Pear Evaluation Program

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Apple & Pear Australia Limited (APAL)

Project Number: AP10029

AP10029

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FINAL REPORT

AP10029 (Completion date: 31 December 2011)

"Pear Evaluation Program"

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Purpose
This report is to present the Final Report of the project known as AP10029 "Evaluation of pear breeding material"

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Date
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Contents

1. Media Summary

The development of new pear varieties is one of the key strategies of the Australian pear industry to revitalise Australian pear production and sales.

The National Pear Breeding Program bred a collection of elite germplasm over the last 17 years. From this material two selections are under commercial trials in regional Australian production areas and overseas.

This project reports progress with evaluation of the elite germplasm described above. Evaluation may lead to the release of further new pear cultivars providing further international competitive advantage for the Australian pear industry. In doing so, the project may help achieve the objective of revitalising the Australian pear industry.

The project is managed by Apple and Pear Australia Limited with contractors, experienced in pear evaluation, conducting day-to-day project operations.

Recommendations for Future R&D

AP10029 was a one year project. Three seasons are needed to complete the evaluation of the germplasm arising from the National Pear Breeding Program. It is recommended that the other two years, needed to complete evaluation of the material from the NPBP, be funded.

Recommendations related to industry applications of this research

The selection ANP-0534 (Dr Jules Guyot x Corella) has shown consistent high quality and productivity attributes over 3 years. It is recommended that this selection be released for commercial evaluation and (if that is successful) commercialisation via Coregeo Australia Photographs of ANP-0534 are provided below.

ANP-0534 (Dr Jules Guyot x Corella) on tree.

ANP-0534 ripened

2. Technical Summary

The development of new pear varieties is one of the key strategies of Apple and Pear Australia Limited (APAL) to revitalise the Australian Pear Industry. The Australian National Pear Breeding Program (ANPBP) has developed an elite collection of germplasm over the last 17 years, of which 2 selections are under commercial evaluation in trials within Australia and overseas. One of the aims of the current pear evaluation project (AP10029) is to complete storage quality and productivity evaluations of selections made in 2009 and prior to 2009 and to identify those suitable for commercial evaluation. A further aim is to complete evaluation of 6,000 second generation seedlings.

A total of 209 selections remain under evaluation after lower performing selections were culled in 2009 and 2010. Table 1 (presented here but arising from page 10) shows the number of selections, their evaluation status and provides some comments on how the candidate varieties have been grown.

Table 1: Summary of pear selections under evaluation.

Year	Number of selections	Status of evaluation	Comments
Prior 2009	90	Complete 2013	Replicated trials, 4 trees each, excludes 167 selections culled in 2009 and 2010
2009	65		Reworked onto rootstock of culled selections in replicated trials, 4 trees each
2010	36	Observe seedling tree, start to fruit on rootstock	Reworked onto culled germplasm 2 trees each, unreplicated
Sub-total	*191*		*Refer AP09036 (2009 - 2010): Perfect Pears for list of pear selections to 2010*
2011	18	Observe fruit on seedling tree	*Refer Table 2*. Selections grafted onto BP1 rootstock, 2 tree each, unreplicated
2012			
2013			
Total	*209*		

The program includes a large range of red blushed pears with exceptional eating quality. Some have a soft melting flesh and others a more crisp texture. These new pears principally come from crosses between Dr Jules Guyot x Rogue Red (and reciprocal cross), and Dr Jules Guyot x Corella. The Dr Jules Guyot x Rogue Red (and reciprocal) crosses have soft melting flesh and strong aromatic flavours typical of traditional European pears, whilst the Dr Jules Guyot x Corella crosses can be eaten either crisp or softened.

Pear Breeding Business Case

An additional component of AP10029 was the development of a Pear Breeding Business Case to assess whether or not there is a business Case for the Australian pear industry to continue to breed.

The Business Case is provided in full as part of this Final Report. It recommends that the Australian industry should continue to breed pears in Australia. However, the decision as to whether or not the industry will adopt this recommendation will be taken by the Board of Apple and Pear Australia Limited.

Release of varieties: Recommendation

The Dr Jules Guyot x Corella selection ANP-0534 has shown consistent high quality and productivity attributes over the last 3 years and is the first selection, in the current project, to be recommended for large scale commercial evaluation (see below). It has strong, bright red blush and when it ripens its skin shows a distinct background colour change from green to yellow taking the difficulty out, for consumers, of determining when a pear is properly softened to eat (see below). It ripens in the first 3 weeks of February and flowers at a similar time to Packham.

ANP-0534 (Dr Jules Guyot x Corella)

ANP-0534 ripened

3. Materials and Methods

3.1 Orchard Management Overview

The project evaluates breeding lines developed in the previous pear breeding projects AP310, AP06032, AP99007, AP04019, AP06049, AP09036, and associated projects AP099007, AP04019, and AP09036.

The evaluation is based at the Department of Primary Industry Victoria's Tatura research complex in Victoria's Goulburn Valley. The candidate varieties being evaluated are set over a range of blocks on the research centre – as set out below. As these are, effectively, orchard blocks, they require routine orchard management, which is provided by the project. An overview of these management operations is provided below.

1) South Farm - Blocks G, I and K

Theses contain seedling trees of the candidate varieties evaluated by the project. The harvests 2012 and 2013 are likely see the end of these blocks.

Normal farm management to continue on those blocks - with slashing, weedicide, pest and disease sprays, irrigation and limited tree management. Trees either side of seedling selections were trimmed last year to allow more light into fruiting seedlings. Scab resistance evaluations will be completed before the candidate varieties are removed.

2) North Farm - Blocks B and C.

Second generation seedling selections9candidate varieties). Total area is about 1.5ha. These commenced fruiting in 2009. By 2013 harvest 80 per cent of the lines are expected to be fruiting. The same orchard management operations were applied to these blocks as described for the south farm seedlings/candidate varieties.

3) North farm Block C,

Demonstration block - a demonstration trial of nine key selections from the seedling blocks. There are 5 rows each of seven varieties and two single rows of a variety each. More management is required in this block, particularly with tree training.

Maintenance of breeding materials

All materials are maintained at the DPI Victoria Tatura site where the evaluation is conducted. Maintained materials include existing parents, elite selections and candidate cultivars as well as released cultivars. Appropriate proceedures have been put in place to ensure the integrity of these materials.

A selection of the important materials from the program is also maintained at the DAFWA site at Manjimup in Western Australia.

3.2 Evaluation Methodology

Essentially, the methods used by the ANPBP were continued. The people who conducted the evaluation when the ANPBP was operating (Mrs S Turpin, Mr R Wall and Mr K Cornwell) conducted the evaluations for AP10029.

A three step process was used to evaluate existing seedlings (or candidate varieties) developed by the ANPBP. All this material has been promoted from Stage 1 evaluation and is now in Stage 2. The three steps were:

- Selection of seedlings for evaluation, harvest of the fruit for these, storage and preparation for fruit evaluation;
- Fruit quality evaluation; and
- Tree evaluation.

3.2.1 Selection of seedlings for harvest and preparation of fruit for evaluation

The material to be evaluated included lines previously selected as "having potential". There are 70 of these planted in the years 2000 and 2001. The remainder was material planted in 2005, 2006 and 2007 that was just beginning to bear. Precocity is an important trait in pears and varieties that have not produced fruit by the time they are in their seventh leaf are excluded from the program

In December and early January, before fruit maturity, potential selections were made on the basis of appearance. To pass this initial stage, fruit from candidate varieties must:

- exhibit a good appearance with a reasonably symmetrical, uniform shape and size;
- produce fruit showing the absence of uneven russet, and;
- exhibit freedom from major tree defects such as rough bark.

For varieties so selected, optimum fruit harvest date was decided on the basis of fruit firmness, starch, sugar and seed colour. For seedling trees with sufficient fruit, three harvests were carried out based on the parental maturity dates. The harvest timings were:

- a fortnight prior to the mid-parental maturity date (MPMD);
- at the MPMD, and;
- a fortnight post MPMD.

Six to twelve representative fruit were harvested from each tree at each harvest. Fruit samples were placed in individual paper bags and stored in the cool room at a temperature of zero degrees. After at least a month in cool storage, the samples were placed in a constant temperature room for seven days to ripen. They were then moved to the laboratory for evaluation. Fruit of parental genotypes were harvested, stored and ripened post storage under the same conditions. These fruit acted as controls.

3.2.2 Fruit quality assessment

Once ripened as described above, the first fruit evaluation was to see if the fruit of the seedling variety is edible. Samples with unpleasant flesh texture and/or undesirable flavours were discarded; the remainder were retained for further sensory assessment along with the fruit of parental genotypes.

The sensory assessment of fruit quality was conducted by a two person panel. Fruit appearance (shape, colour and overall) and eating quality (texture, flavour and overall) of all remaining selections were compared on a seven-point like/dislike scale. Data on storage traits (neck shrivel, scald, internal browning and mealiness) and susceptibility to limb rub were also collected on a five-point scale and compared to the controls.

Both overall fruit appearance and overall eating quality had to rate at least 5 out of 7 to be identified as a new selection.

3.2.3 Tree Evaluation

Data on tree bearing and growth behaviour, phenological traits, fruit quality, yield, storability and disease resistance were taken during the lifetime of the experiments. First flower and full bloom dates were monitored annually.

Comparison of fruit productivity was based on initial fruit set and the average final fruit weight relative to crop load. Fruit quality was evaluated as for the selection process in stage 1. This enables current selections and new selections to be directly comparable within the same season.

Pear Scab. Note that one of the key selection indices used in the ANPBP has been resistance to pear scab. Most of the lines in the material to be evaluated are resistant to scab as susceptible lines are discarded, after screening, early in the evaluation process. Accordingly, there was potential for a scab-resistant cultivar to be selected from the existing material. As scab is a readily apparent cosmetic disease and ubiquitous in pear production regions such as Shepparton, no special skills were required to evaluate candidate varieties where the inbuilt resistance breaks down.

3.3 Business Case for Breeding

3.3.1 AP07032 gives a broad direction towards breeding

The question of continuing APAL's investment in apple and pear breeding has been raised a number of times. Most recently, in January 2008, the Final Report of AP07032 presented a business case and recommendations related to "Options for access to New Genetic Material for Australian Apple and Pear Growers".

The strongly preferred option of this comprehensive analysis of the sources of genetic material available to Australian growers, was to continue to breed;

"Option 1 (continue to breed via the Australian National Apple Breeding Program and the National Pear Breeding Program and Prevar™) *is the strongly preferred option if the industry wishes to maximise its opportunity to compete domestically with imports and expand its export markets. This is the only option that will guarantee the industry access to new premium and niche varieties."*

3.3.2 Pear Breeding Business Case Methodology

The Business Case was required to examine the possibility of re-establishing pear breeding in Australia. The Business Case analysed possible breeding targets, technical approaches and provides a financial evaluation of investing in breeding.

Breeding Targets

The previous breeding program developed a series of "breeding families". In any new breeding program, development of new varieties would be – most efficiently – based around these existing breeding families. The targets that these breeding families represent, and their market importance, are discussed.

Technical Approach

Breeding is an expensive, long term investment. However, the Australian pear industry has a strong relationship with both the New Zealand Institute for Plant and Food Research (PFR) - one of the world leaders in pear genomics and breeding in general - and the Department of Primary Industries, Victoria, which has similar capabilities (but which have not previously worked with pears).

While Australia already has access to PFR-developed varieties for Interspecific (Asian x European crosses) and Nashi-type pears through the Prevar program, re-establishing the Tatura program would allow the opportunity to apply the technology to the European-style germplasm previously developed at Tatura.

Financial evaluation

The third aspect of this Business Case is the financial analysis of the breeding proposition. For this an investment and commercialisation financial model has been developed and the returns from commercialising varieties estimated. Returns to the industry, from accessing the new varieties, have also been estimated and a series of Benefit Cost Analyses, comparing various options, prepared.

4. Results and Discussion

4.1 Evaluation Program

4.1.1 2011 season summary

The development of new pear varieties is one of the key strategies of Apple and Pear Australia Limited (APAL) to revitalise the Australian Pear Industry. The National Pear Breeding Program has bred an elite collection of germplam over the last 17 years, of which 2 selections are under commercial evaluation in trials within Australia and overseas. One of the aims of the current pear evaluation project is to complete storage quality and productivity evaluations of selections made in 2009 and prior to 2009 and to identify those suitable for commercial evaluation. A further aim is to complete evaluation of 6,000 second generation seedlings.

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There are 209 selections under evaluation after 167 lower performing selections were culled in 2009 and 2010 (Table 1).

The program has a large range of red blushed pears with exceptional eating quality. Some have a soft melting flesh and others a more crisp texture. These new pears principally come from crosses between Dr Jules Guyot x Rogue Red (and reciprocal cross), and Dr Jules Guyot x Corella. The Dr Jules Guyot x Rogue Red (and reciprocal) crosses have soft melting flesh and strong aromatic flavours typical of traditional European pears, whilst the Dr Jules Guyot x Corella crosses can be eaten either crisp or softened.

4.1.2 New second-generation selections

Eighteen second generation progeny were selected in season 2011 (Table 2). Second generation crosses utilising the early ripening pear ANP-0118, that is currently under commercial evaluation by Coregeo, aim to improve the flavour of tree ripened fruit, enhance its storage potential, and some crosses have advanced the ripening period of progeny into late December. One of the selections, ANP-1113, from a cross between ANP-0118 (Butirra Precoce Morettini x Corella) and C-53-75 (Josephine x Corella) produced good fruit size and fruit density for its first crop, and is tree ripened similar to ANP-0118 but with a latter harvest period (Photo 1).

Table 2: Summary of 2011 pear selections.

2011 Selections	Harvest	Female	Male
ANP-1101	31-Dec	Precoce di Fiorano	ANP-0118 (BPM x Corella)
ANP-1102	20-Jan	Comice	ANP-0118 (BPM x Corella)
ANP-1103	11 Feb - 5 Mar	Comice	ANP-0118 (BPM x Corella)
ANP-1104	11-Feb	Comice	ANP-0118 (BPM x Corella)
ANP-1105	11-Feb	ANP-0305 (Comice x BPM R)	ANP-0429 (WBC x BPM)
ANP-1106	01-Feb	ANP-0411 (Comice x BPM R)	ANP-0309 (BPM x Corella)
ANP-1107	14-Feb	ANP-0411 (Comice x BPM R)	ANP-0309 (BPM x Corella)
ANP-1108	11-Feb	Comice	ANP-0422 (Guyot x Hood)
ANP-1109	01-Feb	ANP-0118 (BPM x Corella)	ANP-0112 (Corella x Packham)
ANP-1110	14 - 22 Feb	ANP-0118 (BPM x Corella)	ANP-0112 (Corella x Packham)
ANP-1111	22-Feb	ANP-0118 (BPM x Corella)	ANP-0112 (Corella x Packham)
ANP-1112	14-Feb	Comice	ANP-0131 (Corella x Comice S)
ANP-1113	08-Feb	ANP-0118 (BPM x Corella)	C-53-75 (Josephine x Corella)
ANP-1114	14-Feb	ANP-0118 (BPM x Corella)	C-53-75 (Josephine x Corella)
ANP-1115	14-Feb	Prasse Crassane	Corella
ANP-1116	11- 22 Feb	Corella	ANP-0305 (Comice x BPM R)
ANP-1117	22-Feb	Corella	ANP-0305 (Comice x BPM R)
ANP-1118	11-Feb	Rogue Red	ANP-0420 (Guyot x Corella R)

4.1.3 Quality and productivity evaluations of current selections

Postharvest indices of fruit firmness (kg), sugar (^{o}brix), seed colour and starch level have been measured over the last three seasons and compared to appearance and eating quality traits of each of the progeny to develop harvest criteria (Table 3, Appendix 1).

Photo 1: ANP-1113 (ANP-0118 x C-53-75)

The flower and fruit density were also monitored and average fruit weight of harvested fruit measured to determine the most productive selections relative to the control cultivars Packham, Williams and Corella (Table 4, Appendix 2). The quality and productivity ratings and consistency scores are dependent upon the amount of data available for their calculation, as many selections are yet to fruit on replicated trials and are still being evaluated on their seedling tree.

Table 3: Harvest indices of promising pear selections established in a small demonstration trial at DPI Tatura in 2009 and APFIP trials in 2011, based on averaged data from seasons 2009, 2010 and 2011.

Selection	Female	Male	Harvest range		Firmness (kg)	Sugar °Brix	Seed colour[a]	Starch scale[b]	Tree ripen
ANP-1001	Precoce di Fiorano	ANP-0118	v. early	25 Dec - 4 Jan	5.2	17.7	3.0	3.8	yes
ANP-0118	BPM	Corella	early	5 - 25 Jan					yes
WBC	Unknown		early	15 - 30 Jan	8.0	11.4	2.3	2.7	
ANP-0644	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb	6.2	15.2	3.1	3.0	
ANP-0648	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 14 Feb	7.9	14.9	2.0	3.7	yes
ANP-0534	Dr Jules Guyot	Corella	mid	30 Jan - 24 Feb	7.2	15.2	3.0	2.9	yes
Packham	Uvedale St. Germain	WBC ?	mid	30 Jan - 9 Feb	8.0	13.9	2.0	3.0	
ANP-0711	Dr Jules Guyot	Corella	mid-late	9 Feb - 6 Mar	7.3	16.7	4.0	2.4	
ANP-0131	Corella	Comice	mid-late	9 Feb - 1 Mar	6.9	13.6	3.5	3.0	
ANP-0514	Josephine	Comice	late	16 Mar - 5 Apr	2.0	15.7	5.0	3.6	yes
Corella	Forelle?		late	6 -21 Mar	6.6	13.6	4.0	3.2	

a Seed colour: 1 = white, 2 = cream, 3 = light tan, 4 = tan, 5 = brown, 6 = black

b Starch scale: 1 = whole surface black-blue, 2 = some or most of the core clear, 3 = clear just past core, 4 = most of cortex clear (50%), 5 = 90% of the cortex clear (black under the skin) and 6 = all clear of starch.

Table 4: Productivity, appearance and eating quality ratings and consistency scores of promising pear selections established in a small demonstration trial at DPI Tatura in 2009 and APFIP trials in 2011, based on averaged data from seasons 2009, 2010 and 2011.

