Project Title:	Breeding summer and primocane raspberries
Project Number:	SF8a
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Report:	Annual Report – October 1999
Previous reports:	Annual Report – September 1997 Annual Report – October 1998
Location:	HRI – East Malling
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Date commenced:	1 April 1997
Date Completion due:	30 October 2001
Keywords:	Raspberry, breeding, evaluation, breeder's trials

CONTENTS

Practical Section for Growers

Background

The HDC project SF8a provides a vital link between the raspberry breeding and selection programme at HRI-EM, funded by MAFF and the East Malling Trust for Horticultural Research, and the raspberry industry. The main part of the project involves collecting and entering data from the unreplicated breeder's trials at East Malling (known as the Stage 0 Trials). A large 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 shortlist of selections which are worthy of further trialling on growers' farms; funded either by the HDC or Meiosis Limited.

HRI uses the HDC funds to appoint 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. Peter Chorley, from Manchester University, was employed from April to September 1999 and provided valuable support for the breeding programme. Mr Chorley wrote most of this report as part of his university placement report.

Main objectives during 1999

The main objectives for the student in 1999 were as follows:-

1. Record germination in the 1999 seedling progenies and select for spinelessness in segregating progenies.
2. Learn how to screen raspberry seedlings for resistance to the large raspberry aphid, *Amphorophora idaei*, and assist the breeder in screening the 1999 seedling population in the glasshouse.
3. Learn how to make controlled crosses between raspberries in the field and assist the breeder in executing the 1999 crossing programme.
4. Record yield and aspects of fruit quality in promising summer and primocane fruiting selections chosen by the breeder (Stage 0 Trials). Enter the data into Excel for analysis.
5. Set up and record shelf life tests using fruit the Stage 0 Trials and enter the data into Excel for analysis.

Summary of Results

1. The seed trays were divided into two batches and taken out of the cold store at the beginning of March and early April. Final germination ranged from 0-90% for the different Family x seed treatment combinations. Analysis of variance showed that there were highly significant differences between Family, seed treatment and Family x treatment interactions. However, in 24 out 33 families more seedlings germinated following acid treatment whereas bleach was the better treatment in the other nine families.

Two families were intercrosses between spineless parents and all the progeny were spineless. Twenty-four families segregated either 3:1 or 1:1 for spiny:spineless and in 19 families there were sufficient seedlings to be able to pull out the spiny seedlings from the seed trays prior to potting. For the first time, the majority of the seedling population planted in the field were spineless.

2. Thirty-three summer fruiting families, 6673-6705, germinated in spring 1999 and the seedlings were potted into individual small pots. Each seedling was inoculated with three adult *Amphorophora idaei* (strain 2) and recorded for the presence or absence of adults or nymphs after 4 or 5 days. Plants which were completely free of aphids were classified as resistant and retained, while those with aphids were classified as susceptible and used as a source of further aphids for inoculation. During the screening of the first batch of families (from 12 May to 22 June) it was possible to make a clear distinction between the resistant and susceptible seedlings. However, when we came to inoculate the second batch of families we found numerous seedlings were already colonised by aphids. In some families there appeared to be no resistant seedlings, although some were more susceptible than others and an 'intermediate' category was introduced. It appeared that a new biotype evolved in the glasshouse during aphid screening in 1999, which was capable of overcoming to some extent the resistance genes A_{10} and A_{k4a}.

   In total, 5600 seedlings were inoculated with aphids between mid-May and the end of June, of which 1514 were identified as resistant and 725 were classified as 'intermediate'. The resistant and intermediate seedlings were planted in the field.

3. Twenty-two crosses were done in the field and the glasshouse between 7 May and 8 June using primocane fruiting selections and named cvs as parents. All 22 crosses produced more than 600 seeds and 17 crosses produced more than 1000 seeds (the desired number is 1000-2000). Three crosses were performed in an insect-proof glasshouse and, without the restriction of pollinating bags, it was possible to emasculate 40-60 flowers per cross. Two of the glasshouse crosses produced more than 3000 seeds per cross.

   Generally, the crossing programme in 1999 was highly successful and reasonable-sized progenies should be produced in 2000.

4. Thirty-nine summer fruiting (SF) were included in the 1999 Stage 0 Trials and compared with 'Glen Moy', 'Glen Ample' and 'Tulameen'. The SF selections were picked twice a week from 17 June to 5 August and the results are summarised in Tables 8-10. Fifteen primocane fruiting (PF) selections, 'Kiwigold', 'Polana' and 'Joan Squire' are being compared with the industry standard 'Autumn Bliss'. The PF selections and cvs started ripening on 20 July and are still being picked in mid-October.

   Eighteen SF selections produced a higher marketable yield than 'Glen Ample' and 'Tulameen'. Selection 6507/56 had the highest yield of marketable fruit (52.7kg/10m row) and 6514/53 had the highest total yield (63.3kg/10m row). Averaged over the whole season, the mean fruit weight of 'Glen Ample' and Tulameen was 3.76g and 4.18g, respectively. Ten selections had an overall mean

fruit weight greater than 'Glen Ample', while seven had larger fruit than 'Tulameen'. No irrigation was applied to the field plots where the Stage 0 selections were growing.

Fruit quality attributes like colour, texture and flavour are as important as yield and fruit size, but inevitably the highest yielding selections were not good for all quality attributes. Only one selection was scored higher than 'Tulameen' for flavour, but it was poor in other attributes. Several selections were brighter than 'Glen Ample' and most were lighter red than 'Tulameen'. In general, there were some promising selections with high yields of good quality fruit. EM6507/56 was selected for trial on a visual assessment in summer 1998 and this year's performance in the Stage 0 Trials supported this decision. This selection is a candidate for the next HDC replicated SF trials.

Less success was apparent in selecting for earliness; only three selections were one day earlier than 'Glen Moy'. There was some frost damage in 1999 and the early selections which out-yielded 'Glen Moy' in 1999 will be picked again in the Stage 0 Trials in 2000.

5. Shelf life tests were carried out using the marketable fruit picked and recorded in the Stage 0 Trials. Two punnets, each three-quarters full, per selection per pick were placed in a controlled environment cabinet at 18°C and 90% rh for 72h. After storage the punnets were recorded for six shelf life characteristics and the results are being analysed.

The data collected by the HDC-funded student in 1999 will play an important role in deciding which selections should progress further, which should be used as future parents and which should be discarded. Approximately 2200 SF seedlings were established in the field in July 1999, most of which were resistant to *Amphorophora idaei* and most of which were spineless. The crossing programme was largely successful and sufficient seeds were produced from most crosses.

1. Introduction

Raspberries are dicotyledonous flowering plants and are classified under the heading *Rubus Idaeobatus*, which is a sub-genus of the *Rubus* genus. This genus belongs to the family *Rosaceae*, which also includes apples, pears, peaches, plums, cherries and strawberries. *Rubus* species are widely distributed throughout the world, from the Arctic circle to the tropics. The fruit from many species is collected from the wild, although mankind cultivates only a small percentage of the total number of species for fruit production.

There are two main *Rubus* species used in fruit production; the red raspberry (*R. idaeus*) and the blackberry (*Eubatus spp.*) although the former is most commonly grown. *R. idaeus* can also be further subdivided into two separate ecotypes, the European red raspberry (*R. idaeus* subsp. *vulgatus*) and the North American red raspberry (*R. idaeus* subsp. *strigosus*) and this also reflects the major cultivation areas, where most of the breeding programmes occur (Jennings, 1988).

It is difficult to define the general characteristics of *Rubus* due to the great diversity in vegetative habit observed. They occur naturally in mid-successional environments such as woodland edges, mainly in the temperate regions of the world. Raspberry cultivation is largely restricted to these temperate regions due to their chilling requirement. Temperatures of 4°C or below are needed to maintain cane dormancy and initiate synchronised bud break and growth of flowering laterals during the following growing season. In the wild, low temperatures for at least 3 months are needed to break seed dormancy.

