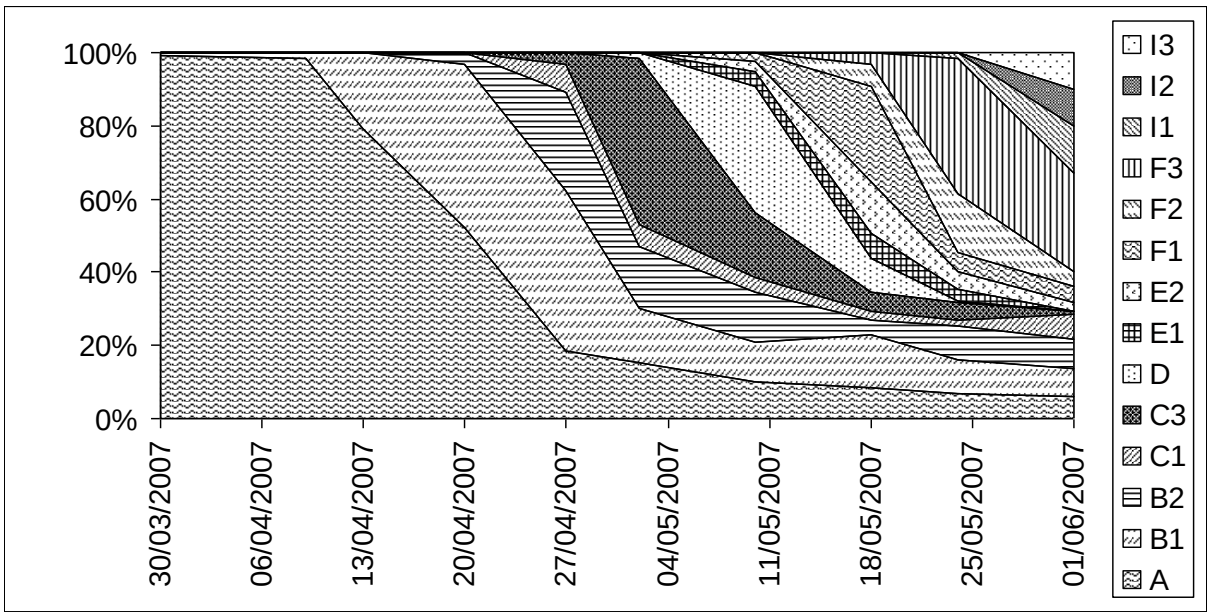


Figure 34. Newent cv Ben Gairn percentage of buds at each growth stage from mid-March to end-April.

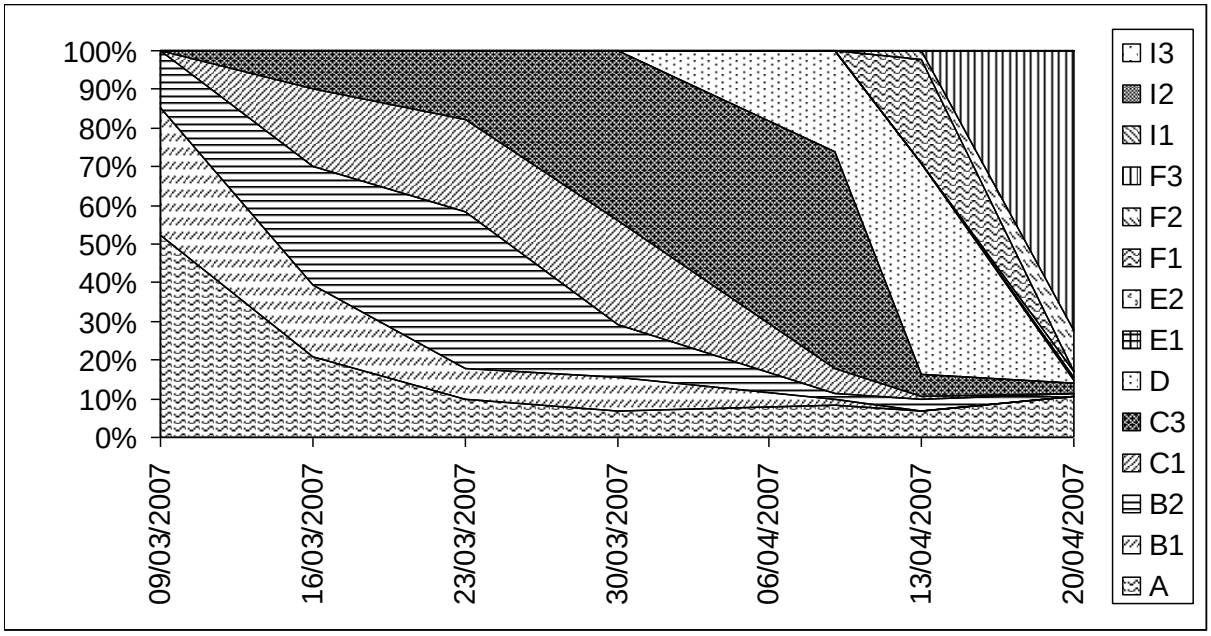


Figure 35. Newent cv Ben Hope percentage of buds at each growth stage from mid-March to end-April.

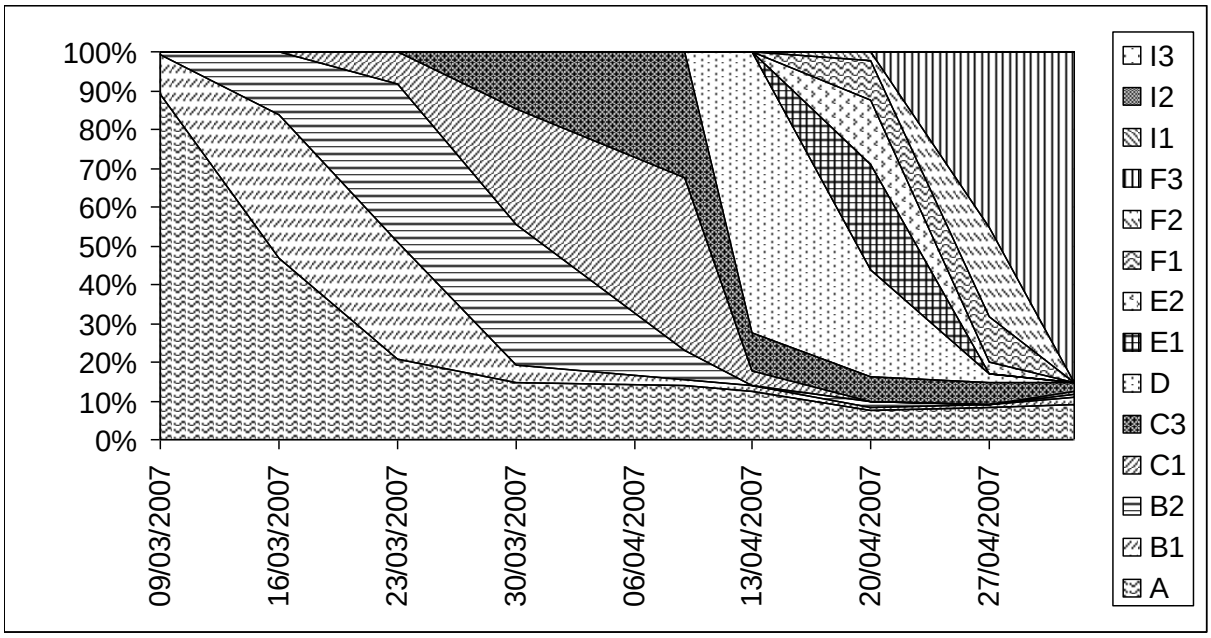


Figure 36. Newent cv S36-1-21 percentage of buds at each growth stage from mid-March to mid-May.

