

*Horticulture Research International
East Malling
West Malling
Kent ME19 6BJ*

*Contract No. 12311
(GEP00/003)*

*For
Valent BioSciences Corporation
and the
UK Apple and Pear Research
Council*

**The impact of ReTain^R
(ABG-3168)
on the quality of
Bramley's Seedling
apples**

July 2001

FINAL SUMMARY REPORT - RETAIN^R APPLES

TITLE: The impact of ReTain^R (ABG-3168) on the quality of Bramley's Seedling apples

INVESTIGATOR: Horticulture Research International (HRI)

TEST SITE: HRI, East Malling

COMPLETE DATE: 4 April 2001

REPORT DATE: 15 July 2001

SUMMARY:

Foliar sprays of ReTain^R were applied in 2000 to heavily cropping Bramley trees approximately 4 weeks before the anticipated harvest for the untreated fruit. One rate of ReTain^R (830 g ha⁻¹) and 2 types of surfactant (ABG-7011 and ABG-7044 at 0.075% v/v) were applied using a 'Hardi' purpose-built sprayer with a measured volume rate of 1000 litres per hectare. Samples for immediate evaluation were harvested on 11, 18 and 25 September and 2 October 2000. On the first 3 harvest dates samples from each of the field treatments were taken for storage in an atmosphere of 5% CO₂ and 1% O₂ (balance N₂) at 4-4.5°C for 6 months followed by a further 7d at 20°C. Samples from trees treated with ReTain^R were stored in separate containers from those from trees that were not treated with ReTain^R.

ReTain^R delayed the rate of fruit maturation on the tree as evidenced by a lower internal ethylene and soluble solids concentration and a higher starch content in the fruit. ReTain^R-treated fruit were also greener at harvest but surprisingly were lower in acidity. Beneficial effects of ReTain^R on the quality of stored fruit included a greener and less yellow background colour, increased firmness (pick 1 fruit only) and reduced incidence of bitter pit. A significant negative effect of ReTain^R was a reduced concentration of soluble solids in the fruit.

The major adverse effect of ReTain^R application was the development of lenticel damage on the fruit at harvest. It was clear that the damaging effect was attributed solely to the surfactants that were added to the ReTain^R solution prior to application. Effects of picking date on maturity of fruit at harvest and on the quality of fruit from store were generally as expected. ReTain^R application retarded maturity on the tree by about a week. Similarly the benefits in storage quality achieved by ReTain^R application were equivalent to that lost by a weeks delay in harvesting.

Objectives

To evaluate the efficacy of ReTain^R (ABG-3168) for improved fruit quality at harvest and improved fruit quality after segregated controlled atmosphere storage.

Materials and methods

The trial was carried out in 2000 in an M9 Bramley / Falstaff (pollinizer) orchard (plot reference WM128) situated on Wiseman at the Home Farm site of HRI-East Malling (see Annexe I, II and III). The trees were planted in 1992 at an in-row spacing of 3 metres and 5 metres between rows. Within each tree row Bramley trees (4) alternated with Falstaff (2).

Home Farm lies between latitudes of 51° 17' and 51° 18' north and at a longitude of 0° 26' to 0° 29' east. Elevation ranges from 15-38 metres above sea level. Soils (Malling series) comprise a sandy loam over ragstone with pH in the range 6.0-7.0. Application of fertilizers and other agrochemicals in orchard WM128 during 2000 are detailed in Annexe IV. No irrigation was applied in 2000. Full bloom occurred on 5 May 2000. The crop load was moderate to heavy and shoot growth was moderately vigorous.

The following treatments were applied on 15 August 2000 (102 days after full bloom):

Untreated
ReTain ^R 830g ha ⁻¹ + ABG-7011 0.075% v/v
ReTain ^R 830g ha ⁻¹ + ABG-7044 0.075% v/v
ReTain ^R 830g ha ⁻¹
ABG-7011 0.075% v/v
ABG-7044 0.075% v/v

Treatments were allocated to 4-tree plots in a randomized block design with 6 replications. Plots were guarded on either side by 2 Falstaff trees (within rows).

Treatments were applied using a 'Hardi' purpose-built sprayer with a measured volume rate of 1000 litres per hectare at an operating pressure of 140 lb in². The efficiency of spraying was typically 95-103%. Spraying commenced at 08.00 hours and finished at 16.00 hours. Dry and wet bulb temperatures at the beginning of spraying were 17 and 15°C respectively. The leaves and fruits were dry prior to application of the treatments and there was no rain during or immediately after application. The weather was sunny with some cloud and with a light breeze (2 metres sec⁻¹).

Fruit was harvested on 11, 18 and 25 September and 2 October 2000. At each harvest 10 fruits were removed at random from each of the 4 experimental trees in each plot and taken immediately to the post-harvest facility at East Malling. The fruit (40) from each plot was divided to form two sub-samples of 20 fruit. One sample was used for harvest evaluations and the other for storage.

Harvest evaluation parameters

The evaluation of harvest parameters followed the sequence indicated below:

Internal ethylene concentration (IEC). IEC was measured on 5 intact undamaged apples from each replicate of each treatment. A sample of the internal atmosphere of each apple was taken by syringe (0.5ml) and injected into a gas chromatograph fitted with an alumina column and FID detector. Results were expressed as log₁₀ parts per billion (ppb) of ethylene.

External disorders. Various types of disorders and diseases affected the fruit at harvest. These included russetting, cracking, and skin darkening at the calyx end of the fruit, lenticel spotting, bitter pit and scab (*Venturia inaequalis*) lesions.

Background colour. The colour of the non-blush side of the fruit was assessed using commercial (World Wide Fruit / Qualytech) colour charts. Background colour of each fruit was compared against 4 cards that range from green (1) to yellow (4). The average score was calculated for each sample.

