

Project Title: Breeding summer and primocane fruiting raspberries

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The results and conclusions in this report are based on investigations conducted over several years. The conditions under which the experiments were carried out and the results obtained have been reported with detail and accuracy in the Annual Reports each year and are summarised in this Final Report. 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 products recommendations.

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PRACTICAL SECTION FOR GROWERS

Commercial benefits

New varieties, adapted to local conditions and management systems, are essential to keep the UK raspberry industry competitive in an increasingly competitive world market. The Stage 0 trials carried out between 1994 and 2001, described in detail in the eight annual reports and summarized in this final report, have played an important role in the evaluation of advanced breeding lines produced at HRI-East Malling and their subsequent progress towards further trialling and release.

Background and objectives

The HDC project SF 8a has provided a vital link between the long-term raspberry breeding programme at HRI-EM and the raspberry industry. The raspberry development programme has been funded largely by MAFF and DEFRA commissions as follows:-

- HH1005SSF - To generate primocane and summer fruiting raspberry lines with improved agronomic features and high levels of resistance to pests and diseases.
1 April 1994 to 31 March 1997
- HH1014SSF - Genetic development of lines of primocane and summer-fruiting raspberries with improved pest and disease resistance.
1 April 1997 to 31 March 2000
- HH1028SSF - Genetic development of raspberry with improved pest and disease resistance.
1 April 2000 to 31 March 2003.

Industry funding has also been provided by the East Malling Trustees, subsequently known as the East Malling Trust for Horticultural Research (EMTHR), since 1994 for a related project entitled - Evaluating summer and primocane fruiting raspberries for agronomic characters. The main objectives of this project are to evaluate fruit quality in the seedling populations and to evaluate harvest season, growth habit, yield potential and all aspects of fruit quality in the propagated selections. All these evaluations are done in the field.

A smaller but critical part of industry funding came from HDC project SF 8a, which ran from April 1994 until October 2001. The main part of the HDC project involved collecting and entering data from the unreplicated breeder's trials at HRI-East Malling (known as the Stage 0 Trials). A number of summer and primocane fruiting selections are included in these trials where they are compared with the current industry standards. The aim of these trials is to identify possible future parents and to produce a short list of selections which are worthy of further trialling, based on the results collected over one to three seasons.

HRI-EM uses the HDC contribution to fund a sandwich student from April to September to assist the breeder in running the Stage 0 Trials, and other labour-intensive activities during the growing season.

Action Points for Growers

The Stage 0 data, which is collected by the HDC-funded student, plays an important role in deciding which selections should progress further, which should be used as parents and which should be discarded. On the basis of their performance over one to three years in the Stage 0 trials, and the breeder's field records, the breeder decides which selections are worthy of further evaluation by the industry. As trialling is so expensive it is vital that only the best go on to industry-funded trials. Selections from HRI progress to different trials, as follows:-

- Replicated trials funded by the HDC and managed by ADAS on grower farms
- Non-replicated observation plots on grower farms, organized by Meiosis Ltd
- Non-replicated machine harvesting trials at the Scottish Crop Research Institute (SCRI), Dundee
- Overseas trials

Replicated trials of summer fruiting (SF) selections from the HRI and SCRI programmes were planted in HDC SF Trial 1 at Thursley, Surrey, in 1996 and 1997 (HDC project SF 41). A smaller version of this trial was also planted in Perthshire, Scotland but much less data has been collected from this site. The HDC have held Open Days at the Surrey trial each year since 1998 and many growers have taken the opportunity to see the new selections and compare them with the industry standards. The trial has now finished and two HRI selections were recommended for release, 5928/114, which is late ripening, good colour and has very good shelf life and 6166/98, which is early ripening, has good quality fruit and a very good habit.

Replicated trials of primocane fruiting (PF) selections from HRI and Medway Fruits Ltd. were planted in HDC PF Trial 1 in 1996 at Chivers Farm, Impington, Cambridge (HDC project SF 41). Again, Open Days were held in 1998 and 1999 and interested growers took the opportunity to see the trial entries and some of the new varieties from overseas which were included as guards. None of the selections or overseas varieties were considered superior to Autumn Bliss. Joan Squire was severely damaged each year by grazing mammals and produced very little fruit and its performance in this trial was no guide to its potential performance. The yellow-fruited selection, 6220/70, was promising for niche marketing.

Since 1996, a number of selections have been identified each season, propagated the following winter and transferred to Meiosis Ltd. In total, 27 SF and 5 PF selections have been identified for Meiosis Farm Trials. Propagator members of Meiosis Ltd undertake further propagation prior to planting unreplicated grower trials in different regions in England. The first Meiosis trials were planted in July 1999 in Kent, Surrey, Oxford and Worcester and produced a small amount of fruit in 2001. More trials were planted in 2000 in Oxford and Hereford. Interested growers should contact Meiosis Ltd and arrange to visit the trials in their area when they are cropping.