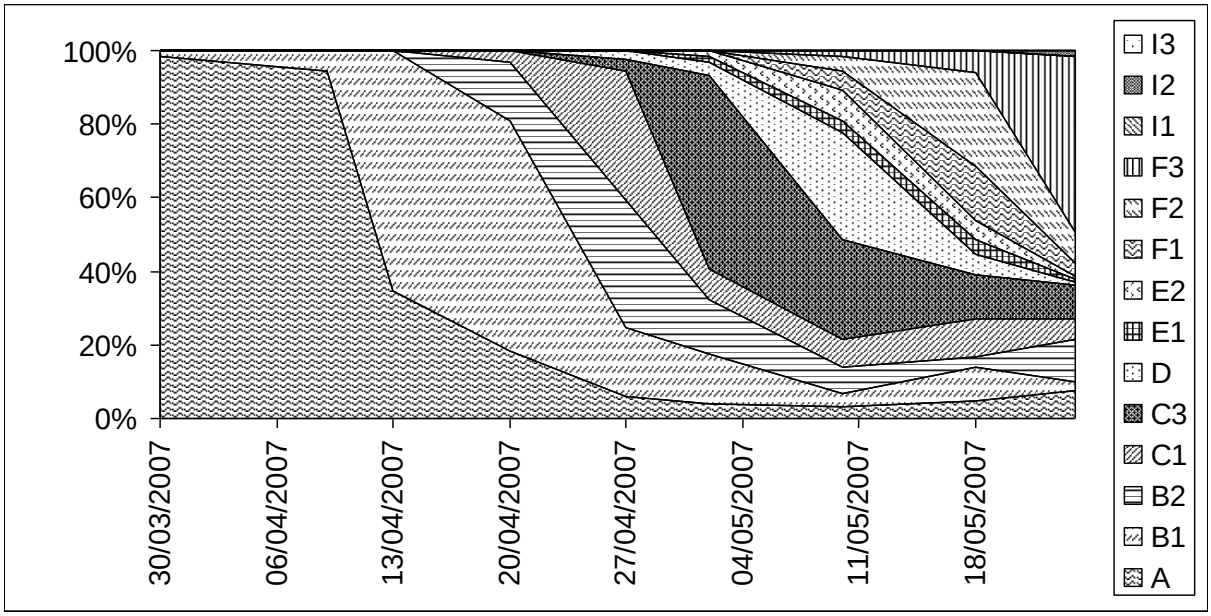
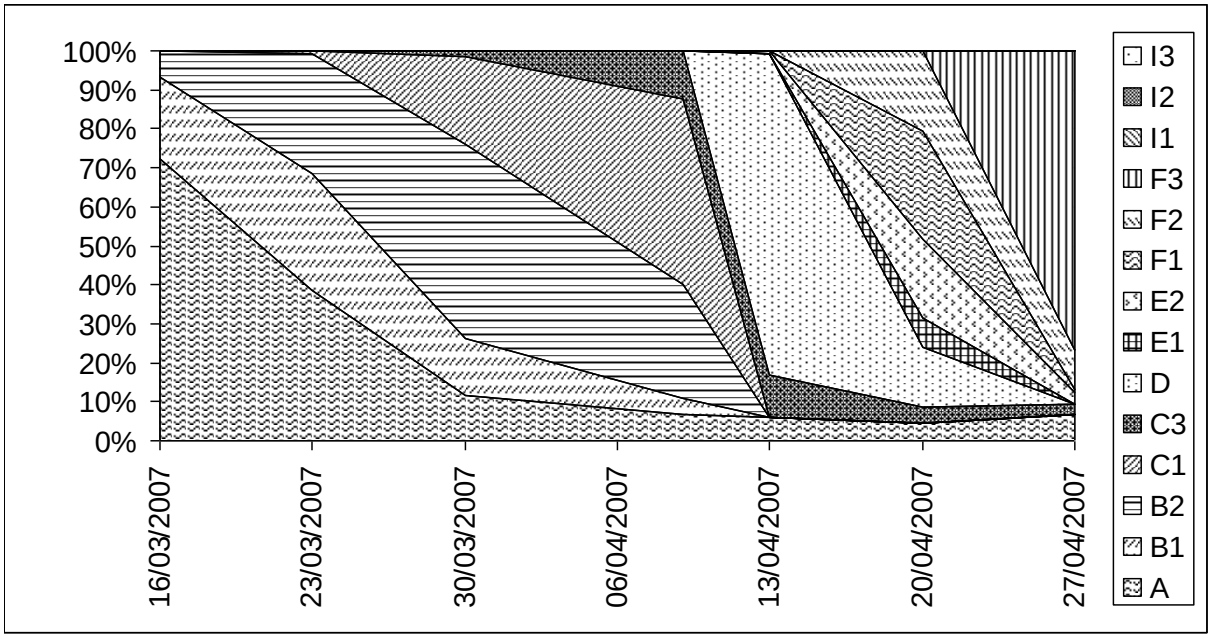


Figure 37. Newent cv Tiben percentage of buds at each growth stage from mid-March to late-April.



In order to quantify the uniformity of bud development, 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 5 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 as a measure of the variability in bud development. The modal growth stage (excluding dormant buds) is shown as this relates most closely to the visual assessment of growth stage.

The results are shown in Appendix 4, Table 7 for the Bradenham site and in Table 8 for the Newent site. The variability around flowering (growth stages F1 – first flower to F3 – 100% open flower) appeared to be the key period for categorizing cultivars for uniformity. These data were used to provide a ranking of uniformity for cultivars based on the mean of the standard deviation of growth stage score at the modal growth stages F1-F3 (Table 2).

Because Newent provides the most complete data set and the more challenging environment for winter chill, the cultivars are ranked in order of their performance at Newent. Bud development was noticeably more uniform at Bradenham, with most cultivars with acceptable evenness. The two exceptions were S36-1-21 and Ben Alder, and both had relatively high variability at both sites. Surprisingly, S36-1-21 performed slightly better at Newent. There were some other inconsistencies between the rankings at the two sites. Baldwin and 91129-1 were more variable at Bradenham than at Newent and the evenness of 9199-4 was moderate at Bradenham but very poor at Newent largely due to 30% of buds remaining dormant throughout the recording period.

Based on the ranking at Newent, the top performing cultivars for evenness were Ben Klibrek, Tiben, 91192-1, Baldwin and 9134-7. The worst performing cultivars were Ben Alder, Ben Lomond, 9311-66, 9311-25, 91994, 9311-82, 934-74 and 938-56.

Table 2: Mean standard deviation of growth stage scores at F1 – F3 growth stage

Cultivar	Newent	Bradenham
B. Klibrek	1.91	-
Tiben	2.37	0.73
91192-1	2.45	2.72
Baldwin	2.58	2.88
9134-7	2.77	0.59
9148-9	3.1	-
B. Hope	3.12	0.79
9154-3	3.21	1.15
B. Gairn	3.24	-
9137-2	3.43	-
9111-14	3.44	-
S36-1-21	3.47	3.71
91129-1	3.59	2.51
9198-1	3.59	-
934-58	3.67	-
934-60	4.05	-
B. Alder	4.05	3.17
B. Lomond	4.14	-
9311-66	4.16	-
9311-25	4.39	-
9199-4	4.44	2.09
9311-82	4.65	-
934-74	4.77	-
938-56	4.78	-

Records were also taken of fruit colour 7 days prior to harvest (Table 3). Although the uniform development of fruit colour should be related to bud development uniformity, other factors come into play. These include: the bush habit and the relative exposure of the fruit, the loss of overripe fruit prior to harvest and the ability of the ripe fruit to “hang” whilst under-ripe fruit ripens.