Selection	Productivity rating[a]	Flower density[b]	Fruit weight (g)	Appearance rating[c]	Appearance consisency[d]	Eating quality rating[e]	Eating quality consistency[f]
ANP-1001	1.5		63	3	3	1	1
ANP-0118	2.3	5.0	100	4	2	3	1
WBC	2.3	3.0	182	2	3	2	3
ANP-0644	2.5	3.5	263	3	2	3	4
ANP-0648	2.0	3.0	192	3	3	5	3
ANP-0534	2.8	3.4	149	3	4	4	5
Packham	3.3	5.5	155	1	1	2	3
ANP-0711	2.8		124	3	5	2	4
ANP-0131	2.4	3.0	188	3	4	4	4
ANP-0514	2.4	3.2	216	2	3	5	2
Corella				3	5	4	3

a Productivity rating: Average of flower density, fruit weight and tree yield ratings; Fruit weight rating 1 < 100g, 2 = 100-199g, 3 = 200-299g, 4 = 300-400 and 5 = >400; Tree yield rating 1 <5kg, 2 = 5 - 9.9, 3 = 10-14.9, 4 = 15 - 20 and 5 >20kg/tree.

b Flower density rating: Based on 2009 season when flower set was below normal; 1 <20, 2 <40, 3 < 60, 4 <80, 5 <100, 6 <120 and 7 >120 flower clusters (For trees on stock ratings increase by an increment of 30 flower clusters).

c Appearance rating: Based on 1 to 7 likeness scale for shape, colour, overall where 1 = dislike very much to 7 = like very much on data from 2008 to 2011. 1 = rating < 5,5,5; 2 = rating 5,5,5; 3 = rating 6 for at least one attribute; 4 = rating 6,6,6 and 5 = rating 7 for at least one attribute.

d Appearance consistency rating: Based on consistency of appearance rating on data from 2008 to 2011 where 1 = low, 2 = low - medium, 3 = medium, 4 = medium to high and 5 = high.

e Eating quality rating: Based on 1 to 7 likeness scale for texture, taste, overall where 1 = dislike very much to 7 = like very much on data from 2008 to 2011. 1 = rating < 5,5,5; 2 = rating 5,5,5; 3 = rating 6 for at least one attribute; 4 = rating 6,6,6 and 5 = rating 7 for at least one attribute

f Eating quality consistency: Based on consistency of eating quality rating on data from 2009 to 2011 where 1 = low, 2 = low - medium, 3 = medium, 4 = medium to high and 5 = high

Table 5: Blush and russet attributes of promising pear selections established in a small demonstration trial at DPI Tatura in 2009 and APFIP trials in 2011, based on data from season 2011.

Selection	Full bloom	Russet rating[a]	Blush					Shape rating[c]
			Consistency	Strength & brightness	% fruit	% coverage range	Rating[b]	
ANP-1001	early							4
ANP-0118	early			L-H	100	50	3	4
WBC	late			L	15	10-20	1	4
ANP-0644	mid	H		H	80	40	5	5
ANP-0648	mid	L	H	L	50	20	1	3
ANP-0534	mid	L	H	H	100	40-80	6	3
Packham	mid	L				0		4
ANP-0711	mid							5
ANP-0131	early		M	L-H	100	30-70	3	4
ANP-0514	mid	L				0		3
Corella	early		M	L-H	95	20-70	3	3

a Russet rating: L=neck and/or calyx russet or low lenticel and/or general russet, M=medium lenticel and/or general russet, H=high lenticel and/or general russet and may include calyx,neck russet.

b Blush rating: Based on strength/brightness and consistency where L, M, and H = low, medium and high blush and % coverage on 2011 data; 1 = L 10-90%, 2 = L-M, M (M,L consistency) 10-90%, 3 = L-M & L-H (H consistency), 10-90%, 4 = M (H consistency), M-H (M consistency), 10-90%, 5 = H (M consistency) <50%, 6 = H (H consistency) <50% and 7 = H (H consistency) >50%.

c Shape rating: 1 = round to flat round, 2 = rounded oblong or obovate pyriform, 3 = globular-acute pyriform or triangular, 4 = oblong-ovate pyriform and 5 = oblong to elongated oblong pyriform.

Strong, consistent blush and uniform shape, with the absence of russet are likely to attract market premiums. There is a range of blush levels between selections from a light lenticel to a strong block blush and a variation in brightness. The percentage coverage of blush can vary from quite low and variable blush levels between fruit to consistent blush greater than 50%. Two of the selections under evaluation have full red blush. There appears to be sufficient genetic diversity for blush in the current selections (Table 5, Appendix 3). Those with consistent strong, bright blush will be preferentially selected for commercial evaluation such as ANP-0534 (Photo 2) and ANP-0948.

Most notably selections in the Dr Jules Guyot x Rogue Red (and its reciprocal) cross have a range of shapes from round to pyriform. Consumers identify European pears as pyriform, so it would be desirable to develop new varieties with a pyriform rather than rounder shape to maintain their distinctiveness in the marketplace. Hence selections with a pyriform shape will be preferentially selected, although some of the round selections with exceptional eating quality may have potential niche market application. With the change in climatic conditions to more regular rain than previous years, selections that have a tendency to develop russet were identified in season 2009. For example, selections ANP-0644 and ANP-0411 both had high levels of general and lenticel russet respectively last season which had not shown up in previous seasons (Table 5, Appendix 3).

Table 6: Levels of scald after 7 days at room temperature post ripening and following 4 months cool storage at 0°C on Dr Jules Guyot x Rogue Red (and reciprocal) selections. Only those that rated no scald on either trial are shown.

Selection	Post ripen scald[a]	Cool store scald[b]
ANP-1011	5	5
ANP-0915	5	5
ANP-0632	5	5
ANP-0923	5	5
ANP-1020	5	4
ANP-0714	5	3
ANP-1010	5	3
ANP-0627	5	3
ANP-0917	5	3
ANP-0922	5	3
ANP-0925	5	3
ANP-0927	5	3
ANP-1007	5	2
ANP-1008	5	2
ANP-1009	5	2
ANP-0916	5	2
ANP-0933	5	2
ANP-0650	5	2
ANP-0622	5	1
ANP-0624	5	1
ANP-0914	5	1
ANP-0938	5	1
ANP-0645	5	1
ANP-0909	4	5
ANP-0911	4	5
ANP-0921	4	5
ANP-0719	4	5
ANP-0720	4	5
ANP-0652	4	5
ANP-0717	3	5
ANP-0930	3	5
ANP-0960		5
ANP-0721		5
ANP-0940		5
% no scald[c]	32%	21%

a Post ripen scald: Based on assessment of fruit ripened for 7 days at room temperature and left for a further 7 days in season 2011 where 1 = extreme, 2 = heavy, 3 = medium, 4 = slight and 5 = no scald.

b Cool store scald: Based on assessment of fruit cool stored for a minimum of 4 months at O°C in season 2011 where 1 = extreme, 2 = heavy, 3 = medium, 4 = slight and 5 = no scald.

c 72 Dr Jules Guyot x Rogue Red selections evaluated

Selections within the Dr Jules Guyot x Rogue Red (and reciprocal) crosses are prone to scald in storage. However a preliminary evaluation indicated that at least one third did not develop scald when picked at the correct harvest period, stored for one month, ripened for 7 days and then left at room temperature for a further 7 days (Table 6, Appendix 4). When the Dr Jules Guyot x Rogue Red (and reciprocal) selections were cool stored for a minimum of 4 months, approximately one fifth of them did not develop scald. Only 4 selections, ANP-1011, ANP-0915, ANP-0632 and ANP0923 did not develop scald under both of these trial conditions. These results indicate that there is some variability within these crosses to select for reduced susceptibility to scald under longer storage.

Photo 2: ANP-0534 (Dr Jules Guyot x Corella)

Photo 3: ANP-0711 (Dr Jules Guyot x Corella)

Photo 4: ANP-0644 (Dr Jules Guyot x Rogue Red)

Photo 5: ANP-0648 (Dr Jules Guyot x Rogue Red)

Photo 6: ANP-1001 (Precoce di Fiorano x ANP-0118)

Photo 7: ANP-0514 (Josephine x Doyenné du Comice)

4.1.4 Selections in APFIP trials

Six promising selections were established in four APFIP sites in Northern Victoria, NSW, SA and WA in winter 2011; ANP-0534 (Photo 2), ANP-0711 (Photo 3), ANP-0644 (Photo 4), ANP-0648 (Photo 5), ANP-1001 (Photo 6) and ANP-0514 (Photo 7).

ANP-0534 and ANP-0711 are examples of selections from the Dr Jules Guyot x Corella cross, whilst ANP-0644 and ANP-0648 are representative of the Dr Jules Guyot x Rogue Red cross. ANP-1001 is a very early selection that has a similar appearance to Corella but higher sugar levels around 17 to 18 ^{o}brix (Table 3). It is tree ripened and eaten crisp similar to its parent ANP-0118. The seedling tree of ANP-1001 only started to crop in 2010 when it was selected; hence the quality and productivity ratings are low until more data becomes available in forthcoming seasons. The late season selection ANP-0514 is a green pear with exceptional eating quality inherited from its parents Josephine and Comice (Table 4). Since the majority of pear selections ripen between late January and early March, any selection such as ANP-1001 and ANP-0514 that ripen at the extremes of the pear season with good appearance and/or eating quality have extra market potential.

4.1.5 Future research

The selections will be assessed for quality attributes across a range of storage times next season to determine their minimum storage period for optimum quality. For example, Packham's Triumph harvested 160-170 days from full bloom and at firmness 6.3 to 8.3kg, requires cold storage for 60-70 days to ripen properly (Richardson and Gerasopoulos, 1994). Based on a minimum storage period of 1 month and 4 months from last season, some of the Dr Jules Guyot x Corella selections require more than 1 month storage to ripen to a consistent high quality. The control Corella achieved optimum eating quality last season when harvested at 6.6kg pressure and starch level 3 and stored for 100 days compared to 30 days. Next season selections will be picked based on their harvest indices (Table, Appendix 1). The main criteria used will be flesh firmness and starch level. Starch levels are likely to be a reliable harvest indicator on a large number but not all pear selections. These values are based on averaged data from the last one to three seasons that corresponded to their best eating quality. Similarly seedlings in the primary assessments blocks will be harvested based on firmness next season rather than on mid harvest date of their parents, as seedling fruit has shown to display a large range in harvest dates in some crosses. The flesh firmness reading that will initially be utilised is 6.5, 7.5 and 8.5kg, and their levels revised the next season.

Detailed evaluation of blush traits will continue to be collected to determine the consistency of blush traits over seasons, and similarly productivity traits to identify consistency of good flower density, fruit set and fruit size. Currently scab levels are low in the assessment blocks and will be evaluated in the field once levels significantly increase.

4.1.6 References

Richardson, D.G. and D. Gerasopoulos, 1994. Controlled atmosphere recommendations for pear fruits and storage chilling satisfaction requirements for ripening winter pears, Acta Horticulturae. 367, 452-455.

4.2 Pear Breeding Business Case

The Pear Breeding Business Case is presented in its entirety at Attachment 2. The Executive Summary from the Breeding Case is presented below.

Executive Summary

This Business Case seeks to address the question "Should the Australian pear industry invest in pear breeding again?"

The document approaches the question by:

- reviewing the novel pear products that might be developed in the short-medium term by breeding again at Tatura, the size of the market for such products and the likely competition from other breeders;
- documenting the technical approaches that could be applied to breeding and identifying the preferred option for a partner to provide the technical services required
- analysing the likely financial returns from breeding and evaluation.
- considering the real reasons why an industry organisation would invest in breeding and looking at the alternatives to breeding

The conclusion from this analysis is that the current strategy that the industry is deploying – to evaluate the existing material at Tatura is a financially attractive one that should result in the Australian industry being provided with superior new varieties in the short and medium terms.

To provide for the long term (the 20 year horizon) the industry has three options – continuing to breed to provide these varieties (which is not a financially attractive proposition), importing varieties and participating in global marketing clubs or waiting for new technology to arrive that will radically alter the existing timeframes required to produce new varieties.

The recommendation for the long term, made after considering the potential of the germplasm at Tatura and the real reasons why industry organisations invest in breeding, and after looking at the alternatives, is that despite direct financial returns not being attractive, the industry should still invest in the breeding of pears in Australia.

5. Technology Transfer

Neither the evaluation program, nor the Pear Breeding Business Case generate outputs where technology transfer is immediately relevant.

Pear selections arising from this work will eventually be commercialised by Coregeo® Australia in a manner similar to that described in the proposal submitted to Agriculture Victoria Services Pty Ltd and HAL for the commercialisation of ANP 0118 and ANP 0131.

The recommendations arising from the Pear Breeding Business Case will be considered by the Board of Apple and Pear Australia Limited.

6. Recommendations

6.1 Evaluation

The Dr Jules Guyot x Corella selection ANP-0534 has shown consistent high quality and productivity attributes over the last 3 years and is the first selection to be recommended for large scale commercial evaluation in the current project.

It has strong, bright red blush and when it ripens its skin shows a distinct background colour change from green to yellow taking the difficulty out, for consumers, of determining when a pear is properly softened to eat (Photo 8b). It ripens in the first 3 weeks of February and flowers at a similar time to Packham.

ANP-0534 (Dr Jules Guyot x Corella)

Photo 8b: ANP-0534 ripened

6.2 Pear Breeding Business Case

The Australian pear industry's need for superior new varieties is provided for in the short and medium terms by recently released varieties and the evaluation (currently 1/3rd complete) of the germplasm remaining after the DPIV Tatura breeding program closed.

The question is the provision of superior new varieties for the long term – the 20 year horizon.

This Business Case has shown that breeding is not a financially attractive proposition. However, financial returns are only one of the criteria that need to be considered in deciding whether the industry should support breeding or not. Other criteria include improved international competitiveness, the ability to develop new global and/or niche markets, a "first mover" advantages for Australian producers, the broadening of export opportunities and assisting growers to compete with imports – all of which arise from breeding new pear varieties in Australia. The Breeding Targets analysis in Section 2 of this report shows that the existing germplasm at Tatura has the potential to be developed into varieties that could achieve these types of benefits.

Importing varieties from overseas remains an option and will probably happen alongside any future breeding program. However, future imported varieties are likely to be commercialised in "club" arrangements which would only allow individual growers or limited groups of growers to participate. Importing varieties does not ensure access for all growers. Nor does it allow the Australian industry to dominate a market, nor have first mover advantages.

Genetically constructed varieties (if they do become a reality) are likely to be expensive and may well have IP restraints associated with them. Both would limit their attractiveness to the industry (but perhaps not to individual growers or groups of growers).

Given the above and the potential of the germplasm developed at Tatura, it would seem that, from an industry perspective, the best option to provide new pear varieties for the Australian industry is to continue to breed.

7. Appendices

7.1 Evaluation Program

7.1.1 Evaluation Appendix 1

Harvest indices of pear selections, based on averaged data from seasons 2009, 2010 and 2011.

Selection	Female	Male	Harvest range		Firmness (kg)	Sugar °Brix	Seed colour[a]	Starch scale[b]	Tree ripen
ANP-1001	Precoce di Fiorano	ANP-0118	v. early	25 Dec - 4 Jan	5.2	17.7	3.0	3.8	yes
ANP-0902	Precoce di Fiorano	ANP-0118	v. early	28 Dec - 4 Jan	6.8	16.0	2.0	3.0	yes
ANP-0901	Comice	ANP-0118	v. early	2 - 9 Jan	2.8	15.7	6.0	6.0	yes
ANP-0118	BPM	Corella	early	5 - 25 Jan					yes
ANP-0903	BPM	Forelle	early	10 - 30 Jan	7.4	22.6		5.0	
ANP-1035	Concord	BPM	early	10 - 30 Jan					
ANP-0310	BPM	Corella	early	12 - 31 Jan	6.4	13.9	3.6	2.6	yes
ANP-0906	BPM	Forelle	early	15 - 30 Jan	8.0	15.9	2.0	1.0	yes
WBC	Unknown		early	15 - 30 Jan	8.0	11.4	2.3	2.7	
ANP-0421	Dr Jules Guyot	Corella	early	20 - 30 Jan	7.2	12.4	2.9	1.6	yes
ANP-0953	Rogue Red	WBC	early	20 - 30 Jan					yes
ANP-0316	WBC	BPM	early	20 - 4 Feb	9.8	12.3		2.0	
ANP-0428	WBC	BPM	early - mid	15 Jan - 4 Feb	8.4	14.7		3.3	yes
ANP-0907	Josephine	Rogue Red	early - mid	15 Jan - 5 Feb	6.6	19.6	3.0	4.0	yes
ANP-0425	WBC	BPM	early - mid	20 Jan - 4 Feb	7.4	16.1		4.0	yes
ANP-0941	Dr Jules Guyot	Corella	early - mid	20 Jan - 4 Feb	7.8	14.6	2.5	1.9	
ANP-0948	Dr Jules Guyot	Corella	early - mid	20 Jan - 4 Feb	5.9	14.3	4.0	3.4	yes
ANP-1006	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	6.9	13.4	2.4	5.0	yes
ANP-1007	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	6.4	14.9	2.8	3.4	yes
ANP-1009	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	7.7	14.9	1.7	3.6	yes
ANP-1010	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	6.8	13.2	2.6	2.6	yes
ANP-0914	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	7.4	14.3	2.7	3.3	yes
ANP-1012	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	7.5	17.0	3.5	4.5	
ANP-0916	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	7.0	12.2	3.0	4.4	
ANP-0919	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	8.0	15.9		3.0	
ANP-0921	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	6.8	15.1	2.5	3.3	
ANP-0922	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	7.4	14.6	1.8	3.7	yes
ANP-0923	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	8.5	14.9	1.7	3.8	yes
ANP-1019	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	6.4	15.4	3.0	3.0	
ANP-1020	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	7.4	15.6	3.0	3.0	
ANP-1023	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	5.0	14.9	4.0	3.8	yes
ANP-1024	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	6.3	12.4	2.2	2.2	yes
ANP-0932	Rogue Red	Dr Jules Guyot	early - mid	20 Jan - 4 Feb					
ANP-0933	Rogue Red	Dr Jules Guyot	early - mid	20 Jan - 4 Feb	5.8	14.0	2.8	3.4	yes
ANP-0938	Rogue Red	Dr Jules Guyot	early - mid	20 Jan - 4 Feb	7.3	17.9	3.0	4.7	yes
ANP-0925	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	5.3	12.9	2.8	3.4	
ANP-0650	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	5.8	12.9	2.4	3.4	yes
ANP-0651	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 4 Feb	7.0	14.0	2.4	3.0	yes
ANP-0622	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 5 Feb	5.6	15.1	2.2	4.3	yes
ANP-0645	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 6 Feb	6.3	14.2	3.0	3.3	yes
ANP-1008	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 9 Feb	6.2	12.3	1.2	3.0	yes
ANP-0632	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 9 Feb	7.3	15.5	3.5	3.4	yes
ANP-0904	BPM	Forelle	early - mid	20 Jan - 9 Feb	7.0	17.5		1.0	
ANP-0905	BPM	Forelle	early - mid	20 Jan - 9 Feb	6.6	14.8		2.5	yes
ANP-0634	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 10 Feb	5.8	13.5	1.4	4.0	yes
ANP-0410	Comice	BPM	early - mid	21 Jan - 10 Feb	5.1	13.6	2.8	4.4	yes
ANP-0427	WBC	BPM	early - mid	20 Jan - 11 Feb	9.3	13.0	3.0	2.6	
ANP-0409	Comice	BPM	early - mid	20 Jan - 13 Feb	5.8	14.8	2.0	4.3	yes
ANP-0406	BPM	Comice	early - mid	20 Jan - 16 Feb	6.5	12.8	3.2	4.2	yes
ANP-0917	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 17 Feb	5.8	14.3	3.0	2.7	yes
ANP-0920	Dr Jules Guyot	Rogue Red	early - mid	20 Jan - 17 Feb	7.8	16.1	2.5	3.2	
ANP-0934	Rogue Red	Dr Jules Guyot	early - mid	20 Jan - 17 Feb	6.1	15.8	3.0	2.1	yes
ANP-0909	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 4 Feb	6.8	16.4	2.0	3.4	yes
ANP-0910	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 4 Feb	5.6	14.8	2.3	2.8	yes
ANP-0924	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 4 Feb	4.4	14.4	4.2	3.6	