Red colour. The percentage area of red colour on each apple was estimated and assigned to one of six categories i.e. 0, 1-5, 6-10, 11-20, 21-50 and >50% that were ascribed a score of 0, 1, 2, 3, 4 and 5 respectively. The maximum score for red colour in a 20-fruit sample was 100. There was no attempt to assess the intensity of red colour.

Fruit mass (weight). Each fruit in the sample was weighed and the mean weight (g) was calculated.

Fruit size. Incremented (5 mm) sizing rings were used to grade all fruits according to their diameters. Size categories for fruit at harvest ranged from 66-70 mm to 100+ mm. The percentage of fruit in each of the 8 size categories was calculated for each 20-fruit sample.

Fruit firmness. Two measurements were made on the opposite sides of each fruit using an automated penetrometer fitted with an 11mm probe. Measurements were made in the equatorial region after removal of the peel. Firmness was the force (N) recorded after insertion of the probe to a depth of 8mm.

Soluble solids concentration. Juice was extracted from each apple using a 'Chylofel' (Copa - Technologie S.A.) apparatus and mixed to form a composite sample. Soluble solids concentration (%) was measured using a hand-held refractometer with automatic temperature compensation.

Acidity. The juice extracted for measurement of soluble solids concentration (see above) was reserved for analysis of acidity (expressed as g kg⁻¹ malic acid) by titration with 0.1 M sodium hydroxide solution to pH 8.1.

Internal disorders. Each fruit was cut at the calyx end and at the equator and examined for the presence of disorders. The incidence of each type of disorder was recorded.

Starch test. Half of each apple cut for internal examination was dipped in a solution containing 0.1% w/v iodine and 4% w/v potassium iodide. Dipped sections were left for at least an hour before being assessed. Each apple was scored (1-slight central discolouration to 10-no peripheral discolouration) using the starch conversion chart for apples (circular type) issued by Ctifl. An average score was calculated for each sample.

Post-storage evaluation parameters

Samples harvested on the first 3 occasions were stored in 0.5 tonne containers in an atmosphere of 5% CO₂ and 1% O₂ (balance N₂) at 4-4.5°C for 183 days. Samples from each of the ReTain^R treatments were stored in separate containers and separately from samples not treated with ReTain^R (segregated storage). Fruit from the three harvests were included in the same containers. To avoid CO₂ injury storage containers were left

unsealed for 16-17 days prior to the establishment of CA conditions. After sealing, the low oxygen conditions were achieved by flushing with nitrogen. Subsequently the CO₂ concentration was allowed to accumulate to 5% by fruit respiration. *[It is the standard recommendation to delay the sealing of stores by 15 days where the 5% CO₂ + 1% O₂ condition is established by flushing with nitrogen. Delayed CA is not required for fruit treated with DPA as this prevents CO₂ injury].* On removal from store all samples were transferred to an air store at 20°C for 7d. An evaluation of post-storage parameters was carried out according to the sequence indicated below:

Internal ethylene concentration (IEC). IEC was measured on 5 intact undamaged apples from each replicate of each treatment as described for samples at harvest. Results were expressed as log₁₀ parts per million (ppm) of ethylene.

Background colour. The colour of the non-blush side of each fruit in a sample was measured using a 'Hunter ColorFlex' instrument. The 'a' value was used as a measure of greenness (the more negative the value the greener the fruit) and the 'b' value as a measure of yellowness (the higher the value the more yellow the fruit).

External disorders. Fruits were examined for the presence of various types of disorders and diseases. The number of fruit affected by each type of disease/disorder was recorded. No attempt was made to identify the pathogens responsible for fungal rotting.

Fruit mass (weight). Each fruit in the sample was weighed and the mean weight (g) was calculated.

Weight loss. The percentage of weight loss in stored samples was calculated from the difference between the weights prior to and subsequent to storage, inclusive of the 7-day period at 20°C.

Fruit size. Fruits were categorised according to their diameters as described for samples at harvest. An additional category was necessary for ex-store fruit (61-65 mm) presumably due to some shrinkage (weight loss) of fruit in store. The percentage of fruit in each of the 9 size categories was calculated for each 20-fruit sample.

Fruit firmness. Measurements were made according to the procedure described for samples at harvest.

Soluble solids concentration. Juice was extracted and soluble solids concentration measured as described for harvest samples.

Acidity. The juice extracted for measurement of soluble solids concentration (see above) was reserved for analysis of acidity using the method described for harvest samples

Internal disorders. Each fruit was cut at the calyx end and at the equator and examined for the presence of diseases and disorders. The number of fruits affected by rotting of the core was recorded. Physiological disorders affecting the fruit included senescent breakdown, bitter pit and core flush. The incidence of each type of disorder was recorded.

Statistical analysis

All data were subjected to an analysis of variance. Results of individual treatments and the mean effects of picking date and chemical treatments are given in the tables of results.

For simplicity the overall effects of picking date and chemical treatments on fruit size were omitted from the tables of results and significant effects of treatments are referred to in the text. The overall effects of picking date and chemical treatments can be compared using the standard errors of the difference between means (s.e.d.) and degrees of freedom (d.f.) given in the tables. The factorial nature of the chemical treatments allowed an assessment of the overall effects of harvest date, ReTain^R and surfactants. These effects will be commented on in the following section of the report. IEC data were transformed to \log_{10} prior to statistical analysis. For some disorders there were insufficient data to justify a formal statistical analysis. In these cases treatment means only are presented in the tables of results.

Results

Harvest evaluations (Tables 1-16)

There was insufficient evidence of cracking, skin darkening, scab, water core and external bitter pit in the harvested crop to justify statistical analysis. Apart from water core there were no internal physiological disorders in the fruit at harvest.