The cultivars that had noticeably variable fruit colour (<96% black) included S36-1-21, 9137-2, 9148-9, 9198-1, Ben Alder and Ben Lomond. Of these Ben Alder was the most variable at both sites.

Table 3*:* Percentage of berries in each fruit colour category, 7 days pre harvest

	Newent			Bradenham		
Cultivar	**Black**	**Red**	**Green**	**Black**	**Red**	**Green**
S36-1-21	95	3	2	95	4	1
9111-14	96	3	1			
91129-1	100	0	0	100	0	0
91192-1	99	1	0	97	3	
9134-7	97	2	1	98	2	0
9137-2	91	7	2			
9148-9	92	4	4			
9154-3	100	0	0	87	8	5
9198-1	95	3	2			
9199-4	99	1	0	96	3	1
9311-25	100	0	0			
9311-66	99	1	0			
9311-82	100	0	0			
934-56	100	0	0			
934-60	99	1	0			
934-74	99	1	0			
938-56	100	0	0			
B. Alder	81	8	11	86	9	5
B. Gairn	100	0	0			
B. Hope	98	2	0	96	2	2
B. Klibrek	100	0	0			
B. Lomond	89	8	3			
Baldwin	99	1	0	100	0	0
Tiben	100	0	0	100	0	0

Conclusions

The winter of 2006/07 was unusually mild. As a result accumulated winter chill units were low at the start of March for both Newent (1212 h < 7^{o}C) and Bradenham (1434 h) sites. These conditions provided a good test for tolerance of low chill, particularly at the Newent site where even by the end of March the chill units only reached 1463 h.

A method for quantifying uniformity of bud development over flowering is proposed based on the mean standard deviation of the bud growth stage during flowering. The value will vary according to the amount of winter chill received, so will always need to be related to standard cultivars such as Baldwin (good evenness), Ben Hope (moderate-good evenness), or Ben Alder (poor-evenness) at the test site. It is proposed that cultivars should be placed in the same category for evenness in relation to the standard cultivars if the mean standard deviation of the bud growth stage during flowering is within approximately 10% of the value for the standard cultivar.

Using this method, and for the conditions prevailing at Newent in 2006/07:

- Baldwin, Ben Klibrek, Tiben, 91192-1, and 9134-7 could be classed as “good” with a mean standard deviation of <3.
- Ben Gairn, Ben Hope, 9148-9 and 9154-3 could be classed as “moderate-good” with a mean standard deviation of 3.0 – 3.39.
- S36-1-21, 9111-14, 9137-2, 9198-1, 91129-1 could be classed as “moderate-poor” with a mean standard deviation of 3.4 – 3.99.
- Ben Alder, Ben Lomond, 9199-4, 934-60, 934-74, 938-56, 9311-25, 9311-66, 9311-82 could be classed as “poor” with a mean standard deviation of >4.
- The results from Bradenham indicated that S36-1-21 might perform relatively worse than indicated above, and 9199-4 better.

Technology transfer

No formal technology transfer activities have taken place during this project. The results may 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

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	1ST Flowers open
F2	50% flowers open
F3	100% flowers open
I1	1st fruit set
I2	50% fruit set
I3	100% fruit set

References

Atwood, J.G. (2004). Winter chilling requirements of blackcurrants: An assessment of the chilling requirements for a range of cultivars at the Bradenham Hall Site 2003-4. HDC/GSK Project report 194.

Appendices

Appendix 1: experiment layout at Newent

North
I
V

< 60m >

Track	**Ben Alder**
	S36-1-21
	9154-3
	9111-14
	9134-7
	91192-1
	Ben Hope
	Ben Lomond
	934-58
	Ben Klibrek
	934-60
	934-74
	938-56
	9311-25
	9311-66
	9311-82
	9137-2
	9198-1
	9148-9
	9199-4
	91129-1
	Tiben
	Ben Gairn
	Baldwin

< 80m >

Appendix 2: experiment layout at Bradenham

North ->

< 50m >

Ben Alder	**Road**
Baldwin	
Ben Hope	
Tiben	
9199-4	
91129-1	
9154-3	
9134-7	
91192-1	
S36-1-21	

< 50m >

Appendix 3: bud development records at Bradenham & Newent

a) Bradenham site, % of buds at each growth stage

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
S36-1-21	8-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
S36-1-21	19-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
S36-1-21	26-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
S36-1-21	2-Apr	100	0	0	0	0	0	0	0	0	0	0	0	0	0
S36-1-21	10-Apr	71	18	0	1	3	7	0	0	0	0	0	0	0	0
S36-1-21	16-Apr	44	53	3	0	0	0	0	0	0	0	0	0	0	0
S36-1-21	23-Apr	29	27	16	18	9	1	0	0	0	0	0	0	0	0
S36-1-21	30-Apr	11	21	15	8	44	2	0	0	0	0	0	0	0	0
S36-1-21	8-May	12	2	15	5	26	15	12	8	4	2	0	0	0	0
S36-1-21	15-May	14	5	9	4	5	10	6	11	29	5	2	0	0	0
S36-1-21	21-May	8	11	4	2	1	5	7	12	12	27	11	2	1	0
S36-1-21	30-May	14	4	5	2	1	0	0	1	3	11	19	13	15	12
91129-1	8-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
91129-1	19-Mar	68	26	5	0	0	0	0	0	0	0	0	0	0	0
91129-1	26-Mar	38	26	28	7	0	0	0	0	0	0	0	0	0	0
91129-1	2-Apr	15	8	29	29	18	1	0	0	0	0	0	0	0	0
91129-1	10-Apr	15	1	9	29	25	22	0	0	0	0	0	0	0	0
91129-1	16-Apr	15	2	2	1	7	19	15	32	7	0	0	0	0	0
91129-1	23-Apr	5	0	0	0	0	1	1	10	20	52	12	0	0	0
91129-1	30-Apr	8	0	2	0	0	0	0	0	0	2	79	8	1	0
91192-1	8-Mar	71	29	0	0	0	0	0	0	0	0	0	0	0	0
91192-1	19-Mar	10	90	0	0	0	0	0	0	0	0	0	0	0	0
91192-1	26-Mar	8	92	0	0	0	0	0	0	0	0	0	0	0	0
91192-1	2-Apr	2	5	93	0	0	0	0	0	0	0	0	0	0	0
91192-1	10-Apr	11	5	0	78	0	7	0	0	0	0	0	0	0	0

a) Bradenham site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
91192-1	16-Apr	3	1	3	5	11	77	1	1	0	0	0	0	0	0
91192-1	23-Apr	6	0	2	0	4	12	8	14	53	0	0	0	0	0
91192-1	30-Apr	4	2	3	0	0	1	2	0	7	23	58	0	0	0
91192-1	8-May	8	3	3	0	0	0	0	0	0	1	75	8	2	0
9134-7	8-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9134-7	19-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9134-7	26-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9134-7	2-Apr	68	32	0	0	0	0	0	0	0	0	0	0	0	0
9134-7	10-Apr	8	7	54	27	4	0	0	0	0	0	0	0	0	0
9134-7	16-Apr	3	9	9	62	11	6	0	0	0	0	0	0	0	0
9134-7	23-Apr	0	1	2	1	19	78	0	0	0	0	0	0	0	0
9134-7	30-Apr	0	0	0	0	0	7	12	36	45	0	0	0	0	0
9134-7	8-May	0	0	0	0	0	0	0	0	0	8	92	0	0	0
9154-3	8-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9154-3	19-Mar	83	14	3	0	0	0	0	0	0	0	0	0	0	0
9154-3	26-Mar	51	44	4	2	0	0	0	0	0	0	0	0	0	0
9154-3	2-Apr	18	8	38	31	4	1	0	0	0	0	0	0	0	0
9154-3	10-Apr	6	5	12	27	15	34	0	0	0	0	0	0	0	0
9154-3	16-Apr	2	4	1	1	2	34	28	22	6	1	0	0	0	0
9154-3	23-Apr	0	0	0	0	0	0	0	2	42	56	0	0	0	0
9154-3	30-Apr	2	0	2	0	0	0	0	2	0	2	88	5	0	0
9199-4	8-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9199-4	19-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9199-4	26-Mar	92	8	0	0	0	0	0	0	0	0	0	0	0	0
9199-4	2-Apr	52	33	12	2	0	0	0	0	0	0	0	0	0	0
9199-4	10-Apr	23	5	8	28	6	29	0	0	0	0	0	0	0	0
9199-4	16-Apr	19	5	6	28	19	23	0	0	0	0	0	0	0	0