Selection	Female	Male	Harvest range		Firmness (kg)	Sugar ^{o}Brix	Seed colour[a]	Starch scale[b]	Tree ripen
ANP-0621	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 9 Feb	7.4	16.4	2.5	1.5	yes
ANP-0716	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 9 Feb	8.6	15.1	2.5	2.6	
ANP-1014	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 9 Feb	4.0	12.3	5.0	2.0	yes
ANP-1015	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 9 Feb	6.7	14.2	3.4	4.6	yes
ANP-0915	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 9 Feb	5.4	15.4	3.1		yes
ANP-0918	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 9 Feb	5.6	14.6	3.4	4.0	yes
ANP-0931	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 9 Feb	6.3	12.8	3.0	3.0	yes
ANP-1025	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 9 Feb	6.1	13.9	2.4	2.6	yes
ANP-1026	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 9 Feb	7.5	14.2	2.4	4.2	yes
ANP-1027	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 9 Feb	7.5				
ANP-1032	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 9 Feb	7.4	16.7	2.8	3.4	yes
ANP-1033	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 9 Feb	7.1	14.9	2.0	3.6	
ANP-0643	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 9 Feb	6.2	14.7	2.0	4.0	
ANP-0725	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 9 Feb	7.4	17.0	3.0	3.6	
ANP-0429	WBC	BPM	early - mid	25 Jan -10 Feb	7.7	13.0	2.0	2.7	yes
ANP-0325	BPM	Comice	early - mid	25 Jan - 10 Feb	5.8	14.7	2.6	3.2	yes
ANP-1030	Vicar of Winkfield	Eldorado	early - mid	25 Jan - 10 Feb	4.5	17.2	3.0	3.8	yes
ANP-0304	WBC	Howell	early - mid	25 Jan - 14 Feb	6.0	14.3	1.7	3.7	yes
ANP-0648	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 14 Feb	7.9	14.9	2.0	3.7	yes
ANP-1034	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 14 Feb	8.1	15.7	3.0	4.8	
ANP-0549	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 14 Feb	8.1	15.2	2.0	2.7	
ANP-0722	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 15 Feb	7.5				
ANP-0942	Dr Jules Guyot	Corella	early - mid	25 Jan - 17 Feb					
ANP-0943	Dr Jules Guyot	Corella	early - mid	25 Jan - 17 Feb	6.6	12.0	3.8	2.8	
ANP-0944	Dr Jules Guyot	Corella	early - mid	25 Jan - 17 Feb	7.0	14.1	2.8	3.2	
ANP-0945	Dr Jules Guyot	Corella	early - mid	25 Jan - 17 Feb	7.3	14.9			yes
ANP-0946	Dr Jules Guyot	Corella	early - mid	25 Jan - 17 Feb					
ANP-0912	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 17 Feb	6.8	15.7	2.0	2.3	yes
ANP-0960	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb	7.0	12.6	2.0	5.0	yes
ANP-0913	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb	5.5	15.5	5.4	3.6	yes
ANP-0935	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 19 Feb	6.2	16.7	2.5	3.1	yes
ANP-0936	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 19 Feb	6.7	13.7	8.8	4.2	
ANP-0937	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 19 Feb	7.5	12.8	2.2	3.4	
ANP-0644	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb	6.2	15.2	3.1	3.0	
ANP-0940	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 19 Feb	8.3	13.0	2.5	1.7	
ANP-0926	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb		13.5	3.0	5.0	
ANP-0927	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb	7.3	15.4	4.0	3.3	
ANP-0929	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb	7.1	15.4	4.0	3.2	
ANP-0930	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 19 Feb	7.3	14.8	3.2	3.8	
ANP-0528	Dr Jules Guyot	Corella	early - mid	25 Jan - 20 Feb	8.5	9.7		1.0	
ANP-0954	Rogue Red	WBC	early - mid	25 Jan - 24 Feb					
ANP-0939	Rogue Red	Dr Jules Guyot	early - mid	25 Jan - 24 Feb	7.1	15.0	2.0	2.1	
ANP-0543	Dr Jules Guyot	Rogue Red	early - mid	25 Jan - 3 Mar	4.6	14.6	3.2	3.1	yes
ANP-0312	Harrow Delight	Packham	mid	23 Jan - 16 Feb	5.9	14.2	2.5	3.1	yes
ANP-0302	Dr Jules Guyot	Comice	mid	25 Jan - 20 Feb	7.9	15.4	2.0	1.8	
ANP-0911	Dr Jules Guyot	Rogue Red	mid	27 Jan - 19 Feb	6.2	14.6	2.5	2.6	yes
ANP-0908	Dr Jules Guyot	Rogue Red	mid	27 Jan - 22 Feb	5.1	14.1	5.0	4.0	yes
ANP-0720	Rogue Red	Dr Jules Guyot	mid	27 Jan - 3 Mar	8.0	15.6	2.3	3.4	
ANP-0721	Rogue Red	Dr Jules Guyot	mid	27 Jan - 3 Mar	9.7	14.0	3.9	3.5	
ANP-0626	Dr Jules Guyot	Rogue Red	mid	27 Jan - 9 Feb	5.9	13.3	3.0	3.7	yes
ANP-0947	Dr Jules Guyot	Corella	mid	29 Jan - 24 Feb	6.0	14.5	3.0	2.6	yes
ANP-0949	Dr Jules Guyot	Corella	mid	29 Jan - 24 Feb	6.1	14.3	4.0	4.0	yes
ANP-0724	Dr Jules Guyot	Rogue Red	mid	30 Jan - 1 Mar	6.4	16.4	2.9	3.8	yes
ANP-0520	I11-13B-83	Packham	mid	30 Jan - 14 Feb	5.9	11.3	2.5	3.5	yes
ANP-1004	Dr Jules Guyot	Corella	mid	30 Jan - 14 Feb	7.5				

Selection	Female	Male	Harvest range		Firmness (kg)	Sugar °Brix	Seed colour[a]	Starch scale[b]	Tree ripen
ANP-0625	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	6.3	15.0	2.5	3.4	
ANP-0628	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	7.6	15.6	2.5	2.6	
ANP-0629	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	7.7	14.6	2.6	2.4	
ANP-0630	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	7.6	16.5	2.7	3.7	yes
ANP-1016	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	5.6	15.8	3.1	4.2	yes
ANP-1017	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	5.9	15.1	3.0	5.0	yes
ANP-0717	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	7.1	15.3	2.3	2.1	
ANP-0647	Dr Jules Guyot	Rogue Red	mid	30 Jan - 14 Feb	4.7	16.5	4.9	4.3	yes
ANP-0719	Rogue Red	Dr Jules Guyot	mid	30 Jan - 19 Feb	6.0	14.5	2.5	2.6	
ANP-0646	Dr Jules Guyot	Rogue Red	mid	30 Jan - 19 Feb	6.1	16.8	3.3	4.2	yes
ANP-1036	Concord	BPM	mid	30 Jan - 19 Feb	10.7	19.1	2.0	3.0	
ANP-0652	Dr Jules Guyot	Rogue Red	mid	30 Jan - 20 Feb	6.7	13.5	4.0	3.8	yes
ANP-0120	Comice	Yali	mid	30 Jan - 24 Feb					yes
ANP-0534	Dr Jules Guyot	Corella	mid	30 Jan - 24 Feb	7.2	15.2	3.0	2.9	yes
ANP-0714	Dr Jules Guyot	Rogue Red	mid	30 Jan - 24 Feb	9.0	16.2		1.4	
ANP-0963	Dr Jules Guyot	Rogue Red	mid	30 Jan - 24 Feb	5.5	17.1	4.0	2.2	yes
ANP-0928	Dr Jules Guyot	Rogue Red	mid	30 Jan - 24 Feb	6.6	16.7	2.8	2.6	
ANP-0726	Concord	BPM	mid	30 Jan - 25 Feb	4.0	15.1		4.2	yes
ANP-0333	Dr Jules Guyot	Corella	mid	30 Jan - 28 Feb	6.5	14.7	3.6	3.3	yes
ANP-0950	Dr Jules Guyot	Corella	mid	30 Jan - 9 Feb					
ANP-0951	Dr Jules Guyot	Corella	mid	30 Jan - 9 Feb					
ANP-1011	Dr Jules Guyot	Rogue Red	mid	30 Jan - 9 Feb	7.6	15.4	2.0	3.9	yes
ANP-1013	Dr Jules Guyot	Rogue Red	mid	30 Jan - 9 Feb	7.5	16.6	2.8	3.2	
ANP-1018	Dr Jules Guyot	Rogue Red	mid	30 Jan - 9 Feb	6.6	15.2	3.2	4.2	yes
Packham	Uvedale St. Germain	WBC ?	mid	30 Jan - 9 Feb	8.0	13.9	2.0	3.0	
ANP-0608	Dr Jules Guyot	Comice	mid	1 - 15 Feb	6.6	11.6		3.0	yes
ANP-0423	US 56112-146	Packham	mid	2 Feb - 7 Mar	5.2	11.8	3.0	3.6	yes
ANP-0705	Dr Jules Guyot	Corella	mid	4 - 14 Feb	5.9	14.2	4.8	2.0	yes
ANP-0957	Eldorado	Rogue Red	mid	4 - 14 Feb					
ANP-0114	BPM	Corella	mid	4 - 16 Feb	5.0	14.2		4.2	yes
ANP-0620	Rogue Red	Eldorado	mid	4 - 18 Feb	7.1	10.9		2.2	
ANP-1005	Dr Jules Guyot	Corella	mid	4 - 19 Feb	6.8	13.5	4.8	2.4	
ANP-0624	Dr Jules Guyot	Rogue Red	mid	4 - 19 Feb	6.4	15.8	3.0	4.0	yes
ANP-0627	Dr Jules Guyot	Rogue Red	mid	4 - 19 Feb	7.2	16.8	2.5	3.6	yes
ANP-0962	Dr Jules Guyot	Rogue Red	mid	4 - 19 Feb	7.0	14.5	4.2	2.6	
ANP-0506	Comice	Howell	mid	4 - 24 Feb	5.7	12.9	2.6	4.0	yes
ANP-0323	WBC	Howell	mid	4 - 24 Feb	8.9	12.3	2.0	3.4	
ANP-0432	Dr Jules Guyot	Corella	mid	4 - 24 Feb	6.5	14.8	4.1	1.7	
ANP-0952	Corella	Dawn	mid	4 - 24 Feb					
ANP-0961	Dr Jules Guyot	Rogue Red	mid	4 - 25 Feb	8.4	15.1	3.0	3.5	
ANP-0642	Eldorado	Rogue Red	mid	4 Feb - 2 Mar	6.3	16.1	5.0	2.5	
ANP-0132	Dr Jules Guyot	Comice	mid	4 Feb - 1 Mar	7.0	13.3	2.5	3.2	yes
ANP-0958	Eldorado	Rogue Red	mid	4 Feb - 3 Mar					
ANP-0956	Josephine	Rogue Red	mid	4 Feb - 3 Mar	6.6	14.8	3.0	2.5	
ANP-0708	Dr Jules Guyot	Corella	mid	5 - 19 Feb	7.2	16.8	3.5	2.7	yes
ANP-0715	Dr Jules Guyot	Rogue Red	mid	5 - 28 Feb	7.5	15.7		1.6	
ANP-0710	Dr Jules Guyot	Corella	mid	5 Feb - 1 Mar	7.5				
ANP-0121	HW606	Packham	mid	8 - 28 Feb	5.9	13.0	4.5	4.5	
ANP-0712	Corella	Dawn	mid	9 - 19 Feb	5.7	17.4		4.0	yes
ANP-0615	Packham	Comice	mid	9 - 24 Feb	4.3	14.2	5.0	4.0	
ANP-0713	Dr Jules Guyot	Corella	mid	9 - 24 Feb					
ANP-1028	Eldorado	C-31-42	mid	9 - 24 Feb					
ANP-0613	Packham	Comice	mid-late	9 Feb - 3 Mar	4.4	18.2		3.0	yes
ANP-0131	Corella	Comice	mid-late	9 Feb - 1 Mar	6.9	13.6	3.5	3.0	
ANP-0711	Dr Jules Guyot	Corella	mid-late	9 Feb - 6 Mar	7.3	16.7	4.0	2.4	

Selection	Female	Male	Harvest range		Firmness (kg)	Sugar °Brix	Seed colour[a]	Starch scale[b]	Tree ripen
ANP-0345	BPM	Corella	mid-late	11 Feb - 4 Mar	5.8	13.6	3.6	2.9	yes
ANP-0801	Comice	Howell	mid-late	11 Feb - 7 Mar	7.5	13.1	3.3	2.5	
ANP-0101	BPM	Corella	mid-late	13 Feb - 1 Mar	6.3	15.7	4.5	3.4	yes
ANP-0638	Rogue Red	Josephine	mid-late	13 Feb - 1 Mar	5.1	16.7	4.1	2.3	yes
ANP-0955	Josephine	Rogue Red	mid-late	14 Feb - 1 Mar					
ANP-0308	BPM	Corella	mid-late	14 Feb - 11 Mar	6.5	14.1	4.5	3.3	yes
ANP-0964	Josephine	Rogue Red	mid-late	14 Feb - 11 Mar					
ANP-1031	Josephine	Rogue Red	mid-late	14 Feb - 11 Mar	5.5	14.3	4.5	2.8	
ANP-0959	Rogue Red	Josephine	mid-late	14 Feb - 18 Mar	6.6	16.0		2.0	
ANP-0521	I11-13B-83	Packham	mid-late	19 Feb - 11 Mar	5.9	12.8	4.0	4.0	
ANP-0612	Packham	Comice	mid-late	19 Feb - 11 Mar	4.3	13.3	5.0	4.2	yes
ANP-0965	Josephine	Rogue Red	mid-late	19 Feb - 18 Mar	5.8	16.6	5.3	3.5	
ANP-0727	Clapps ?	20th Century ?	mid-late	24 - 28 Feb					
ANP-0535	Packham	Comice	mid-late	24 Feb - 11 Mar	5.2	13.3	6.0	4.1	yes
ANP-0320	WBC	Howell	mid-late	24 Feb - 6 Mar	8.3	13.4	4.0	3.8	yes
ANP-0616	Packham	Comice	mid-late	24 Feb - 6 Mar	4.5	16.5		2.0	yes
ANP-0411	Comice	BPM	late	18 Feb - 16 Mar	5.7	15.8	4.5	3.2	yes
Corella	Forelle?		late	6 -21 Mar	6.6	13.6	4.0	3.2	
ANP-1002	BPM	Ya Li	late	7 -31 Mar	3.1	10.0	5.6	6.0	yes
ANP-0518	BPM	Ya Li	late	7 -31 Mar					
ANP-0701	Comice	Josephine	late	11 -21 Mar					
ANP-0703	Packham	Comice	late	11 Mar -5 April	5.5	17.0		2.0	yes
ANP-0341	WBC	Howell	late	16 -25 Mar	7.3	12.5	5.0	3.0	yes
ANP-1021	Rogue Red	Yali	late	16 -26 Mar	4.7	14.5	5.4	5.0	yes
ANP-1022	Rogue Red	Yali	late	16 -26 Mar	3.6	13.1	5.0	6.0	yes
ANP-1029	Rogue Red	Yali	late	16 -26 Mar					
ANP-0514	Josephine	Comice	late	16 Mar - 5 Apr	2.0	15.7	5.0	3.6	yes
ANP-0639	Packham	Comice	late	24 Feb - 11 Mar	4.8	16.0	5.0	3.5	yes
ANP-1003	Unknown		v. late	31 Mar -25 Apr	5.4	11.2	5.5	5.0	yes

a Seed colour: 1 = white, 2 = cream, 3 = light tan, 4 = tan, 5 = brown, 6 = black

b Starch scale: 1 = whole surface black-blue, 2 = some or most of the core clear, 3 = clear just past core, 4 = most of cortex clear (50%), 5 = 90% of the cortex clear (black under the skin) and 6 = all clear of starch.