Effects of harvest date (independent of interactions with chemical treatments)

Delay in harvesting was associated with general progressive changes in a number of parameters although the differences between consecutive harvests were not always statistically significant. Generally there was a progressive increase in mean fruit weight and red colour index with later picking and a progressive reduction in fruit firmness, starch and acidity. There were no significant differences in mean fruit weight and acidity of fruits from the second and third harvests. Soluble solids concentrations were higher in fruit from picks 3 and 4 than in those from picks 1 and 2. Internal ethylene concentration (IEC) was at a minimum in fruit from the second pick but increased progressively thereafter. Contrary to expectations there were significant effects of harvest date on the incidence of russetting and lenticel damage. The incidence of russetting recorded at pick 2 was lower than at subsequent picks. Conversely, lenticel damage was significantly worse on fruit from pick 2 than on those from other picks. There was no significant effect of harvest date on the background colour of the fruit judged by comparison with colour cards.

There was a progressive reduction in the proportion of fruit in the smaller size ranges (71-75, 76-80mm) and an increase in the proportion of fruit in the larger size ranges (86-90, 91-95 and 96-100mm) with delay in harvesting. There was insufficient fruit in the lowest size range (66-70mm) and the highest size range (100+mm) to justify a statistical analysis.

Effects of ReTain^R treatments (independent of interactions with harvest date or surfactants)

The overall significant effects of ReTain^R application were to reduce IEC (1.28 to 0.76 \log_{10} ppb), acidity (12.9 to 12.7 mg kg⁻¹ malic acid) and soluble solids concentration (11.2 to 11.0%) and to increase greenness (1.2 to 1.1 card score) and starch content (5.5 to 5.0 on Ctifl chart). These effects are consistent with those expected since they show an effect of ReTain^R in slowing the rate of fruit maturation. However the magnitude of the effects of ReTain^R on fruit maturity parameters were small compared to those associated with harvest delay. There was a slight but significant effect of ReTain^R in reducing the overall

incidence of lenticel injury from 31.5 to 28.0%. ReTain^R treatment resulted in a higher proportion of fruit in the 76-80mm range and a lower proportion in the 91-95mm range.

None of the other harvest parameters were affected significantly by treatment with ReTain^R.

Effects of surfactants (independent of interactions with harvest date or ReTain^R treatments)

Both types of surfactant caused damage to the lenticels of the fruit. Overall ABG-7044 was more damaging than ABG-7011. Surfactant application resulted in a higher proportion of fruit in the 71-75mm size range.

Interactions between ReTain^R and surfactant treatments

Effects of these interactions on fruit firmness are confusing. Application of surfactants alone, reduced fruit firmness compared with no treatment. ReTain^R applied without surfactant or with ABG-7011 had no effect on firmness. However, ReTain^R in combination with ABG-7044 improved fruit firmness. Untreated fruit had the largest mean fruit weight (231g). This was reduced to an equivalent extent by the application of the two types of surfactant alone (214-219g) and by ReTain^R applied with (211-218g) and without surfactants (214g). There was no additive effect of ReTain^R and surfactants in reducing fruit size.

There were no other significant interactions.

Interactions between ReTain^R and harvest date

There were no significant interactions.

Interactions between surfactants and harvest date

There were no significant interactions.

Interactions between ReTain^R, surfactants and harvest date

There were no significant interactions.

Ex-store evaluations (Tables 17-31)

There was insufficient fruit in some of the size categories (61-65mm, 66-70mm and 100+mm) and insufficient incidence of rotting, core rots, corky core, core flush and senescent breakdown in fruits removed from storage to justify statistical analysis.

Effects of harvest date (independent of interactions with chemical treatments)

Delay in harvesting was associated with a progressive decline in greenness (more negative 'a' values) and acidity and a progressive increase in yellowness ('b' values) and soluble solids concentration. Fruits from pick 1 were smaller (lower mean weight) and firmer and developed a higher incidence of bitter pit than those from subsequent picks.

Samples from the first harvest comprised a higher proportion of fruits in the smaller size ranges (71-75 and 81-85mm) and a lower proportion in the larger ranges (86-90 and 96-100mm).

Effects of ReTain^R treatments (independent of interactions with harvest date or surfactants)

Fruit treated with ReTain^R were greener, less yellow, lower in soluble solids and developed less bitter pit than fruit that received no ReTain^R. There were other effects of ReTain^R that interacted with effects of picking date and surfactants (see below).

Effects of surfactants (independent of interactions with harvest date or ReTain^R treatments)

Fruit treated with either type of surfactant were firmer, greener and less yellow than fruits that received no surfactant. The overall effects of surfactants were highly significant. There was significantly less bitter pit in fruits treated with ABG-7044 than in fruits that received no surfactant.

Interactions between ReTain^R and surfactant treatments

ReTain^R in combination with either surfactant reduced significantly the internal ethylene concentration (IEC) in the fruit. Surfactants and ReTain^R applied alone had no effect on IEC. In comparison with no chemical treatment, ReTain^R applied without surfactant and ABG-7011 alone significantly reduced mean fruit weight.

Interactions between ReTain^R and harvest date

ReTain^R application improved the firmness of fruits from the first pick. IEC of fruits not treated with ReTain^R did not increase with harvest date, presumably these had reached their maximum rate of ethylene production. ReTain^R application reduced IEC in fruits from all picks and particularly in fruits from picks 1 and 2. ReTain^R application reduced the acidity in fruits from the final pick.

Interactions between surfactants and harvest date

There were no significant interactions.

Interactions between ReTain^R, surfactants and harvest date

There were no significant interactions.