Between 1997 and 1999 eleven SF selections have been sent to SCRI for inclusion in their machine harvesting trials. To date, six selections have been harvested by machine, some have performed well and all the HRI selections have been notable for their medium red, bright colour.

Seven PF selections were sent to Belgium for glasshouse production trials in 1998 and two selections (6471/98 and 6481/17) have been the most promising to date. The yield of 6471/98 is lower than that of Autumn Bliss but the fruit is bright, uniform in size and shape and the flavour is good. 6481/17 had a similar yield as Autumn Bliss and the fruit was a good colour, firm and the shelf life was good. 6471/98 has been sent to Meiosis for farm trials, but unfortunately 6481/17 has become infected with raspberry bushy dwarf virus (RBDV).

The HDC have agreed to fund another SF trial and six HRI selections have been suggested as main trial entries, plus another four selections as guards. It is proposed that this trial will be planted in summer 2002 in Oxford.

Anticipated practical and financial benefits

New varieties are vital to the raspberry industry and the HDC project SF 8a is one link in the HRI raspberry breeding and release chain. Six new varieties are in the pipeline which have been identified since SF 8a began in 1994. Two summer fruiting types, 5928/114 and 6166/98, have been recommended for release on the basis of their performance in HDC SF Trial 1 in Surrey. An apricot SF selection, 6432/71, is going ahead, largely for the amateur market, on the basis of its performance in the Stage 0 trials at East Malling in 1997 and 1998. A very late selection, 6512/50, was identified in the Stage 0 trials in 1999 and 2000 and is being micro-propagated for large scale commercial trials prior to release. A yellow PF selection, 6220/70, and an apricot PF selection, 6378/47, are being propagated for niche marketing following their performance as guards in the HDC PF Trial 1 in Cambridge.

Many more HRI selections are currently being propagated for trial or are planted but will not produce a full crop until 2002 or 2003. The new varieties and the potential new varieties from the HRI programme will give the growers a choice of varieties in the future and hopefully the flexibility to choose different varieties for different growing systems and thereby supply a range of markets with quality fresh raspberries over a long season.

INTRODUCTION

Both the UK and the world raspberry markets have changed greatly in the last decade and the UK needs new, improved varieties more than ever to sustain raspberry production in this country. The future of the UK raspberry grower is with the fresh market and fruit quality is of paramount importance. The majority of the fresh raspberries grown in the UK are sold via the major multiples (Sainsbury's, Tesco, Waitrose, Marks & Spencer, Safeway and ASDA) and most of this fruit is marketed through three marketing organizations - Kentish Garden, BerryWorld and American Fruit Importers.

When this project started in 1994 the most widely grown varieties were Glen Moy, Glen Prosen, Leo and Autumn Bliss but in the last few years Glen Ample and Tulameen have been widely planted. The multiples have indicated their preference for Glen Ample and Tulameen and many growers are increasingly relying on these two varieties. Several of the multiples have de-listed Glen Moy, Glen Prosen, Leo and Autumn Bliss and growers with young, productive plantations of these varieties will find it increasingly difficult to sell their fruit for a good price.

Glen Ample and Tulameen produce high yields of very good quality fruit but they are susceptible to all the major pests and diseases which affect raspberries and ripen at a similar time. Both are vigorous varieties, which produce tall new canes and very long laterals and are not particularly well suited to growing under protection. UK growers need new varieties with the quality and yield of Glen Ample and Tulameen but with better pest and disease resistance, a wider range of ripening seasons and better growth habit for protected cropping.

Many growers in Scotland are picking by machine for the processing market but they are facing increasing competition from Serbia, Poland and Hungary. Suitability for mechanical harvesting is no longer a primary objective of the breeding programme at HRI but selections which appear to have mechanical harvesting potential are identified and sent for trial at the Scottish Crop Research Institute (SCRI), Dundee.

Potential new SF and PF varieties are being produced in the raspberry breeding programme at HRI, East Malling and the main aim of this project was to identify which breeding lines had the greatest commercial potential.

MATERIALS AND METHODS

Each year there are up to 250 summer fruiting (SF) and primocane fruiting (PF) selections growing as single 10-plant plots in the breeding plots at HRI but we do not have the resources to pick all the fruit. Some selections are breeding lines with known good and bad attributes or specific resistance genes and generally these are not picked. Selections which are producing a full crop for the first time and which look good in the field prior to the start of harvest are included in the Stage 0 trials. In the following year some of these selections are picked for a second or third time, while other younger selections are picked for the first time. Each year promising seedlings are identified during the fruiting season and propagated during the following winter to produce the 10-plant plots.