7.1.2 Evaluation Appendix 2

Productivity, appearance and eating quality ratings of pear selections based on averaged data from seasons 2009, 2010 and 2011.

Selection	Productivity rating[a]	Flower density[b]	Fruit weight (g)	Appearance rating[c]	Appearance consisency[d]	Eating quality rating[e]	Eating quality consistency[f]
ANP-0101	2.2	1.0	174	4	4	4	4
ANP-0114	1.3	1.0	205	3	4	2	1
ANP-0118	2.3	5.0	100	4	2	3	1
ANP-0120	2.5		220	2	5	2	1
ANP-0121	2.1	3.0	195	3	3	4	1
ANP-0131	2.4	3.0	188	3	4	4	4
ANP-0132	2.3	4.0	159	1	2	2	3
ANP-0302	2.4	1.8	253	2	5	3	5
ANP-0304	2.5	4.3	172	3	1	4	2
ANP-0308	2.8	2.8	167	3	5	4	3
ANP-0310	3.0	5.0	151	4	3	4	1
ANP-0312	3.0	4.8	205	3	3	2	1
ANP-0316	2.3	2.8	133	1	4	2	1
ANP-0320	2.8	4.0	434	2	1	4	4
ANP-0323	3.4	5.5	223	3	3	4	5
ANP-0325	3.5	5.8	236	2	2	4	2
ANP-0333	3.3	4.3	280	4	2	4	1
ANP-0341	4.1	5.0	345	4	3	2	1
ANP-0345	2.8	2.8	237	4	4	4	4
ANP-0406	3.7	4.1	253	1	4	4	2
ANP-0409	2.8	4.3	188	4	4	4	1
ANP-0410	2.1	4.3	143	1	4	4	3
ANP-0411	3.2	3.7	303	2	4	5	3
ANP-0421	2.5	4.0	190	4	3	4	4
ANP-0423	3.0	4.3	243	3	2	2	4
ANP-0425	2.4	4.0	138	3	3	4	1
ANP-0427	2.5	2.5	195	4	1	3	2
ANP-0428	2.9	3.3	156	3	2	2	1
ANP-0429	2.6	3.0	208	2	3	4	4
ANP-0432	3.7	5.0	187	2	2	4	2
ANP-0506	3.0	4.1	208	2	3	4	4
ANP-0514	2.4	3.2	216	2	3	5	2
ANP-0518	4.2	5.5	174	2	4	3	1
ANP-0520	4.1	6.3	193	3	2	3	4
ANP-0521	3.4	3.7	286	1	5	2	4
ANP-0528	3.0	3.5	185	2	3	2	2
ANP-0534	2.8	3.4	149	3	4	4	5
ANP-0535	2.8	5.7	187	1	4	4	1
ANP-0543	4.7	6.0	226	1	4	4	1
ANP-0549	2.6	2.8	177	2	2	5	4
ANP-0608	3.0	4.0	329	1	3	1	1
ANP-0612	3.1	3.3	405	1	3	3	1
ANP-0613	1.0	1.0		1	3	2	1
ANP-0615	2.0	2.0	208	1	5	3	2
ANP-0616				1	1	2	1
ANP-0620	1.7	1.0	206	2	3	2	1
ANP-0621	1.7	1.5	195	1	1	5	2
ANP-0622	2.0	3.3	143	1	2	4	1
ANP-0624	2.0	3.0	214	1	4	3	4
ANP-0625	2.1	2.8	163	3	3	4	4
ANP-0626	2.1	3.8	150	2	2	4	4
ANP-0627	1.5	1.5	101	2	1	4	5
ANP-0628	1.8		119	3	1	5	1
ANP-0629	2.5		107	4	1	4	1

Selection	Productivity rating[a]	Flower density[b]	Fruit weight (g)	Appearance rating[c]	Appearance consisency[d]	Eating quality rating[e]	Eating quality consistency[f]
ANP-0630	2.4	3.3	232	1	2	4	2
ANP-0632	1.8	3.0	147	3	3	4	4
ANP-0634	2.0		133	1	3	5	1
ANP-0638	1.3	1.0	107	1	4	5	2
ANP-0639	2.3	2.8	287	1	3	3	1
ANP-0642	1.5	2.0	105	1	2	3	1
ANP-0643	2.3	4.0	137	4	4	2	1
ANP-0644	2.5	3.5	263	3	2	3	4
ANP-0645	1.8	3.0	164	4	2	3	4
ANP-0646	2.4	3.3	217	2	4	3	3
ANP-0647	1.6	2.0	150	2	2	5	1
ANP-0648	2.0	3.0	192	3	3	5	3
ANP-0650	2.5		191	2	4	5	4
ANP-0651	2.8	4.5	233	4	1	2	4
ANP-0652	2.3	1.0	304	2	2	3	4
ANP-0701	3.3	3.5	267	1	3	4	1
ANP-0703				1	3	2	1
ANP-0705	1.5		120	5	3	3	4
ANP-0708	1.5		90	3	3	4	5
ANP-0710	1.0		70	3	3	3	1
ANP-0711	2.8		124	3	5	2	4
ANP-0712				3	4	2	1
ANP-0713	1.0		88	2	4	2	1
ANP-0714	2.5		105	1	3	4	2
ANP-0715	1.5		116	3	3	3	1
ANP-0716	2.3	4.0	147	3	4	2	1
ANP-0717	1.5		142	3	5	4	1
ANP-0719	2.0		94	2	3	3	4
ANP-0720	2.0		123	2	2	5	2
ANP-0721	2.0		163	5	3	3	2
ANP-0722	1.5		95	1	5		1
ANP-0724	3.0	4.0	259	1	4	3	1
ANP-0725	1.6	2.0	101	2	2	3	1
ANP-0726	1.0			2	4	1	1
ANP-0727	1.6	1.7	181	3	2	1	1
ANP-0801	3.2	4.5	234	2	4	3	1
ANP-0901	1.0		80	2	2	2	1
ANP-0902	1.0		59	3	3	2	1
ANP-0903	1.3		150	3	3	3	1
ANP-0904	1.0			3	4	3	1
ANP-0905	1.0			3	5	5	2
ANP-0906	1.0		78	1	4	4	1
ANP-0907				4	4	4	2
ANP-0908	1.8		133	2	3	4	2
ANP-0909	1.8		131	3	3	4	1
ANP-0910				4	4	3	1
ANP-0911	2.0		165	4	4	2	2
ANP-0912	1.5		120	1	4	4	2
ANP-0913	1.5		159	1	2	5	3
ANP-0914	1.5		95	3	4	3	4
ANP-0915	2.3		170	1	5	3	1
ANP-0916				3	4	4	1

Selection	Productivity rating[a]	Flower density[b]	Fruit weight (g)	Appearance rating[c]	Appearance consisency[d]	Eating quality rating[e]	Eating quality consistency[f]
ANP-0917	2.0		129	3	4	2	4
ANP-0918	1.0		68	2	3	4	1
ANP-0919	1.5		152	3	4	2	1
ANP-0920	1.5		90	3	4	4	3
ANP-0921	1.8		154	3	3	3	4
ANP-0922	2.5		85	5	1	3	1
ANP-0923	1.8		103	3	3	4	4
ANP-0924	2.0		188	2	4	3	1
ANP-0925				3	3	3	1
ANP-0926	2.5		107	3	3	3	3
ANP-0927	2.0		132	1	3	5	2
ANP-0928	2.0		119	3	3	4	2
ANP-0929	1.8		79	3	5	3	3
ANP-0930	1.5		98	3	3	2	4
ANP-0931	2.5		223	2	3	5	1
ANP-0932	2.0		161	2	3	3	1
ANP-0933	1.5		95	4	4	4	2
ANP-0934	1.5		117	4	1	5	3
ANP-0935	3.0		102	3	3	5	3
ANP-0936	3.0	5.0		3	4	5	2
ANP-0937	1.8		126	2	3	4	2
ANP-0938	1.5		98	3	2	4	1
ANP-0939	1.5		110	1	1	4	3
ANP-0940	2.0		119	3	3	3	1
ANP-0941	1.0		71	3	5	4	1
ANP-0942				2	3	3	2
ANP-0943	1.5		128	4	4	3	1
ANP-0944	1.8		105	3	5	4	2
ANP-0945	2.0		126	1	3	4	3
ANP-0946				3	3	4	2
ANP-0947	2.3		133	3	4	5	2
ANP-0948	2.5		120	3	4	1	1
ANP-0949	2.3		128	3	3	4	2
ANP-0950				3	3	4	1
ANP-0951				3	3	1	1
ANP-0952				3	3	3	2
ANP-0953	1.3		165	4	4	1	1
ANP-0954	1.3		112	3	4	4	1
ANP-0955				3	3	4	1
ANP-0956	1.5		116	3	4	4	2
ANP-0957				2	3	3	1
ANP-0958				1	3	3	1
ANP-0959	2.5		141	1	2	2	2
ANP-0960	2.3		211	3	3	2	1
ANP-0961	1.8		141	2	3	4	2
ANP-0962	2.0		115	3	3	3	1
ANP-0963	1.5		143	3	3	3	2
ANP-0964	1.3		195	1	5	3	1
ANP-0965	1.8		143	3	4	4	4
ANP-1001	1.5		63	3	3	1	1
ANP-1002	4.1	6.0	320	3	4	2	1
ANP-1003	2.8	6.0	221	2	5	4	4
ANP-1004	2.3		124	4	4	4	2

Selection	Productivity rating[a]	Flower density[b]	Fruit weight (g)	Appearance rating[c]	Appearance consisency[d]	Eating quality rating[e]	Eating quality consistency[f]
ANP-1005	2.3		113	3	3	4	1
ANP-1006	1.8		96	2	4	4	1
ANP-1007	2.0		142	3	5	1	1
ANP-1008	1.5		96	3	4	4	1
ANP-1009	2.3		103	1	5	4	1
ANP-1010	1.8		117	3	3	3	1
ANP-1011	2.3		83	3	5	4	4
ANP-1012	2.0		154	3	4	4	4
ANP-1013	1.8		97	1	1	4	1
ANP-1014	2.5		116	2	4	4	2
ANP-1015	2.0		101	2	5	3	1
ANP-1016	1.8		109	3	4	3	4
ANP-1017	1.8		126	2	4	4	1
ANP-1018	2.0		112	1	3	4	1
ANP-1019	2.0		110	2	4	5	2
ANP-1020	2.3		99	2	5	3	4
ANP-1021	2.3		136	3	5	4	2
ANP-1022	3.0		255	1	5	4	1
ANP-1023	1.8		131	3	5	5	1
ANP-1024	2.3		172	1	5	3	2
ANP-1025	1.8		97	2	5	4	1
ANP-1026	2.5		101	3	3	3	1
ANP-1027	2.5		166	1	5	3	1
ANP-1028				3	3	2	1
ANP-1029	1.5		295	2	3	3	1
ANP-1030	2.0			1	2	4	1
ANP-1031	3.0		231	2	3	4	1
ANP-1032	1.0		70	2	3	3	1
ANP-1033	1.5		71	3	3	4	3
ANP-1034	2.0		122	2	3	4	3
ANP-1035	1.0			1	3	4	1
ANP-1036	1.0			2	3	4	2
Corella				3	5	4	3
Packham	3.3	5.5	155	1	1	2	3
WBC	2.3	3.0	182	2	3	2	3

a Productivity rating: Average of flower density, fruit weight and tree yield ratings; Fruit weight rating 1 < 100g, 2 = 100-199g, 3 = 200-299g, 4 = 300-400 and 5 = >400; Tree yield rating 1 <5kg, 2 = 5 - 9.9, 3 = 10-14.9, 4 = 15 - 20 and 5 >20kg/tree.

b Flower density rating: Based on 2009 season when flower set was below normal; 1 <20, 2 <40, 3 < 60, 4 <80, 5 <100, 6 <120 and 7 >120 flower clusters (For trees on stock ratings increase by an increment of 30 flower clusters).

c Appearance rating: Based on 1 to 7 likeness scale for shape, colour, overall where 1 = dislike very much to 7 = like very much on data from 2008 to 2011. 1 = rating < 5,5,5; 2 = rating 5,5,5; 3 = rating 6 for at least one attribute; 4 = rating 6,6,6 and 5 = rating 7 for at least one attribute.

d Appearance consistency rating: Based on consistency of appearance rating on data from 2008 to 2011 where 1 = low, 2 = low - medium, 3 = medium, 4 = medium to high and 5 = high.

e Eating quality rating: Based on 1 to 7 likeness scale for texture, taste, overall where 1 = dislike very much to 7 = like very much on data from 2008 to 2011. 1 = rating < 5,5,5; 2 = rating 5,5,5; 3 = rating 6 for at least one attribute; 4 = rating 6,6,6 and 5 = rating 7 for at least one attribute

f Eating quality consistency: Based on consistency of eating quality rating on data from 2009 to 2011 where 1 = low, 2 = low - medium, 3 = medium, 4 = medium to high and 5 = high

7.1.3 Evaluation Appendix 3:
Blush and russet attributes of pear selections based on data from season 2011.

Selection	Full bloom	Russet rating[a]	Blush					Shape rating[c]
			Consistency	Strength & brightness	% fruit	% coverage range	Rating[b]	
ANP-0101	mid		H	M	100	30-50	4	5
ANP-0114	mid		M	L	60	10-30	1	4
ANP-0118	early			L-H	100	50	3	4
ANP-0120	mid	L				0		4
ANP-0121	mid	L	H	L	30	20-30	1	5
ANP-0131	early		M	L-H	100	30-70	3	4
ANP-0132	mid	L	H	L	50	10-30	1	2
ANP-0302	mid			L	100	10-20	1	3
ANP-0304	late	L				0		5
ANP-0308	mid		H	H	100	20-60	6	2
ANP-0310	early		M	M	90	20-50	2	4
ANP-0312	mid	L				0		4
ANP-0316	late	L	L	L	50	5-20	1	4
ANP-0320	mid		H	L	100	10	1	4
ANP-0323	late		M	L	30	5-30	1	3
ANP-0325	mid	L		L	20	10-20	1	2
ANP-0333	mid	L	M	M	100	10-50	2	4
ANP-0341						0		3
ANP-0345	mid	L	H	L	90	20-40	1	3
ANP-0406	early			L	10	10	1	4
ANP-0409	mid			H	80	20-50	5	3
ANP-0410	mid	M	H	L-M	100	30-60	3	3
ANP-0411	mid	H	M	L	20	20	1	4
ANP-0421	mid			H	90	10-50	5	4
ANP-0423	mid	H				0		3
ANP-0425	late	L	M	M	60	30-50	2	3
ANP-0427	mid			L	10	10	1	2
ANP-0428	late	L	L	L	20	20-30	1	4
ANP-0429	mid	L				0		2
ANP-0432	early		M	L	20	10-20	1	4
ANP-0506	late					0		2
ANP-0514	mid	L				0		3
ANP-0518		L	H	L	25	5-10	1	3
ANP-0520	mid					0		1
ANP-0521	mid							4
ANP-0528	early		L	L-H	50	20-40	3	2
ANP-0534	mid	L	H	H	100	40-80	6	3
ANP-0535	mid	M				0		2
ANP-0543	late		L	L	50	20-40	1	2
ANP-0549	mid			H	50	10-50	5	3
ANP-0608	late		H	L	50	10-30	1	2
ANP-0612	mid							4
ANP-0613	mid							4
ANP-0615	mid	H				0		5
ANP-0616	mid							4
ANP-0620	mid		M	L-H	100	40-60	3	5
ANP-0621	early	M	H	H	65	10-50	5	2
ANP-0622	mid							1
ANP-0624	mid	H	M	L	50	30-60	1	2
ANP-0625	mid	L	M	H	100	25-75	5	2

Selection	Full bloom	Russet rating[a]	Blush					Shape rating[c]
			Consistency	Strength & brightness	% fruit	% coverage range	Rating[b]	
ANP-0626	mid		M	L	80	10-30	1	1
ANP-0627	mid	H	H	M	70	20-40	3	1
ANP-0628	mid		M	M-H	100	20-50	4	2
ANP-0629	late		L	M-H	100	20-40	3	3
ANP-0630		H	H	H	100	50-90	7	3
ANP-0632	mid			H	100	50-80	7	3
ANP-0634	mid			L-H	100	20-60	3	2
ANP-0638	mid							4
ANP-0639	mid	L				0		4
ANP-0642	mid							3
ANP-0643			H	L	100	100	7	4
ANP-0644	mid	H		H	80	40	5	5
ANP-0645	mid			L	80	30-50	1	3
ANP-0646	mid		H	H	100	30-70	6	5
ANP-0647	mid	H	M	M	100	20-70	2	2
ANP-0648	mid	L	H	L	50	20	1	3
ANP-0650	mid		H		60	20-50		4
ANP-0651	mid			H	100	20-80	5	2
ANP-0652	mid	M	M	M	90	20-70	2	4
ANP-0701								
ANP-0703	mid							1
ANP-0705	mid		H	M	100	70-90	4	3
ANP-0708	early		L	L-H	100	30-60	3	5
ANP-0710	mid		H	L-M	100	30-50	3	3
ANP-0711	mid							5
ANP-0712	mid							1
ANP-0713	mid							4
ANP-0714	mid		M	H	100	30-70	5	3
ANP-0715	mid			H	100	50-80	7	2
ANP-0716	mid		H	H	100	50-70	7	3
ANP-0717	early		M	H	100	40-80	5	1
ANP-0719	mid	L	H	H	100	50-80	7	2
ANP-0720	mid	H	H	M	100	40-60	4	1
ANP-0721	late		H	H	100	100	7	1
ANP-0722	late	M	M	M		30-80	2	4
ANP-0724	mid		H	L	20	40-50	1	2
ANP-0725	mid	M	M	M-H	100	30-80	4	4
ANP-0726	mid							3
ANP-0727			H	L	66	20-40	1	3
ANP-0801	mid					0		3
ANP-0901	early							3
ANP-0902	early							4
ANP-0903	early							2
ANP-0904	early							3
ANP-0905	mid							3
ANP-0906	early							4
ANP-0907	mid							5
ANP-0908	late		M	M	90	20-60	2	4
ANP-0909	mid		H	H	100	30-60	6	1
ANP-0910	mid		H	H	100	50-90	7	3