Conclusions

Physical and chemical changes in the fruit that occurred with a delay in harvesting were generally in line with those expected. Fruit left on the tree continued to grow and develop red colour. They also increased their ethylene concentration (IEC) and became softer, higher in soluble solids (sugars) and lower in starch and acidity. Early harvesting is advised where long-term storage of fruit is required in order to achieve fruits from store that are sufficiently green and firm and are free of internal disorders such as low

temperature and senescent breakdown. Unlike in most dessert cultivars increased red coloration in Bramley apples that results from later picking has a negative impact on market quality. Early harvesting is likely to increase the risk of bitter pit and superficial scald. To offset the risk of bitter pit in store routine application of calcium sprays is advised and scrubbed low oxygen storage conditions such as 6% CO₂ + 2% O₂ and particularly 5% CO₂ + 1% O₂ are preferred. Scald is controlled by the post harvest application of diphenylamine (DPA). Currently risk of bitter pit and scald are not considered when picking date advice is formulated for Bramley apples.

The application of ReTain^R delayed the rate of fruit maturation on the tree as evidenced by a lower IEC, higher starch, lower soluble solids and increased greenness of the fruit. It follows that ReTain^R application provides the prospect of extending the picking period for long-term storage. This could be commercially beneficial given that many growers find it difficult to harvest sufficient quantity of fruit before the suggested finish dates that are prescribed for long-term storage.

A major negative effect of ReTain^R application that was found in a previous trial on Bramley in 1999 (see report prepared in May 2000 for Abbott Laboratories and APRC) was the damaging effect on the fruit. The factorial nature of the trial carried out in 2000 allows the separation of the effects of ReTain^R and surfactants. It is clear that ReTain^R itself is non-damaging to the fruit. However, both types of surfactant, and particularly ABG-7044, caused a serious amount of lenticel injury to the fruit. Consequently application of ReTain^R with these surfactants is unsuitable for Bramley's Seedling.

Whether or not the application of ReTain^R is worthwhile is dependent not only on its potential to extend the picking period but also on improvements in the storage quality of fruit. In this trial fruit was stored under the best CA conditions (5% CO₂ + 1% O₂) where the deterioration of fruit over a 6-month storage period was likely to be minimal.

The effects of delayed harvest on fruit quality at harvest were generally maintained during storage. Thus later picked fruit were less green, more yellow with higher soluble solids and lower acidity. Picking on 11 September as opposed to the 18 or 25 September improved fruit firmness although fruit size was reduced slightly and fruit developed a higher incidence of bitter pit. ReTain^R application improved the background colour (less yellow and more green) of stored fruit and reduced bitter pit. On the early harvested fruit ReTain^R application increased firmness although as expected soluble solids concentration in the fruit was generally reduced. It was interesting to note physiological effects on the stored fruit related to the application of surfactants. Both types of surfactant increased firmness of the flesh and increased greenness and reduced yellowness of the skin. ABG-7044 reduced the incidence of bitter pit. These data suggest that some of the beneficial effects of ReTain^R on these particular attributes were due partly to the surfactant used in the formulation. It can only be speculated whether the observed effects of the surfactants were due to subsequent applications of calcium sprays on 23 and 28 August (see Annex IV).

Recommendations

Overall the storage quality of the fruit from the orchard used in the study was good. This was expected in view of the heavy crop of moderately sized fruit (50% of the fruits were in the 81-90mm range). Smaller fruits are normally high in calcium and are generally more suitable for long-term storage. The overall levels of disorders were low and precluded an assessment of treatment effects on many of the physiological disorders that

typically affect Bramley apples. Unlike in the previous trial CO₂ injury did not develop on the stored fruit. This was undoubtedly due to the delayed establishment of CA conditions that is recommended where storage in 5% CO₂ + 1% O₂ is used for Bramley apples not treated with DPA. A major potential advantage of ReTain^R application is the control of scald in fruit stored for longer than 6 months in a CA regime of 5% CO₂ + 1% O₂. This is likely to be the limit for commercial fruit stored without prior treatment with DPA. In any future trials provision should be made for an examination of fruit after 6 months and a further examination after 9-10 months.

The primary concern about ReTain^R application to Bramley is the development of lenticel damage on the fruit. This was the main concern expressed in the report of the trial carried out in the previous year. It is clear from the 2000 trial that the surfactants are the cause of the damage and not ReTain^R itself. Clearly the damage problem needs to be resolved before any commercial evaluation of the beneficial effects of ReTain^R is made. Past work at East Malling to evaluate surfactants for post-harvest chemical treatments showed a range of responses in terms of efficacy and phytotoxicity and indicated that non-ionic surfactants such as 'Agral' were particularly acceptable for this purpose (Report of the East Malling Research Station for 1983, 148-9).

Once a non-damaging surfactant has been found for ReTain^R application on Bramley further work appears to be warranted on rates and timing of application. As stated in the previous report unlike dessert cultivars, Bramley is harvested commercially up to 5 weeks prior to the onset of the climacteric rise in respiration rate of fruit on the tree. For Cox and Bramley ReTain^R has been applied in about mid-August i.e. 4 weeks prior to anticipated harvest for untreated fruit. However in physiological terms Bramley apples are very unripe in mid-September compared to Cox. An application of ReTain^R much later than mid-August may be appropriate for Bramley.