Each season the poorest selections are discarded on the basis of their field performance and the results from the Stage 0 trials. It is a continuous process and every year there are different selections included in the Stage 0 trials. Selections that have produced low yields or have had serious defects are rejected after one season, while the more promising selections are picked for two or three seasons. Very promising selections can be put forward after one year in the Stage 0 trials but are often picked a second or third time to confirm their earlier promise.

Each year a small number of named varieties are picked as controls and ideally early, midseason and late ripening SF controls plus early and midseason PF controls are included. Named varieties are planted at intervals in the breeding plots and variety plots of an equivalent age and vigour are chosen as the controls. Between 1994 and 2001 the number of genotypes included in the Stage 0 trials each year has ranged from 46 to 77 (Table 1) and the varieties used as the controls has changed as the varietal make-up of the industry has changed (Table 1).

Malahat was used as the early SF control in 2000 and 2001 because the plots of Glen Moy had died over-winter in the previous two very wet winters. Autumn Bliss and Polana have been included as the early and midseason PF controls, respectively, each year. Joan Squire was included for the first time in 1999 but the unsprayed plot at HRI has not grown well and it was so poor in 2000 that it was not picked.

Table 1. The number of summer and primocane fruiting selections included in the Stage 0 trials from 1994-2001 and the controls used each year

Year	Number of SF selections	SF controls	Number of PF selections	PF controls
1994	31	Leo, Augusta	34	Autumn Bliss, Polana
1995	42	Julia, Leo	29	Autumn Bliss, Polana
1996	48	Julia, Glen Ample, Leo, Gaia	24	Polana
1997	37	Julia, Glen Ample, Leo, Gaia	20	Autumn Bliss, Polana, Terri-Louise, Heritage
1998	52	Glen Ample, Tulameen, Leo	15	Autumn Bliss, Terri-Louise, Heritage
1999	42	Glen Moy, Glen Ample, Tulameen	16	Autumn Bliss, Polana Joan Squire
2000	47	Malahat, Glen Ample, Tulameen	30	Autumn Bliss, Polana
2001	27	Malahat, Glen Ample, Tulameen	19	Autumn Bliss, Polana Joan Squire

All selections and controls were picked twice a week from the first ripe fruit to the last ripe fruit. In some years very wet and windy weather in September meant primocane picking stopped prematurely. This meant that the recorded yield was lower than the potential yield and biased the yield figures in favour of the earlier ripening types. The 10-plant plots were approximately 5.0m long but it took too long to pick the whole plots. A reasonably good growing, representative sample of each plot, between 1.0 and 3.0m in length, was marked off with tape and only this section of the plot was picked and recorded. When the data was summarized all the yield data were converted to kg/10m of row so that the selections could be compared. However the yield data cannot be analysed statistically because there is no replication in the field.

All the fruit was picked and classified into marketable and unmarketable by the pickers in the field. The following records were taken at each pick:-

1. Weight of marketable fruit in grammes
2. Weight of unmarketable fruit in grammes
3. Weight of 50 marketable fruits in grammes

Nine fruit quality attributes were recorded at each pick, provided there were at least 25 marketable fruits, and graded on a 1 - 5 scale (Table 2).

Table 2. Fruit quality attributes graded on a 1-5 scale

Redness				
5	4	3	2	1
Pale	fairly pale	medium	dark	very dark
Brightness				
5	4	3	2	1
very bright	bright	medium	dull	very dull
Shape				
5	4	3	2	1
long conical	conical	blunt conical	roundish	round
Outline				
5	4	3	2	1
very even	even	medium	irregular	very irregular
Uniformity of size				
5	4	3	2	1
very uniform	uniform	medium	variable	very variable
Texture				
5	4	3	2	1
very firm	firm	moderate	soft	very soft
Cohesion				
5	4	3	2	1
all whole	mostly whole	a few crumbly	crumbly	very crumbly
Skin strength				
5		3		1
none broken		1, 2 or 3 out of 5 broken		4 or 5 broken
Flavour				
5	4	3	2	1
very good, aromatic, strong raspberry flavour	good	slightly acid, moderate, bland	poor, acid, weak	very poor, very acid, foreign, no raspberry flavour

For skin strength, the skin of five fruits was rubbed gently five times and the number of fruits where the skin had ruptured was noted. For most attributes the higher the score the better but the shape score is descriptive and all shapes, except long conical, are probably acceptable. Moderately conical is fine but very conical fruit can be difficult to plug and can leave the tip of the plug inside the cavity.

The yield data was used to calculate the accumulative percentage of the total crop picked at each pick and from this information the 5, 50 and 95% pick dates were calculated. Each season varies depending on the weather and the calendar dates for 5, 50 and 95% pick varied by more than two weeks between years. However by comparing the selections with the controls it was possible to identify SF selections which were consistently earlier than Glen Moy or Malahat, or later than Leo and PF selections which were earlier or similar in season to Autumn Bliss.

