Perfect Pears-the National Pear Breeding Program

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Perfect Pears – The National Pear Breeding Program

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Technical summary

The National Pear Breeding Program aims to develop new high-quality pears with good fruit appearance, good storage and shelf potential, diversified maturity, better scab resistance and grower-friendly tree characteristics. This report summarises the progress of the program in the period 2003/04 to 2005/06.

Over 61,000 seedling hybrids from over 170 controlled crosses were planted at the DPI Victoria Tatura site, since the commencement of the program in 1991. Over 44 existing pear varieties and 18 elite selections from the program itself were used for crossing. Currently over 31,000 seedling trees, varying in age from 1 to 10 years, remain in seedling orchards, with 76% of them having produced fruits.

Each cropping season about 1000 seedling trees were visually selected and their fruit subjected to storage under refrigerated cold room conditions (1 °C). The fruit quality was assessed by a sensory panel after at least six weeks of storage followed by one week of allowing the fruit to ripen. Respectively, 33 and 44 selections were identified in 2003/04 and 2004/05, which resulted in a total of 149 selections by the end of the 2004/05 cycle. Assessment of the 2005/06 harvest is ongoing and will be reported at another opportunity.

Over 100 selections are now under evaluation as orchard trees under the open Tatura Trellis system in three 2nd stage trials at the Tatura site, planted from 2003 onwards. The Australian Pome Fruit Improvement Program (APFIP) is evaluating seven selections in different regions. Selections of 2004/05 are currently being grown as nursery trees, and will be planted as an evaluation trial in the coming spring. Five elite selections will be given to the APFIP for regional evaluation.

When 28 selections identified in 2003/04 were reassessed for their fruit quality in 2004/05, two thirds were again regarded as acceptable to good, using a 5 point scale for scoring. Four pre-2002 selections in the evaluation trial produced fruit with an appearance and eating quality better than the commercial control, Packham's Triumph.

Two selections matured earlier or similar to WBC, but produced much better looking fruit. Their fruit can be eaten immediately of the tree and also after storage, but their longer term storage potential was only moderate. A large variation among selections resistant to scab infection was noted, and some of them showed high levels of disease resistance both on the leaves and the fruit.

Heritability estimates of sensory quality attributes were generally low. It appears that better genetic gain can be achieved by phenotypic selection for juiciness, sweetness and acidity. For selecting materials with an appropriate sugar:acid balance in the flesh of the fruit, emphasis should be more so on the ratio of °Brix and titratable acid, than the sensory data. In order to identify one or more potential seedlings in individual families with all required quality traits, a family size of between 110 and 170 seedling trees would be required.

The screening method for scab resistance employed by the program was very well able to differentiate the various reactions of seedling trees to scab under orchard conditions, both on the leaves and the fruit. These results also demonstrated the effectiveness of glasshouse screening of seedlings at a young age. The degree of leaf infection by scab showed a moderate correlation with infection of the fruit.

Additional seedling hybrids with various combinations of fruit appearance, flesh texture and flavour, maturity time and scab resistance are continuously being identified, representing a pipeline of new varieties into the future, and indicative of proper breeding methods being used. In addition, recent analyses of genetic data have identified potentially even more efficient strategies of breeding, which will be scrutinised. Work is ongoing to bring molecular tools into the breeding scene soon as well.

Materials and Methods

Hybridisation and seedling establishment

Since 2003 selections from the program with improved quality characters have been extensively used as parents in crosses. They were crossed with each other and with major varieties, and several proved to be excellent parents based on their new progenies. On average, 16 crosses were made each season with a targeted family size of about 200 seedling trees per cross (Appendix 1).

During the initial stage of the program, crosses were conducted in WA by the state Department of Agriculture. Since 2003, hybridisation has been conducted at the DPI Tatura site, and improved methods for hybridisation and seedling establishment were developed. These are described below.