a) Bradenham site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
9199-4	23-Apr	14	1	0	0	12	34	8	18	13	0	0	0	0	0
9199-4	30-Apr	6	6	1	0	1	4	1	1	5	65	10	0	0	0
9199-4	8-May	0	2	0	0	0	0	0	0	0	3	78	16	1	0
B. Alder	8-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	19-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	26-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	2-Apr	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	10-Apr	62	38	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	16-Apr	32	46	21	0	0	0	0	0	0	0	0	0	0	0
B. Alder	23-Apr	15	24	30	14	18	0	0	0	0	0	0	0	0	0
B. Alder	30-Apr	4	5	15	15	35	26	0	0	0	0	0	0	0	0
B. Alder	8-May	5	2	12	3	15	29	7	5	20	2	0	0	0	0
B. Alder	15-May	5	4	7	1	5	5	8	15	22	19	8	1	0	0
B. Alder	21-May	2	3	4	5	8	2	0	5	15	27	17	9	2	0
B. Alder	30-May	4	1	2	2	7	1	0	0	2	5	14	17	22	25
B. Hope	8-Mar	92	8	0	0	0	0	0	0	0	0	0	0	0	0
B. Hope	19-Mar	13	47	38	2	0	0	0	0	0	0	0	0	0	0
B. Hope	26-Mar	12	28	56	3	0	0	0	0	0	0	0	0	0	0
B. Hope	2-Apr	3	0	44	53	0	0	0	0	0	0	0	0	0	0
B. Hope	10-Apr	3	0	0	15	25	57	0	0	0	0	0	0	0	0
B. Hope	16-Apr	0	0	0	0	0	77	17	3	0	0	0	0	0	0
B. Hope	23-Apr	0	0	2	0	0	2	2	21	72	1	0	0	0	0
B. Hope	30-Apr	0	0	0	0	0	0	0	0	1	65	32	2	0	0
B. Hope	8-May	0	0	0	0	0	0	0	0	0	0	50	30	15	5
Baldwin	8-Mar	54	35	10	1	0	0	0	0	0	0	0	0	0	0
Baldwin	19-Mar	21	17	36	13	10	2	0	0	0	0	0	0	0	0
Baldwin	26-Mar	18	18	26	17	10	10	0	0	0	0	0	0	0	0
Baldwin	2-Apr	2	18	16	28	15	12	10	0	0	0	0	0	0	0