Table 1. Ethylene. The effects of ReTain^R application and harvest date on the concentration of ethylene (log₁₀ parts per billion) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 0.099, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	1.07	0.68	1.49	1.83	1.27
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	0.71	0.32	0.93	1.28	0.81
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0.39	0.08	0.94	1.09	0.62
ReTain ^R 830g ha ⁻¹	None	0.75	0.28	1.11	1.23	0.84
None	ABG-7011 0.075% v/v	1.09	0.83	1.56	1.68	1.29
None	ABG-7044 0.075% v/v	1.05	0.43	1.91	1.73	1.28
Means (s.e.d. = 0.081, 115 d.f.)		0.84	0.44	1.33	1.47	

Table 2. Russetting. The effects of ReTain^R application and harvest date on the incidence of russetting (%) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 3.39, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	40.8	34.8	50.0	50.8	44.1
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	50.0	45.0	49.2	45.0	47.3
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	45.0	38.3	50.0	48.3	45.4
ReTain ^R 830g ha ⁻¹	None	37.5	40.0	45.8	48.3	42.9
None	ABG-7011 0.075% v/v	43.3	40.0	45.8	47.5	44.2
None	ABG-7044 0.075% v/v	49.2	44.2	46.7	51.7	47.9
Means (s.e.d. = 2.77, 115 d.f.)		44.3	40.4	47.9	48.6	

Table 3. Cracking. The effects of ReTain^R application and harvest date on the incidence of cracking (%) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	1.7	0	0	0	0.4
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	1.7	0.8	1.7	0	1.0
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0.8	0.8	0	0.8	0.6
ReTain ^R 830g ha ⁻¹	None	0	0	0	0.8	0.2
None	ABG-7011 0.075% v/v	0.8	0.8	0.8	0	0.6
None	ABG-7044 0.075% v/v	0.8	1.7	0.8	0	0.8
Means*		1.0	0.7	0.6	0.3	

*Insufficient data to justify statistical analysis

Table 4. Lenticel injury. The effects of ReTain^R application and harvest date on the incidence of lenticel injury (%) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 2.79, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	0.8	4.1	1.7	2.5	2.3
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	36.7	40.8	35.0	28.3	35.2
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	40.8	54.2	43.3	41.7	45.0
ReTain ^R 830g ha ⁻¹	None	1.7	5.8	5.0	3.3	4.0
None	ABG-7011 0.075% v/v	28.3	48.3	42.5	42.5	40.4
None	ABG-7044 0.075% v/v	43.3	58.3	55.0	50.0	51.7
Means (s.e.d. = 2.27, 115 d.f.)		25.3	35.3	30.4	28.1	

Table 5. Skin darkening. The effects of ReTain^R application and harvest date on the incidence of skin darkening on Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	0	0	0	0	0
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	0	0	0.8	0	0.2
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0	1.7	0	0	0.4
ReTain ^R 830g ha ⁻¹	None	0	0	0	0	0
None	ABG-7011 0.075% v/v	0.8	0.8	0	0	0.4
None	ABG-7044 0.075% v/v	0	0	0	0	0
Means*		0.1	0.4	0.1	0	

*Insufficient data to justify statistical analysis

Table 6. External bitter pit. The effects of ReTain^R application and harvest date on the incidence of external bitter pit (%) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	0	0	0	0	0
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	0	0.8	0	0.8	0.4
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0	0	0	0	0
ReTain ^R 830g ha ⁻¹	None	0	0	0	0	0
None	ABG-7011 0.075% v/v	0	0	0	0	0
None	ABG-7044 0.075% v/v	0	0	0	0	0
Means*		0	0.1	0	0.1	

*Insufficient data to justify statistical analysis

Table 7. Scab. The effects of ReTain^R application and harvest date on the incidence of scab (%) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	3.3	2.5	5.8	1.7	3.3
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	1.7	3.3	6.7	5.8	4.4
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	2.5	2.5	4.2	4.2	3.3
ReTain ^R 830g ha ⁻¹	None	0	1.7	5.0	0.8	1.9
None	ABG-7011 0.075% v/v	2.5	2.5	8.3	5.8	4.8
None	ABG-7044 0.075% v/v	5.0	1.7	1.7	3.3	2.9
Means*		2.5	2.4	5.3	3.6	

*Insufficient data to justify statistical analysis

Table 8. Background colour. The effects of ReTain^R application and harvest date on the background colour (1-green, 4-yellow) of Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 0.021, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	1.0	1.0	1.2	1.2	1.10
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	1.0	1.0	1.1	1.1	1.06
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	1.0	1.0	1.1	1.2	1.07
ReTain ^R 830g ha ⁻¹	None	1.0	1.0	1.1	1.1	1.06
None	ABG-7011 0.075% v/v	1.0	1.0	1.2	1.2	1.11
None	ABG-7044 0.075% v/v	1.0	1.0	1.2	1.2	1.09
Means (s.e.d. = 0.017, 115 d.f.)		1.00	1.00	1.18	1.16	

Table 9. Red colour. The effects of ReTain^R application and harvest date on the amount of red colour (max score of 100) on Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 1.06, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	72.7	79.1	76.0	81.8	77.4
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	77.5	76.3	75.2	79.0	77.0
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	75.8	77.5	78.5	80.3	78.0
ReTain ^R 830g ha ⁻¹	None	75.7	76.3	75.8	81.7	77.4
None	ABG-7011 0.075% v/v	75.7	79.5	79.2	83.3	79.4
None	ABG-7044 0.075% v/v	75.7	76.7	77.3	82.8	78.1
Means (s.e.d. = 0.87, 115 d.f.)		75.5	77.6	77.0	81.5	

Table 10. Average fruit weight. The effects of ReTain^R application and harvest date on the average weight (g) of Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 5.22, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	207.3	241.0	231.0	244.8	231.0
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	195.5	217.9	221.4	237.6	218.1
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	192.2	212.4	211.5	228.8	211.2
ReTain ^R 830g ha ⁻¹	None	194.6	217.9	214.6	230.6	214.4
None	ABG-7011 0.075% v/v	191.2	207.8	216.3	238.7	213.5
None	ABG-7044 0.075% v/v	198.7	217.1	220.3	240.7	219.2
Means (s.e.d. = 4.26, 115 d.f.)		196.6	219.0	219.2	236.9	

Table 11. **Fruit diameter.** The effects of ReTain^R (830g ha⁻¹) and surfactant (0.075% v/v) application and harvest date on the percentage of Bramley's Seedling apples in different size (mm diameter) categories. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