Controlled pollination was carried out in orchards during springtime at the DPI Tatura site. Flowers of the female parents were first hand-emasculated at the 'balloon' stage, followed by hand pollination and then bagging of the inflorescence. Within each flower cluster only the most advanced 3-4 flowers were kept and emasculated. Pollen was collected and used in the same season when crossing was being conducted or was collected during the previous season and stored in a freezer until use. Hand pollination was conducted immediately after emasculation for the first time and was then repeated after 5 days. The covering bags were removed seven days after the last pollination. For each cross, up to 50 flower clusters were hand-pollina' ', so as to obtain about 200 hybrid seeds, which would give rise to 150-180 healthy seedlings.

Fruits that have set after hand-pollination are harvested at physiological maturity stage and stored in a cool room (1°C) for 6 to 8 weeks. After about 4 to 7 days of ripening at room temperature, seeds are extracted, cleaned and surface sterilized with 2.5% common bleach. The seeds are then planted in propagation tubes with Debco® Seed Raising mixture (one seed per tube) and placed into a cool room for stratification for about 6 weeks. The seeded tubes are then placed in a heated glasshouse for germination and seedling establishment. Four weeks after seedling establishment, they are progressively hardened, first by moving them into an unheated glasshouse and then outdoors.

Seedlings are planted in orchard blocks at a row x tree spacing of 3.5 m x 0.5 m in early spring. The orchard blocks are managed using the accepted methods for weed, pest and disease control, and receive the required fertilization and irrigation. Seedling trees are not pruned regularly, but branches along the leader trunk up to 1 m above ground are removed during the first three seasons to ensure rapid growth of the leader trunk and subsequent ease of access to mature orchards for regular maintenance.

Flowering survey

Pear seedling trees generally require about 4 to 7 years of juvenile growth to begin the adult phase of growth characterised by flowering and setting of fruit. Each spring between 2003/04 and 2005/06 a flowering survey was conducted among the established seedling families. Seedling trees under densely planted conditions tended to flower or set fruit in alternate seasons. Once fruiting structures (i.e. buds or flowers) are observed in a season, from then on the trees are considered able to successfully set fruit.

Identification of desirable hybrids from established seedling population

A three step strategy developed in 2003/04 is used to identify desirable hybrids in seedling families that have begun to set fruit. The strategy includes visual selection in the orchard, followed by cold storage and then comprehensive quality assessment after the fruit has fully ripened. This process is described in detail in the final project report of 2003.

Based on predefined 1-5 and 1-9 point scales, sensory scores are given for fruit appearance, including such attributes as: fruit symmetry, bumpiness, smoothness, shape, and skin and lenticel colour. The following quality attributes are also determined during the assessment: flesh firmness, juiciness, fineness, grittiness, sweetness, acidity, sugar/acid balance and aromatic flavour. Seedling trees with desirable fruit quality compared to the commercial varieties, WBC and Buerre Bosc, are identified. Selected trees are then propagated on commercial rootstocks, D6 and Quince A, to produce orchard tree response. 97 selected hybrids were assessed for their reactions to scab on both foliage and fruit (Table 6).

The assessment was conducted in late spring or early summer in each cropping season. Foliage infection was assessed at three different tree canopy positions, from the top to the bottom, and the highest infection score was recorded. Fruit scab severity was obtained based on the assessment of at least 10 fruits from individual trees, with the scores of most severely infected fruit being recorded. The biannual fruit bearing habit of seedling trees made reassessment of fruit infection impossible to carry out in some of trees, which did not set fruit 2005/06.

Data analyses

Fruited and selected seedling trees in established breeding population

The total number of seedling trees and those setting fruit were respectively pooled across seasons, and gave the percent of fruited trees based on the number of available trees in the seedling population. Similarly, the number of visually selected trees per cross was pooled over three seasons, and provided the proportion of selected trees based on the number of fruited trees.