All raspberry plants possess perennial roots and can exhibit vegetative reproduction through their adventitious root growth and formation of new suckers (shoots). In their first season, these new shoots are termed 'primocanes'. These primocanes initiate flower buds in late summer/early autumn and overwinter as dormant canes. During the next season these canes produce laterals which are capable of flowering and subsequent fruiting in the following summer. These processes occur simultaneously and both primocane and mature cane will be present on the same plant in any season. However, there are some raspberries that produce flowering laterals at the tips of their primocanes and fruit in their first season. They exhibit an annual flowering pattern because these primocanes die at the end of the season and are replaced by new primocane growth from the roots in the following year. Raspberry breeders therefore classify their plants into summer-fruiting and primocane-fruiting types according to their flowering behaviour. The use of both types in horticulture effectively allows the fruit-picking season in the open field to last for up to 14 weeks. In Kent, the summer fruiting period usually lasts from late June to mid August, whilst primocane fruiting begins from early August until the first frost. With protection, primocane fruiters can continue until late November (Knight, 1995).

Raspberries do not produce true berries. Instead they produce aggregate fruits through the adhesion of many separate carpels (drupelets) derived from single, five-petalled flowers. The adhesion of the individual carpels is achieved through interactions between the fine hairs on their surface (which can also give the fruit a dusty appearance) and can be disrupted by virus. Raspberries can be distinguished from blackberries, which are in the subgenus of Eubatus, by their fruit-harvesting behaviour. With mature blackberry fruit,

the carpels are detached along with the receptacle (torus). However raspberry picking entails the separation of the carpels from the receptacle, which remains attached to the plant and results in the formation of hollow, thimble-like fruits.

Cultivars of raspberry are typically diploid (2n = 14), although tetraploid (2n = 4x = 28) individuals do exist. The flowers are usually self-compatible and will therefore produce satisfactory fruit yields without the need for cross-pollination. This is advantageous for fruit production, especially when the clones are grown commercially, en-mass. However, for breeding purposes selfing is undesirable because even one inbreeding cycle results in progeny that have noticeably impaired characteristics (Lewis *et al.*, 1983).

1.1 The HRI raspberry breeding programme

The raspberry breeding programme at Horticulture Research International (HRI), East Malling, Kent, aims to develop new summer fruiting and primocane fruiting cultivars which have good quality fruit, high yield, good habit and resistance to pests and diseases. The desired fruiting qualities include high yields with acceptable fruit size, colour and flavour. This fruit must also demonstrate both physical cohesion and disease resistance at both the pre- and post-harvest levels. Specific pest and disease resistance attributes of the plants are also desirable, particularly because raspberry is a perennial, long-term crop, which can have a productive commercial life in the field of 10-15 years. Great effort continues to be directed towards the breeding of plant resistance to four strains of the large raspberry aphid (*Amphorophora idaei*). This aphid is the vector of four detrimental raspberry viruses. Other attributes, for example the production of spineless, self-supporting canes with strong fruiting laterals and a fruiting behaviour that lends itself to mechanical harvesting are also desirable and are incorporated into the aims of the breeding programme.

Each year a new seedling population is raised from seed produced during the previous year, new crosses are planned and executed, and all existing plant material is assessed in the field. From their second season in the field onwards, seedlings are assessed for fruiting season, fruit quality, yield and plant habit. Seedlings that prove to have unacceptable qualities or are diseased will be grubbed from the field plots. This helps to reduce the number of seedlings that require fruit assessment and remove sources of virus inoculum. After two or three fruiting seasons, the most promising seedlings are identified and vegetatively propagated for further observation and/ or use as future parents in the crossing programme.

This placement report, which covers 6 months in a long term, established breeding programme, describes in detail the 1999 crossing programme, pre-field selection in the 1999 seedling population and the Stage 0 trials. The latter involves the evaluation of fruit from existing primocane and summer-fruiting selections currently in the field at East Malling.

2. Seed treatments, germination and selection for spinelessness

2.1 Introduction

Germination in raspberry seed lots is extremely variable and has ranged from 0-85% over a period of years (Knight, unpublished data). All *Rubus* seed requires a period of moist chilling to break seed dormancy and germination can be improved further by scarifying the seed with sulphuric acid, sodium hypochlorite or by physically nicking the seed coat (Jennings and Tulloch, 1965; Nesme, 1985; Campbell *et al.*, 1988). Seed treatment with sulphuric acid or bleach generally improves germination so all seed lots are treated in the HRI raspberry breeding programme.

Germination is restricted by the seed coat (testa) and by inhibiting substances present in the endosperm. In nature *Rubus* seeds are exposed to a period of moist chilling over winter and during this time the seed coat softens and the inhibiting substances leach out of the endosperm and growth-promoting substances are produced. The hard seed coat protects the embryo but gaseous exchange and water uptake can only occur after the seed coat has started to breakdown. In nature *Rubus* seeds often pass through the gut of birds or animals and this helps breakdown the seed coat and disperse the seed over a wider area (Salisbury and Ross,1992).

2.2 Materials and Methods

The 33 seed lots from the 1998 crosses (families 6673-6705) were divided into two by weight and each half was subjected to a different seed treatment in January 1999.

Treatment 1 – The seeds were soaked for 24 hours in 2.5% NaOCl (50% Domestos) solution. They were then washed with running water for 10 minutes and stored in vials in distilled water at 4°C in the fridge. The distilled water was changed on days 4, 6 and 8 and the seeds were then dried briefly before sowing.

Treatment 2 – The seeds were placed into a test tube and covered with concentrated sulphuric acid. The labelled test tubes were then placed in an ice bath for 90 minutes. The seeds were then soaked in 20% bleach solution for 20 minutes and then washed under running water for a further 10 minutes. They were then placed into labelled vials of distilled water as in treatment 1. The distilled water was changed on days 2, 5, 7 and 9, and the seeds were then dried briefly to facilitate handling.

After treatment, each seed lot was divided accurately, by weight, into 1-5 samples so that a reasonable number of seeds could be sown per tray. One sample per family per treatment was then counted, and this number assumed to be the same for the other samples. Between 220 and 375 seeds were sown per tray, which was labelled with the family number and seed treatment. The seed trays were stored at 4°C for five weeks and the first batch (families 6673-6685 and 6701-6705) were transferred into a warm glasshouse (20-25°C) to germinate on 1 March 1999. The germinating seedlings were counted twice a week and the

accumulative number recorded. The second batch (families 6686-6700) were held in the cold store for ten weeks and moved to the glasshouse on 6 April. The first batch was recorded from 15 March-22 April (14-52 days after coming out of cold store), while the second batch was recorded from 19 April-10 May (14-36 days).

Selection for spinelessness was carried out whilst recording germination. The allele for spines is dominant (S) over that for spinelessness (s). This trait is advantageous for raspberry breeding because thornless canes are much easier to handle. A spiny seedling could be recognised by observing the perimeter of the cotyledons; if small, opaque glandular hairs (trichomes) were present, then the seedling would develop spiny canes. These trichomes were absent on seedlings that would develop spineless canes. Some of the families segregated for this trait and therefore it was possible to select against spiny seedlings, providing that the total number of germinated seedlings for that family was high enough. Spiny seedlings were identified using a x10 lens and removed by forceps, but the numbers removed were included in the accumulated numbers germinated.

The germination records were analysed to establish which seed treatment gave the highest percentage germination figures in each family. The seedlings were allowed to grow until they were large enough to handle and sufficient numbers had germinated, before they were individually potted and set out in their families for aphid screening.

2.3 Results

Table 1 shows the mean percentage germination, and the associated standard error, for each of the families following the bleach and acid seed treatments. Analysis of variance showed that there were highly significant differences between families, treatments and family x treatment interactions.