a) Bradenham site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
Baldwin	10-Apr	0	1	4	0	8	55	20	9	4	0	0	0	0	0
Baldwin	16-Apr	3	0	0	0	0	6	2	20	46	20	3	0	0	0
Baldwin	23-Apr	1	0	0	0	0	0	0	1	12	55	25	5	2	0
Baldwin	30-Apr	0	0	0	0	0	0	0	0	0	11	39	25	25	0
Tiben	8-Mar	98	1	0	0	0	0	0	0	0	0	0	0	0	0
Tiben	19-Mar	19	72	11	0	0	0	0	0	0	0	0	0	0	0
Tiben	26-Mar	5	41	52	2	0	0	0	0	0	0	0	0	0	0
Tiben	2-Apr	1	3	51	43	2	1	0	0	0	0	0	0	0	0
Tiben	10-Apr	0	3	4	7	11	75	0	0	0	0	0	0	0	0
Tiben	16-Apr	0	0	0	0	5	48	26	17	3	0	0	0	0	0
Tiben	23-Apr	0	0	0	0	0	3	2	13	45	32	5	0	0	0
Tiben	30-Apr	0	0	0	0	0	0	0	0	1	2	78	20	0	0
Tiben	8-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiben	15-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiben	21-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiben	30-May	0	0	0	0	0	0	0	0	0	0	0	0	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
S-36-1-21	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
S-36-1-21	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
S-36-1-21	23-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
S-36-1-21	30-Mar	98	2	0	0	0	0	0	0	0	0	0	0	0	0
S-36-1-21	9-Apr	95	5	0	0	0	0	0	0	0	0	0	0	0	0
S-36-1-21	13-Apr	35	65	0	0	0	0	0	0	0	0	0	0	0	0
S-36-1-21	20-Apr	18	62	16	3	0	0	0	0	0	0	0	0	0	0
S-36-1-21	27-Apr	6	18	35	35	3	2	0	0	0	0	0	0	0	0
S-36-1-21	2-May	4	14	15	8	52	4	2	2	0	0	0	0	0	0
S-36-1-21	10-May	3	4	7	8	27	29	3	8	5	4	2	0	0	0
S-36-1-21	18-May	5	9	3	10	12	5	4	5	15	25	6	0	0	0
S-36-1-21	24-May	8	2	12	5	9	1	1	1	4	8	48	0	2	0
9111-14	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9111-14	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9111-14	23-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9111-14	30-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9111-14	9-Apr	98	2	0	0	0	0	0	0	0	0	0	0	0	0
9111-14	13-Apr	52	48	0	0	0	0	0	0	0	0	0	0	0	0
9111-14	20-Apr	31	24	25	18	2	0	0	0	0	0	0	0	0	0
9111-14	27-Apr	8	9	20	20	27	15	0	0	0	0	0	0	0	0
9111-14	2-May	5	9	9	6	36	15	8	8	2	1	0	0	0	0
9111-14	10-May	4	6	5	0	23	15	0	15	5	13	6	3	6	0
9111-14	18-May	8	2	2	4	10	5	2	4	2	13	47	2	0	0
91129-1	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
91129-1	16-Mar	88	8	4	0	0	0	0	0	0	0	0	0	0	0
91129-1	23-Mar	58	19	21	2	0	0	0	0	0	0	0	0	0	0
91129-1	30-Mar	30	18	29	17	5	0	0	0	0	0	0	0	0	0
91129-1	9-Apr	21	8	11	45	14	2	0	0	0	0	0	0	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
91129-1	13-Apr	15	2	1	2	9	70	0	2	1	0	0	0	0	0
91129-1	20-Apr	17	1	0	0	2	6	7	25	12	23	7	0	0	0
91129-1	27-Apr	20	0	0	0	0	1	0	1	1	13	62	2	0	0
91192-1	9-Mar	78	22	0	0	0	0	0	0	0	0	0	0	0	0
91192-1	16-Mar	55	39	5	0	0	0	0	0	0	0	0	0	0	0
91192-1	23-Mar	15	62	23	1	0	0	0	0	0	0	0	0	0	0
91192-1	30-Mar	5	43	50	2	0	0	0	0	0	0	0	0	0	0
91192-1	9-Apr	3	9	75	9	3	0	0	0	0	0	0	0	0	0
91192-1	13-Apr	3	4	1	2	34	53	3	0	0	0	0	0	0	0
91192-1	20-Apr	2	0	2	1	10	60	15	5	5	0	0	0	0	0
91192-1	27-Apr	3	2	0	2	3	4	6	12	7	29	32	0	0	0
91192-1	2-May	2	0	5	0	3	2	0	0	0	0	88	0	0	0
9134-7	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9134-7	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9134-7	23-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9134-7	30-Mar	89	10	1	0	0	0	0	0	0	0	0	0	0	0
9134-7	9-Apr	67	20	13	0	0	0	0	0	0	0	0	0	0	0
9134-7	13-Apr	12	29	58	0	0	1	0	0	0	0	0	0	0	0
9134-7	20-Apr	13	1	10	11	42	23	0	1	0	0	0	0	0	0
9134-7	27-Apr	6	1	2	3	12	54	22	0	0	0	0	0	0	0
9134-7	2-May	7	1	2	2	7	5	3	6	12	24	33	0	0	0
9134-7	10-May	2	3	0	1	2	6	2	5	5	14	59	0	0	0
9137-2	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9137-2	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9137-2	23-Mar	94	6	0	0	0	0	0	0	0	0	0	0	0	0
9137-2	30-Mar	83	14	3	0	0	0	0	0	0	0	0	0	0	0
9137-2	9-Apr	52	16	29	2	0	0	0	0	0	0	0	0	0	0
9137-2	13-Apr	23	13	31	8	19	6	0	0	0	0	0	0	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
9137-2	20-Apr	15	3	6	0	31	32	11	2	0	0	0	0	0	0
9137-2	27-Apr	15	3	3	3	11	12	4	9	27	9	3	0	0	0
9137-2	2-May	11	4	0	1	11	5	0	1	3	24	42	0	0	0
9137-2	10-May	7	4	2	3	5	5	2	4	1	1	46	22	0	0
9148-9	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9148-9	16-Mar	65	27	7	1	0	0	0	0	0	0	0	0	0	0
9148-9	23-Mar	24	37	34	5	0	0	0	0	0	0	0	0	0	0
9148-9	30-Mar	19	10	40	25	5	0	0	0	0	0	0	0	0	0
9148-9	9-Apr	12	5	19	48	15	1	0	0	0	0	0	0	0	0
9148-9	13-Apr	12	4	0	0	8	75	0	0	0	0	0	0	0	0
9148-9	20-Apr	9	2	2	0	7	12	9	17	11	14	17	0	0	0
9148-9	27-Apr	8	2	0	1	3	1	0	1	3	9	71	2	0	0
9154-3	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9154-3	16-Mar	92	7	2	0	0	0	0	0	0	0	0	0	0	0
9154-3	23-Mar	75	15	10	0	0	0	0	0	0	0	0	0	0	0
9154-3	30-Mar	51	16	19	12	2	0	0	0	0	0	0	0	0	0
9154-3	9-Apr	25	6	14	28	27	0	0	0	0	0	0	0	0	0
9154-3	13-Apr	9	8	0	1	21	46	15	0	0	0	0	0	0	0
9154-3	20-Apr	11	2	1	2	3	12	12	7	21	23	8	0	0	0
9154-3	27-Apr	11	0	0	0	11	1	0	0	0	14	61	0	2	2
9198-1	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9198-1	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9198-1	23-Mar	64	25	11	0	0	0	0	0	0	0	0	0	0	0
9198-1	30-Mar	52	22	23	3	0	0	0	0	0	0	0	0	0	0
9198-1	9-Apr	35	18	35	8	4	0	0	0	0	0	0	0	0	0
9198-1	13-Apr	20	10	18	12	21	19	0	0	0	0	0	0	0	0
9198-1	20-Apr	19	6	5	5	27	34	4	0	0	0	0	0	0	0
9198-1	27-Apr	13	5	4	0	6	8	15	2	20	16	9	1	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
9198-1	2-May	15	5	0	2	2	2	2	2	2	15	50	3	0	1
9198-1	10-May	12	4	4	0	2	2	0	2	2	0	13	51	8	2