RESULTS AND DISCUSSION

Much of the Stage 0 data was collected by a sandwich course student employed each summer and detailed results of the summer fruiting selections were presented in the SF 8a Annual Reports each year. However the reporting deadline of 31 October meant that the data from the primocane fruiting selections was not included. The PF selections are often still being picked when the student returns to university and the data were not summarized until November/December each year.

1. Yield

Yield varies from year to year and the yield figures only gave an estimate of yield potential. When picking from such a small and non-replicated area a particularly good stool can inflate the yield while a few poor or dying canes can drastically lower the yield. The variation in yield in the control varieties is illustrated in Table 3 and it is obvious that some varieties were much more variable than others.

Table 3. Total yield (kg/10m row) in the control varieties, in descending order of ripening season, from 1994-2001

Variety	1994	1995	1996	1997	1998	1999	2000	2001
Summer fruiteders								
Glen Moy						20.3		
Malahat		26.6	30.9				27.8	19.4
Julia		42.0	22.6	39.9				
Glen Ample			45.9	33.3	34.7	36.1	89.2	51.0
Tulameen					51.8	41.1	62.2	49.8
Leo	24.7	26.1	34.7	24.0	27.0			
Augusta	42.6							
Gaia			51.5	15.1				
Primocane fruiteders								
Autumn Bliss	26.8	23.3		33.9	9.3	17.6	17.3	17.3
Polana	25.0	19.0		51.6		33.7	29.0	25.6
Joan Squire						24.8		19.4
Terri-Louise				62.1	12.4			
Heritage				28.14	3.4			

The controls are chosen so that the control plants are the same age as the majority of the selections under test. From 1996-1999 Glen Ample produced, on average, 37.5 kg/10.0m row and between nine and 29 selections out-yielded it per year during this period. In 2000 Glen Ample produced an exceptional yield from a new plot which had been planted in March 1998 and out-yielded all the selections.

Glen Moy was severely damaged by frost in 1997 and sufficiently damaged in other years for the yield and ripening season to be unrepresentative of the variety and so it was not picked. It has barely survived the recent very wet winters and a new plot

planted in late spring 2001 has not established well. Glen Moy and Malahat have not produced high yields in the Stage 0 trials and very early or early selections with moderate yields are worth trialling further because the industry needs a new early variety to replace Glen Moy. Similarly several late and very late selections have failed to out-yield Glen Ample but have produced higher yields than Leo, Gaia and Augusta.

Autumn Bliss produced 20.8 kg/10m row /year on average over the period 1994-2001 while Polana produced 29.9 kg/10m row/year averaged over six years. Joan Squire out-yielded Autumn Bliss in 1991 and 2001 but produced less fruit than Polana. Terri-Louise produced an exceptionally heavy crop in 1997 but this was from a very small plot and the yield (from the same plot) in 1998 was drastically reduced and neither figure is reliable. In 1996 primocane growth was very poor and the yield data was not collected, only fruit quality records were taken. 1998 was another poor year when the yields were very low and these years illustrate the huge year to year variation recorded. However in all years there were selections which out-yielded Autumn Bliss, Polana or Joan Squire so there is scope for improvement in PF yield. The following numbers of selections out-yielded Autumn Bliss - 15 in 1994, 3 in 1995, 8 in 1997, 15 in 1998, 12 in 1999, 24 in 2000 and 7 in 2001.

The Stage 0 trials are picked twice a week and so the proportion of unmarketable fruit (which is mainly over-ripe fruit) is much higher than it would be on a good commercial farm that was picking at least every other day. The total yield gives a better indication of the yield potential than the marketable yield. The yields of the selections were compared with that of the controls and selections which produced much lower yields than the control of a similar season were dismissed as trial entries.

2. Fruit quality

Quality attributes were scored on a 1-5 scale where 5=good and 1=poor and selections which average less than 2.5 for any quality attribute are unlikely to be commercial but average quality scores can mask a wide variation between picks. Selections which are graded 1 for any attribute (except shape) on any occasion are rejected. Selections which are graded 2 on two or more occasions are generally rejected but if they are good for most attributes they may be looked at again.

Redness - on the redness scale 1 and 2 are too dark while 3, 4 and 5 are all acceptable. Glen Ample, Glen Moy, Julia and Tulameen were all medium red, all were graded 2 occasionally but the overall scores ranged from 2.9- 3.3. Leo, Malahat, Augusta and Gaia were too dark, especially Gaia. Many SF selections were too dark but some of them were backcrosses from very dark-fruited species so this was not surprising. The average scores for redness for Autumn Bliss, Polana and Joan Squire were 2.6, 2.6 and 2.8, respectively and all were considered slightly too dark on occasions. There were several PF selections which were paler red than the controls and some which were darker than Autumn Bliss, which were unacceptable.