Differences were observed between the final percentage germination of the seed lots, both within and between the 33 families, with regards to the seed treatments used. Some families (6675, 6690, 6693, 6694 and 6700-6704) achieved better germination with the bleach treatments. However, the majority of families (24 out of 33) achieved a higher percentage germination where the seed was subjected to the acid treatment.

Four families (6680, 6701, 6703 and 6705) displayed low percentage germination values with both seed treatments. Seven families (6678, 6680, 6681, 6683, 6685, 6696 and 6705) achieved a germination rate with the bleach seed treatment that was less than the average 10 % germination rate of untreated seed. However, only three families (6700, 6701 and 6703) achieved a germination rate with the acid seed treatment that was less than the average 10% of untreated seed.

The seeds of family 6700 that were subjected to the acid treatment displayed the worst germination, with nil germination after five weeks, whilst the seeds of family 6690, which had undergone the bleach seed treatment achieved the best germination in the same time period.

Two families were intercrosses between two spineless parents, so all the seedlings were homozygous for the recessive spineless allele. Twenty-four out of 33 families were segregating for spinelessness (either *Ss* x *Ss* or *Ss* x *ss*) and in 19 families the spiny seedlings were discarded prior to potting. However, there was insufficient germination to remove the spiny seedlings in five families and in these families a mixture of spiny and spineless seedlings were planted in the field. In the remaining seven families, all the seedlings were phenotypically spiny, but in two families the seedlings were heterozygous for spinelessness (*Ss*). Overall out of 33 progenies, 28 are either totally spineless, segregating for spinelessness or are heterozygous for spinelessness and only five are all homozygous spiny.

2.4 Discussion

When comparisons are made between the final percentage germination for each family, it seems that the acid treatment was more successful for the majority of the families. In all families one or other treatment increased germination to above 10%, so either treatment is preferable to no seed treatment at all. We could not use a proportion of the seed as an untreated control in this study due to the limited quantity of seed available and the need to raise sufficient seedlings in each family for the breeding programme.

The reasons why some families achieve a higher percentage germination rate with one treatment as opposed to another are not fully known. One possible reason could be genetic differences governing the testa thickness and durability when subject to chemical scarification. A second reason may be possible environmental differences in the cold store or glasshouse, although these should be minimal. A further reason could be possible fungal infections within individual seed trays, although again these should be minimal because the seed, soil and trays were sterilised previously.

Where a family achieved a low percentage germination value with both treatments, this could be the result of variation in the initial viability of the seeds between different families. However, this risk should be minimal as most of the non-viable seeds were removed through floatation when the seeds were initially extracted.

Either 200 or 150 seedlings were required per family and in all families the required number were potted. Without seed treatment it was likely that 11 families would have had insufficient numbers of seedlings. Seed treatments enabled us to produce enough plants for aphid screening and selecting for spinelessness produced a predominantly spineless seedling population in the field.

Table 1. The final percentage germination values following acid and bleach treatments of seeds in families 6673-6705

Family	Treatment 1: Bleach treatment				Treatment 2: Acid treatment			
	Total seeds sown	Total seeds germin-ated	% Germin-ation	Standard Error	Total seeds Sown	Total seeds germin-ated	% Germin-ation	Standard Error
6673	1315	219	16.7	1.52	1460	1141	78.2	1.60
6674	1312	411	31.3	1.89	1296	976	75.3	1.77
6675	262	228	87.0	0.00	259	139	53.7	0.00
6676	1320	411	31.1	1.88	1392	937	67.3	1.86
6677	1316	172	13.1	1.37	1296	925	71.4	1.86
6678	732	23	3.1	0.95	768	337	43.9	2.65
6679	912	242	26.5	2.16	855	581	68.0	2.36
6680	1456	11	0.8	0.34	1444	348	24.1	1.66
6681	1508	2	0.1	0.14	1376	570	41.4	1.96
6682	1092	240	22	1.85	1020	444	43.5	2.29
6683	1068	65	6.1	1.08	1080	628	58.1	2.22
6684	714	142	19.9	2.21	735	240	32.7	2.56
6685	1320	47	3.6	0.75	1328	727	54.7	2.02
6686	1160	360	31	2.79	1216	633	52.1	2.94
6687	687	160	23.3	3.31	723	465	64.3	3.66
6688	1032	161	15.6	2.32	1032	462	44.8	3.18
6689	1740	926	53.2	2.46	1795	1353	75.4	2.09
6690	1212	1087	89.7	1.80	1116	615	55.1	3.06
6691	1080	458	42.4	3.09	1096	643	58.7	3.06
6692	1575	502	31.9	2.41	1430	559	39.1	2.65
6693	771	386	50.1	3.70	657	207	31.5	3.72
6694	249	189	75.9	0.00	251	149	59.4	0.00
6695	1072	505	47.1	3.13	1224	915	74.8	2.55
6696	1328	51	3.8	1.08	1360	986	72.5	2.49
6697	1416	405	28.6	2.47	1472	1143	77.6	2.23
6698	1412	812	57.5	2.70	1460	1056	72.3	2.41
6699	1480	468	31.6	2.48	1405	792	56.4	2.72
6700	582	179	30.8	3.93	592	0	0.0	0.02
6701	490	98	20.0	2.67	444	10	2.3	1.04
6702	729	348	47.7	2.73	786	198	25.2	2.29
6703	1044	164	15.7	1.66	1024	89	8.7	1.30
6704	602	286	47.5	3.01	566	238	42.0	3.07
6705	1164	67	5.8	1.01	1120	247	22.1	1.83

3. Seedling resistance to *Amphorophora idaei*

3.1 Introduction

Aphids are capable of transmitting plant viruses between individual plants through their feeding behaviour. The raspberry breeding programme at HRI-EM is concerned with the large raspberry aphid (*Amphorophora idaei*) because this species is the vector of four damaging raspberry viruses, namely raspberry leaf spot (RLSV), *Rubus* yellow net (RYNV), black raspberry necrosis (BRNV) and raspberry leaf mottle (RLMV). No immunity to these viruses is known in the current raspberry breeding germplasm and therefore these viruses cannot be controlled at the plant cell level. Also it would take many years to combine resistance to all four viruses. However genes exist which confer resistance to the insect vector and offer the chance to prevent the raspberry from the initial contact with the four viruses.

There are five biotypes of *A. idaei* in the UK and varying levels of plant resistance have been found against biotypes 1-4. Some resistance genes provide resistance to only one or two biotypes; however the major gene A_{10}, which was originally found in *R. occidentalis,* offers protection against biotypes 1-4 (Keep and Knight, 1968). Recently there have been reports of *A. idaei* colonising A_{10}-carrying cvs such as Autumn Bliss, Leo and Julia. The first positive identification of an *A. idae*i population on Autumn Bliss was in 1994, and this was confirmed in 1995 and 1996 (Birch *et al.*, 1997). This biotype, which can overcome A_{10}, is known as biotype X and is expected to spread in any region where A_{10}–carrying cvs are widely planted.

3.2 Materials and Methods

Thirty-three summer fruiting families were raised in 1999 and all were screened for aphid resistance. The seed trays were moved from the cold store to the glasshouse in two batches in order to stagger pricking out and aphid screening. Families 6673-6685 and 6701-6705 made up the first batch, which came out on 1 March 1999, while families 6686-6700 came out on cold store on 6 April 1999. Either 200 or 150 seedlings per family were pricked out into 7.5cm pots and were laid out in families, arranged in blocks of 10x10 or 10x5 on the glasshouse bench. The plants at each corner of each family group were labelled. A colony of *Amphorophora idaei,* biotype 2 was built up from a small sample of aphids supplied by the Scottish Crop Research Institute (SCRI) at the end of April 1999. These were allowed to multiply asexually on two plants of Malling Landmark, which contains A_1. The gene A_1 confers resistance to biotypes 1 and 3, while the gene A_{10} confers resistance to biotypes 1-4. By using Malling Landmark we ensured that we were culturing biotype 2 rather than biotype 1 or 3. Aphids of biotype 2 were used in order to distinguish between seedlings with A_{10} and A_1. Plants with A_{10} are desirable because biotype 2 has become widespread in the last 30 years (Birch *et al.*, 1997). Once sufficient numbers of aphids were present on the aphid stock plants, it was possible to start inoculating the raspberry seedlings.