		Fruit diameter range (mm)								
		66-70	71-75	76-80	81-85	86-90	91-95	96-100	100+	
ReTain ^R	Surfactant									
Pick 1										
No	No	0	8.3	24.2	26.7	25.0	12.5	3.3	0	
Yes	ABG-7011	0	15.8	24.2	31.7	18.3	7.5	1.7	0.8	
Yes	ABG-7044	2.5	16.7	31.7	16.7	26.7	2.5	1.7	1.7	
Yes	No	1.7	9.2	33.3	28.3	17.5	8.3	1.7	0	
No	ABG-7011	5.8	14.2	18.3	32.5	20.0	7.5	0.8	0.8	
No	ABG-7044	3.3	9.2	25.8	27.5	22.5	8.3	3.3	0	
Pick 2										
No	No	0	0	9.9	32.1	22.3	19.9	10.8	5.0	
Yes	ABG-7011	0	7.5	23.3	25.8	20.0	12.5	5.0	5.8	
Yes	ABG-7044	0.8	9.2	18.9	30.5	20.7	12.5	4.1	3.3	
Yes	No	0	5.8	14.2	30.8	30.8	14.2	4.2	0	
No	ABG-7011	2.5	9.2	15.0	32.5	25.0	11.7	3.3	0.8	
No	ABG-7044	0	5.0	19.4	26.0	26.1	20.2	2.5	0.8	
Pick 3										
No	No	0	2.5	18.3	22.5	29.2	17.5	3.3	6.7	
Yes	ABG-7011	0	5.8	18.3	31.7	20.0	14.2	6.7	3.3	
Yes	ABG-7044	0	6.7	21.7	33.3	20.8	10.8	5.0	1.7	
Yes	No	0	0.8	20.8	34.2	30.8	10.8	2.5	0	
No	ABG-7011	1.7	10.8	11.7	26.7	31.7	11.7	4.2	1.7	
No	ABG-7044	0.8	2.5	20.8	30.8	25.0	10.8	7.5	1.7	
Pick 4										
No	No	0	0	7.6	23.4	30.9	21.6	12.5	4.1	
Yes	ABG-7011	0	0	10.8	24.0	33.1	21.3	6.7	4.1	
Yes	ABG-7044	0	2.5	15.0	30.3	26.9	17.7	2.5	5.0	
Yes	No	0	1.7	11.7	29.2	30.0	17.5	8.3	1.7	
No	ABG-7011	0	2.5	7.4	30.7	26.4	20.6	9.1	3.3	
No	ABG-7044	0	2.5	7.5	20	34.2	23.3	9.2	3.3	

Table 12. Firmness. The effects of ReTain^R application and harvest date on the firmness (N) of Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 0.61, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	83.1	77.8	77.1	73.7	77.9
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	81.2	78.3	75.9	72.7	77.0
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	83.5	78.1	77.2	74.0	78.2
ReTain ^R 830g ha ⁻¹	None	81.2	77.3	75.6	73.0	76.8
None	ABG-7011 0.075% v/v	79.9	77.2	75.0	72.0	76.0
None	ABG-7044 0.075% v/v	79.9	77.4	75.6	72.6	76.4
Means (s.e.d. = 0.50, 115 d.f.)		81.5	77.7	76.1	73.0	

Table 13. Soluble solids. The effects of ReTain^R application and harvest date on the concentration of soluble solids (%) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 0.084, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	11.1	11.0	11.5	11.5	11.25
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	11.0	10.8	11.4	11.2	11.09
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	10.9	10.6	11.4	11.3	11.03
ReTain ^R 830g ha ⁻¹	None	10.8	10.8	11.1	11.2	10.98
None	ABG-7011 0.075% v/v	11.0	11.2	11.5	11.5	11.28
None	ABG-7044 0.075% v/v	11.0	10.6	11.3	11.5	11.11
Means (s.e.d. = 0.069, 115 d.f.)		10.95	10.81	11.34	11.39	

Table 14. Titratable acid. The effects of ReTain^R application and harvest date on titratable acid concentration (g malic acid kg⁻¹) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 0.14, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	14.0	12.8	13.2	12.5	13.1
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	13.3	12.5	12.8	12.1	12.7
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	13.8	12.6	12.6	12.2	12.8
ReTain ^R 830g ha ⁻¹	None	13.8	12.5	12.5	11.9	12.7
None	ABG-7011 0.075% v/v	13.7	12.7	12.7	12.1	12.8
None	ABG-7044 0.075% v/v	14.0	12.6	12.7	12.3	12.9
Means (s.e.d. = 0.12, 115 d.f.)		13.8	12.6	12.8	12.2	

Table 15. Watercore. The effects of ReTain^R application and harvest date on the incidence of watercore (%) in Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	0.8	0	2.5	0	0.8
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	0.8	1.7	0	1.7	1.1
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0	0	0.8	0	0.2
ReTain ^R 830g ha ⁻¹	None	0.8	0.8	0	0.8	0.6
None	ABG-7011 0.075% v/v	2.5	0	0.8	0	0.8
None	ABG-7044 0.075% v/v	0.8	1.7	0	0.8	0.8
Means*		1.0	0.7	0.7	0.6	

*Insufficient data to justify statistical analysis

Table 16. Starch test. The effects of ReTain^R application and harvest date on the starch staining (1-black, 10-white) of Bramley's Seedling apples. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest				Means (s.e.d. = 0.19, 115 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	Pick 4	
None	None	3.6	4.4	5.9	7.2	5.3
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	3.9	3.6	6.0	6.8	5.1
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	2.8	4.3	5.6	6.6	4.8
ReTain ^R 830g ha ⁻¹	None	3.5	3.9	5.8	7.1	5.1
None	ABG-7011 0.075% v/v	4.8	4.2	6.7	7.4	5.8
None	ABG-7044 0.075% v/v	4.2	4.3	6.6	7.2	5.6
Means (s.e.d. = 0.16, 115 d.f.)		3.8	4.1	6.1	7.0	