Brightness - on the brightness scale 1 and 2 are too dull and the higher the score the better. Malahat, Tulameen and Glen Ample had the brightest fruit of the controls and Glen Moy, Julia and Augusta were too dull. The colour of Glen Ample and Tulameen are considered good by the market and it is unlikely that very dull raspberries would be

acceptable to the market. A range of redness is still acceptable given that the fruit is reasonably bright. SF selections with pale red, very dull fruit look very unattractive and have been rejected. Polana was consistently bright (4.1), Joan Squire was moderately bright (3.3) and Autumn Bliss was slightly duller (2.9). Many PF selections were brighter than Autumn Bliss but unfortunately some of these were too crumbly.

Shape - the majority of SF selections were scored 2-4, from roundish to conical where as the PF selections were scored 2-3, roundish to blunt conical. Only Terri-Louise and a few PF selections were conical. The actual shape is less important than the regularity of outline and the shape of the collar. Extremely long conical fruit often do not plug readily and seedlings with hairy plugs or plugs that break as the fruit is picked are discarded in the seedling population.

Regularity of outline - very few SF selections were judged irregular or very irregular in outline on any occasion. Irregularity in fruit outline is one of the major selection criteria in the seedling population and in the early cropping years of the 10-plant plots. The absence of irregularity in the Stage 0 SF selections is a reflection of earlier and continuing selection for a smooth, regular outline regardless of the actual fruit shape. Autumn Bliss varied from year to year and in 1998 and 1999 it was the most irregular of the PF types. Polana was more regular in outline than Autumn Bliss and several selections were more regular than Polana. The few SF and PF selections which were recorded as irregular in the Stage 0 trials were usually found to have become infected with RBDV that year and discarded.

Uniformity of size - Fruit in the punnet is more attractive if it is reasonably uniform in size. Small fruited types tend to be more uniform in size and the greatest range in size is seen in very large fruited types. It is possible to get fruit weighing 6.0-7.0g in the same punnet as fruits weighing 2.0-3.0g, which can look like a mixture of genotypes. Although uniformity is desirable, fruit size is much more important and the larger the fruit the greater likelihood there is of a range of sizes at any one pick.

Texture - Texture is notoriously difficult to judge subjectively and consistently, and it is the fruit characteristic that the students have the greatest difficulty in recording. Texture measuring instruments have been tried but not successfully and we have persevered with the fingers and thumb approach. The overall mean texture scores for the main controls corresponded with the general industry opinion that Glen Ample (3.7) is slightly firmer than Tulameen (3.4) and that Leo is too soft (2.4). Many selections were dismissed because they were too soft and very few were consistently firm. Texture was considered very important and several SF selections which were firmer than Glen Ample were progressed to further trials, some for hand picking and the smaller-fruited firm selections for machine picking.

The PF material was generally softer than the SF material and texture is one important aspect of fruit quality where the summer fruited are superior to the primocane fruited. In several years all the PF selections were considered too soft but some were softer than others. The overall mean texture scores for Autumn Bliss, Polana and Joan Squire were 2.7, 2.8 and 3.2, respectively. Heritage was the firmest of the controls and there were very few selections that were as firm as Heritage.

Cohesion - the majority of SF selections had mean cohesion scores of more than 4.0 and reflects prior rigorous selection in the seedling population and propagated selections. A few PF selections were moderately crumbly in the early years (mostly very bright, roundish fruit) and some of these subsequently indexed positive for RBDV and were discarded.

Skin strength - initially the students were often nervous of scoring this characteristic but with practice they learnt to apply similar pressure to each fruit. Most SF selections were rated weak or moderately weak skinned on two or more picks but there were some selections with consistently strong skins. The overall mean skin strength scores for Glen Ample, Tulameen and Leo were 3.8, 4.0 and 2.4, respectively. Several SF selections which had stronger skins than Glen Ample in two years went forward for trial, mainly for hand picking but a couple for machine harvesting trials.

The overall mean skin strength scores for Autumn Bliss, Polana and Joan Squire were 3.0, 3.4 and 3.7, respectively. Between 1994 and 1997 the fruit of most of the PF selections had soft skins but after 1999 the proportion with strong skins had increased.

Flavour - very few samples were rated very good (5) for flavour and few SF varieties or selections were scored 4 or 5 on every pick. However, each year there were at least some SF selections that were always scored 3 or higher and the numbers of good-flavoured selections are given in Table 4. The overall mean flavour scores of Glen Ample, Tulameen and Leo were 3.4, 3.7, and 3.1 respectively, indicating that in these trials Glen Ample and Tulameen were both preferred to Leo and that Tulameen was preferred to Glen Ample.