To perform the inoculations it was necessary to be able to distinguish between adults and fourth stage nymphs. Adult aphids could be recognised by their more

extensive dorsal pigmentation and abdomen shape, as only the adults have a more pointed rear which ends with an extended subgenital plate (Barbagallo *et al.*, 1997). Three aphids were transferred manually using the end of a label, moistened with water to help adherence, to the youngest expanded leaves on each plant. Great care was taken to ensure that plants did not initially receive more than three aphids, or that they were not knocked off during this process. After a row had been inoculated, the first plant was labelled with the family number, the number of aphids on each plant and the date of inoculation.

The seedlings could be recorded 3 or 4 days after inoculation through inspection of the undersides of the foliage and stem. The plants were classified according to the following categories:

1. RESISTANT – completely free of aphids, no adults or new nymphs
2. SUSCEPTIBLE –one or more adults and several nymphs
3. INTERMEDIATE – either one or two adults but no nymphs, or few nymphs and no adults

A record of the results was made for each family using a tally scheme. Resistant plants were transferred to well-labelled crates, which were placed outside to harden off before being planted out in the field plots. Susceptible plants became aphid stock plants and were used for future inoculations. Intermediate plants were re-tested by the addition of another adult aphid and left for another 3-4 days before recording again. The numbers of broken and dead plants were also recorded.

3.3 Results

Table 2 summarises the number of seedlings from each family that were resistant and susceptible to *A. idaei* and shows the aphid resistant genes that were carried by their parents. Tables 3 and 4 show the percentages of plants in each classification, for each batch, to allow easier comparison of the values. Between 0 and 28% of seedlings within each family either died or were broken during the aphid screening.

The results show that a range of different levels of resistance to *A. idaei* was found between families. During assessment of the first batch from 12 May-22 June, it was possible to make a clear distinction between 'resistant' and 'susceptible' plants within a family (Table 3). However, when we started inoculating batch 2 on 22 June we found that there were numerous aphids already colonising the seedlings in families 6686-6700. In some families there appeared to be no resistant seedlings, but some seedlings were more susceptible than others and an intermediate category was introduced (Table 4). The aphids were able to colonise plants carrying A_{10} in families 6686-6700. It is unlikely that the resistance genes in the parents of the 15 families broke down simultaneously, and it is more likely that an A_{10}-breaking biotype developed in glasshouse M7 in 1999. A sample of live aphids was collected for further analysis by entomologists at SCRI.

If both parents of a progeny were heterozygous for a dominant resistance gene, then through Mendelian inheritance, a ratio of 3:1 resistant to susceptible would be expected. Families 6673, 6675-6679, 6682, 6683, 6703 and 6705 were expected to show a 3:1 segregation but only 6676, 6679 and 6683 did. In 6673, 6678 and 6705 there were more resistant than susceptible seedlings but less than expected resistant. In 6675, 6682 and 6703 there were many more susceptible seedlings than expected and it is possible that resistance-breaking aphids had evolved and were building up gradually in the glasshouse population.

Where only one parent was heterozygous for a major aphid resistance gene a 1:1 ratio of resistant to susceptible plants was expected; in families 6674, 6680, 6681, 6684, 6685, 6701, 6702 and 6704. Families 6681, 6685 and 6702 showed a reasonable 1:1 segregation but some families had more resistant seedlings than expected (6674 and 6704) while others had far more susceptible seedlings than expected (6680, 6684 and 6701). It is difficult to comment on the segregations in the families in the second batch because the classification of the seedlings into intermediate and susceptible was rather arbitary.

Family 6687 and 6690 were the only families to have all plants recorded as susceptible. This was not expected because major aphid resistance genes were present in both parents of 6690 and the male parent of 6687. These families were included in the second batch, when a possible change in the ability of the aphids to overcome the resistance genes was detected. Nevertheless, a few plants of these families were planted in the field because they may have other valuable characteristics.

3.4 Discussion

During the early stages of the screening programme, a clear distinction between susceptible or resistant plants could be made. However this year, as the aphid population inside the glasshouse increased and aphids began to inoculate the families themselves, it became impossible to distinguish between the resistant and susceptible categories according to the system previously used. In the second batch very few seedlings were resistant (Table 4) although all families were expected to segregate either 3:1 or 1:1, resistant to susceptible.

There are several possible reasons for this. One reason could be that a new biotype capable of colonising plants with A_{10} had evolved in response to the high selection pressure applied to the aphid population. This biotype could be another form of biotype X which arose naturally in fields of A_{10}-carrying cvs in 1994-96. A second reason could be that the resistance genes of the resistant seedlings in batch 2 (expected to be approximately 1600 individuals) had broken down simultaneously but this seems unlikely. A third reason is that the original aphid stocks were misclassified or a mixture of biotypes 2 and X. This is extremely unlikely because the families in the first batch segregated into resistant and susceptible seedlings, and if biotype X had been present from the beginning, all the seedlings in batch 1 would have been susceptible. To help resolve this matter, living samples of the glasshouse aphid population at the end of July were sent back to SCRI for analysis. The results of which are still unknown.

The incidence of deaths/breakage in families could be due to excessive competition between the young seedlings for light. Although they were individually potted, these pots were tightly spaced together because of the limited glasshouse space between April and June. Many plants became etiolated and prone to breakage even when separated from their neighbours.

Table 2. The *Amphorophora idaei* resistance genes found in the parents of families 6673-6705, the number of seedlings potted per family and the results of the 1999 screening programme

Family	Female Parent	Male Pa rent	*A. idaei* resistance genes in female parent	*A. idaei* resistance genes in male parent	No. Potted	No. resistant	No. intermediate	No. susceptible
6673	6414/14	6390/47	A_{10} +/-A_1 +/- A_2	A_{10}	150	75	0	66
6674	6414/14	6488/102	A_{10} +/-A_1 +/- A_2	?	200	111	0	71
6675	6417/9	6390/47	A_{10}	A_{10}	150	61	0	71
6676	6417/37	6414/14	A_{10}	A_{10} +/-A_1 +/- A_2	150	117	0	26
6677	6451/120	6390/47	A_{10} or A_{k4a}	A_{10}	150	60	0	87
6678	6451/120	6417/37	A_{10} or A_{k4a}	A_{10}	150	88	0	53
6679	6416/1	6504/11	A_{10}	A_{10} +/-A_1 +/- A_2	150	95	0	28
6680	6488/102	6305/12	?	A_{10}	200	25	0	131
6681	6488/102	6511/53	?	A_{10} or A_{k4a}	200	90	0	79
6682	6504/11	6305/12	A_{10} +/-A_1 +/- A_2	A_{10}	150	38	0	93
6683	6504/11	6399/84	A_{10} +/-A_1 +/- A_2	A_{10} +/- A_1	150	110	0	35
6684	6429/6	Glen Ample	A_{10} or A_{k4a}	A_1	200	72	0	133
6685	6429/6	Malahat	A_{10} or A_{k4a}	-	200	105	0	83
6686	Glen Ample	6305/12	A_1	A_{10}	200	0	45	117
6687	Glen Ample	6399/84	A_1	A_{10} +/-A_1	200	0	0	200
6688	Tulameen	6511/58	-	A_{10} or A_{k4a}	200	0	65	135
6689	6448/10	6449/108	A_{10} or A_{k4a}	A_{10}	150	0	69	39
6690	6448/19	6449/108	A_{10} or A_{k4a}	A_{10}	150	0	0	140
6691	6451/39	6449/108	A_{10} or A_{k4a}	A_{10}	150	27	70	47
6692	6511/58	6448/19	A_{10} or A_{k4a}	A_{10} or A_{k4a}	150	0	47	95
6693	6385/1	Tulameen	A_{10} +/-A_1	-	200	0	42	125
6694	6385/1	6428/77	A_{10} +/-A_1	A_{10} or A_{k4a} +/- A_1	150	0	55	85
6695	6428/1	Tulameen	A_{10} or A_{k4a} +/-A_1	-	200	41	26	120
6696	6428/1	6385/1	A_{10} or A_{k4a} +/-A_1	A_{10} A_1	150	0	50	76
6697	6428/1	6511/58	A_{10} or A_{k4a} +/-A_1	A_{10} or A_{k4a}	150	0	81	50
6698	6428/77	Tulameen	A_{10} or A_{k4a} +/-A_1	-	200	29	70	93
6699	5802/71	Glen Rosa	A_{10} +/-A_1	A_{10}	150	0	65	79
6700	5802/95	Glen Ample	A_{10} +/-A_1	A_1	200	0	40	130
6701	Gaia	W.stephan18	A_{10}	?	150	15	0	117
6702	Gaia	6434/54	A_{10}	-	200	111	0	81
6703	Gaia	6461/30	A_{10}	A_{10} or A_{k4a}	150	45	0	90
6704	W.stephan18	6434/54	?	-	150	93	0	49
6705	W.stephan18	6461/50	?	A_{10} or A_{k4a}	200	106	0	74