Fruit quality assessment for the 2005/06 season has not been completed, thus only 2003/04 and 2004/05 data were used for pooling. These two data sets were also used to obtain the number of selected trees with or without taking into consideration acceptable fruit appearance and eating quality. Then the percent of seedling trees retained was calculated based on the initial seedling tree numbers at each of the three assessment steps.

Based on their pedigree information, families which are currently under evaluation were grouped into different maturity combinations according to parental maturity types (Table 1), and the number of progeny selections identified since 1998 were listed for each combination.

Heritability estimates of fruit eating quality attributes

Data from about 390 seedling progenies of 48 intervarietal European pear families was used to estimate the heritability of the following eight sensory attributes: flesh firmness, juiciness, fineness, grittiness, sweetness, acidity, sweet-acid balance, aromatics, and three objective (machine-measured) attributes: °Brix, titratable acid and their ratio. An individual gametic mixed model (Lynch and Walsh 1999) was fitted as follows, for individual attributes based on the restricted maximum likelihood approach, using the ASREML programme (Gilmour *et al.* 2000).

$$y=X\beta+Z\alpha+W\delta+e,$$

where y is the vector for observations of individual attributes; β is the vector for fixed block effects; α is the vector for additive genetic effects and δ is the vector for environmental effects. X, Z, and W are, respectively, incidence matrices relating to observations of the effects in the model.

Additive genetic, environmental and residual effects were assumed to have independent normal distributions, with means of zero and expected variances of $A\sigma^2_a$, σ^2_{pe} and σ^2_e, respectively. A is a numerical relationship matrix, which accounts for the pedigree information of individual progenies. The expectation of phenotypic variance for attributes is $\sigma^2_p=\sigma^2_a+\sigma^2_{pe}+\sigma^2_e$ and the estimates were derived for heritability in the narrow-sense (h^2) ($4\sigma^2_a/\sigma^2_p$).

Analyses of Scab assessment data

Scab infection was considerably higher during the spring of 2005 than in 2004. Some seedling trees rated to be moderately resistant in 2004 scored as quite susceptible in 2005. Disease assessments during 2005 were conducted twice, once at mid-spring and a second time in late spring. The infection scores obtained at different times were highly correlated in 2005, and overall, higher scores were recorded at the second time (Data not shown). Therefore, only the data from 2005 late spring was used for reporting here.

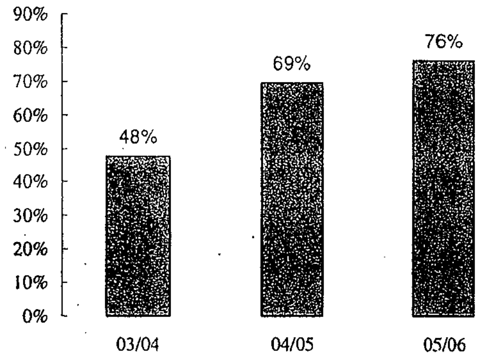

Figure 1. Change in the proportion of trees setting fruit in the seedling populations of pre-2003 crosses.

Identification of desirable hybrid trees from fruited seedling population

About 1,000 seedling trees were visually selected each season from among fruit-bearing seedling populations (Appendix 3). This resulted in a proportion of 14% of fruited trees being visually selected from 2003/04 to 2005/06. As selection at this stage is mainly based on fruit appearance, this proportion varied greatly among crosses. For example, in those families with at least 100 seedling trees, this proportion ranged from 3% to 27%.

Thirty three and 44 seedling trees were selected in 2003/04 and 2004/05, respectively, after sensory assessment (Table 1). Fruit assessment in 2005/06 has not completed. However, it is expected that an additional 30 to 40 seedling trees will be identified from this latter season, resulting in about 200 promising hybrid progenies.

Until 2004/05, 149 selections had been identified from seedling populations. These derive from crosses involving parents with different maturity profiles (Table 1).

Only a few truly interspecific crosses were made, as breeding interspecific hybrids is only a minor component of the program. However, four desirable seedling hybrids were identified so far.