Table 4. Mean flavour scores of the SF controls and their ranking each year, plus the number of good-flavoured SF selections recorded each year from 1994 to 2001

	1994	1995	1996	1997	1998	1999	2000	2001
No.of genotypes picked/year	31	42	48	37	52	44	47	27
Glen Moy						3.0 ^{10th}		
Malahat		2.9	2.9				3.4	3.1
Julia		3.3	3.4 ^{2nd}	3.4				
Glen Ample			2.7	3.6 ^{2nd}	3.4 ^{5th}	3.3 ^{4th}	3.7 ^{3rd}	3.7 ^{2nd}
Tulameen					3.4 ^{6th}	3.4 ^{2nd}	3.8 ^{2nd}	4.0 ^{1st}
Leo	4.3 ^{1st}	3.2 ^{8th}	2.8	2.6	2.8			
Augusta	1.4 ^{31st}							
Gaia			3.1 ^{7th}	3.2 ^{4th}				
No.of good-flavoured selections *	13	8	10	3	8	8	15	6

* Good-flavoured selections were always scored 3.0 or higher, moderate to very good, they were never rated poor or very poor

In general, the flavour of the PF varieties and selections was inferior to that of the SF types and this is another serious defect in the PF material which the breeding programme is trying to address. It is partly genetic but partly environmental and a result of the fruit ripening later in the season when there is not enough sunshine to produce the necessary sugars. The overall mean flavour scores for Autumn Bliss, Polana and Joan Squire were 2.8, 3.0 and 2.3, respectively (all lower than the SF controls) and the annual mean flavour scores are given in Table 5.

Table 5. Mean flavour scores of the PF controls and their ranking each year from 1994 to 2001

Variety	1994	1995	1996	1997	1998	1999	2000	2001
Autumn Bliss	3.4 ^{2nd}	2.9		3.4 ^{1st}	2.5	2.6 ^{7th}	2.8	2.3
Polana	3.2 ^{6th}	3.1 ^{3rd}	3.1 ^{4th}	2.9 ^{4th}		2.6 ^{6th}	3.4 ^{2nd}	3.0 ^{1st}
Joan Squire						2.5 ^{8th}		2.0
Terri-Louise				3.2 ^{2nd}	2.7 ^{4th}			
Heritage				2.8	2.8 ^{2nd}			

The PF selections were mostly rated poor in 1994-1999, but a few selections were rated moderately good in 2000 and 2001. No PF selections were always scored 3 or higher and on at least some occasions all the PF selections were rated poor or very poor.

Flavour is very subjective and varies between individuals. Some of the students had eaten very few fresh raspberries before coming to HRI and had their own personal preferences. The flavour scores from the Stage 0 trials were looked at in conjunction with the breeder's field notes and the opinions of others in the fruit industry who ate fruit in the field during the season. Most of the selections that have gone forward for trial were ranked in the top quarter for flavour, although with the PF material this still did not mean they were considered to have a particularly good flavour.

3. Season of ripening

The yield data collected was used to calculate the 5, 50 and 95% pick dates and the earliest and latest ripening SF selections are shown in Table 6. There is greatest industry interest in early ripening varieties to replace Glen Moy and in varieties that are significantly later than Glen Ample and Tulameen.

Table 6. Early and late ripening SF selections identified in the Stage 0 trials between 1994 and 2001

Year	50% pick date >5 days earlier than Glen Moy	50% pick date >5 days later than Leo
1994		5802/22, 6310/123, 6310/126, 6338/18
1995	6305/12, 6389/96, 6390/47, 6399/84	5958/28, 5958/41, 6309/142, 6310/123, 6343/14, 6343/15, 6343/21, 6346/154
1996	6389/86, 6390/47, 6390/66, 6399/7	5958/28, 5958/41, 6343/15, 6343/21, 6384/66
1997	6425/37, 6432/71, 6451/120	6226/37, 6384/66, 6385/1, 6425/86, 6427/62, 6428/1, 6428/77, 6429/82, 6430/112, 6432/32
1998	6482/128, 6488/122, 6489/10, 6489/128	6428/1, 6428/10, 6454/76, 6456/12
1999	6504/11, 6511/12	6495/38, 6512/50, 6513/53
2000	6544/6	6495/58, 6512/50, 6560/17
2001	6541/24, 6544/80	6558/78, 6558/83

Autumn Bliss and Polana were fairly similar in ripening season in most years and the 50% pick dates are given in Table 7. Joan Squire was a few days later than Autumn Bliss while Terri-Louise and Heritage were a month later. Each year there were a number of selections which were earlier ripening than Autumn Bliss. Some were a few days earlier but some were more than a week earlier (early and very early in Table 7). Some UK growers want PF varieties earlier than Autumn Bliss to grow in the open field but other growers are more interested in better quality fruit than earliness and are able to protect midseason/late PF crops for later production.