Table 17. Ethylene. The effects of ReTain^R application and harvest date on the internal ethylene concentration (\log_{10} parts per million) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments					Means (s.e.d. = 0.057, 85 d.f.)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	2.25	2.26	2.25	2.25
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	1.61	1.64	1.98	1.74
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	1.61	1.73	1.94	1.76
ReTain ^R 830g ha ⁻¹	None	2.20	2.15	2.27	2.21
None	ABG-7011 0.075% v/v	2.39	2.30	2.30	2.33
None	ABG-7044 0.075% v/v	2.31	2.30	2.27	2.29
Means (s.e.d. = 0.040, 85 d.f.)		2.06	2.07	2.17	

Table 18. Background colour. The effects of ReTain^R application and harvest date on the background colour (Hunter 'a') in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments					Means (s.e.d. = 0.06, 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	-13.6	-13.3	-12.7	-13.2
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	-14.0	-13.7	-13.3	-13.7
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	-13.9	-13.6	-13.2	-13.6
ReTain ^R 830g ha ⁻¹	None	-13.7	-13.5	-12.9	-13.4
None	ABG-7011 0.075% v/v	-13.7	-13.4	-12.9	-13.3
None	ABG-7044 0.075% v/v	-13.7	-13.5	-12.9	-13.4
Means (s.e.d. = 0.04, 85 d.f)		-13.8	-13.5	-13.0	

Table 19. Background colour. The effects of ReTain^R application and harvest date on the background colour (Hunter 'b') in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments					Means (s.e.d. = 0.18, 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	29.2	29.8	30.1	29.7
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	27.8	28.7	29.2	28.6
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	28.2	29.1	29.3	28.8
ReTain ^R 830g ha ⁻¹	None	28.7	29.2	29.6	29.2
None	ABG-7011 0.075% v/v	28.5	29.2	29.7	29.1
None	ABG-7044 0.075% v/v	28.7	29.2	29.7	29.2
Means (s.e.d. = 0.13, 85 d.f)		28.5	29.2	29.6	

Table 20. Average fruit weight. The effects of ReTain^R application and harvest date on the average fruit weight (g) of Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments					Means (s.e.d. = , 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	204.3	223.2	225.5	217.6
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	193.1	212.9	212.5	206.2
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	185.6	210.3	205.9	200.6
ReTain ^R 830g ha ⁻¹	None	183.0	207.9	206.4	199.1
None	ABG-7011 0.075% v/v	190.5	203.3	207.3	200.4
None	ABG-7044 0.075% v/v	195.0	215.3	212.7	207.7
Means (s.e.d. = , 85 d.f)		191.9	212.2	211.7	

Table 21. Weight loss. The effects of ReTain^R application and harvest date on the weight loss (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means (s.e.d. = 0.09, 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	3.1	3.4	3.4	3.3
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	3.1	3.3	2.7	3.0
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	3.0	3.3	2.7	3.0
ReTain ^R 830g ha ⁻¹	None	3.2	3.2	2.9	3.1
None	ABG-7011 0.075% v/v	2.9	3.3	3.3	3.2
None	ABG-7044 0.075% v/v	2.9	3.0	3.3	3.1
Means (s.e.d. = 0.06, 85 d.f)		3.0	3.3	3.1	

Table 22. **Fruit diameter.** The effects of ReTain^R (830g ha⁻¹) and surfactant (0.075% v/v) application and harvest date on the percentage of Bramley's Seedling apples in different size (mm diameter) categories. Fruit was stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

		Fruit diameter range (mm)									
		61-65	66-70	71-75	76-80	81-85	86-90	91-95	96-100	100+	
ReTain ^R	Surfactant										
Pick 1											
No	No	0	0.8	10.2	11.8	32.9	22.6	15.0	5.0	2.5	
Yes	ABG-7011	0	1.8	12.7	14.3	41.5	11.1	14.4	1.8	2.5	
Yes	ABG-7044	0	2.5	15.0	17.5	36.7	19.2	9.2	0	0	
Yes	No	0	3.3	10.8	22.5	39.2	14.2	8.3	1.7	0	
No	ABG-7011	1.7	2.5	10.8	15.8	30.0	23.3	11.7	1.7	0	
No	ABG-7044	0.8	0.8	10.8	11.7	40.8	21.7	8.3	4.2	0.8	
Pick 2											
No	No	0	0	1.7	20.1	23.7	27.7	15.1	10.1	0.8	
Yes	ABG-7011	0	0.8	6.7	19.2	30.8	20.0	13.3	5.0	2.5	
Yes	ABG-7044	0	0	10.0	17.5	26.7	28.3	11.7	3.3	1.7	
Yes	No	0	0	6.7	20.9	28.9	31.0	11.6	0.8	0.9	
No	ABG-7011	0.8	0	10.0	21.7	28.3	27.5	5.0	5.8	0.8	
No	ABG-7044	0	0	8.3	17.6	29.5	24.4	13.5	5.9	0.8	
Pick 3											
No	No	0	0	2.5	13.3	34.2	27.5	14.2	1.7	5.8	
Yes	ABG-7011	0	0	4.3	24.0	27.9	27.2	12.5	4.2	0	
Yes	ABG-7044	0	0	9.2	24.2	25.8	28.3	8.3	4.2	0	
Yes	No	0	0	4.2	26.7	29.2	32.5	6.7	0.8	0	
No	ABG-7011	0	0.8	9.2	19.2	30.8	21.7	15.0	2.5	0.8	
No	ABG-7044	0	1.7	7.5	14.5	29.8	24.4	12.6	9.4	0	