Table 1. Number of selections identified from crosses between parents with different maturity profiles since 1998.

Combination*	Number of desired selections				
of crosses	98/02	02/03	03/04	04/05	TOTAL
Early x Early	2	2	8	1	13
Early x Medium	10	11	2	5	28
Early x Late	11	18	23	23	75
Med x Late	3	1	1	8	13
Late x Late	2	2		7	11
Unknown#	4				4
Interspecific	1		4		5
	33	34	38	44	149

* Different combinations of maturity profiles (early, medium and late maturity).
# Pedigree of the cross was lost.

When data for 2003/04 and 2004/05 was pooled, only about one quarter of visually selected trees per seedling population was worth further assessment, because they had edible fruit flesh, when ripened following cold storage (1°C). The other seedling trees were discarded because either their fruit suffered internal breakdown during the storage or the ripe fruit proved inedible (Figure 2).

When selection was conducted either for acceptable fruit appearance or for eating quality, or for both based on sensory scores, the seedling trees retained after selection could be separated into four groups (Figure 2 on right). Overall, only 3% of seedling trees possessed fruit appearance and eating quality worthy of further evaluation as orchard trees; about 5% either had acceptable fruit appearance or eating

Table 2. Sensory scores of fruit quality of 15 selections assessed by fruit growers in Victoria and WA.

Selection-id	Pedigree	Year selected	Appearance*	Eating quality*	Weighed score#	People&
DPIV-0407	Comice x BPM	2004	3.3	3.5	3.4	4
DPIV-0409	Comice x BPM	2004	3.4	4.1	3.9	15
DPIV-0324	Comice x Howell	2003	3.5	3.5	3.5	2
DPIV-0405	Guyot x Comice	2004	2.9	3.6	3.4	10
DPIV-0414	Guyot x Corella	2004	2.1	3.4	3.0	10
DPIV-0417	Guyot x Corella	2004	2.5	2.7	2.6	11
DPIV-0328	Guyot x Corella	2003	2.5	3.2	3.0	11
DPIV-0420	Guyot x Corella	2004	3.8	2.6	3.0	11
DPIV-0333	Guyot x Corella	2003	3.7	2.8	3.1	15
DPIV-0432	Guyot x Corella	2004	2.0	4.0	3.4	2
DPIV-0422	Guyot x Hood	2004	2.3	2.9	2.7	14
DPIV-0312	Harrow Delight x Packham's T	2003	2.6	3.1	3.0	8
DPIV-0311	HW606 x Packham's T	2003	3.5	3.9	3.8	8
DPIV-0425	WBC x BPM	2004	3.5	4.0	3.9	4
DPIV-0429	WBC x BPM	2004	3.3	3.0	3.1	3

* 1 to 5 point scale: 1 = poor, 2 = fair, 3 = acceptable, 4 = good and 5 = excellent.
# Weighed scores = 0.3 x the score of fruit appearance + 0.7 x the score of eating quality. A higher weight is given for eating quality, because eating quality more so than fruit appearance is associated with consistent purchasing behaviour among consumers (Hampson and Quamme 2000).
& Number of participants (evaluators).

Table 3. Average sensory scores and ranges for fruit appearance and eating quality of five selections in the 2nd evaluation trial.

Select ID	Pedigree	Appearance*		Eating quality*		Weighed# score	People&
		Average	Range	Average	Range		
E-42-98	Guyot x Packham's	6.2	5-7	5.4	3-7	5.6	5
B-14-40	Packham's x Comice	4.5	3-6	4.8	4-6	4.7	4
F-12-45	Guyot x Comice	4.2	2-6	4.8	4-6	4.6	5
C-27-42	BPM x Corella	3.6	3-5	4.9	4-6	4.5	7
C-31-42	BPM x Corella	5.0	3-6	3.3	2-5	3.8	7
Control	Packham's	3.5	3-4	4.5	4-5	4.2	4

* 1 to 7 point scale: 1 = dislike extremely, 2 = dislike moderately, 3 = dislike slightly, 4 = neutral, 5 = like slightly, 6 = like moderately, and 7 = like extremely.
# Weighed scores = 0.3 x the score of fruit appearance + 0.7 x the score of eating quality. A higher weight is given for eating quality, because eating quality more so than fruit appearance is associated with consistent purchasing behaviour among consumers (Hampson and Quamme 2000).
& Number of participants (evaluators).