Selection	Full bloom	Russet rating[a]	Blush					Shape rating[c]
			Consistency	Strength & brightness	% fruit	% coverage range	Rating[b]	
ANP-0911	mid		L	L-H	100	30-60	3	3
ANP-0912	mid	M	M	M	100	20-60	2	4
ANP-0913	early	H	M	L	40	20-30	1	3
ANP-0914	mid			L-H	100	50-80	3	3
ANP-0915	mid		H	H	90	20-60	5	4
ANP-0916				L	100	50-90	2	3
ANP-0917	mid			H	100	50-90	7	3
ANP-0918	mid	M		H	100	40-80	5	1
ANP-0919	mid		M	H	100	30-60	5	3
ANP-0920	mid	L	H	H	100	50-90	7	2
ANP-0921	mid	M	H	H	100	40-70	6	2
ANP-0922	mid		H	H	100	50-90	7	3
ANP-0923	mid			H	100	70-90	7	1
ANP-0924	mid		M	M	100	5-50	2	5
ANP-0925	mid			L	60	20-50	1	4
ANP-0926	late		L	L-M	80	10-60	2	3
ANP-0927	mid	H	M	M	100	20-50	2	2
ANP-0928	mid	H	H	H	100	50-70	7	3
ANP-0929	mid			H	100	30-70	5	2
ANP-0930	mid			H	100	50-60	7	2
ANP-0931	mid			L-H	50	30-40	3	5
ANP-0932	late		M	M	100	10-60	2	2
ANP-0933	mid			H	100	40-80	5	2
ANP-0934	early		L	M	80	10-40	2	3
ANP-0935	late	M	H	H	100	20-60	6	3
ANP-0936		M		H	100	60-90	7	5
ANP-0937	late			L	20	50	1	3
ANP-0938	mid			L-H	50	20-30	3	4
ANP-0939	mid	M		L	20	10	1	2
ANP-0940	mid			H	100	20-60	5	5
ANP-0941	late		H	H	100	70-90	7	2
ANP-0942								3
ANP-0943	early		H	H	100	60-100	7	1
ANP-0944	early		H	M	100	60-80	4	4
ANP-0945	mid		L	H	50	40-90	5	3
ANP-0946								3
ANP-0947	mid	L	M	H	100	20-70	5	1
ANP-0948	early		H	H	100	40-80	6	4
ANP-0949	mid		L	L-H	100	30-70	3	2
ANP-0950								4
ANP-0951	mid							3
ANP-0952	early							2
ANP-0953	mid							1
ANP-0954	mid							4
ANP-0955	early							3
ANP-0956	mid	L	H	M	100	80	4	3
ANP-0957	early							3
ANP-0958								3
ANP-0959	mid	M	M	M-H	100	30-70	4	2
ANP-0960	mid		H	H	100	40-60	6	2
ANP-0961	early	M	M	H	100	20-50	5	4

Selection	Full bloom	Russet rating[a]	Blush					Shape rating[c]
			Consistency	Strength & brightness	% fruit	% coverage range	Rating[b]	
ANP-0962	mid		M	M-H	100	30-60	4	3
ANP-0963	mid		H	M	100	40-60	4	5
ANP-0964	mid							3
ANP-0965	mid		M	M-H	100	30-50	4	3
ANP-1001	early							4
ANP-1002			M	L-M	33	10-20	2	
ANP-1003	mid					0		3
ANP-1004			H	H	100	30-60	6	3
ANP-1005			H	H	100	60-100	7	3
ANP-1006				H	100	40-90	7	3
ANP-1007				H	100	50-80	7	3
ANP-1008				L-H	100	10-70	3	3
ANP-1009				H	100	20-60	5	2
ANP-1010						0		4
ANP-1011			H	H	100	30-50	6	3
ANP-1012		L	M	H	100	30-80	5	4
ANP-1013			H	M-H	100	40-60	5	2
ANP-1014		M	L	H	100	20-50	5	
ANP-1015		L	M	L	50	20-40	1	4
ANP-1016			H	L-H	100	40-60	3	2
ANP-1017			M	H	90	20-50	5	3
ANP-1018		L	L	L	40	20	1	5
ANP-1019			M	H	100	50-70	7	4
ANP-1020			M	H	100	20-40	5	3
ANP-1021		L	M	L-H	100	30-70	3	3
ANP-1022		L	M	L-M	100	5-40	2	5
ANP-1023		L	M	H	100	10-50	5	3
ANP-1024			H		100	50-80		3
ANP-1025		M	H	H	100	20-50	6	3
ANP-1026			L	L-H	90	10-60	3	1
ANP-1027			M	M-H	80	30-70	4	5
ANP-1028								3
ANP-1029								
ANP-1030		H		H	90	10-50	5	4
ANP-1031		H	M	M-H	100	40-60	4	2
ANP-1032				L	40	10-20	1	
ANP-1033				H	100	50-90	7	4
ANP-1034				H	100	50-70	7	4
ANP-1035								3
ANP-1036								5
Corella	early		M	L-H	95	20-70	3	3
Packham	mid	L				0		4
WBC	late			L	15	10-20	1	4

a Russet rating: L=neck and/or calyx russet or low lenticel and/or general russet, M=medium lenticel and/or general russet, H=high lenticel and/or general russet and may include calyx,neck russet.

b Blush rating: Based on strength/brightness and consistency where L, M, and H = low, medium and high blush and % coverage on 2011 data; 1 = L 10-90%, 2 = L-M, M (M,L consistency) 10-90%, 3 = L-M & L-H (H consistency), 10-90%, 4 = M (H consistency), M-H (M consistency), 10-90%, 5 = H (M consistency) <50%, 6 = H (H consistency) <50% and 7 = H (H consistency) >50%.

c Shape rating: 1 = round to flat round, 2 = rounded oblong or obovate pyriform, 3 = globular-acute pyriform or triangular, 4 = oblong-ovate pyriform and 5 = oblong to elongated oblong pyriform.

7.1.4 Evaluation Appendix 4: Levels of scald after 7 days at room temperature post ripening and following 4 months cool storage at 0oC on Dr Jules Guyot x Rogue Red and reciprocal selections.

Selection	Post ripen scald[a]	Cool store scald[b]
ANP-0543	4	2
ANP-0549	2	2
ANP-0621	3	2
ANP-0622	5	1
ANP-0624	5	1
ANP-0625	4	
ANP-0626	3	
ANP-0627	5	3
ANP-0628	4	2
ANP-0629	3	1
ANP-0630	4	3
ANP-0632	5	5
ANP-0634	4	2
ANP-0643		
ANP-0644		
ANP-0645	5	1
ANP-0646	3	1
ANP-0647	4	2
ANP-0648	2	
ANP-0650	5	2
ANP-0651	4	1
ANP-0652	4	5
ANP-0714	5	3
ANP-0715		
ANP-0716	3	2
ANP-0717	3	5
ANP-0719	4	5
ANP-0720	4	5
ANP-0721		5
ANP-0722		
ANP-0724	2	1
ANP-0725	4	3
ANP-0908		3
ANP-0909	4	5
ANP-0910	4	
ANP-0911	4	5
ANP-0912	4	2
ANP-0913	4	
ANP-0914	5	1
ANP-0915	5	5
ANP-0916	5	2
ANP-0917	5	3
ANP-0918	3	
ANP-0919		
ANP-0920	3	1
ANP-0921	4	5
ANP-0922	5	3
ANP-0923	5	5

Selection	Post ripen scald[a]	Cool store scald[b]
ANP-0924	4	
ANP-0925	5	3
ANP-0926	2	1
ANP-0927	5	3
ANP-0928	4	1
ANP-0929		1
ANP-0930	3	5
ANP-0931		
ANP-0932		
ANP-0933	5	2
ANP-0934	4	2
ANP-0935	3	1
ANP-0936		
ANP-0937		
ANP-0938	5	1
ANP-0939		
ANP-0940		5
ANP-0960		5
ANP-0961	3	
ANP-0962		1
ANP-0963		
ANP-1006	4	1
ANP-1007	5	2
ANP-1008	5	2
ANP-1009	5	2
ANP-1010	5	3
ANP-1011	5	5
ANP-1012	3	3
ANP-1013	1	2
ANP-1014	4	3
ANP-1015	4	1
ANP-1016	2	2
ANP-1017	3	2
ANP-1018	3	3
ANP-1019	1	1
ANP-1020	5	4
ANP-1023	3	3
ANP-1024	4	2
ANP-1025	2	2
ANP-1026	3	1
ANP-1027		
ANP-1032	4	
ANP-1033		2
ANP-1034		
% no scald[c]	32%	21%

a Post ripen scald: Based on assessment of fruit ripened for 7 days at room temperature and left for a further 7 days in season 2011 where 1 = extreme, 2 = heavy, 3 = medium, 4 = slight and 5 = no scald.

b Cool store scald: Based on assessment of fruit cool stored for a minimum of 4 months at $O^{o}C$ in season 2011 where 1 = extreme, 2 = heavy, 3 = medium, 4 = slight and 5 = no scald.

c 72 Dr Jules Guyot x Rogue Red selections evaluated

Pear Breeding Business Case

Should the Australian pear industry re-establish a pear breeding program?

January 2012

Contents

Executive Summary

This Business Case seeks to address the question "Should the Australian pear industry invest in pear breeding again?"

The document approaches the question by:

- reviewing the novel pear products that might be developed in the short-medium term by breeding again at Tatura, the size of the market for such products and the likely competition from other breeders;
- documenting the technical approaches that could be applied to breeding and identifying the preferred option for a partner to provide the technical services required
- analysing the likely financial returns from breeding and evaluation.
- considering the real reasons why an industry organisation would invest in breeding and looking at the alternatives to breeding

The conclusion from this analysis is that the current strategy that the industry is deploying – to evaluate the existing material at Tatura is a financially attractive one that should result in the Australian industry being provided with superior new varieties in the short and medium terms.

To provide for the long term (the 20 year horizon) the industry has three options – continuing to breed to provide these varieties (which is not a financially attractive proposition), importing varieties and participating in global marketing clubs or waiting for new technology to arrive that will radically alter the existing timeframes required to produce new varieties.

The recommendation for the long term, made after considering the potential of the germplasm at Tatura and the real reasons why industry organisations invest in breeding, and after looking at the alternatives, is that despite direct financial returns not being attractive, the industry should still invest in the breeding of pears in Australia.

1. Introduction

Between 1993 and 2010, the Australian apple and pear industry, in partnership with DPI Victoria (DPIV) and Horticulture Australia Limited (HAL), invested in pear breeding[1]. The work was led by Mrs Susanna Turpin (other breeders were Mr Graeme McGregor and Dr Shiming Liu) and conducted at the DPIV research centre at Tatura in Victoria's Goulburn Valley. The program was successful and released 2 high quality varieties – ANP 0118 and ANP 0131 – which are now being commercialised by Coregeo. Evaluation of the remaining material in the breeding program is continuing, under Coregeo management, through AP10029.

This Business Case looks at the possibility of re-establishing pear breeding in Australia. The Business Case analyses possible breeding targets, technical approaches and provides a financial evaluation of investing in breeding.

Breeding Targets

The previous breeding program developed a series of "breeding families". In any new breeding program, development of new varieties would be – most efficiently – based around these existing breeding families. The targets that these breeding families represent, and their market importance, are discussed below.

The information in this section of the Business Case is summarised from documentation prepared by Mrs Susanna Turpin from DPIV Tatura. Her paper is provided in full at Attachment 1.

Technical Approach

Breeding is an expensive, long term investment. However, the Australian pear industry has a strong relationship with both the New Zealand Institute for Plant and Food Research (PFR) - one of the world leaders in pear genomics and breeding in general - and the Department of Primary Industries, Victoria, which has similar capabilities (but which have not previously worked with pears).

While Australia already has access to PFR-developed varieties for Interspecific (Asian x European crosses) and Nashi-type pears through the Prevar program, re-establishing the Tatura program would allow the opportunity to apply the technology to the European-style germplasm previously developed at Tatura.

Financial evaluation

The third aspect of this Business Case is the financial analysis of the breeding proposition. For this an investment and commercialisation financial model has been developed and the returns from commercialising varieties estimated. Returns to the industry, from accessing the new varieties, have also been estimated and a series of Benefit Cost Analyses, comparing various options, prepared.

[1] Project numbers were: AP310, AP96032, AP99007, AP04019, AP06049 and AP09036

2. Breeding Targets

The two new varieties released by DPIV and being commercialised by Coregeo® Australia provide

- novel and attractive appearance (ANP0118: red blush on a lime green to yellow background and ANP013: red blush on a green background)
- superior eating quality (sweet, aromatic flavour, low grit levels)
- traditional pyriform shape

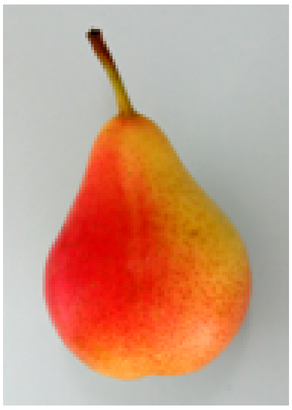
In themselves they offer a "next generation" of productive pear varieties that will allow the category to be re-launched and, if skilfully commercialised, provide a sustainable price premium over existing pear products.

This section of the Business Case looks at the other product opportunities that could be developed from the existing germplasm at Tatura.

2.1 New Market Segments and Products based on existing Tatura material

Based on information received from Mrs Susanna Turpin from DPI Tatura (See Attachment 1), the following market segments could be developed.

Christmas Pears. There is potential to develop highly coloured, pyriform pears that ripen in December in time for the Christmas market. Already selections BB-29-16 and ANP_1001 ripen in the window 25 December to 4 January. Further cross breeding, using ANP0118 and Precoce di Fiorano as parents, has the potential to bring this ripening window into mid-December.



ANP_0118

Red European Pears. Again, selections already exist that could become the basis of attractive, (almost) block red pears. Examples are ANP_0643, ANP_0715 and ANP_0721

Disease Reistant pears. DPIV has studed the genetics of inheritance of pear **scab resistance** and note that the current germplasm at Tatura contains selections likely to be resistant to pear scab. For robust resistance further crossing would probably be required.

There is also potential for **fireblight resistant** varieties. Fireblight resistant selections currently exist (e.g. ANP_0312) but resistance is not in varieties with high eating quality or good appearance.
As with the apple variety RS103-130 being commercialised by Coregeo, resistance to major diseases allows the potential for commercially produced **organic pears**.

More bi-coloured pears: Several existing families exhibit attractive colour, shape and good eating quality. They include the "Bi-colour Series", the "Guyot/Corella Blushed" series, and the "Guyot/Rogue Blushed" series. These candidates provide the attractive base germplasm for further breeding to achieve the targets industry requires related to seasonality, yield/production, disease resistance etc

While all these products would take some time to develop (in the Financial Analysis section a period of 8 years for breeding and a further 3 for large scale evaluation has been allowed prior to the release of a single variety), it is likely that various targets can be progressed in parrallel rather than in series. This would allow release of a series of new pear products targetted at major, attractive-to-consumers market segments.

Associated Research. DPIV has expressed interest in co-investing in agronomic research aimed at consistently producing high yields of good quality fruit in the desired size classes. This would include the evaluation of rootstocks (for precociousness and vigour control), tree training (for precociousness), crop load/nutrition/irrigation for consistent fruit size, fruit maturity and pollination. An initial step by DPIV has been the planting, in winter 2011, of a new "Pear Field Laboratory" at Tatura.

2.2 Market Size and Market Shares

In Australia. APAL estimates are that an average of around 130,000 tonnes of pears are produced in Australia annually. At an average price (across all sizes and varieties) of $1.40/kg, this is equivalent to a wholesale market size of $182,000,000.

Currently the main varieties are Williams Bon Cretin (49%), Packham's Triumph (39%), Burre Bosc (7%), Josephine (2%) and Corella, Red Sensation ,Red d'Anjou and some other minor varieties making up the other 3%.

New varieties have the potential to take market share form the older varieties but to also "grow the pie" – to increase total pear consumption. Skilfully commercialised and marketed they also have the potential to return, compared to existing pears, a higher price – a sustainable premium – to growers.

Our Financial Evaluation section estimates that new variety(ies) will capture a market share of around a third of the existing plantings. We believe this to be a realistic estimate – give the "variety vacuum" in which the varieties will be commercialised.

Overseas. Varieties that have the attributes of ANP0118 and ANP0131 are rare – world wide. We believe that the potential for global marketing clubs – along the lines of PINK LADY – are possible. This would provide additional opportunities for Australian producers to supply in the Northern Hemisphere winter/early spring when little local fruit exists. It is too early to make any meaningful comments on the size of these markets.

2.3 Competition

A detailed analysis of the characteristics of the varieties emerging from the various breeding programs, in various countries of the world, breeding European pears, is beyond the scope of this paper – largely because the data is difficult/impossible to access.

Programs breeding European pears exist in several countries. The table below lists these together with a brief comment. This is based on the experience of APAL/Coregeo staff.

Country	Comment
South Africa.	Government program. Have developed varieties similar in appearance to ANP0118 (blushed pear with cream/yellow background) but anecdotal evidence suggests that these are not colouring well in hot environments.
Belgium. Better 3fruit.	Good program. Little known about current European pear releases.
Italy. CIV.	Little known
USA – Washington.	WSU program. Little known. See commercialisation comments, below.
USA – West Virginia.	USDA program. Little known.
Canada – Vineland, Ontario.	Previously a government program. Fire blight resistance but quality limiting
China and Japan	Each country has several programs breeding Nashi-types.
Prevar	Only breeds Nashi-types.

Overall, breeding programs can be classified into three groups

- those breeding for marginal improvements over what is available now
- those breeding for pest and disease resistance
- those breeding to create novelty and new market niches

The Tatura program could be thought of as being in the third group as ANP 0118 and ANP0131 offer considerable novelty over what is currently available (see photographs above). The breeding families listed above also demonstrate the capacity to develop novel products in the medium term.