9199-4	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9199-4	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9199-4	23-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9199-4	30-Mar	88	7	5	0	0	0	0	0	0	0	0	0	0	0
9199-4	9-Apr	63	13	18	5	1	0	0	0	0	0	0	0	0	0
9199-4	13-Apr	40	3	13	42	0	2	0	0	0	0	0	0	0	0
9199-4	20-Apr	32	2	5	4	25	12	2	15	2	2	0	0	0	0
9199-4	27-Apr	26	2	3	0	8	6	6	5	3	20	20	0	0	0
9199-4	2-May	34	3	2	1	4	0	0	0	1	17	35	2	2	0
9199-4	10-May	23	10	2	3	3	2	2	0	0	3	41	7	5	0
9311-25	9-Mar	81	12	7	0	0	0	0	0	0	0	0	0	0	0
9311-25	16-Mar	48	13	27	9	2	0	0	0	0	0	0	0	0	0
9311-25	23-Mar	38	11	38	9	4	0	0	0	0	0	0	0	0	0
9311-25	30-Mar	28	5	25	30	12	0	0	0	0	0	0	0	0	0
9311-25	9-Apr	20	3	12	23	38	4	0	0	0	0	0	0	0	0
9311-25	13-Apr	25	3	0	1	6	62	2	0	2	0	0	0	0	0
9311-25	20-Apr	29	3	0	0	3	2	2	2	1	21	36	0	0	0
9311-66	9-Mar	88	12	0	0	0	0	0	0	0	0	0	0	0	0
9311-66	16-Mar	75	14	8	3	0	0	0	0	0	0	0	0	0	0
9311-66	23-Mar	65	10	20	5	0	0	0	0	0	0	0	0	0	0
9311-66	30-Mar	62	6	8	21	3	0	0	0	0	0	0	0	0	0
9311-66	9-Apr	54	5	7	16	16	2	0	0	0	0	0	0	0	0
9311-66	13-Apr	55	6	2	0	2	35	0	0	0	0	0	0	0	0
9311-66	20-Apr	48	3	2	0	8	3	2	5	2	9	17	0	0	0
9311-82	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
9311-82	16-Mar	66	15	12	5	2	0	0	0	0	0	0	0	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
9311-82	23-Mar	45	8	35	12	0	0	0	0	0	0	0	0	0	0
9311-82	30-Mar	42	7	8	28	14	0	0	0	0	0	0	0	0	0
9311-82	9-Apr	36	5	8	13	34	5	0	0	0	0	0	0	0	0
9311-82	13-Apr	45	2	3	0	8	36	4	2	0	0	0	0	0	0
9311-82	20-Apr	50	0	1	0	5	1	0	6	0	5	33	0	0	0
934-58	9-Mar	58	22	19	0	0	0	0	0	0	0	0	0	0	0
934-58	16-Mar	25	15	38	22	0	0	0	0	0	0	0	0	0	0
934-58	23-Mar	0	19	28	30	23	0	0	0	0	0	0	0	0	0
934-58	30-Mar	18	8	6	28	26	12	0	0	0	0	0	0	0	0
934-58	9-Apr	22	1	7	9	2	24	35	0	0	0	0	0	0	0
934-58	13-Apr	20	3	0	0	1	0	0	1	75	0	0	0	0	0
934-58	20-Apr	20	0	0	0	0	0	0	1	0	0	79	0	0	0
934-60	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
934-60	16-Mar	56	18	25	1	0	0	0	0	0	0	0	0	0	0
934-60	23-Mar	38	22	30	8	2	0	0	0	0	0	0	0	0	0
934-60	30-Mar	24	16	31	18	8	2	0	0	0	0	0	0	0	0
934-60	9-Apr	19	13	15	8	8	32	5	0	0	0	0	0	0	0
934-60	13-Apr	18	2	0	4	8	9	34	0	23	1	1	0	0	0
934-60	20-Apr	21	0	0	0	1	0	1	1	2	3	72	0	0	0
934-74	9-Mar	76	15	8	0	0	0	0	0	0	0	0	0	0	0
934-74	16-Mar	66	11	14	9	0	0	0	0	0	0	0	0	0	0
934-74	23-Mar	41	15	25	11	8	0	0	0	0	0	0	0	0	0
934-74	30-Mar	42	7	30	12	9	0	0	0	0	0	0	0	0	0
934-74	9-Apr	43	8	12	12	10	8	8	0	0	0	0	0	0	0
934-74	13-Apr	40	5	0	1	2	29	18	0	4	0	0	0	0	0
934-74	20-Apr	42	0	2	0	3	2	0	3	0	0	48	0	0	0
938-56	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
938-56	16-Mar	85	6	8	1	0	0	0	0	0	0	0	0	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
938-56	23-Mar	62	12	22	5	0	0	0	0	0	0	0	0	0	0
938-56	30-Mar	49	15	18	13	5	0	0	0	0	0	0	0	0	0
938-56	9-Apr	35	12	11	14	3	25	0	0	0	0	0	0	0	0
938-56	13-Apr	28	8	0	0	1	28	24	4	8	0	0	0	0	0
938-56	20-Apr	37	0	2	0	0	1	0	0	0	8	52	0	0	0
B. Alder	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	23-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	30-Mar	99	1	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	9-Apr	98	2	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	13-Apr	79	21	0	0	0	0	0	0	0	0	0	0	0	0
B. Alder	20-Apr	52	45	3	0	0	0	0	0	0	0	0	0	0	0
B. Alder	27-Apr	18	44	27	8	3	0	0	0	0	0	0	0	0	0
B. Alder	2-May	15	15	17	6	45	2	0	0	0	0	0	0	0	0
B. Alder	10-May	10	11	14	4	18	35	4	3	2	0	0	0	0	0
B. Alder	18-May	8	15	4	2	5	9	7	14	26	6	3	0	0	0
B. Alder	24-May	7	9	9	2	5	1	3	5	5	16	37	2	0	0
B. Alder	1-Jun	6	8	8	7	1	0	0	2	5	4	27	13	10	10
B. Gairn	9-Mar	52	33	15	0	0	0	0	0	0	0	0	0	0	0
B. Gairn	16-Mar	21	18	31	20	10	0	0	0	0	0	0	0	0	0
B. Gairn	23-Mar	10	8	41	24	18	0	0	0	0	0	0	0	0	0
B. Gairn	30-Mar	7	8	14	27	44	0	0	0	0	0	0	0	0	0
B. Gairn	9-Apr	8	2	2	6	56	26	0	0	0	0	0	0	0	0
B. Gairn	13-Apr	7	0	3	1	5	55	0	0	27	2	0	0	0	0
B. Gairn	20-Apr	11	0	1	0	2	1	1	2	0	11	72	0	0	0
B. Hope	9-Mar	89	10	1	0	0	0	0	0	0	0	0	0	0	0
B. Hope	16-Mar	47	37	16	0	0	0	0	0	0	0	0	0	0	0
B. Hope	23-Mar	21	30	41	8	0	0	0	0	0	0	0	0	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
B. Hope	30-Mar	15	5	36	30	15	0	0	0	0	0	0	0	0	0
B. Hope	9-Apr	14	2	8	45	32	0	0	0	0	0	0	0	0	0
B. Hope	13-Apr	12	2	0	4	10	72	0	0	0	0	0	0	0	0
B. Hope	20-Apr	8	1	2	0	6	28	27	17	10	2	0	0	0	0
B. Hope	27-Apr	8	1	0	0	5	2	0	3	12	23	45	0	0	0
B. Hope	2-May	9	2	1	1	2	0	0	0	0	0	85	0	0	0
B. Klibrek	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Klibrek	16-Mar	90	10	0	0	0	0	0	0	0	0	0	0	0	0
B. Klibrek	23-Mar	49	38	12	2	0	0	0	0	0	0	0	0	0	0
B. Klibrek	30-Mar	25	42	32	1	0	0	0	0	0	0	0	0	0	0
B. Klibrek	9-Apr	5	18	64	13	0	0	0	0	0	0	0	0	0	0
B. Klibrek	13-Apr	0	0	0	5	88	8	0	0	0	0	0	0	0	0
B. Klibrek	20-Apr	0	0	0	0	43	47	8	0	2	0	0	0	0	0
B. Klibrek	27-Apr	2	0	0	0	6	13	4	3	38	17	17	0	0	0
B. Klibrek	2-May	0	0	0	6	0	0	0	0	0	1	93	0	0	0
B. Lomond	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Lomond	16-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Lomond	23-Mar	73	17	9	1	0	0	0	0	0	0	0	0	0	0
B. Lomond	30-Mar	56	14	25	5	0	0	0	0	0	0	0	0	0	0
B. Lomond	9-Apr	36	13	28	18	5	0	0	0	0	0	0	0	0	0
B. Lomond	13-Apr	27	8	0	0	16	49	0	0	0	0	0	0	0	0
B. Lomond	20-Apr	27	8	3	0	6	19	15	15	5	2	0	0	0	0
B. Lomond	27-Apr	21	5	0	0	5	5	2	4	2	11	43	1	0	0
Baldwin	9-Mar	79	19	2	0	0	0	0	0	0	0	0	0	0	0
Baldwin	16-Mar	1	55	33	9	2	0	0	0	0	0	0	0	0	0
Baldwin	23-Mar	12	20	55	7	6	0	0	0	0	0	0	0	0	0
Baldwin	30-Mar	3	6	29	45	15	1	0	0	0	0	0	0	0	0
Baldwin	9-Apr	3	3	12	23	28	30	0	0	0	0	0	0	0	0