The assessment results of two early season selections demonstrated great potential, due to their earliness, good fruit quality and acceptable storage capacity. The earliest selection matured early January and could be harvested 10 days before WBC this past season. Its fruit has a crisp texture and sweet taste when eaten just after harvest (Photo 1). The second early selection is a pear with a red blush on the skin, and matured at a similar time to WBC. Its ovate pyriform fruit is very symmetrical and appealing because of its smooth, yellow green skin finish and light pink blush (Photo 2). Similarly to the other early selection, its fruit has a crisp texture and a sub-acid sweet taste when consumed after harvest.

Table 4. Narrow sense heritability estimates of fruit texture and flavour attributes of pear breeding population in the 2003/04 season.

Attributes	Heritability, in narrow sense
Firmness	0.13±0.13
Juiciness	0.32±0.17
Fineness	0.04±0.10
Grittiness	0.03±0.10
Sweetness	0.22±0.13
Acidity	0.74±0.28
Sweet and acid balance	0.09±0.16
Aromatic liking	0.16±0.22
Aromatic intensity	0.07±0.13
°Brix	0.49±0.32
Titratable acid (TA)	0.41±0.39
°Brix/TA ratio	0.38±0.30

Table 5. Mean leaf infection scores and standard deviations (sd) under orchard conditions, for respective groups of resistant and susceptible trees based on earlier seedling glasshouse screening.

Cross	Type	Response under glasshouse screening		t value	P value
		Resistant	Susceptible		
Comice x BPM	S x R				
Tree no.		38	40		
Average ± sd		2.7±1.5	4.6±1.8	-4.93	<0.01
Guyot x Hood	R x R				
Tree no.		43	36		
Average ± sd		1.8±0.7	2.0±0.8	-1.28	0.21
Guyot x Comice	R x S				
Tree no.		61	41		
Average ± sd		4.4±2.1	4.7±2.2	-0.35	0.72
Guyot x Bosc	R x S				
Tree no.		41	42		
Average ± sd		3.4±2.1	4.2±1.9	-2.83	<0.01
Eldorado x Guyot	S x R				
Tree no.		46	40		
Average ± sd		2.7±1.6	3.8±1.9	-3.30	<0.01

x Hood and Guyot x Comice. Hence the value of the seedling disease screening method could not be shown to be consistent, and warrants further study.

Selected hybrids responded to scab infection differently, depending on whether it affected foliage or fruit (Table 6). This was also the case among selections derived from the same cross. The cross of Guyot x Corella is a good example: 28 selected hybrids were assessed, and scab ratings ranged from 1 (no scab symptoms) to 8 (whole leaf covered by scab), and for fruit ranged from 1 (free of scab) to 4 (fruit with >10 mm scab flecks). The scab score for leaves was only moderately correlated with that for fruit ($r = 0.42$, $P<0.05$, $df = 30$).

Discussion

High gemination rates of hybrid seeds from the crosses made in 2003/04 and 2004/05 suggests that highly successful methods were employed by the program in hybrid seedling establishment (from seed extraction, decontamination, stratification, to germination). However, lower seed germination rates were observed in two crosses, where a very early season Italian summer pear was used as the mother tree. Poor seed germination has also been observed in early x early crosses of other fruit species, such as in the case of table grape and low chilling stone fruits (Ramming *et al.* 1990; Ramming 1990). Research nature of the maturity trait, the fact that it is reported here that two very promising early season selections were identified, suggests that good progress is being made by the program towards to the objective of expanding pear production seasonality on the early side.