Table 23. Firmness. The effects of ReTain^R application and harvest date on the firmness (N) of Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means (s.e.d. = 0.79, 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	50.7	46.2	46.9	47.9
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	60.5	51.1	47.7	53.1
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	61.2	49.8	48.0	53.0
ReTain ^R 830g ha ⁻¹	None	54.5	47.9	46.5	49.6
None	ABG-7011 0.075% v/v	52.8	50.5	51.4	51.6
None	ABG-7044 0.075% v/v	53.3	47.7	48.3	49.8
Means (s.e.d. = 0.56, 85 d.f)		55.5	48.9	48.1	

Table 24. Soluble solids concentration. The effects of ReTain^R application and harvest date on the soluble solids concentration (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means (s.e.d. = 0.11, 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	11.1	11.1	11.4	11.2
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	10.8	11.1	11.4	11.1
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	10.7	11.1	10.7	10.9
ReTain ^R 830g ha ⁻¹	None	10.6	11.1	11.4	11.0
None	ABG-7011 0.075% v/v	11.1	11.4	11.4	11.3
None	ABG-7044 0.075% v/v	11.1	11.3	11.7	11.4
Means (s.e.d. = 0.08, 85 d.f)		10.9	11.2	11.3	

Table 25. Acidity. The effects of ReTain^R application and harvest date on the titratable acidity (g malic acid kg⁻¹) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means (s.e.d. = 0.12, 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	10.3	9.5	9.8	9.8
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	9.9	9.7	9.3	9.6
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	10.0	9.8	8.7	9.5
ReTain ^R 830g ha ⁻¹	None	9.8	9.4	9.3	9.5
None	ABG-7011 0.075% v/v	10.1	9.4	9.6	9.7
None	ABG-7044 0.075% v/v	10.0	9.8	9.7	9.8
Means (s.e.d. = 0.09, 85 d.f)		10.0	9.6	9.4	

Table 26. Rotting. The effects of ReTain^R application and harvest date on the incidence of rotting (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	2.5	1.7	1.7	1.9
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	1.7	2.5	2.5	2.2
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0.8	2.5	0.8	1.4
ReTain ^R 830g ha ⁻¹	None	0	1.7	0	0.6
None	ABG-7011 0.075% v/v	0.8	0	0	0.3
None	ABG-7044 0.075% v/v	0.8	3.3	3.3	2.5
Means*		1.1	1.9	1.4	

*Insufficient data to justify statistical analysis

Table 27. Core rots. The effects of ReTain^R application and harvest date on the incidence of core rots (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	3.3	2.5	0	2.0
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	1.7	0	1.7	1.1
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	1.7	0.8	1.7	1.4
ReTain ^R 830g ha ⁻¹	None	1.7	2.5	0.8	1.7
None	ABG-7011 0.075% v/v	1.7	0.8	2.5	1.7
None	ABG-7044 0.075% v/v	2.5	0.8	0.9	1.4
Means*		2.1	1.3	1.3	

*Insufficient data to justify statistical analysis

Table 28. Internal bitter pit. The effects of ReTain^R application and harvest date on the incidence of internal bitter pit (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means (s.e.d. = 1.56, 85 d.f)
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	10.0	5.0	5.0	6.7
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	5.1	1.7	2.5	3.1
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0	0.8	0.8	0.6
ReTain ^R 830g ha ⁻¹	None	5.0	3.3	1.7	3.3
None	ABG-7011 0.075% v/v	12.5	3.3	4.2	6.7
None	ABG-7044 0.075% v/v	5.9	1.7	3.5	3.7
Means (s.e.d. = 1.10, 85 d.f)		6.4	2.7	3.0	

Table 29. Corky core. The effects of ReTain^R application and harvest date on the incidence of corky core (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	3.3	3.4	2.5	3.1
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	0.9	1.7	2.5	1.7
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	2.5	0.8	2.5	1.9
ReTain ^R 830g ha ⁻¹	None	5.0	0.8	1.7	2.5
None	ABG-7011 0.075% v/v	4.2	4.2	0.8	3.1
None	ABG-7044 0.075% v/v	2.5	2.6	2.6	2.6
Means*		3.1	2.3	2.1	

*Insufficient data to justify statistical analysis

Table 30. Senescent breakdown. The effects of ReTain^R application and harvest date on the incidence of senescent breakdown (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	0.8	1.7	2.5	1.7
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	0	0.9	0.8	0.6
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	0	0	0.8	0.3
ReTain ^R 830g ha ⁻¹	None	0	0	0	0
None	ABG-7011 0.075% v/v	0.8	1.7	0	0.8
None	ABG-7044 0.075% v/v	0	0	0.9	0.3
Means*		0.3	0.7	0.8	

*Insufficient data to justify statistical analysis

Table 31. Core flush. The effects of ReTain^R application and harvest date on the incidence of core flush (%) in Bramley's Seedling apples stored in 5% CO₂ and 1% O₂ at 4°C for 183 days followed by a further 7 days in air storage at 20°C. Dates for picks 1, 2, 3 and 4 were 11, 18 and 25 September and 2 October 2000 respectively.

Chemical treatments		Harvest			Means*
ReTain ^R	Surfactant	Pick 1	Pick 2	Pick 3	
None	None	0.8	0.8	0	0.6
ReTain ^R 830g ha ⁻¹	ABG-7011 0.075% v/v	2.6	6.0	0	2.9
ReTain ^R 830g ha ⁻¹	ABG-7044 0.075% v/v	1.8	0.8	0	0.9
ReTain ^R 830g ha ⁻¹	None	0	0	0	0
None	ABG-7011 0.075% v/v	0	0	0	0
None	ABG-7044 0.075% v/v	0	0	0	0
Means*		0.9	1.3	0	

*Insufficient data to justify statistical analysis