b) Newent site (continued)

Cultivar	Date	A	B1	B2	C1	C3	D	E1	E2	F1	F2	F3	I1	I2	I3
Baldwin	13-Apr	3	0	0	0	1	58	18	14	5	2	0	0	0	0
Baldwin	20-Apr	8	0	0	0	0	0	0	5	12	43	33	0	0	0
Baldwin	27-Apr	8	0	1	1	0	0	0	1	1	78	9	2	0	0
Tiben	9-Mar	100	0	0	0	0	0	0	0	0	0	0	0	0	0
Tiben	16-Mar	72	21	7	0	0	0	0	0	0	0	0	0	0	0
Tiben	23-Mar	38	30	31	1	0	0	0	0	0	0	0	0	0	0
Tiben	30-Mar	12	15	50	22	2	0	0	0	0	0	0	0	0	0
Tiben	9-Apr	7	4	29	48	12	0	0	0	0	0	0	0	0	0
Tiben	13-Apr	6	0	0	0	11	82	0	1	0	0	0	0	0	0
Tiben	20-Apr	5	0	0	0	4	15	8	20	28	21	0	0	0	0
Tiben	27-Apr	7	0	0	0	2	0	0	3	1	10	77	0	0	0

Appendix 4: growth stage variability

a) Bradenham site

Cultivar	Date	Growth Stage Score	Median Growth Stage	Standard Deviation
S36-1-21	10-Apr	1.7	B1	1.43
S36-1-21	16-Apr	1.6	B2	0.55
S36-1-21	23-Apr	2.5	B2	1.36
S36-1-21	30-Apr	3.6	C3	1.51
S36-1-21	8-May	5.0	C3	2.28
S36-1-21	15-May	6.2	F1	3.11
S36-1-21	21-May	7.4	F2	3.45
S36-1-21	30-May	9.2	F3	4.57
91129-1	19-Mar	1.4	B1	0.59
91129-1	26-Mar	2.0	B2	0.98
91129-1	2-Apr	3.3	C1	1.30
91129-1	10-Apr	4.1	C1	1.60
91129-1	16-Apr	6.1	E2	2.53
91129-1	23-Apr	9.2	F2	2.03
91129-1	30-Apr	10.1	F3	2.98
91192-1	8-Mar	1.3	B1	0.46
91192-1	19-Mar	1.9	B1	0.30
91192-1	26-Mar	1.9	B1	0.27
91192-1	2-Apr	2.9	B2	0.36
91192-1	10-Apr	3.7	C1	1.17
91192-1	16-Apr	5.5	D	1.14
91192-1	23-Apr	7.5	F1	2.21
91192-1	30-Apr	9.7	F3	2.65
91192-1	8-May	9.8	F3	3.31
9134-7	2-Apr	1.3	B1	0.47
9134-7	10-Apr	3.1	B2	0.91
9134-7	16-Apr	3.9	C1	1.04
9134-7	23-Apr	5.7	E1	0.64
9134-7	30-Apr	8.2	F1	0.90
9134-7	8-May	10.9	F3	0.28
9154-3	19-Mar	1.2	B1	0.47
9154-3	26-Mar	1.6	B1	0.65
9154-3	2-Apr	3.0	B2	1.15
9154-3	10-Apr	4.4	D	1.50
9154-3	16-Apr	6.6	D	1.67
9154-3	23-Apr	9.5	F2	0.53
9154-3	30-Apr	10.6	F3	1.77
9199-4	26-Mar	1.1	B1	0.27
9199-4	2-Apr	1.6	B1	0.79
9199-4	10-Apr	3.8	C1	1.89
9199-4	16-Apr	3.9	C1	1.76
9199-4	23-Apr	6.0	D	2.40
9199-4	30-Apr	8.7	F2	2.96
9199-4	8-May	11.0	F3	1.22
B. Alder	10-Apr	1.4	B1	0.49
B. Alder	16-Apr	1.9	B1	0.72

a) Bradenham site (continued)

Cultivar	Date	Growth Stage Score	Median Growth Stage	Standard Deviation
B. Alder	23-Apr	3.0	B2	1.3
B. Alder	30-Apr	4.5	C3	1.37
B. Alder	8-May	5.9	D	2.30
B. Alder	15-May	7.6	F1	2.89
B. Alder	21-May	8.6	F2	3.03
B. Alder	30-May	11.0	F3	3.59
B. Hope	8-Mar	1.1	B1	0.27
B. Hope	19-Mar	2.3	B1	0.71
B. Hope	26-Mar	2.5	B2	0.75
B. Hope	2-Apr	3.5	C1	0.66
B. Hope	10-Apr	5.3	D	1.07
B. Hope	16-Apr	6.2	D	0.50
B. Hope	23-Apr	8.6	F1	1.05
B. Hope	30-Apr	10.3	F2	0.52
B. Hope	8-May	11.7	I1	0.88
Baldwin	8-Mar	1.6	B1	0.71
Baldwin	19-Mar	2.8	B2	1.29
Baldwin	26-Mar	3.1	B2	1.55
Baldwin	2-Apr	4.1	C1	1.59
Baldwin	10-Apr	6.3	D	1.18
Baldwin	16-Apr	8.6	F1	1.72
Baldwin	23-Apr	10.2	F2	1.16
Baldwin	30-Apr	11.6	I1	0.97
Tiben	19-Mar	1.9	B1	0.54
Tiben	26-Mar	2.5	B2	0.63
Tiben	2-Apr	3.4	B2	0.66
Tiben	10-Apr	5.5	D	1.00
Tiben	16-Apr	6.6	D	0.93
Tiben	23-Apr	9.2	F1	0.99
Tiben	30-Apr	11.2	F3	0.47

b) Newent site

Cultivar	Date	Average Score	Median Growth Stage	Standard Deviation
S-36-1-21	9-Mar	1.0	A	0
S-36-1-21	16-Mar	1.0	A	0
S-36-1-21	23-Mar	1.0	A	0
S-36-1-21	30-Mar	1.0	B1	0.12
S-36-1-21	9-Apr	1.1	B1	0.23
S-36-1-21	13-Apr	1.7	B1	0.48
S-36-1-21	20-Apr	2.0	B1	0.69
S-36-1-21	27-Apr	3.2	C1	1.05
S-36-1-21	2-May	4.2	C3	1.45
S-36-1-21	10-May	5.7	D	2.09
S-36-1-21	18-May	6.9	F2	3.14
S-36-1-21	24-May	7.9	F3	3.79
9111-14	9-Mar	1.0	A	0
9111-14	16-Mar	1.0	A	0
9111-14	23-Mar	1.0	A	0
9111-14	30-Mar	1.0	A	0
9111-14	9-Apr	1.0	B1	0.12
9111-14	13-Apr	1.5	B1	0.5
9111-14	20-Apr	2.4	B2	1.17
9111-14	27-Apr	3.9	C3	1.49
9111-14	2-May	5.0	C3	1.95
9111-14	10-May	7.1	C3	3.21
9111-14	18-May	8.4	F3	3.44
91129-1	9-Mar	1.0	A	0
91129-1	16-Mar	1.2	B1	0.46
91129-1	23-Mar	1.7	B2	0.88
91129-1	30-Mar	2.5	B2	1.23
91129-1	9-Apr	3.3	C1	1.41
91129-1	13-Apr	5.1	D	1.87
91129-1	20-Apr	7.3	F2	3.21
91129-1	27-Apr	8.8	F3	3.97
91192-1	9-Mar	1.2	B1	0.41
91192-1	16-Mar	1.5	B1	0.6
91192-1	23-Mar	2.1	B1	0.63
91192-1	30-Mar	2.5	B2	0.63
91192-1	9-Apr	3.0	B2	0.66
91192-1	13-Apr	5.3	D	1.21
91192-1	20-Apr	6.1	D	1.28
91192-1	27-Apr	9.0	F3	2.44
91192-1	2-May	10.1	F3	2.46
9134-7	9-Mar	1.0	A	0
9134-7	16-Mar	1.0	A	0
9134-7	23-Mar	1.0	A	0
9134-7	30-Mar	1.1	B1	0.34
9134-7	9-Apr	1.5	B1	0.72
9134-7	13-Apr	2.5	B2	0.77
9134-7	20-Apr	4.4	C3	1.62
9134-7	27-Apr	5.6	D	1.49
9134-7	2-May	8.6	F3	2.99

b) Newent site (continued)