One would expect that fruit quality of various selections will be subject to the influence of climatic conditions when they are grown in different growing seasons. However, the across-season assessment of 28 selections demonstrated that fruit quality of most selections (>2/3) were not in fact altered greatly by season. Initially promising fruit quality results of a few selections from pre-2002 indicated that they were better than the major control variety, Packham's Triumph. However, also a large difference was noted among individual taste panel evaluators when testing the same fruit samples. Participants involved in fruit quality assessment are DPI staff volunteers or fruit growers, and not pre-trained. They rate fruit samples based on their own sensory experience, and not some non-arbitrary consumer standard. Therefore, such differences are to be expected. Nevertheless, this experience suggests the urgent need of a pre-trained group (such as a professional panellist or focus group) for fruit quality assessment, so ranking of selections is more consistent. Eventually trait-dissection may de-construct flavour components to the level that simple chemical tests can determine (distinct) flavour profiles. That would also open the way to identify and use linked molecular markers. The higher heritabilities, to be discussed below, for such machine-measured traits as sugar and acid content are illustrative of the potential of a trait dissection approach linked to molecular breeding.

Pear fruit eating quality is mainly determined by flesh juiciness, sweetness and acidity. Heritability estimates suggest that some genetic gain can be achieved based on phenotypic selection for these traits in breeding populations. In contrast, much gain as a result of phenotypic selection for other sensory attributes is highly unlikely, as they have very low heritability estimates. For sugar and acid balanced flesh, selection is quite effective as this is based on instrumental rather than sensory measurements. However, only a relatively small data set was used for the analyses, and all estimates were associated with relatively large errors. The question whether the above estimates can be improved using across-season data needs to be answered in the future.

Scab screening under glasshouse conditions at the young seedling stage proved to be quite effective in identifying resistant trees in orchard conditions. However, in this study it did fail in two of five crosses examined in this report. Environmental conditions may affect infection, resulting in differences in disease response rankings. This may mean that screening over several seasons may be needed to determine true disease response. The moderate correlation between foliage and fruit infection suggests that selection for leaf resistance, either using young seedlings or orchard seedling trees, could be somewhat indicative of fruit scab resistance.

In conclusion, the program has made good progress in identifying desirable seedling trees from breeding populations. It also embarked on a new phase of germplasm enhancement, in which scientific outputs are more expressly used in breeding. Research undertaken in quantitative genetics and in the determination of optimum population sizes may provide good knowledge and guidance in improving the breeding process. Exploring the role of early scab screening in identifying mature tree resistance, and studying the relation between foliar and fruit infection will further increase breeding efficiency. Most interestingly, across-season assessment of selections in regard to their fruit quality demonstrated good consistency, highlighting the effectiveness of the three step strategy used by the program in identifying the few seedling trees from among large breeding families carrying all the desirable traits. Recent fruit quality assessments identified some selections with good potential in terms of earliness combined with overall fruit quality. Nevertheless, there are still many challenges ahead for correctly evaluating pear productivity, disease response and quality. With our intention to employ more intensively the biotechnological skill-base within DPI, we are optimistic that further substantial breakthroughs in pear breeding lie just over the horizon.

Acknowledgements

During this period of the program, we have lost our program leader, Mr Graeme McGregor, as he sadly passed away following his battle with cancer, in December, 2005. He was a greater campaigner for the program. Under his leadership, the program he designed developed a solid foundation. His great contributions are gratefully acknowledged.

David Haberfield and Michael Jordon have provided valuable technical support to this program.

John Washbourne and Paul Pierce both retired from DPI-Victoria during the life-time of this project. They made important contributions to the program.

Drs Jill Campbell and Susie Newman represented NSW Dept of Agriculture until 2002.

Drs Richard Bell, USDA and David Hunter, Ag Canada, both collaborated in the creation of crosses including their own elite selections as parents in a project managed by Dr Jill Campbell in 1996. Seed was sent to Australia, and several selections have resulted from this collaboration.