3. Technical Approach

3.1 Breeding Partners

Coregeo had hoped that an overseas investor/partner may have been identified. After discussions with both European and US breeders such a partner has not been found. The main reasons for this difficulty relate to commercialisation issues.

In the US varieties from the Washington State University and the Cornell University pear breeding programs are to be made available to growers in Washington and New York (respectively) only. While this seems like a very conservative position (akin to a variety bred in WA not being made available in (say) NSW), it is the stated commercialisation position.

In Europe, Coregeo has had discussions with Better 3fruit – the company that breeds and commercialises varieties bred in association with the University of Leuven, Belgium. Again, commercial realities (e.g. the right to commercialise any varieties developed in Europe) make them un-attractive as a partner.

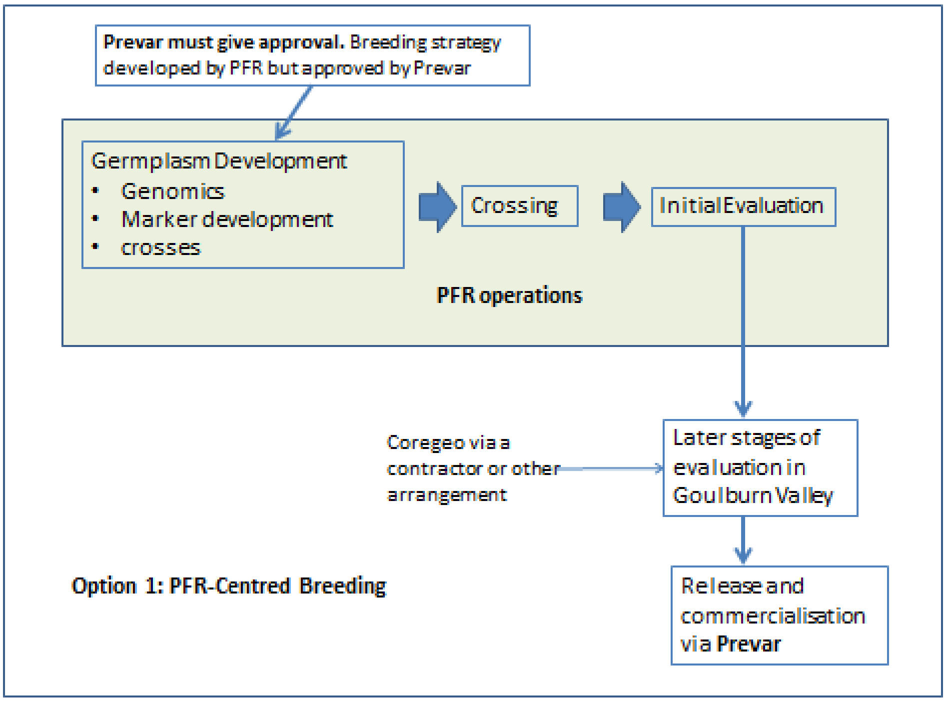
In the end, Coregeo's potential partners for breeding are

- Plant and Food Research, New Zealand
- Department of Food and Agriculture, Western Australia and
- Department of Primary industries, Victoria

How these groups could work with Coregeo is described in the diagrams below.

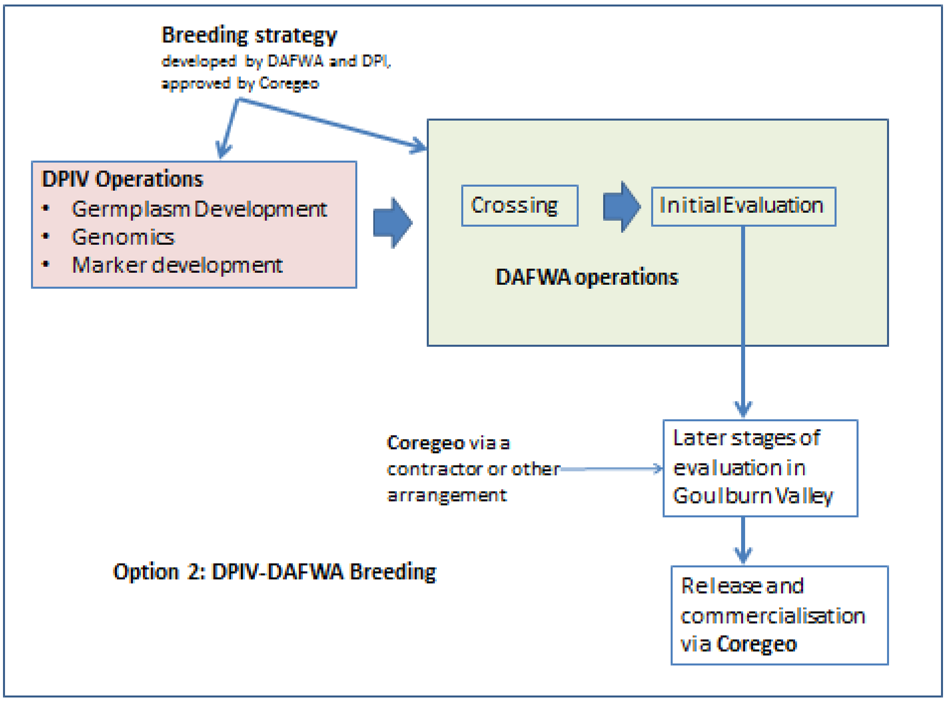
3.2 Possible Breeding relationships

Two preferred options are available to Coregeo.



Under Option 1, the main breeding work – genomics/marker development, germplasm development, crossing and initial evaluation - is carried out by PFR, probably in New Zealand (seed and pollen can be imported into Australia relatively easily). Seedling evaluations are conducted in the Goulburn Valley, managed by Coregeo. Commercialisation is through Prevar. Prevar would need to give its approval for the whole program to proceed. In the commercialisation arrangements, Australia and New Zealand "commercialisation advantage" clauses would remain (over the "rest of the world") and it is likely that, for a program funded by Australia, preference for Australian commercialisation over New Zealand could be negotiated. Note that PFR have stated that they would license an Australian research agency the technology or products (e.g. molecular markers)they have developed to make breeding quicker and more efficient but their preference is for a collaboration beyond licensing that improves the science outcome. Note also that as APAL is a major shareholder in Prevar, commercialisation through Prevar is not a major issue for Coregeo.

Under Option 2, Coregeo is much more in control. It would approve the breeding strategy and be central to commercialisation. DPIV have indicated that they may co-invest in genomics/marker development and germplasm development. DAFWA possibly have similar capability through one of their University partnerships. In comparison to PPR, both of these are unproven in the field of pears. Crossings and initial evaluation, managed by DAFWA would probably occur in WA. Coregeo would manage the final stages of evaluation in the Goulburn Valley.



No costings have yet been developed for either option. In the financial analysis section of the paper an investment of $300,000 per year was allowed for breeding costs. Final evaluation, for 3 years, is also costed at $300,000 per year.

The **preferred option** is to partner with PFR as they have a proven track record in the area, and the overlay of commercialising via Prevar is something that requires more thought but is not considered a serious issue for the industry.

4. Financial Evaluation

A series of benefit cost analyses have been developed based on financial models of breeding and commercialisation. Note that some of the BCA's assume a partner is found to invest in the program. At the time of writing this Business Case, no partner had been identified and the prospects of identifying one were not high.

4.1 Assumptions behind the models

The following assumptions have been made for each of the Benefit: Cost Analyses (BCAs) discussed below:

- breeding work results in the release of one or more new varieties that are planted at the tree numbers listed below and have the production listed below. For the sake of simplicity it is assumed that this is only one variety but it could be two or more varieties sharing the same number of trees.
- over 14 years, 1.543 million trees of the new variety developed by the breeding work are planted in Australia – replacing around one third of total national trees
- In Australia, the planting peak is 200,000 trees per year in the 7th, 8th and 9th years after release
- for the last 3 years of planting a "steady state" situation is reached where plantings average 50,000 trees per year – about the same as annual pear plantings now
- The varieties are commercialised, in both Europe and the US, with a 4 year lag compared to Australia and the planting rates in both of these territories is the same as in Australia
- incomes etc are estimated for 14 years after release of the variety
- The trees are planted on precocious rootstocks and fruit in their 3rd leaf. "Packable" (class 1) production per tree is as follows

Year	1	2	3	4	5	6	7	Mature
Production (Kg/tree)	0	0	3	6	14	23	25	25

- Tree royalty rate: $2.00/tree, paid once at purchase of the tree
- Fruit Royalty Rate: 5%
- Treatment of average wholesale fruit price (i.e. price at first point of sale) in the period 2023/24 to 2038/39. Current average wholesale prices for Packhams and Bosc are around $1.10/kg. At an average of 3% inflation, $1.00 in 2011 terms would be worth $1.65 in 2029/30 or 165% of the 2011 dollar. Fruit prices are driven by supply more than anything else but if, over the period 2011 to 2029/30 fruit prices increased at half this rate reasonable "conservative", "likely" and "optimistic" prices would be
    - "conservative" $2/kg ($2,000/tonne)
    - "likely" $2.50/kg ($2,500/tonne
    - "optimistic" $3.0/kg ($3,000/tonne)

  These prices would take into account both inflation and the premium associated with a new, high quality, variety.
- Benefit Cost Ratio = Discounted royalty income divided by Discounted costs
- Net Present Value[2] (NPV) of investment = NPV of income- NPV of costs
- Discount rates: 10%, 12%, 14%[3].

[2] The value of a future cash flow (income minus expenses) in today's terms
[3] Discounting can be thought of as the inverse of compound interest. In the same way as an investment grows more rapidly at a high interest rate, the value of an investment shrinks more over time at a higher discount rate. Discount rates are related to risk, inflation and other "forward" issues. In the past APAL has used 8, 10 and 12%

- It is assumed that any breeding or evaluation work would be funded through HAL . The additional investment would alter the existing equity shares in the pear germplasm and royalties would be shared with HAL and other investors in proportion to their equity (see below).

4.2 BCA's arising from Scenario 1: breed for 8 years, evaluate for 3 years, release 1 variety

The financial model for Scenario 1 (see Attachment 2) gives the following results:

Table 1: Benefit: Cost ratios for pear breeding under Scenario 1 - no partner

	Future Fruit Price		
Discount Rate	**$2.00/kg (conservative)**	**$2.50/kg (likely)**	**$3.00/kg (optimistic)**
10%	1.510	1.309	1.466
12%	0.845	0.957	1.07
14%	0.623	0.704	0.786

At the "likely" fruit price and the 12% discount rate, the Net Present Value[4] of the income stream is -$85,000 – i.e. after investing (in today's terms $1,995 million) over 11 years and waiting another 14 years for income, the return from the investment (in today's terms) is -$85,000. Not a very exciting proposition.

Note that Tables 1 to 6 show returns as though they were solely to APAL. In reality they will be shared with HAL and DPIV in proportion to equity in the variety released. This split of income is discussed below.

4.3 BCA's arising from Scenario 2: Breed, evaluate and release as for Scenario 1 but include a partner.

In Scenario 2 APAL takes a partner who meets 50% of the costs of the breeding and evaluation project in return for 20% of the income. The 20% is an indicative figure as the actual amount would depend on the equity split with HAL and other stakeholders. The partner would be required to agree to this in recognition of the substantial investment to date by APAL, HAL, DPIV etc.
Similarly, the 50% share of costs is indicative. This will depend on why the partner is investing, what is in the program the partner particularly wants etc.

Should there be a need the model can be easily changed to reflect other scenarios similar to the one actually modelled.

Table 2: Benefit: Cost ratios for pear breeding under Scenario 2 - take partner

	Future Fruit Price		
Discount Rate	**$2.00/kg (conservative)**	**$2.50/kg (likely)**	**$3.00/kg (optimistic)**
10%	1.842	2.094	2.345
12%	1.351	1.532	1.713
14%	0.997	1.127	1.257

At the "likely" fruit price and the 12% discount rate, the Net Present Value of the income stream is $531,000. Taking a partner under these conditions substantially improves the attractiveness of the breeding proposition.

A partner may also bring other benefits such as access to germplasm for breeding and a driver for commercialisation in particular territories.

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as the discount rates for its variety investment models, however, as breeding and commercialisation are generally thought of as highly risky, the higher rates of 10%,12% and 14% have been used.

4.4 BCA's arising from Scenario 3: Evaluate existing germplasm and release 1 variety. Commercialise as for Scenario 1 and 2.

This is a scenario that APAL is actually playing out at the moment. We are currently evaluating, for 3 years, the germplasm collection at Tatura remaining after the breeding program closed. It is assumed that one variety is released from this evaluation process.

Fruit prices for Scenario 3 and 4. As these scenarios are situated "only" 18 years into the future (compared to 25 for Scenarios 1 and 2), indicative mean fruit prices have been set at lower levels than for Scenarios 1 and 2. They are

- "conservative" $1.50/kg ($1,500/tonne)
- "likely" $2.00/kg ($2,000/tonne
- "optimistic" $2.50/kg ($2500/tonne)

Table 3: Benefit: Cost ratios for pear breeding under Scenario 3 – evaluate only, no partner

	Future Fruit Price		
Discount Rate	**$1.50/kg (conservative)**	**$2.00/kg (likely)**	**$2.50/kg (optimistic)**
10%	6.21	7.27	8.32
12%	4.95	5.77	6.59
14%	3.98	4.62	5.26

At the "likely" fruit price and the 12% discount rate, the Net Present Value of the income stream is $3,852,000. The returns are much more attractive because

- first income is received in year 4 – not year 12 as with Scenarios 1 and 2.
- APAL's costs are lower. In present day terms the investment is only $807K, only 40% of the $1,995k expended in Scenario 1 to breed then evaluate

4.4 BCA's arising from Scenario 4: Evaluate existing germplasm and release 1 variety. Share 50% of costs and 20% of income with a partner. Commercialise as for Scenario 1 and 2.

Scenario 4 uses the same fruit price as scenario 3.

Table 4: Benefit: Cost ratios for pear breeding under Scenario 4– evaluate only, partner pays 50% of the costs for 20% of the returns.

	Future Fruit Price		
Discount Rate	**$1.50/kg (conservative)**	**$2.00/kg (likely)**	**$2.50/kg (optimistic)**
10%	9.93	11.63	13.32
12%	7.92	9.24	10.55
14%	6.36	7.39	8.42

At the "likely" fruit price and the 12% discount rate, the Net Present Value of the income stream is $3,323,000. This becomes a financially attractive proposition.

4.5 BCAs based on estimates of Industry benefit rather than financial returns

4.5.1 Breed for 8 years, test for 3 years, release 1 variety, commercialise over 14 years

This scenario assumes that the grower receives a premium, at the first point of sale, of $0.50/kg over existing varieties due to the new variety being superior and being marketed /promoted as a premium variety. It is assumed that this is average premium ($0.50/kg) is able to be maintained over the life of the variety.

*Table 5. Estimates of Benefit : Cost ratios at the **industry** level - for breeding*

Discount Rate	**10%**	**12%**	**14%**
B:C ratio	2.24	1.62	1.17

At a discount rate of 12%, the investment in breeding, measured at the industry level, returned a net present value of $1,242,000 after an investment stream totalling (in present day values) $1,995,000 over 11 years and waiting 14 years for first income. Still not an exciting investment

4.5.2 Test for 3 years, release 1 new variety able to return a premium of $0.50/kg over its life

This analysis assumes that, after a 3 year evaluation period, one variety is released and the variety returns a premium of $0.50/kg over its life – due to its quality and the way it is commercialised and marketed.

*Table 6. Estimates of Benefit : Cost ratios at the **industry** level - for evaluating*

Discount Rate	**10%**	**12%**	**14%**
B:C ratio	13.58	10.69	8.46

At a discount rate of 12%, the investment in evaluation, measured at the industry level, returned a net present value of $7,817,000. An attractive investment.

4.6 Summary

Table 7. Summary of B:C Analyses

Scenario	B:C ratio ("likely" price, 12% discount rate)	Net Present Value ("likely" price, 12% discount rate)	Comments
1 Breed, evaluate, release one variety, no partners	0.957	-$85,000	Investment to achieve this income stream was $1,995 million. First income received in year 15. Not an attractive investment.
2 Breed, evaluate, release one variety, partner	1.53	$531,000	Presence of a partner substantially improves attractiveness of the investment. Still not good
3 Evaluate only. No partner	5.77	$3,852,000	Looks better
4 Evaluate, take partner	9.24	$3,323,000	Becomes attractive
5 Industry level: breed as per Scenario 1	1.62	$1,242, 000	Slightly better bet at the industry level than as a financial proposition
6 Industry level : evaluate as per Scenario 3	10.69	$7,817,000	Attractive investment to industry

5. Discussion

5.1 Existing Germplasm holds potential

It is apparent that the existing germplasm at Tatura holds potential for a range of new pear products. These would give the pear industry tools to compete (with other fruits and "nutritious snacks") in Australia and with other pears internationally. They could also provide the basis for new "global club" marketing schemes – with export capacity for Australian growers built into the arrangements.

5.2 Evaluation a good bet, breeding not so good

All the Benefit : Cost (B:C) studies show that evaluating the existing pear germplasm, as APAL is currently doing, is an attractive investment – both financially and at the industry level. Breeding is not nearly as attractive although the current "evaluate" scenarios would not exist without a breeding phase preceding them.[5]

5.3 Taking a breeding partner

Evaluation is attractive enough such that a partner is not required. A partner for breeding could come as an investor or as a technology provider.

5.3.1 A Partner as an investor

Scenario 2 shows that taking an investment partner improves the B:C ratio for breeding ,but, with the Scenario 2 assumptions of the partner sharing 50% of costs for 20% of the returns, the B:C ratio for the investment is not dramatically improved. The NPV of the proposition (to APAL) is $1,172,000 against the investment (in real terms) of $1,072,000

5.3.2 A Technology partner

It is likely that a technology partner will want a return on the technology they bring to the program. This may be a reasonable request if the technology shortened the time frame or cost of breeding. Molecular markers for various traits have the capacity to do this.