Cultivar	Date	Average Score	Median Growth Stage	Standard Deviation
9134-7	10-May	9.5	F3	2.56
9137-2	9-Mar	1.0	A	0
9137-2	16-Mar	1.0	A	0
9137-2	23-Mar	1.1	B1	0.24
9137-2	30-Mar	1.2	B1	0.47
9137-2	9-Apr	1.8	B2	0.94
9137-2	13-Apr	3.1	B2	1.57
9137-2	20-Apr	4.8	D	1.95
9137-2	27-Apr	6.4	F1	3.14
9137-2	2-May	8.3	F3	3.56
9137-2	10-May	9.1	F3	3.58
9148-9	9-Mar	1.0	A	0
9148-9	16-Mar	1.4	B1	0.66
9148-9	23-Mar	2.2	B1	0.87
9148-9	30-Mar	2.9	B2	1.15
9148-9	9-Apr	3.5	C1	1.2
9148-9	13-Apr	5.1	D	1.75
9148-9	20-Apr	7.5	E2	2.98
9148-9	27-Apr	9.6	F3	3.1
9154-3	9-Mar	1.0	A	0
9154-3	16-Mar	1.1	B1	0.35
9154-3	23-Mar	1.4	B1	0.66
9154-3	30-Mar	2.0	B2	1.16
9154-3	9-Apr	3.3	C1	1.53
9154-3	13-Apr	5.1	D	1.82
9154-3	20-Apr	7.5	F2	2.97
9154-3	27-Apr	9.2	F3	3.46
9198-1	9-Mar	1.0	A	0
9198-1	16-Mar	1.0	A	0
9198-1	23-Mar	1.5	B1	0.68
9198-1	30-Mar	1.8	B1	0.91
9198-1	9-Apr	2.3	B2	1.13
9198-1	13-Apr	3.6	C3	1.8
9198-1	20-Apr	4.3	D	1.98
9198-1	27-Apr	6.9	F1	3.32
9198-1	2-May	8.5	F3	3.89
9198-1	10-May	9.6	I1	4.2
9199-4	9-Mar	1.0	A	0
9199-4	16-Mar	1.0	A	0
9199-4	23-Mar	1.0	A	0
9199-4	30-Mar	1.2	B1	0.48
9199-4	9-Apr	1.7	B2	0.98
9199-4	13-Apr	2.7	C1	1.47
9199-4	20-Apr	4.3	C3	2.69
9199-4	27-Apr	6.5	F2	3.97
9199-4	2-May	6.8	F3	4.69
9199-4	10-May	7.2	F3	4.68
9311-25	9-Mar	1.3	A	0.58
9311-25	16-Mar	2.0	B2	1.16

b) Newent site (continued)

Cultivar	Date	Average Score	Median Growth Stage	Standard Deviation
9311-25	23-Mar	2.3	B2	1.18
9311-25	30-Mar	2.9	C1	1.4
9311-25	9-Apr	3.7	C3	1.58
9311-25	13-Apr	4.7	D	2.28
9311-25	20-Apr	7.1	F3	4.39
9311-66	9-Mar	1.1	A	0.32
9311-66	16-Mar	1.4	B1	0.77
9311-66	23-Mar	1.7	B2	0.98
9311-66	30-Mar	2.0	C1	1.35
9311-66	9-Apr	2.4	C3	1.71
9311-66	13-Apr	3.0	D	2.36
9311-66	20-Apr	4.7	F3	4.16
9311-82	9-Mar	1.0	A	0
9311-82	16-Mar	1.6	B1	0.98
9311-82	23-Mar	2.1	B2	1.12
9311-82	30-Mar	2.6	C1	1.58
9311-82	9-Apr	3.2	C3	1.84
9311-82	13-Apr	3.5	D	2.48
9311-82	20-Apr	5.4	F3	4.65
934-58	9-Mar	1.6	B1	0.79
934-58	16-Mar	2.6	B2	1.09
934-58	23-Mar	3.6	C1	1.05
934-58	30-Mar	3.7	C1	1.66
934-58	9-Apr	4.8	E1	2.36
934-58	13-Apr	7.1	F1	3.33
934-58	20-Apr	9.0	F3	4.01
934-60	9-Mar	1.0	A	0
934-60	16-Mar	1.7	B2	0.87
934-60	23-Mar	2.1	B2	1.08
934-60	30-Mar	2.8	B2	1.35
934-60	9-Apr	3.9	D	2.05
934-60	13-Apr	6.0	E1	2.79
934-60	20-Apr	8.7	F3	4.05
934-74	9-Mar	1.3	B1	0.62
934-74	16-Mar	1.7	B2	1.03
934-74	23-Mar	2.3	B2	1.31
934-74	30-Mar	2.4	B2	1.37
934-74	9-Apr	2.9	C1	2.1
934-74	13-Apr	4.0	D	2.77
934-74	20-Apr	6.3	F3	4.77
938-56	9-Mar	1.0	A	0
938-56	16-Mar	1.3	B2	0.64
938-56	23-Mar	1.7	B2	0.96
938-56	30-Mar	2.1	B2	1.27
938-56	9-Apr	3.1	D	2.02
938-56	13-Apr	4.9	D	2.85
938-56	20-Apr	7.1	F3	4.78
B Klibrek	9-Mar	1.0	A	0
B Klibrek	16-Mar	1.1	B1	0.3

b) Newent site (continued)

Cultivar	Date	Average Score	Median Growth Stage	Standard Deviation
B Klibrek	23-Mar	1.7	B1	0.74
B Klibrek	30-Mar	2.1	B1	0.77
B Klibrek	9-Apr	2.8	B2	0.71
B Klibrek	13-Apr	5.0	C3	0.35
B Klibrek	20-Apr	5.7	D	0.75
B Klibrek	27-Apr	8.6	F1	2.13
B Klibrek	2-May	10.6	F3	1.69
B Lomond	9-Mar	1.0	A	0
B Lomond	16-Mar	1.0	A	0
B Lomond	23-Mar	1.4	B1	0.69
B Lomond	30-Mar	1.8	B2	0.98
B Lomond	9-Apr	2.4	B2	1.27
B Lomond	13-Apr	4.2	D	2.21
B Lomond	20-Apr	4.9	D	2.93
B Lomond	27-Apr	7.5	F3	4.14
Baldwin	9-Mar	1.2	B1	0.45
Baldwin	16-Mar	2.6	B1	0.77
Baldwin	23-Mar	2.7	B2	0.97
Baldwin	30-Mar	3.7	C1	0.94
Baldwin	9-Apr	4.6	D	1.28
Baldwin	13-Apr	6.5	D	1.43
Baldwin	20-Apr	9.4	F2	2.57
Baldwin	27-Apr	9.3	F2	2.58
Ben Alder	9-Mar	1.0	A	0
Ben Alder	16-Mar	1.0	A	0
Ben Alder	23-Mar	1.0	A	0
Ben Alder	30-Mar	1.0	A	0.09
Ben Alder	9-Apr	1.0	B1	0.12
Ben Alder	13-Apr	1.2	B1	0.41
Ben Alder	20-Apr	1.5	B1	0.56
Ben Alder	27-Apr	2.3	B1	0.97
Ben Alder	2-May	3.6	C3	1.58
Ben Alder	10-May	4.6	D	2.04
Ben Alder	18-May	6.3	F1	3.11
Ben Alder	24-May	7.8	F3	3.75
Ben Alder	1-Jun	9.0	F3	4.34
Ben Gairn	9-Mar	1.6	B1	0.73
Ben Gairn	16-Mar	2.8	B2	1.26
Ben Gairn	23-Mar	3.3	B2	1.15
Ben Gairn	30-Mar	3.9	C3	1.24
Ben Gairn	9-Apr	4.8	C3	1.36
Ben Gairn	13-Apr	6.4	D	2.18
Ben Gairn	20-Apr	9.5	F3	3.24
Ben Hope	9-Mar	1.1	B1	0.34
Ben Hope	16-Mar	1.7	B2	0.74
Ben Hope	23-Mar	2.4	B2	0.91
Ben Hope	30-Mar	3.3	B2	1.21
Ben Hope	9-Apr	3.8	C3	1.3
Ben Hope	13-Apr	5.1	D	1.69

b) Newent site (continued)

Cultivar	Date	Average Score	Median Growth Stage	Standard Deviation
Ben Hope	20-Apr	6.5	D	2.07
Ben Hope	27-Apr	9.1	F3	3
Ben Hope	2-May	9.7	F3	3.24
Tiben	9-Mar	1.0	A	0
Tiben	16-Mar	1.3	B1	0.61
Tiben	23-Mar	1.9	B2	0.85
Tiben	30-Mar	2.9	B2	0.94
Tiben	9-Apr	3.5	C1	1
Tiben	13-Apr	5.6	D	1.24
Tiben	20-Apr	7.9	F1	2.1
Tiben	27-Apr	10.0	F3	2.64