Dr Andrew Granger represented SARDI on this program until 2002, and contributed particularly to rootstock breeding.

Dr Eleanor Melvin-Carter continues to represent WA Dept of Agriculture on the program and has managed the production of most of the seed received since 2001.

We also thank the valuable contributions of the Steering Committee at its Annual General Meeting and subsequent discussions.

Our special thanks go to our colleague, Dr Maarten Van Ginkel, for his comments and suggestions and the great effort of improving the English of this report during its preparation.

List of Appendices

Appendix 2. Breeding families entirely or partially removed in the winters of 2003 and 2005.

Cross ID	Female	Male	No trees planted	No tree removed* 2003	No tree removed* 2005	Trees remained	% trees removed
91-03	Packham's Triumph	Nijisseiki	19	19			100
93-01	BPM	Corella	91	87	4		100
93-02	Packham's Triumph	Comice	172	172			100
93-03	Packham's Triumph	Corella	124	123	1		100
93-04	Packham's Triumph	Tsu Li	53	53			100
93-05	Packham's Triumph	Josephine	605	601	4		100
93-06	Packham's Triumph	Howell	254	250	4		100
93-07	Potomac	Packham's Triumph	165	163	2		100
93-08	Packham's Triumph	Ya Li	85	85	1		100
93-09	Comice	Packham's Triumph	196	196			100
93-10	Dr Jules Guyot	Packham's Triumph	78	78			100
93-11	Josephine	Packham's Triumph	494	249	245		100
93-12	Vicar Winkfield	Packham's Triumph	6	3			100
94-01	Comice	Dr Julies Guyot	498	259	157	82	84
94-01R	Dr Jules Guyot	Comice	901	553	203	145	84
94-02	Comice	Vicar Winkfield	58	15	43	43	26
94-03	Eldorado	Comice	673	295	194	184	73
94-04	BPM	Comice	100	60	40	40	60
94-05	Howell	Comice	578	269	182	127	78
94-05R	Comice	Howell	1003	466	214	323	68
94-06	WBC	Ya Li	123	111			100
94-07	Packham's Triumph	Ya Li	2241	2238			100
94-08	Packham's Triumph	Tsu Li	59	41			100
94-09	Eldorado	Howell	67	57			100
94-10	Packham's Triumph	BPM	25	14	2	9	64
94-11	Packham's Triumph	Hood	354	313			100
94-12	Corella	Hood	355	349			100
94-14	Corella	Comice	765	604	3	158	79
94-15	WBC	Howell	709	308	1	400	44
94-17	L'inconnue	Corella	296	296			100
94-18	Josephine	Corella	1232	1032	194		100
94-19	FLa 58-45	OP	663	663			100
94-20	FLa 39-40	OP	80	80			100
94-21	FLa 57-75	OP	332	332			100
94-23	Flordahome	Fla 57-75	225	225			100
94-26	Corella	OP	460	460			100
94-27	Pound	OP	20	20			100
94-28	20th Century	OP	38	38			100
95-01	BPM	Corella	398	398			100
95-02	BPM	Dawn	237	237			100
95-03	BPM	Josephine	54	54			100
95-04	Comice	Ya Li	154	154			100
95-05	Corella	Packham's Triumph	89	55	34		100
95-06	Eldorado	BPM	37	37			100
95-07	Eldorado	Corella	26	26			100
95-08	Eldorado	Dawn	72	72			100
95-09	Eldorado	Packham's Triumph	37	37			100
95-10	Packham's Triumph	Corella	403	403			100

Appendix 3. Number of trees visually selected before fruit maturity from 115 pre-2003 families, between 2003/04 and 2005/06.