5.4 Equity issues - who gets what

At the end of the current evaluation project (AP10029) the equity shares in the pear germplasm and any varieties released are:

Table 8: Equity shares in pear varieties at the end of AP10029

Party	Investment ($)	Equity (%)
DPIV	5,419,151	51.14
DAFWA	1,128,426	10.65
NSW DPI	440,756	4.16
PIRSA	762,630	7.20
HAL	1,423,118	13.43
APAL	1,423,118	13.43
TOTAL	**10,597,200**	**100.00**

Table 8 shows that at the end of the current evaluation project (AP10029) DPIV remains the major equity holder with 51.14%. If DPIV were not involved in future breeding, their equity and the shares of DAFWA, NSW DPI and PIRSA would be diluted.

[5] Note: as neither the "Breeding" scenarios nor the "Evaluate" scenarios take the investment in the previous breeding program into account, the comparison is still "fair".

5.5 To Breed or not to Breed?

The germplasm at Tatura holds potential. Some$10.6 million has already been invested in developing this potential. Breeding is not a particularly attractive **financial** proposition – neither in terms of return on APAL's investment nor in terms of the financial estimate of industry benefit.

There are two responses to this. They are:

Evaluate, take the varieties and move on: In contrast to breeding, evaluation of the existing germplasm is a financially attractive proposition. Should evaluation yield one or more varieties there are good returns to be had – financially and at the industry level.

Invest in breeding for the future: The essential conclusion of the Thorne Report (AP07032) was that breeding provided the products with which to compete with imported pears and for international competitive advantage and therefore export trade.

"Option 1 (continue to breed via the Australian National Apple Breeding Program and the National Pear Breeding Program and Prevar™) is the strongly preferred option if the industry wishes to maximise its opportunity to compete domestically with imports and expand its export markets. This is the only option that will guarantee the industry access to new premium and niche varieties." [6]

Straight financial analysis is possibly a too-simplistic basis for deciding whether to breed or not. The ability to achieve market entry and capture market share through new and novel products are probably better indicators of the commercial benefit of breeding. Thorne lists the following additional benefits (other than financial) arising from breeding. They include:

- improved international competitiveness
- ability to develop new global and/or niche markets
- "first mover" advantages for Australian producers
- broadened export opportunities
- assist growers to compete with imports

This combination of these difficult-to-quantify benefits (Thorne does not attempt to quantify these benefits) provide the real reasons for breeding.

5.6 Importing Varieties

Australia currently imports pear varieties and it is likely that we will continue to do so whether the industry breeds in Australia or not. The best pear varieties are likely to be made available to Australian growers as "club" varieties. There are few/no varieties in the public domain.

Club varieties have the benefit of controlled imports and exports and are often associated with premiums for all supply chain participants. However, frequently they also have production caps, limiting the number of growers who can be involved and the extent that participating growers can plant.

Importing varieties is really a strategy for an individual grower or a group of growers – not so much for the Australian industry. Thorne sees importing as a poorer alternative, not delivering many of the benefits described in Section 5.5, when compared with breeding.

[6] The financial analyses in the Thorne Report were for apples only and can be thought of as "optimistic" as they assumed that a breeding program would develop (i) a variety that would capture 0.2% of world trade every 5 years and (ii) a second variety that would capture 2% of world trade every 10 years. Experience shows that this is (to say the least) "optimistic". After 25 years PINK LADY has captured less than 1.0% of world trade.

5.7 Next Generations of breeding technology

A final thought is that gene technology is rapidly improving. ANP0118 and ANP0131 provide superior varieties for the short term. The current evaluation program is likely to provide some superior varieties for the mid-term. The real issue is provision of varieties for the long term – perhaps 20 years from today.

In 2032, will breeding technology be so advanced that the selection of genes for a superior variety might be achieved in a relatively short time – say 3 years? Given that the industry's short and medium term requirements for varieties are met, should the industry simply wait for the new technology to arrive? If this technology was available (a big "if" in itself), it is likely to be expensive and to come with intellectual property restraints, limiting its attractiveness. Obviously, any future breeding program needs to licence-in any such genetic developments as they occur.

6. Conclusion

The Australian pear industry's need for superior new varieties is provided for in the short and medium terms by recently released varieties and the evaluation (currently 1/3rd complete) of the germplasm remaining after the DPIV Tatura breeding program closed.

The question is the provision of superior new varieties for the long term – the 20 year horizon.

This Business Case has shown that breeding is not a financially attractive proposition. However, financial returns are only one of the criteria that need to be considered in deciding whether the industry should support breeding or not. Other criteria include improved international competitiveness, the ability to develop new global and/or niche markets, a "first mover" advantages for Australian producers, the broadening of export opportunities and assisting growers to compete with imports – all of which arise from breeding new pear varieties in Australia. The Breeding Targets analysis in Section 2 of this report shows that the existing germplasm at Tatura has the potential to be developed into varieties that could achieve these types of benefits.

Importing varieties from overseas remains an option and will probably happen alongside any future breeding program. However, future imported varieties are likely to be commercialised in "club" arrangements which would only allow individual growers or limited groups of growers to participate. Importing varieties does not ensure access for all growers. Nor does it allow the Australian industry to dominate a market, nor have first mover advantages.

Genetically constructed varieties (if they do become a reality) are likely to be expensive and may well have IP restraints associated with them. Both would limit their attractiveness to the industry (but perhaps not to individual growers or groups of growers).

Given the above and the potential of the germplasm developed at Tatura, it would seem that, from an industry perspective, the best option to provide new pear varieties for the Australian industry is to continue to breed.

Attachment 1: Notes re potential of pear germplasm at Tatura

Future Directions for Pear Breeding:

Mrs S Turpin, DPIV, Tatura, September 2011

Background:

The period of breeding from 1993 to 2006 by the Australian Pear Breeding Program aimed to create varieties that would reinvigorate demand in the pear market and attract a premium price for Australian Pear growers in domestic and international markets. In addition some progress in breeding for resistance to diseases such as pear scab (*Venturia pirina*) and fireblight (*Erwinia amylovora*) was achieved.

The new generation of blushed pears from the Australian Pear Breeding Program have the potential to attract both new and traditional pear consumers with highly attractive red blush and superior eating quality compared to traditional varieties. Some selections can be eaten either crisp and/or ripened to a traditional soft buttery texture. Whilst other selections show a distinct background colour change from green to yellow when fully ripened taking the difficulty out of determining when a pear is properly softened to eat, and providing a marketing edge.

The most successful crosses from the previous series of breeding are Dr Jules Guyot x Rogue Red (and its reciprocal cross), Dr Jules Guyot x Corella and Precoce di Fiorano x ANP0118. The varieties developed from the Dr Jules Guyot x Corella cross are similar in appearance to Corella with a crisp juicy texture, some have a unique musk flavour and can be eaten crisp like an Asian pear or softened like a traditional European pear to a soft melting texture. Selections from the Dr Jules Guyot x Rogue Red cross have fine buttery textures and aromatic pear flavours that are superior to current varieties. They have varying levels of red blush and shape can vary from round to pyriform. The second generation crosses utilising ANP0118 (Butirra Precoce Morettini x Corella) aimed to produce progeny that ripen late December/early January that are tree ripened and can be the first season pears into the market.

Market potential:

"The potential for sales growth for pears is huge", Dhingra said. Northwest apples account for about $2.4 billion, while Northwest pears total just about $400 million. "The next opportunity is in pears," he said. "I think the pear category is totally in a growth mode," said Scott Marboe, director of marketing for Oneonta Starr Ranch Growers, Wenatchee (Karst, 2011)..

Currently there are no blushed pears that dominate the domestic or international markets, with many of the European countries still growing russet pears, as the focus of the majority of pear breeding programs has been on fireblight resistance. A high level of awareness and subsequent interest has been generated in access to the Australian pear germplasm because of their superior eating quality and attractive blushed appearance, principally from the major nursery consortiums: namely INN (International New Varieties Network) which includes Flemings and AIGN (Associated International Group of Nurseries) which includes ANFIC.

Recommendations:

There is further potential to add value to the Australian pear germplasm with research and breeding to incorporate resistance to major diseases such as pear scab and fireblight resistance utilising the elite selections principally from the Dr Jules Guyot x Rogue Red (and its reciprocal), Dr Jules Guyot x Corella and Precoce di Fiorano x ANP0118 crosses as parents.

Pear Scab resistance: Pear scab is one of the major pear biotic stresses which effects pear fruit quality and productivity in Australia. A loss of up to 40% of the crop has been reported in unsprayed orchards in Australia under weather conditions conducive to the disease (Washington *et al.* 1998). Leaf and fruit resistance are controlled by different genes based on research in New Zealand by HortResearch (Brewer et al, 2005). Greenhouse screening of young seedling trees based on foliage reaction, which is commonly used in apple scab resistance breeding, was found to be ineffective for selecting scab resistance pears. It is speculated that scab pathogen variants exist in Australia (Villalta et al, 2005).

The Australian germplasm currently contains selections potentially resistant to pear scab via crosses that have utilised the parents Dr Jules Guyot and Corella that contain some resistance. Lui and colleagues from the Australian Pear Breeding Program proposed a two triallelic gene model to interpret segregation ratio of leaf scab resistance in pear families and parents (Liu et al, 2009). The segregation ratio of the families of which the Australian pear breeding program has the majority of selections is 7 R:9 S for the Dr Jules Guyot x Corella cross, and 1 R:3 S for the Dr Jules Guyot x Rogue Red cross, where R encompasses progeny from slight to high scab resistance. However selections from these crosses have not been screened for leaf and fruit scab resistance to identify parents suitable for further pear scab resistance breeding.

Scab resistance breeding would also benefit from a concurrent study to determine the different biotypes (races) of *V. pirina* scab present in Australia. This would enable resistance of different genotypes/cultivars and leaf and fruit organs to be more accurately defined. A variety release with pear scab resistance could reduce cost inputs to control pear scab which can range in economic costs (Vic) from $2.75 to 7.6 Million per annum depending on the seasonal conditions (Turpin, 2010).

Fireblight resistance: With the recent opening of imports of NZ apples into Australia, there is a higher biosecurity risk for a fireblight outbreak. A desirable risk management strategy would be to continue to develop fireblight resistance varieties suitable for Australian conditions in a future breeding program. Some crosses were made between the variety Packham and fireblight resistant parents from Canada and the USA in the previous breeding program and some selections have been retained for future cross breeding. None of the current fireblight resistant selections are yet suitable for release as their level of resistance needs to be evaluated and further cross breeding with more recent firebight resistant parents may be required to increase their level of resistance.

It is also recommended that the superior blushed selections within the Australian pear germplasm are crossed with recent fireblight resistant varieties developed overseas to improve their appearance and eating quality. The current Australian blushed germplasm is likely highly susceptible to fireblight as one of the main parents used in the elite crosses, Dr Jules Guyot is susceptible to firelight and Forelle which is likely parent of Corella is also reported to be highly susceptible. However, the other major parent used by breeding program, Rogue Red is moderately resistant to fireblight. Fireblight resistant varieties with improved appearance and eating quality would be well sought after by pear growing countries with regions prone to fireblight outbreaks.

Other traits of interest: Other key traits of interest to add value to the Australian pear germplasm include research and breeding to ensure consistent eating quality and appearance, improved storage, very early ripening and consistently high productivity.

Consistent eating quality*: "***Many consumers perceive pears to be bland, and Dhingra believes there are opportunities in coming years to open more of the flavor profile to consumers" (Karst 2011).* The current Australian pear germplasm already have the superior flavour profiles that will attract repeat purchases from consumers. Further research and breeding will include exploitation of distinct pear aromatics and further lowering of grit levels. The novel blushed Australian pear germplasm is designed to attract a new generation of consumers. Pear consumption rates per person in Australia are significantly lower in pear than apple, orange and banana because of lack of new varieties to ignite consumer interest. Consumer studies have found that there are a higher percentage of impulse buyers of pears than in other fruits. More than 50% of impulse buying is based on appearance (The Perishables Group, 2001). Consumers tend to consume pears as a snack food rather than a dessert. The majority of pear consumers in Australia are willing to try new pears (Dignam, 2000). To sustain increased pear consumption we need to ensure that new varieties produce consistently high eating quality. This will involve research to identify the genes that control the particular pear aromatics that consumers prefer. Pears are typically characterised by grit in their flesh. There is considerable phenotypic variation for grit levels in the Dr Jules Guyot x Corella (and is reciprocal) crosses.

In the long term, one game-changer for the pear industry could be the development of a pear variety suitable for the fresh-cut category. "If we could work with (fresh-cut processors), that could be a huge stimulus," he said. In general, he said flavor, convenience and added varieties are elements that could influence the popularity of pears in the future (Karst, 2011). To expand the market for pear consumers, new varieties that can be eaten tree ripened as a crisp fruit or softened depending on the level of post-harvest ripening is desirable. They must also possess a sweet, aromatic flavour typical of European pears that distinguishes them from Asian pears. Selections currently being made from the Dr Jules Guyot x Corella crosses have this versatile texture trait, of which some selections show a distinct background colour change from green to yellow when fully ripened taking the difficulty out, for consumers, of determining when a pear is properly softened to eat.

Consistent appearance: This includes research and breeding to ensure strong blush and uniform shape, preferably pyriform. A blushed russet pear may also be considered desirable for European markets. Italian researchers (Pierantoni et al 2010) have recently looked at the genes responsible for skin blush in pears. Identification of these genes will enable breeding for strong, consistent blush that the markets will demand in any new red blushed variety. There is sufficient genetic diversity for red blush in the current selections to identify those with superior blush and they would provide a good resource for studying this trait. The Dr Jules Guyot x Rogue Red (and its reciprocal) crosses in particular tend to have asymmetrical necks that tend to shrivel under storage. They could be improved with further breeding utilising parental germplasm with a more smooth and symmetrical pyriform shape. Consumers identify European pears as pyriform, so it is desirable to develop new varieties with a pyriform rather than rounder shape to maintain their distinctiveness in the marketplace.

Improved storage: The superior crosses from the previous breeding program, Dr Jules Guyot x Rogue Red (and its reciprocal cross), Dr Jules Guyot x Corella and Precoce di Fiorano x ANP0118, have limited storage and the Dr Jules Guyot x Rogue Red (and its reciprocal) crosses in particular are prone to scald. However there is sufficient genetic diversity with current germplasm to select for improved storage and to cross with other parental germplasm such as ANP0131 that has much longer storage potential.

Very early ripening: There is potential with further cross breeding to develop varieties that ripen in December utilising ANP0118 and selections from second generation ANP0118 crosses such as Precoce di Fiorano x ANP0118 as parents. These selections have potential to yield high returns from being the first pears into the market and may have potential in Asian markets as gifts providing varieties have good sizing ability.

Consistent productivity: *Some newer pear varieties with good potential have failed to reach consumers, and growers, discouraged with poor returns of those varieties, have dropped them, Lutz said. (Karst, 2011).* It is essential for all new pear varieties to have sufficient productivity to be economically viable to grow. Hence the importance of the current pear evaluation project (AP10029) which is focusing on evaluation for consistent productivity and quality. Part of improved productivity is:

1. Availability of rootstocks to control tree vigour and/or selection for new varieties with growth and bearing habit conducive to high, consistent production.

2. Precociousness. In the Tree structure sub-project (AP09032) of the current Apple and Pear Orchard Productivity Program funded by APAL, preliminary work is being conducted on two of the pear breeding selections currently under commercial evaluation by Coregeo, to determine techniques such as limb bending to increase precocity, which will also provide useful information for tree management in pear breeding seedling blocks.

3. Good sizing ability of fruit and consistent size profiles, which is an important requirement from marketers.

4. Good pollination. Pollination could be improved via self-compatibility and tendency for parthnocarpy. These attributes are desirable in pear varieties where frequent frosts and *Varroa* mites that are an external parasite of native and European honey bees are a problem. Parthnocarpic fruit reportedly achieve better fruit set in frost prone areas. With the threat of Varroa mite invading major fruit growing areas in Australia in the future new varieties that are self-compatible will aide pollination where pollination from bees may be reduced.

New technologies that could be used to shorten the time frame of the breeding/evaluation process: The obvious technologies that can be used to shorten the breeding process are the development of molecular markers for traits of interest. However biotechnology research is not as advanced in pears as it is in other crops, so there is a lot of research required to identify the genes responsible and suitable molecular markers, before they are able to be routinely implemented into a breeding program to reduce the length of the first stage of breeding and/or to cull out undesirable seedling at an earlier stage in the breeding program to reduce the size of seedling blocks required for evaluation of the remainder of desirable breeding traits.

In apple breeding, seedling trees are induced to fruit earlier by grafting wood from seedling trees onto an established rootstock. Grafting wood is taken from seedling trees once they reach 1.8m in height, as they are deemed to have transitioned from the vegetative to the reproductive stage. In preliminary research in the previous Australian pear breeding program, immature wood grafted onto established rootstock have taken as long as the seedling on its own roots to bare fruit. Results from more mature grafting wood taken from older seedlings and grafted onto established rootstocks is yet to be established.

The NZ pear breeding program has developed management techniques to reduce the juvenility period and increase precocity. They successfully utilised tree top bending and girdling to encourage inter-specific crosses to fruit earlier and produce more flowers (Brewer et al, 2008). It is recommended that similar techniques are developed for future breeding of European crosses as most European crosses take from 5 to 8 years to bare fruit on their own roots. In addition seedling trees that are managed without pruning can become very large and difficult to harvest once they start to fruit as the fruit tend to set near the top of the tree. Earlier tree management in seedlings trees, although more expensive, can limit their height and save management and harvest labour costs especially if seedlings can be induced to fruit earlier to shorten the selection cycle.

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Attachment 2: Benefit Cost Analyses

Six Benefit: Cost Analyses follow. The assumptions related to these are listed in Section 4.1 above.