Notes:

? From their ancestry it is possible that these parents have one or more resistance genes but not tested enough to know which one(s).

\- No resistance genes present in these parents.

\- 'W.stephan18' is short for the selection 'Weinhenstephan 18', which has subsequently been named 'Rubaca'.

Tables 3 and 4 The results of the 1999 *A. idaei* screening programme. The families are grouped into batch 1 (Table 3) and batch 2 (Table 4). The numbers of plants in each of the three categories are expressed as a percentage of the total number of plants per family.

Table 3. Batch 1

Family	*A. idaei* 'resistant' plants (%)	*A. idaei* 'intermediate' plants (%)	*A. idaei* 'susceptible' plants (%)	% broken/ dead
6673	50.0	0.0	44.0	6.0
6674	55.5	0.0	35.5	9.0
6675	40.7	0.0	47.3	12.0
6676	78.0	0.0	17.3	4.7
6677	40.0	0.0	58.0	2.0
6678	58.7	0.0	35.3	6.0
6679	63.3	0.0	18.7	18.0
6680	12.5	0.0	65.5	22.0
6681	45.0	0.0	39.5	15.5
6682	25.3	0.0	62.0	12.7
6683	73.3	0.0	23.3	3.3
6684	34.7	0.0	64.3	1.0
6685	52.5	0.0	41.5	6.0
6701	10.0	0.0	78.0	12.0
6702	55.5	0.0	40.5	4.0
6703	30.0	0.0	60.0	10.0
6704	62.0	0.0	32.7	5.3
6705	53.0	0.0	37.0	10.0

Table 4. Batch 2

Family	*A. idaei* 'resistant' plants (%)	*A. idaei* 'intermediate' plants (%)	*A. idaei* 'susceptible' plants (%)	% broken/ dead
6686	0.0	22.5	58.5	19.0
6687	0.0	0.0	100.0	0.0
6688	0.0	32.5	67.5	0.0
6689	0.0	46.0	26.0	28.0
6690	0.0	0.0	93.3	6.7
6691	18.0	46.7	31.3	4.0
6692	0.0	31.3	63.3	5.3
6693	0.0	21.0	62.5	16.5
6694	0.0	36.7	56.7	6.7
6695	20.5	13.0	60.0	6.5
6696	0.0	33.3	50.7	16.0
6697	0.0	54.0	33.3	12.6
6698	14.5	35.0	46.5	4.0
6699	0.0	43.3	52.7	4.0
6700	0.0	20.0	65.0	15.0

4. The 1999 Crossing Programme

4.1 Introduction

During the period from 7 May to 8 June controlled cross-pollinations were made in the field and glasshouse using raspberry plants selected as parents by the breeder. Crosses were designed in which both parents had complimentary positive characteristics and the aim is to identify individuals in the progeny that possess a combination of all these positive characteristics. This breeding strategy is known as recurrent selection. Male parents were those plants that were used as a source of pollen, whereas the female parents were those plants which had their flowers emasculated. Reciprocal crosses were not usually performed because maternal inheritance is of minor importance in raspberries. Between 25 and 30 individual raspberry fruits are required to produce adequate seed number for future use. The main aims of the 1999 crossing programme are set out in Table 5.

Table 5. The raspberry cultivars and selections used as parents in the 1999 crossing programme with a summary of the major objectives of each group of crosses

Family	Parents		Major objectives of each cross
	Female	Male	
6706	Joan Squire	6523/8	Combine high yield with good quality fruit.
6707	Polana	6523/8	
6708	6479/37	6523/8	
6709	6481/17	6529/85	
6710	6481/17	6535/1	
6711	6523/8	6531/79	
6712	6535/1	6523/8	
6713	Joan Squire	6529/85	Combine high yield with firm fruit.
6714	6529/85	6220/72	
6715	Joan Squire	6531/79	Combine firm fruit and/ or strong skin with good shelf life.
6716	6478/55	6535/1	
6717	6528/59	6531/62	
6718	6528/59	6531/79	
6719	6531/62	6378/19	
6720	6378/19	6471/98	Combine medium red and bright colour with firm fruit and/ or strong skin.
6721	6479/37	6471/98	
6722	Joan Squire	6442/139	Improve yield and texture in progenies which are slow to become infected with RBDV in the field.
6723	6378/19	6442/139	
6724	6378/19	6442/155	
6725	6479/37	6442/139	
6726	6479/37	6442/155	
6727	6482/112	6442/155	

4.2 Materials and Methods

To make controlled crosses in raspberry

To prepare the female parent for pollination, strong flowering laterals with between 4 and 15 unopened flower buds were identified. Mature flower buds were chosen in order to remove the anthers before they had dehisced and self-pollinated the stigmas. To emasculate the flower, a scalpel was dipped in alcohol to denature any extraneous pollen or bacteria and allowed to dry. This was used to carefully remove the sepals, petals and anthers in one circular incision around the base of the sepals. Immature flower buds were not used because, if emasculated at a very immature stage, the development of the stigma, style and ovaries would be halted and the fruit would not set. Frost damage could be observed clearly in some flowers with blackened, dead stigmas. Flower buds that had already opened, or were too immature were also removed from the lateral to prevent selfing. The laterals with emasculated flowers were then labelled and covered with pollination bags to protect the stigmas from extraneous pollen carried by insects and wind and to protect to the developing fruit from predation. Accurate labelling was essential; the label had the identity of both parents, the number of flowers and emasculation date.

To prepare the male parent, laterals with many unopened flower buds were covered with thin, perforated plastic bread bags to prevent future contamination with unknown raspberry pollen. After 2-3 days, the opened male flowers were collected and their anthers brushed over the surface of the now receptive stigmas to achieve pollination. The female pollination bags were then replaced until the fruit had ripened. Where the males were used for many separate crosses, or where there were few suitable flowers, buds were collected and their anthers excised. These anthers were allowed to release their pollen grains into small, labelled petri dishes and were stored at 4°C in a dessicator to be used at a future date. The period between pollination and fruit maturation can take around 5 weeks in the field. However, where crosses were performed in the glasshouse this timespan was much reduced.

Fruit retrieval, seed extraction and estimation of seed number

Ripened fruit was harvested very carefully and each lateral recorded for fruit set (Table 6). The seed was extracted when all of the fruit from a particular cross had been collected. This was achieved by placing the fruit into a blender with 300ml of tap water, agitated for ten seconds and allowed to settle. After a further five-second period of agitation, the top layer of pulp and floating, non-viable seeds were decanted away, leaving only viable seeds at the base of the container. These seeds were transferred back to their original, labelled container and soaked for 2 minutes in a 1% bleach solution to surface sterilise them. The seeds were then rinsed thoroughly in running tap water and emptied onto a labelled filter paper. The seed was left to dry overnight before being transferred into labelled, waxed paper, 'Press Seal' seed packets and placed in the fridge.