Code	Female	Male	Fruit-bearing trees	Number of visually selected trees				
				2003	2004	2005	Total	%
1	Guyot	Corella	1548	200	166	64	430	27.8
2	Guyot	Rogue Red	1477	107	76	136	319	21.6
3	Packham's T	Comice	1022	38	76	51	165	16.1
4	Eldorado	BPM	931	32	49	84	165	17.7
5	Guyot	Hood	884	83	49	9	141	16.0
6	Comice	Packham's T	660	31	21	20	72	10.9
7	Comice	Winter Cole	659	18	7	6	31	4.7
8	Rogue Red	WBC	655	21	14	40	75	11.5
9	Guyot	Beurre Bosc	644	40	9	12	61	9.5
10	Winter Cole	Packham's T	597	12	10	9	31	5.2
11	Beurre Bosc	Guyot	585	25	25	36	86	14.7
12	WBC	BPM	553	53	18	10	81	14.6
13	Packham's T	Dawn	545	39	13	17	69	12.7
14	Eldorado	Comice	525	21	9	10	40	7.6
15	Comice	Howell	512	36	24	16	76	14.8
16	WBC	Corella	482	31	19	6	56	11.6
17	Comice	Dawn	473	16	12	41	69	14.6
18	Comice	Josephine	460	19	13	17	49	10.7
19	Comice	Nicholas	415	13	19	19	51	12.3
20	WBC	Howell	392	30	38	19	87	22.2
21	Guyot	Packham's T	372	31	15	35	81	21.8
22	WBC	Packham's T	368	15	5	6	26	7.1
23	Guyot	Howell	365	35	13	18	66	18.1
24	Rogue Red	Guyot	355	15	22	29	66	18.6
25	Josephine	Comice	331	6	13	11	30	9.1
26	Guyot	Comice	330	24	9	8	41	12.4
27	Corella	Dawn	314	27	15	20	62	19.7
28	Comice	Corella	309	26	9	11	46	14.9
29	Dawn	Packham's T	298	5	6	2	13	4.4
30	Howell	Comice	293	13	5	9	27	9.2
31	WBC	Dawn	269	20	11	1	32	11.9
32	Eldorado	Rogue Red	245	6	3	18	27	11.0
33	Josephine	Packham's T	245	3	1		4	1.6
34	Comice	Guyot	233	9	13	1	23	9.9
35	Ya Li	Eldorado	229	1	6		7	3.1
36	Josephine	Rogue Red	218	0	4	6	10	4.6
37	I11-13B-83	Packham's T	211	13	25	11	49	23.2
38	BPM	Ya Li	211	24	1	1	26	12.3
39	Dawn	Guyot	202	12	9	7	28	13.9
40	Eldorado	Kosui	196	12	9	10	31	15.8
41	Josephine	Corella	194	7	10		17	8.8
42	Eldorado	Guyot	179	3	11	3	17	9.5
43	Guyot	Dawn	175	20	9	6	35	20.0
44	Comice	BPM	159	23	9	20	52	32.7
45	HW606	Packham's T	147	14	5	5	24	16.3
46	Rogue Red	Josephine	144	2	4	5	11	7.6
47	Eldorado	Ya Li	144	5	1	2	8	5.6
48	Red Sensation	Ya Li	142	7	2	2	11	7.7
49	Corella	Comice	138	11	5	2	18	13.0

104	Hood	Comice	3	1			1	33.3
105	WBC	Vicar Winkfield	3				0	0.0
106	N.J.Rock R23-T352	Packham's T	2		1		1	50.0
107	Eldorado	Concord	2			1	1	50.0
108	Beurre Bosc	Vicar Winkfield	2	0	1	0	1	50.0
109	BPM	Forelle	1		1	1	1	100.0
110	Ya Li	OP	1				0	0.0
111	Vicar Winkfield	Howell	1				0	0.0
112	St.Lucia	OP	1				0	0.0
113	Packham's T	Corella	1				0	0.0
114	Howell	Guyot	1				0	0.0
115	BPM	Eldorado	1				0	0.0
Total			22889	1345	974	979	3297	14.4