Table 7. Numbers of early and very early ripening PF selections identified in the Stage 0 trials from 1994-2001

Year	50% pick date (August)		No. selections earlier than Autumn Bliss	No. of very early selections
	Autumn Bliss	Polana		
1994	20	30	8	7
1995	15	18	14	10
1997	18	20	9	4
1998	22		2	
1999	20	20	6	3
2000	28	20	12	6
2001	26	22	14	9

4. Selections identified for further trial

Since 1994, 35 SF and 15 PF selections have been identified as worthy of further trial and these are listed in Tables 8 and 9. The decision to trial these individuals further was based on the breeder's field notes, the Stage 0 results and discussion with representatives of the raspberry industry. The MAFF Raspberry Steering Group was founded in 1998 and at the annual summer meeting many of these selections have been put in front of growers, advisors and soft fruit technologists from the major multiples. The project coordinator, David Heaton, has also visited in late August and eaten the PF selections in the field. Detailed descriptions of all these selections have been sent to interested parties.

After a selection has been identified at HRI the timescale for planting the next trials varies depending on where the material is going. HDC trial entries and guards were propagated at HRI from roots lifted during the winter and pot canes supplied to the grower site in July. Machine harvesting types are lifted from the breeders plots and dormant roots sent to SCRI during the winter. SCRI then produce sufficient plants to establish a single plot in the machine harvesting plots. Sometimes propagation from roots has gone well and the plots were planted within 9 months and these selections can be harvested two seasons later. Other selections have not propagated readily from roots and the few plants produced initially have been re-propagated the following year. Out of the 12 machine harvesting selections sent to SCRI since winter 1996/97, five were harvested by machine for the first time in 1999 and a sixth selection was picked for the first time in 2001.

Table 8. Summer fruiting lines selected for further trial between 1994 and 2001

Selection	Included in Stage 0 trials	Year selected	Trial destination	Year planted in trial
5795/93	1994	1994	HDC SF Trial 1	1996
6166/98	1994	1994	HDC SF Trial 1	1996
6312/5	1994, 1997	1996	SCRI machine harvesting trial	1997
		1996	Meiosis farm trials	1999
6312/66	1994, 1995	1996	SCRI machine harvesting trial	
6346/142	1994 - 1996	1996	SCRI machine harvesting trial	1997
6346/154	1994, 1995	1996	SCRI machine harvesting trial	1997
6346/174	1995 - 1997	1996	Meiosis farm trials	1999
6347/40	1995, 1996	1996	SCRI machine harvesting trials	1997
6390/47	1995, 1996	1996	Meiosis farm trials	1999
6396/46	1995, 1996	1996	SCRI machine harvesting trials	
		1996	Meiosis farm trials	1999
6399/84	1995, 1996	1996	SCRI machine harvesting trial	1997
		1996	Meiosis farm trials	
6413/59		1996	Meiosis farm trials	1999
6226/37	1997	1997	SCRI machine harvesting trial	
6385/1	1997	1997	Meiosis farm trials	2000
6414/14		1997	Meiosis farm trials	2000
6432/71	1997, 1998	1997	Meiosis farm trials	2000
6448/10	1997, 1999	1997	Meiosis farm trials	2000
6455/72	1998	1997	SCRI machine harvesting trial	
6166/98	1994	1998	SCRI machine harvesting trials	
6428/1	1996 - 1998	1998	Meiosis farm trials	
6429/6	1996 - 1998	1998	Meiosis farm trials	
6487/74	1998 - 2000	1998	Meiosis farm trials	2000
6490/95	1998, 2000	1998	SCRI machine harvesting trial	1999
6507/56	1999	1998	Meiosis farm trials	
6508/135	1999	1998	Meiosis farm trials	2000
6428/80	1996, 1998	1999	Meiosis farm trials	
6505/7	1999, 2000	1999	Meiosis farm trials	
6506/37	1999, 2000	1999	Meiosis farm trials	
6514/53	1999	1999	Meiosis farm trials	
6495/53	2000	2000	Meiosis farm trials	
6495/58	2000	2000	Meiosis farm trials	
6507/35	1999, 2000	2000	Meiosis farm trials	
6215/20	1999, 2000	2000	Grower trials	
6385/1	1997	2001	HDC SF Trial 2	
6390/47	1995, 1996	2001	HDC SF Trial 2	
6413/59		2001	HDC SF Trial 2, guard	
6428/1	1996 - 1998	2001	HDC SF Trial 2	
6487/74	1998 - 2000	2001	HDC SF Trial 2, guard	
6506/37	1999, 2000	2001	HDC SF Trial 2	
6507/35	1999, 2000	2001	HDC SF Trial 2, guard	
6512/50	1999, 2000	2001	HDC SF Trial 2	
6544/80	2001	2001	HDC SF Trial 2, guard	
6545/12	2001	2001	HDC SF Trial 2	

Table 9. Primocane fruiting lines selected for further trial between 1995 and 2000