For each seed lot, the average weight of 100 seeds per cross was found by recording the individual weights of three separate samples of 100 seeds. By

weighing the total amount of seed produced per cross, an estimation of the number of seeds obtained per cross could be calculated (Table 6). These seeds will be stored at 4°C until January 2000, when they will be treated with concentrated sulphuric acid and sown in seed trays, before being transferred to the cold store.

4.3 Results

The results obtained from the 1999 crossing programme are summarised in Table 6. This table shows the numbers of flowers emasculated for each cross, the number of fruit that have set well, the number of fruit that have less than 10 druplets and those which have failed altogether; plus an estimation of the number of seeds obtained.

Between 26 and 46 flowers per cross were emasculated in the field. The female plants that were used to produce families 6709, 6723 and 6724 were pot plants that were kept inside an insect-proof glasshouse and subsequently higher numbers of flowers were emasculated.

Of the nine crosses which had more than five failed flowers (families 6706, 6707, 6708, 6712, 6717, 6719, 6720, 6726 and 6727), eight were subject to breakage of either one or more flowering laterals due to high winds. In spite of choosing strongly attached laterals, the pollinating bags are blown about in the wind and sometimes the laterals break.

Large differences in the number of seeds obtained for each family can be seen. In Family 6709, all 40 well-set fruit gave rise to 3046 seeds, whilst Family 6723 had 49 well-set and eight poorly-set fruits, but only achieved 1557 seeds.

4.4 Discussion

From these results we can see that a substantial number of seeds were produced, with all crosses achieving over 600 seeds. However, some of the crosses seem to have been more successful than others. There can be several reasons for this. The inherent differences in fruit size in different genotypes can affect seed number per fruit, even though similar numbers of flowers were emasculated. Inefficient pollen transfer during pollination can lead to reduced carpel development or damage to the stigmas could have arisen as a result of the emasculation process itself. Not all raspberry seeds are viable and therefore seed number is not necessarily correlated with subsequent progeny size, although the removal of the floating seeds during seed extraction should mean a higher germination rate. Overall, a good number of seeds were produced and 22 progenies of reasonable size will be raised in 2000.

Table 6. Results of the 1999 raspberry cross-pollination programme

Family number	Parents		No. of flowers emasculated	Fruit Set			Estimated No. of seeds
	Female	Male		Well	Poor	Fail	
6706	Joan Squire	6523/8	33	11	16	6	906
6707	Polana	6523/8	37	15	5	16	633
6708	6479/37	6523/8	33	23	1	9	1483
6709	6481/17	6529/85	40	40	0	0	3046
6710	6481/17	6535/1	33	27	3	3	2034
6711	6523/8	6531/79	35	23	12	0	1964
6712	6535/1	6523/8	31	15	9	7	1241
6713	Joan Squire	6529/85	31	25	3	3	1774
6714	6529/85	6220/72	31	30	0	1	2328
6715	Joan Squire	6531/79	26	20	3	3	940
6716	6478/55	6535/1	38	37	1	0	2624
6717	6528/59	6531/62	40	30	0	10	2744
6718	6528/59	6531/79	30	26	1	3	1917
6719	6531/62	6378/19	45	16	13	17	743
6720	6378/19	6471/98	40	29	2	9	1330
6721	6479/37	6471/98	30	30	0	0	2111
6722	Joan Squire	6442/139	33	30	1	2	2107
6723	6378/19	6442/139	60	49	8	3	1557
6724	6378/19	6442/155	60	59	1	0	3108
6725	6479/37	6442/139	30	14	12	4	674
6726	6479/37	6442/155	32	26	0	6	2062
6727	6482/112	6442/155	42	23	8	11	2120

5. The Stage 0 Trials

5.1 Introduction

These trials involve the most promising summer fruiting (SF) and primocane fruiting (PF) selections out in the field. The fruit from a known length of row per selection was picked and assessed twice a week, throughout their fruiting seasons, for marketable, unmarketable and total yield and nine aspects of fruit quality covering appearance, texture and flavour. A measure of fruiting season is found from the 5, 50 and 95% pick dates. These selections are compared with the existing industry SF and PF standard cultivars. For a selection to go forward from Stage 0 trials at East Malling to further trials, it must perform better in most categories than these standard cultivars, or be exceptional for a smaller number of interesting characters e.g. significantly earlier ripening than 'Glen Moy'.

Both fruiting types are assessed in the same way, but for the purpose of this report, only the summer-fruiting results are presented as the primocane-fruiting selections are still cropping.

5.2 Materials and Methods

Thirty-nine promising summer-fruiting selections were compared to three existing cultivars, 'Glen Moy', 'Glen Ample' and 'Tulameen') in 1999. 'Glen Moy' is included because it is the earliest-ripening summer fruiting cultivar, whilst 'Glen Ample' and 'Tulameen' have good yield and fruit qualities and are rated highly by the supermarkets. Fifteen primocane-fruiting selections and two cultivars, 'Kiwigold' and 'Polana', are currently being assessed and compared with the two industry standards 'Autumn Bliss' and 'Joan Squire'.

All 42 SF genotypes were inspected and known lengths of row were marked out using yellow streamers tied to the support wires. The aim was to pick approximately 2.0m of row which was representative of the whole plot. The row lengths picked ranged from 0.9-2.9m, depending on the condition plants in the plot and the mean was 1.9m. In order to compare selections, the fruit yield data was multiplied up to give the equivalent yield in kg per 10m of row.

The ripe fruit from within these marked areas was picked twice a week from the start of the season until all the fruit had been harvested. The fruit from each selection was sorted into marketable and unmarketable by the pickers, before the punnets were placed in a tray labelled with the selection number. Once in the laboratory, the marketable and unmarketable fruit was weighed and the average fruit weight per selection was found by weighing a sample of 50 marketable fruits at each pick. The marketable fruits were then spread out on a work surface and assessed for nine aspects of fruit quality using a 1-5 scale, where generally 5 = best and 1 = worst (Table 7).

Table 7. 1999 raspberry fruit quality assessment guide for the Stage 0 trials

1. Redness				
pale	fairly pale	medium	dark	very dark
5	4	3	2	1
2. Brightness				
very bright	bright	medium	dull	Very dull
5	4	3	2	1
3. Shape				
long conical	conical	blunt conical	roundish	round
5	4	3	2	1
4. outline				
very even	even	medium	irregular	very irregular
5	4	3	2	1
5. Uniformity of size				
very uniform	uniform	medium	variable	very variable
5	4	3	2	1
6. Texture				
very firm	firm	medium	soft	very soft
5	4	3	2	1
7. Cohesion				
all whole	mostly whole	slightly crumbly	crumbly	very crumbly
5	4	3	2	1
8. Skin Strength				
strong [1]		moderate[2]		weak[3]
5		3		1
9. Flavour				
very good, aromatic, strong raspberry flavour	good	moderate, bland	poor, acid, weak	v. poor, v. acid, no raspberry flavour, foreign
5	4	3	2	1

Note:

For skin strength analysis the following definitions were used:

1. Strong skin strength was were no drupelets were ruptured on five different fruits, when rubbed gently five times
2. Moderate skin strength is between 1-3 fruits out of five with ruptured drupelets
3. Weak skins are when all five fruits have ruptured drupelets.

5.3. Results

Table 8 shows the total yield of marketable and unmarketable fruit (converted to yield in kg/10m row) and the selections are displayed in descending order of marketable yield. The average values for each fruit quality character assessed over the season are summarised in Table 9. Again the selections are displayed in order of descending marketable yield. The relative fruiting seasons of the 39 selections can be made by comparing the 5, 50 and 95% pick dates of the selections with those of the three industry standards. These results are shown in Table 10 and the genotypes are displayed in descending order of 5% pick date (earliest first).

Table 8 shows that 18 summer-fruiting selections produced a higher yield of marketable fruit than 'Tulameen' and 'Glen Ample'. The early-ripening cultivar 'Glen Moy' produced the lowest total yield (20.33 kg/10m row)and the second lowest marketable yield (15.27 kg/10m row). There was some frost damage in April 1999 and 'Glen Moy' and early-flowering selections were adversely affected and their yield would have been less than usual, but difficult to quantify how much less. Twenty-four out of 42 summer-fruiting genotypes harvested in 1999 produced more than 30kg of marketable fruit/10m row length. This included the two standard cultivars 'Tulameen' and 'Glen Ample' and 22 HRI selections. Selection 6507/56 had the highest marketable yield (52.66 kg/10m row) while 6514/53 had the highest total yield (63.33 kg/10 row).

Seven selections and the cultivar 'Tulameen' had an overall mean individual fruit weight of 4.0g or over (Table 8). Averaged over the whole fruiting season, seven selections had larger fruit than 'Tulameen' while 10 had larger fruit than 'Glen Ample'. The highest value for mean weight of individual fruit came from selection 6506/37, which also appears in the top three selections for marketable yield. Selection 6495/38 had the lowest value for mean individual fruit weight (2.40g) which appears in the middle third for total marketable yield (Table 8).

Table 9 summarises over all the picks, the mean scores of the quality characters for each genotype. Selection 6507/56 which gave the highest marketable yield, scored 3.0 or higher for seven quality characters and was scored only slightly low for brightness and skin strength (2.6 for both characters). Sixteen out of 42 genotypes sampled scored 3.0 or higher for flavour, including the three cultivars used as controls (3.4, 3.3 and 3.0 for 'Tulameen', 'Glen Ample' and 'Glen Moy', respectively). Only selection 6511/12 scored higher than 'Tulameen' for flavour (3.7) but this selection was low yielding and too soft; it had the lowest texture and skin strength scores (1.8 and 1.7, respectively).

'Glen Ample', 'Glen Moy' and 'Tulameen' are all considered a satisfactory colour by the market and several selections were an improvement on these cultivars. Half the selections were brighter than 'Glen Ample', which is considered the brightest of the existing cultivars, and only two were duller than 'Glen Moy'. Thirty-two selections were a lighter red than 'Tulameen' and 11 were lighter than 'Glen Moy'. Only two selections (6508/119 and 6488/91) scored a mean value for cohesion that was lower than 4.0, indicating that none of the Stage 0 selections were crumbly-fruited in 1999.

Table 10 shows the picking season of the three cultivars and the 39 selections with the earliest ripening genotypes at the top. This year, 5% of 'Glen Moy' was picked by 15 June, which is a reflection of the early season. This cultivar is judged by the industry as the earliest summer-fruiting raspberry, but in 1999 three HRI selections (6511/12, 6504/11 and 6511/22) were a day earlier than 'Glen Moy'. Two of these selections (6511/12 and 6504/11) also gave 50 and 95% pick dates that were earlier than 'Glen Moy' and indicate slightly earlier fruiting seasons. All three selections had higher values for total yield, marketable yield and mean fruit weight and lower values for unmarketable yield compared to 'Glen Moy', indicating that they were slightly better in many respects. However, the yields of all these early selections were unacceptably low in 1999, but this was probably due to frost damage and they are worth further examination in the next season.

Ten selections had 50% pick dates that were later than 'Tulameen' and five of these selections had 95% pick dates that were later, but only 6513/53, 6512/50 and 6495/38 were significantly later than 'Tulameen'.

5.4. Discussion

Fruit size is a major yield component of raspberry and eight genotypes with an average fruit weight greater than 4.0g are in the top half the yield table. However, fruit number is also an important yield component and selections such as 6495/38, 6495/97 and 6495/99 all had relatively high yields of smallish fruit. Genotypes with an average fruit size between 2.5 and 3.0g are too small to pick by hand for the fresh market, but may have potential for machine harvesting.

All the 1999 Stage 0 data, plus the breeder's field notes, will be used to decide if a selection should be picked again in Stage 0 trials in 2000 or is worthy of going forward for future trials on growers' farms. Selections with one or two drawbacks can still be selected for use as parents for future crosses if they are particularly good for other attributes.

Table 8. The 1999 summer-fruiting raspberry genotypes arranged in descending order of marketable fruit weight. The unmarketable fruit weight, total fruit yields and mean individual fruit weights are also given for each selection

Selection	Weight of marketable fruit (Kg/10m row)	Weight of unmarketable fruit (Kg/10m row)	Total weight of fruit (Kg/10m row)	Mean weight of individual fruit (g)
6507/56	52.66	7.70	60.36	4.32
6514/53	50.98	12.34	63.33	4.20
6506/37	48.48	8.39	56.87	4.72
6513/6	48.11	12.62	60.73	4.25
6513/53	43.15	16.08	59.23	3.70
6495/99	41.72	12.46	54.18	2.74
6489/111	41.21	9.65	50.86	4.24
6489/131	39.86	9.00	48.86	3.87
6507/35	39.71	6.56	46.27	3.50
6511/58	39.23	6.53	45.77	3.60
6505/7	38.76	9.81	48.58	4.78
6494/53	36.15	10.94	47.08	3.04
6508/27	36.14	4.80	40.94	3.09
6448/10	35.45	19.06	54.51	4.34
6312/5	34.95	19.03	53.98	3.48
6495/97	34.51	13.52	48.04	2.86
6451/142	34.16	11.26	45.42	3.31
6487/74	33.64	8.62	42.26	3.12
Tulameen	33.07	8.02	41.09	4.18
6512/50	31.96	12.74	44.71	3.92
6451/128	31.79	9.66	41.44	3.17
Glen Ample	31.76	4.37	36.13	3.76
6508/119	31.67	4.27	35.94	2.56
6493/50	31.05	8.89	39.94	2.67
6495/38	28.65	13.39	42.04	2.40
6508/139	28.02	2.55	30.57	3.03
6488/58	27.73	5.46	33.19	3.08
6508/116	27.52	5.08	32.60	3.27
6494/115	26.14	11.82	37.97	3.12
6489/40	24.94	3.81	28.75	2.64
6511/53	24.41	6.01	30.42	3.03
6495/3	23.37	5.69	29.05	3.19
6504/11	23.28	4.39	27.67	3.66
6494/22	23.17	7.89	31.06	3.11
6508/68	21.36	2.24	23.60	3.37
6511/22	21.06	4.23	25.28	3.67
6488/91	20.25	3.07	23.32	2.52
6511/12	18.92	4.09	23.01	3.73
6517/11	16.49	4.56	21.05	3.03
6508/135	15.80	4.83	20.63	3.46
Glen Moy	15.27	5.05	20.33	3.61
6490/24	12.71	10.13	22.84	3.68

Table 9. The mean fruit character scores for each of the summer-fruit genotypes sampled in the 1999 stage 0 trials