Selection	Included in Stage 0 trials	Year selected	Trial destination	Year planted in trial
6251/39	1994	1995	HDC PF Trial 1	1996
6220/72	1996, 1997	1995	HDC PF Trial 1	1996
6220/70	1997	1995	HDC PF Trial 1, guard	1996
6378/4	1994	1995	HDC PF Trial 1, guard	1996
6378/47	1994, 1995	1995	HDC PF Trial 1, guard	1996
6220/72	1996, 1997	1998	Glasshouse trial, Belgium	1999
6251/39	1994	1998	Glasshouse trial, Belgium	1999
6378/19	1995 -1997	1998	Glasshouse trial, Belgium	1999
6442/139	1997	1998	Glasshouse trial, Belgium	1999
6471/98	1996 - 2001	1998	Glasshouse trial, Belgium	1999
6479/37	1996 - 2000	1998	Glasshouse trial, Belgium	1999
6481/17	1998 - 2000	1998	Glasshouse trial, Belgium	1999
6523/8	1998, 1999	1998	Meiosis farm trials	2000
6529/85	1999, 2001	1998	Meiosis farm trials	
6471/98	1996 - 2001	1999	Meiosis farm trials	
6584/51	2000, 2001	2000	Meiosis farm trials	
6593/85	2001	2000	Meiosis farm trials	
6597/46	2001	2000	Meiosis farm trials	

There are a number of reasons why fewer PF selections have gone forward for trial, compared to SF selections. Firstly, RBDV has been a serious problem in the PF breeding material and several promising selections have become total infected and have been destroyed to prevent further spread. It is extremely time consuming to eradicate RBDV from raspberries (involves serial heat therapy and meristem culture) and there is a low success rate. We do not have the manpower to undertake virus eradication and if we cannot find RBDV-negative plant material of a selection it is lost. The HRI breeding programme operates field selection for pollen-transmitted resistance to RBDV infection and it is considered undesirable to release a variety which is infected rapidly in the field.

Secondly, the fruit quality of the PF material is inferior to that of the SF material and with many PF selections the fruit is too small, too soft or has a poor flavour. Although Autumn Bliss is considered to be too dark and soft by the multiple retailers, many of the PF selections produced at HRI are not significantly better than Autumn Bliss on all counts. Much of the breeding material is a better colour (lighter red and much brighter), is a more regular shape and is easier to plug but the fruit size is often similar or smaller than Autumn Bliss.

5. Selections identified as parents

Many potential trial selections were used as parents because they often represented the best available for different characteristics. The Stage 0 trials also helped identify

breeding lines with good attributes but with one or more major defects, not all of which were so obvious in the field. Information from the Stage 0 trials was very useful when designing the crossing programme because the second parent in any one cross can be specifically selected to counteract that particular weakness. For example very early ripening SF selections with good colour and fair flavour but soft skin were crossed with early types with strong skin. Summer fruiting crosses were made in 1996, 1998 and 2000 and the SF selections used as parents are shown in Table 10. Similarly the Stage 0 trials helped identify the best available PF lines which were used as parents between 1995 and 2001 (Table 11).

Table 10. SF selections recorded in the Stage 0 trials from 1994-2001, which were used as parents in 1996, 1998 and 2000

Year	SF selections used as parents
1996	5833/9, 6166/98, 6305/12, 6310/123, 6343/14, 6346/154, 6346/174, 6347/40, 6383/53, 6388/28, 6389/37, 6389/89, 6396/46, 6399/84, 6428/77, 6429/90
1998	5802/71, 6305/12, 6385/1, 6390/47, 6399/84, 6428/1, 6428/102, 6429/6, 6448/10, 6449/108, 6504/11, 6511/53, 6511/58
2000	6312/66, 6343/15, 6385/1, 6390/47, 6399/84, 6428/1, 6428/80, 6454/76, 6487/74, 6488/58, 6489/111, 6490/36, 6505/7, 6506/37, 6507/35, 6507/56, 6508/135, 6511/22, 6511/53, 6512/50, 6514/53

Table 11. PF selections recorded in the Stage 0 trials from 1994-2001, which were used as parents in 1995, 1997, 1999 and 2001

Year	PF selections used as parents
1995	6220/26, 6220/72, 6321/17, 6321/23, 6322/34, 6322/45, 6328/45, 6330/28, 6330/96, 6362/75, 6378/4, 6378/47, 6411/75, 6411/90, 6442/45
1997	6220/72, 6251/39, 6330/27, 6378/19, 6441/31, 6442/45, 6442/155, 6471/98, 6474/89, 6479/37, 6481/21, 6482/112
1999	6220/72, 6378/19, 6442/139, 6442/155, 6471/98, 6478/55, 6479/37, 6481/17, 6482/112, 6523/8, 6528/59, 6529/85, 6531/62, 6531/79, 6535/1
2001	6471/98, 6523/8, 6529/85, 6531/62, 6531/76, 6531/79, 6583/44, 6584/51, 6590/113, 6590/149, 6592/11, 6593/85, 6593/39, 6597/46

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