Selection	Quality Characteristics								
	Redness	Brightness	Shape	Outline	Uniformity	Texture	Cohesion	Skin strength	Flavour
6507/56	3.2	2.6	3.0	3.2	3.3	3.3	4.4	2.6	3.0
6514/53	3.0	3.7	1.7	3.8	3.4	2.5	4.3	3.5	2.5
6506/37	2.8	3.2	3.9	3.8	3.3	3.8	5.0	3.7	3.1
6513/6	2.5	3.6	1.9	3.3	4.0	2.6	4.2	2.6	3.0
6513/53	3.1	3.3	1.5	3.3	3.9	2.8	4.0	3.2	2.8
6495/99	3.6	3.8	3.7	3.5	3.4	2.6	4.5	2.6	2.4
6489/111	2.4	3.4	3.8	3.6	3.3	3.5	4.6	3.0	2.7
6489/131	3.2	3.2	3.7	3.5	3.4	3.2	4.6	2.9	3.1
6507/35	2.9	2.6	2.6	3.0	3.1	3.4	4.7	4.1	3.1
6511/58	2.5	3.1	3.8	3.9	3.5	2.6	4.5	2.8	2.5
6505/7	2.4	3.3	3.9	3.5	3.4	3.4	4.6	3.0	3.2
6494/53	3.4	3.6	4.0	3.1	3.0	2.5	4.5	3.0	3.4
6508/27	3.0	4.1	3.8	3.3	3.1	3.7	4.1	3.4	2.8
6448/10	3.1	3.2	2.8	3.2	3.2	1.9	4.1	2.3	2.0
6312/5	2.6	3.3	3.0	3.1	3.8	3.1	4.9	3.0	2.4
6495/97	3.1	3.5	3.8	3.5	3.1	2.9	4.5	2.6	2.4
6451/142	3.0	3.1	3.0	3.3	3.2	3.0	4.4	3.0	2.4
6487/74	4.1	2.6	1.9	3.3	4.2	2.7	4.2	3.2	2.6
Tulameen	2.6	3.7	4.0	3.6	3.0	3.4	4.5	4.1	3.4
6512/50	2.8	2.6	2.5	3.2	3.7	3.9	4.5	3.8	2.5
6451/128	3.8	3.1	2.5	3.4	3.8	2.8	4.6	3.2	3.2
Glen Ample	2.6	3.2	2.4	3.1	3.6	3.5	4.6	3.7	3.3
6508/119	3.6	3.8	2.5	2.7	3.8	3.3	3.2	3.3	3.3
6493/50	3.1	2.6	3.7	2.9	3.8	2.8	4.1	3.0	2.5
6495/38	4.0	3.4	2.8	3.4	3.3	2.7	4.3	2.6	2.0
6508/139	3.1	3.3	3.2	3.2	3.2	2.6	4.4	2.8	2.6
6488/58	2.9	3.3	3.1	2.9	3.4	3.4	4.3	3.3	2.9
6508/116	3.0	3.4	3.1	3.3	3.6	2.4	4.1	3.0	2.5
6494/115	4.3	2.7	3.1	3.3	3.6	3.0	4.2	3.2	3.1
6489/40	3.1	2.8	2.9	3.1	3.0	3.7	4.3	3.4	2.8
6511/53	2.4	2.3	3.0	3.0	3.4	3.1	4.1	3.9	3.1
6495/3	3.3	4.0	3.6	3.4	2.8	2.9	4.5	2.8	2.4
6504/11	3.0	2.8	3.2	3.3	3.0	3.7	4.5	3.7	2.0
6494/22	3.8	3.6	2.5	3.2	3.8	3.4	4.2	3.6	2.7
6508/68	2.9	4.0	3.0	3.8	3.2	3.2	4.4	3.2	2.9
6511/22	2.3	2.1	3.4	3.6	3.0	2.7	4.4	3.9	2.9
6488/91	3.0	3.0	3.8	3.4	3.7	2.9	3.9	3.4	2.7
6511/12	3.0	3.2	4.0	3.3	3.5	1.8	4.2	1.7	3.7
6517/11	2.1	2.1	4.0	3.7	3.2	3.6	4.8	4.0	2.7
6508/135	2.7	3.6	4.0	3.9	3.6	3.3	4.1	4.1	3.0
Glen Moy	3.1	2.3	3.0	2.6	2.4	2.7	4.1	3.0	3.0
6490/24	3.0	3.5	3.5	3.3	3.6	3.3	4.4	3.0	2.9

Table 10. The 5%, 50% and 95% pick dates for the 39 summer-fruiting selections and the three named cultivars used as standards in 1999. These selections are arranged in order of earliest to latest 5% pick date

Selection	5% Pick Date	50% Pick Date	95% Pick Date
6511/12	14-Jun	20-Jun	05-Jul
6504/11	14-Jun	21-Jun	05-Jul
6511/22	14-Jun	25-Jun	08-Jul
Glen Moy	15-Jun	22-Jun	07-Jul
6511/53	15-Jun	24-Jun	07-Jul
6488/91	16-Jun	28-Jun	12-Jul
6489/40	16-Jun	02-Jul	17-Jul
6488/58	17-Jun	27-Jun	09-Jul
6511/58	17-Jun	27-Jun	09-Jul
6508/139	17-Jun	28-Jun	10-Jul
6489/131	17-Jun	07-Jul	22-Jul
6508/116	18-Jun	28-Jun	13-Jul
6508/68	18-Jun	29-Jun	13-Jul
6508/27	18-Jun	30-Jun	13-Jul
6505/7	18-Jun	30-Jun	17-Jul
Glen Ample	18-Jun	03-Jul	19-Jul
6514/53	18-Jun	07-Jul	24-Jul
6493/50	19-Jun	01-Jul	15-Jul
6507/35	19-Jun	02-Jul	18-Jul
6490/24	19-Jun	04-Jul	19-Jul
6494/53	19-Jun	05-Jul	18-Jul
6517/11	19-Jun	06-Jul	20-Jul
6506/37	19-Jun	07-Jul	20-Jul
6489/111	20-Jun	07-Jul	20-Jul
6507/56	21-Jun	03-Jul	19-Jul
6494/22	21-Jun	05-Jul	19-Jul
6487/74	21-Jun	07-Jul	19-Jul
6451/128	21-Jun	07-Jul	21-Jul
6513/6	21-Jun	07-Jul	22-Jul
6495/99	22-Jun	04-Jul	19-Jul
6448/10	22-Jun	05-Jul	16-Jul
Tulameen	22-Jun	06-Jul	22-Jul
6508/119	23-Jun	08-Jul	21-Jul
6495/97	23-Jun	09-Jul	19-Jul
6495/3	24-Jun	09-Jul	23-Jul
6494/115	25-Jun	09-Jul	23-Jul
6508/135	25-Jun	10-Jul	21-Jul
6312/5	26-Jun	07-Jul	18-Jul
6451/142	26-Jun	09-Jul	21-Jul
6513/53	26-Jun	12-Jul	28-Jul
6512/50	27-Jun	15-Jul	28-Jul
6495/38	02-Jul	16-Jul	30-Jul

6. Summary

The 6-month period that I have worked in the raspberry breeding programme here at Horticulture Research International was only a small part of a long-term programme. Plant breeding is a lengthy process which involves the rapid processing of large volumes of material. It usually takes between 10 and 15 years between making the initial cross and releasing a new raspberry variety.

The aim of the breeding programme is to provide raspberry growers with new, improved summer-fruiting and primocane-fruiting varieties, and will always be subject to the changing standards of the fruit growing industry and the consumers. The programme has to anticipate and keep abreast of the changes in the industry, in order to continue breeding raspberries with ever increasing improvements.

The programme is also subject to the varying weather conditions, such as late frosts. This was a factor in the results obtained in the Stage 0 trials this year, and was shown by the lower yields obtained for the early flowering 'Glen Moy'. Milder winters in the 1990's have resulted in earlier development in the spring and significant amounts of frost damage to flower buds in April.

Whilst at HRI-East Malling I have been able to learn a number of new techniques. I now appreciate the importance of a common methodology, accurate record keeping and other skills such as planning and team working.

7. Acknowledgements

I would like to thank the Horticultural Development Council (HDC) for funding this placement, which has made it possible for me to develop my knowledge of fruit breeding, understand the organisational process involved and further my practical experience of working Biology.

I also would like to express my thanks to my supervisor, Mrs Vicky Knight, for the supreme help and guidance that she has afforded me throughout the duration of this placement. I would also like to express my thanks to my fellow members of the raspberry breeding team; Macarena Blanco and Claire Senner, and to other members of the Plant Breeding and Biotechnology Department, all of whom have helped to make my placement here in Kent a worthwhile and memorable experience.

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