Scenario 1. Breed for 8 years, test for 3, no partners

Year	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2010/21	2021/22	2022/23	2023/24	2024/25
	0	1	2	3	4	5	6	7	8	9	10	11	12
Activity	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Testing	Testing	Testing	Prod'n	Prod'n
Trees planted that year - Australia												3000	10000
Trres planted that year - Over seas												0	0
Total trees Annually												3000	10000
Cummulative total trees												3000	13000
increase in tree number that year												3000	10000
Production Scenario - Tree Ages													
Trees 1 year old												3000	10000
Trees 2 year old													3000
Trees 3 yr old													
Trees 4 yr old													
Trees 5 year old													
Trees 6 years old													
Mature trees													
Calculation of Production													
Year													
Tree Age												1	2
Kg/tree at each age												0	0
Production (tonnes)												0	0
Royalties													
Tree royalty rate	$2.00	per tree											
Fruit Price	$2,500.00	per tonne											
Fruit Royalty Rate	0.05												
APAL Income ($'000)													
Tree royalty income ($'000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	20.0
Fruit Royalty income ($'000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total APAL royalty income ($'000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	20.0
Discount Rate	0.1200												
Discount Factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220	0.2875	0.2567
Dicounted total APAL Income ('000)	0	0	0	0	0	0	0	0	0	0	0	2	5
Present value of APAL income stream ($'000)			**1,910**										
APAL Costs ($'000)	300	300	300	300	300	300	300	300	300	300	300		
Discont Factor	0.1400	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220		
Discounted Costs	42	268	239	214	191	170	152	136	121	108	97		
Present value of APAL Costs ($'000)			**1,737**										
Benefit cost ratio			1.09971										
Mean NPV ($'000)			173										

Year	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37	2037/38
	13	14	15	16	17	18	19	20	21	22	23	24	25
Activity	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n
Trees planted that year - Australia	30,000	50,000	100,000	100000	200000	200,000	200,000	150,000	150,000	100,000	100,000	50,000	50,000
Trres planted that year - Over seas	0	0	6000	20000	60000	100000	200000	200000	400000	400000	400000	300000	300000
Total trees Annually	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000
Cummulative total trees	43000	93000	199000	319000	579000	879000	1279000	1629000	2179000	2679000	3179000	3529000	3879000
increase in tree number that year	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000
Production Scenario - Tree Ages													
Trees 1 year old	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000
Trees 2 year old	10,000	30000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000	500000	350000
Trees 3 yr old	3000	10,000	30,000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000	500000
Trees 4 yr old		3000	10,000	30000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000
Trees 5 year old			3000	10,000	30000	50,000	106,000	120000	260000	300000	100000	350000	550000
Trees 6 years old				3000	10,000	30000	50,000	106,000	120000	260000	300000	100000	350000
Mature trees					3000	10000	30000	50000	106000	120000	260000	300000	610000
Calculation of Production													
Year													
Tree Age	3	4	5	6	Mature	Mature	Mature	Mature	Mature	Mature			
Kg/tree at each age	3	6	14	23	25	25	25	25	25	25			
Production (tonnes)	9	48	192	539	1343	2636	4884	7828	11000	14530	18550	19500	35500
Royalties													
Tree royalty rate													
Fruit Price													
Fruit Royalty Rate													
APAL Income ($'000)													
Tree royalty income ($'000)	60.0	100.0	212.0	240.0	520.0	600.0	800.0	700.0	1,100.0	1,000.0	1,000.0	700.0	700.0
Fruit Royalty income ($'000)	1.1	6.0	24.0	67.4	167.9	329.5	610.5	978.5	1,375.0	1,816.3	2,318.8	2,437.5	4,437.5
Total APAL royalty income ($'000)	61.1	106.0	236.0	307.4	687.9	929.5	1,410.5	1,678.5	2,475.0	2,816.3	3,318.8	3,137.5	5,137.5
Discount Rate													
Discount Factor	0.2292	0.2046	0.1827	0.1631	0.1456	0.1300	0.1161	0.1037	0.0926	0.0826	0.0738	0.0659	0.0588
Dicounted total APAL Income ('000)	14	22	43	50	100	121	164	174	229	233	245	207	302

Scenario 2: Breed for 8 years, test for 3. Share 50% of the costs for 20% of the income

Year	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2010/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37	2037/38
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Activity	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Testing	Testing	Testing	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n
Trees planted that year - Australia												3000	10000	30,000	50,000	100,000	100000	200000	200,000	200,000	150,000	150,000	100,000	100,000	50,000	50,000
Trres planted that year - Over seas												0	0	0	0	6000	20000	60000	100000	200000	200000	400000	400000	400000	300000	300000
Total trees Annually												3000	10000	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000
Cummulative total trees												3000	13000	43000	93000	199000	319000	579000	879000	1279000	1629000	2179000	2679000	3179000	3529000	3879000
increase in tree number that year												3000	10000	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000
Production Scenario - Tree Ages																										
Trees 1 year old												3000	10000	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000
Trees 2 year old													3000	10,000	30000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000	500000	350000
Trees 3 yr old														3000	10,000	30,000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000	500000
Trees 4 yr old															3000	10,000	30000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000
Trees 5 year old																3000	10,000	30000	50,000	106,000	120000	260000	300000	100000	350000	550000
Trees 6 years old																	3000	10,000	30000	50,000	106,000	120000	260000	300000	100000	350000
Mature trees																		3000	10000	30000	50000	106000	120000	260000	300000	610000
Calculation of Production																										
Year																										
Tree Age												1	2	3	4	5	6	Mature	Mature	Mature	Mature	Mature	Mature			
Kg/tree at each age												0	0	3	6	14	23	25	25	25	25	25	25			
Production (tonnes)												0	0	9	48	192	539	1343	2636	4884	7828	11000	14530	18550	19500	35500
Royalties																										
Tree royalty rate	$2.00	per tree																								
Fruit Price	$2,500.00	per tonne																								
Fruit Royalty Rate	0.05																									
APAL Income ($'000)																										
Tree royalty income ($'000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	20.0	60.0	100.0	212.0	240.0	520.0	600.0	800.0	700.0	1,100.0	1,000.0	1,000.0	700.0	700.0
Fruit Royalty income ($'000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	6.0	24.0	67.4	167.9	329.5	610.5	978.5	1,375.0	1,816.3	2,318.8	2,437.5	4,437.5
Total APAL royalty income ($'000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	20.0	61.1	106.0	236.0	307.4	687.9	929.5	1,410.5	1,678.5	2,475.0	2,816.3	3,318.8	3,137.5	5,137.5
80% of APAL income	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	16.0	48.9	84.8	188.8	245.9	550.3	743.6	1,128.4	1,342.8	1,980.0	2,253.0	2,655.0	2,510.0	4,110.0
Discount Rate	0.1200																									
Discount Factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220	0.2875	0.2567	0.2292	0.2046	0.1827	0.1631	0.1456	0.1300	0.1161	0.1037	0.0926	0.0826	0.0738	0.0659	0.0588
Dicounted total APAL Income ('000)	0	0	0	0	0	0	0	0	0	0	0	1	4	11	17	34	40	80	97	131	139	183	186	196	165	242
Present value of APAL income stream ($'000)			1,528																							
APAL Costs ($'000)	300	300	300	300	300	300	300	300	300	300	300															
50% of APAL costs	150	150	150	150	150	150	150	150	150	150	150															
Discont Factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220															
Discounted Costs	150	134	120	107	95	85	76	68	61	54	48															
Present value of APAL Costs ($'000)			998																							
Benefit cost ratio			1.532		Net Present Value:				531																	

Scenario 3: release varieties after 3 years evaluation, no partner

Year	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2010/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Activity	Testing	Testing	Testing	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n
Total Tree Number - Australia				3000	10000	30,000	50,000	100,000	100000	200000	200,000	200,000	150,000	150,000	100,000	100,000	50,000	50,000	50,000
Total Tree Number Over seas				0	0	0	0	6000	20000	60000	100000	200000	200000	400000	400000	400000	300000	300000	200000
Total trees Annually				3000	10000	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000	250000
Cummulative total trees				3000	13000	43000	93000	199000	319000	579000	879000	1279000	1629000	2179000	2679000	3179000	3529000	3879000	4129000
increase in tree number that year				3000	10000	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000	250000
Production Scenario - Tree Ages																			
Trees 1 year old				3000	10000	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000	250000
Trees 2 year old					3000	10,000	30000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000	500000	350000	350000
Trees 3 yr old						3000	10,000	30,000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000	500000	350000
Trees 4 yr old							3000	10,000	30000	50,000	106,000	120000	260000	300000	50000	350000	550000	500000	500000
Trees 5 year old								3000	10,000	30000	50,000	106,000	120000	260000	300000	100000	350000	550000	500000
Trees 6 years old									3000	10,000	30000	50,000	106,000	120000	260000	300000	100000	350000	550000
Mature trees										3000	10000	30000	50000	106000	120000	260000	300000	610000	350000
Calculation of Production																			
Year																			
Tree Age				1	2	3	4	5	6	Mature	Mature	Mature	Mature	Mature	Mature				
Kg/tree at each age				0	0	3	6	14	23	25	25	25	25	25	25				
Production (tonne)				0	0	9	48	192	539	1343	2636	4884	7828	11000	14530	18550	19500	35500	32450
Royalties																			
Tree Royalty Rate	$2.00	per tree																	
Fruit Wholesale Price	$2,000.00	per tonne																	
Royalty	0.05																		
APAL Income ($'000)																			
Tree Royalty Income ($'000)	0	0	0	6	20	60	100	212	240	520	600	800	700	1100	1000	1000	700	700	500
Fruit Royalty Income ($'000)	0.0	0.0	0.0	0.0	0.0	0.9	4.8	19.2	53.9	134.3	263.6	488.4	782.8	1,100.0	1,453.0	1,855.0	1,950.0	3,550.0	3,245.0
Total APAL royalty income ($'000)	0.0	0.0	0.0	6.0	20.0	60.9	104.8	231.2	293.9	654.3	863.6	1,288.4	1,482.8	2,200.0	2,453.0	2,855.0	2,650.0	4,250.0	3,745.0
Discount Rate	0.1200																		
Discount Factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220	0.2875	0.2567	0.2292	0.2046	0.1827	0.1631	0.1456	0.1300
Dicounted total APA royalty Income (	0	0	0	4	13	35	53	105	119	236	278	370	381	504	502	522	432	619	487
Present value of APAL income stream ($'000)			4,659																
APAL Costs ($'000)	300	300	300																
Discont Rate	0.1200																		
Discount Factor	1.0000	0.8929	0.7972																
Discounted Costs	300	268	239																
Present value of APAL Costs ($'000)			807																
Benefit cost ratio			**5.77**																
Net present value			**3,852**																

Scenario 4: Release varieties after 3 years evaluation. Share 50% of the costs for 20% of the Royalties

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Increase in tree numbers that year	0	0	0	3000	10000	30000	50000	106000	120000	260000	300000	400000	350000	550000	500000	500000	350000	350000	250000
Production (tonnes)	0	0	0	0	0	9	48	192	539	1343	2636	4884	7828	11000	14530	18550	19500	35500	32450
Royalties																			
Tree Royalty Rate	$2.00	tree																	
Wholesale Price	$2,000	per tonne																	
Royalty	0.05																		
APAL Income ($'000)																			
Tree Royalties ($'000)	0.0	0.0	0.0	6.0	20.0	60.0	100.0	212.0	240.0	520.0	600.0	800.0	700.0	1100.0	1000.0	1000.0	700.0	700.0	500.0
Fruit royalties ($'000)	0.0	0.0	0.0	0.0	0.0	0.9	4.8	19.2	53.9	134.3	263.6	488.4	782.8	1,100.0	1,453.0	1,855.0	1,950.0	3,550.0	3,245.0
Total APAL Rotyalty income ($'000)	0.0	0.0	0.0	6.0	20.0	60.9	104.8	231.2	293.9	654.3	863.6	1,288.4	1,482.8	2,200.0	2,453.0	2,855.0	2,650.0	4,250.0	3,745.0
80% of total APAL royalty income	0.00	0.00	0.00	4.80	16.00	48.72	83.84	184.96	235.12	523.44	690.88	1030.72	1186.24	1760.00	1962.40	2284.00	2120.00	3400.00	2996.00
Discount Rate	0.1200																		
Discount Factor	1.0000		0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220	0.2875	0.2567	0.2292	0.2046	0.1827	0.1631	0.1456	0.1300
Discounted 80% of APAL Income ('000)	0.00	0.00	0.00	3.42	10.17	27.65	42.48	83.67	94.96	188.76	222.44	296.31	304.48	403.35	401.55	417.28	345.82	495.19	389.60
Present value of 80% of income stream($'000)			3727.10																

APAL Costs ($'000)	300	300	300
50% of APAL's cost	150	150	150
Discount rate	0.1200		
Discount Factor	1	0.892857	0.797194
APAL's costs - Discounted ($'000)	150.0	133.9	119.6
Present value of APAL Costs ($'000)			403.5077
Benefit cost ratio			**9.24**
Net present Value ($'000)			3323.59

Scenario 5: Industry benefit from new pear varieties. Breed for 7 years, test for 3, no partners

Year	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2010/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32	2032/33	2033/34	2034/35	2035/36	2036/37	2037/38
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Activity	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Breeding	Testing	Testing	Testing	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n
Total Tree Number - Australia												3000	10000	30,000	50,000	100,000	100000	200000	200,000	200,000	150,000	150,000	100,000	100,000	50,000	50,000
Total Tree Number Over seas												0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total trees Annually												3000	10000	30000	50000	100000	100000	200000	200000	200000	150000	150000	100000	100000	50000	50000
Cummulative total trees												3000	13000	43000	93000	193000	293000	493000	693000	893000	1043000	1193000	1293000	1393000	1443000	1493000
increase in tree number that year												3000	10000	30000	50000	100000	100000	200000	200000	200000	150000	150000	100000	100000	50000	50000
Production Scenario - Tree Ages																										
Trees 1 year old												3000	10000	30000	50000	100000	100000	200000	200000	200000	150000	150000	100000	100000	50000	50000
Trees 2 year old													3000	10,000	30000	50,000	100,000	100000	200000	200000	50000	150000	150000	100000	100000	50000
Trees 3 yr old														3000	10,000	30,000	50,000	100,000	100000	200000	200000	50000	150000	150000	100000	100000
Trees 4 yr old															3000	10,000	30000	50,000	100,000	100000	200000	200000	50000	150000	150000	100000
Trees 5 year old																3000	10,000	30000	50,000	100,000	100000	200000	200000	100000	150000	150000
Trees 6 years old																	3000	10,000	30000	50,000	100,000	100000	200000	200000	100000	150000
Mature trees																		3000	10000	30000	50000	100000	100000	200000	200000	610000
Calculation of Production																										
Year																										
Tree Age												1	2	3	4	5	6	Mature	Mature	Mature	Mature	Mature	Mature			
Kg/tree at each age												0	0	3	6	14	23	25	25	25	25	25	25			
Production (tonnes)												0	0	9	48	192	539	1325	2540	4500	6750	8950	10650	12350	10600	21700
Premium associated with the new variety	$500.00	per tonne																								
Industry benefit ($'000)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	24.0	96.0	269.5	662.5	1,270.0	2,250.0	3,375.0	4,475.0	5,325.0	6,175.0	5,300.0	10,850.0
Discount Rate	0.1200																									
Discount Factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220	0.2875	0.2567	0.2292	0.2046	0.1827	0.1631	0.1456	0.1300	0.1161	0.1037	0.0926	0.0826	0.0738	0.0659	0.0588
Dicounted Industry benefit ('000)	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	18	44	96	165	261	350	414	440	456	349	638
Present value of industry benefit ($'000)			3,238																							
APAL Costs ($'000)	300	300	300	300	300	300	300	300	300	300	300															
Discont Factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220															
Discounted Costs	300	268	239	214	191	170	152	136	121	108	97															
Present value of APAL Costs ($'000)			1,995																							
Benefit cost ratio			1.62276																							
NPV			1,242																							

Scenario 6: Industry Benefit from new pears. Test for 3 years

Year	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31	2031/32
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Activity	Testing	Testing	Testing	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n	Prod'n
Total Tree Number - Australia				3000	10000	30,000	50,000	100,000	100000	200000	200,000	200,000	150,000	150,000	100,000	100,000	50,000	50,000	50,000
Total Tree Number Over seas				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total trees Annually				3000	10000	30000	50000	100000	100000	200000	200000	200000	150000	150000	100000	100000	50000	50000	50000
Cummulative total trees				3000	13000	43000	93000	193000	293000	493000	693000	893000	1043000	1193000	1293000	1393000	1443000	1493000	1543000
increase in tree number that year				3000	10000	30000	50000	100000	100000	200000	200000	200000	150000	150000	100000	100000	50000	50000	50000
Production Scenario - Tree Ages																			
Trees 1 year old				3000	10000	30000	50000	100000	100000	200000	200000	200000	150000	150000	100000	100000	50000	50000	50000
Trees 2 year old					3000	10,000	30000	50,000	100,000	100000	200000	200000	50000	150000	150000	100000	100000	50000	50000
Trees 3 yr old						3000	10,000	30,000	50,000	100,000	100000	200000	200000	50000	150000	150000	100000	100000	50000
Trees 4 yr old							3000	10,000	30000	50,000	100,000	100000	200000	200000	50000	150000	150000	100000	100000
Trees 5 year old								3000	10,000	30000	50,000	100,000	100000	200000	200000	100000	150000	150000	100000
Trees 6 years old									3000	10,000	30000	50,000	100,000	100000	200000	200000	100000	150000	150000
Mature trees										3000	10000	30000	50000	100000	100000	200000	200000	610000	150000
Calculation of Production																			
Year																			
Tree Age				1	2	3	4	5	6	Mature	Mature	Mature	Mature	Mature	Mature				
Kg/tree at each age				0	0	3	6	14	23	25	25	25	25	25	25	25	25	25	25
Production (tonnes)				0	0	9	48	192	539	1325	2540	4500	6750	8950	10650	12350	10600	21700	9350
Premium associated with the new variety	$500.00	per tonne	or	50c/kg															
Industry benefit ($'000)	0.0	0.0	0.0	0.0	0.0	4.5	24.0	96.0	269.5	662.5	1,270.0	2,250.0	3,375.0	4,475.0	5,325.0	6,175.0	5,300.0	10,850.0	4,675.0
Discount Rate	0.1200																		
Discount Factor	1.0000	0.8929	0.7972	0.7118	0.6355	0.5674	0.5066	0.4523	0.4039	0.3606	0.3220	0.2875	0.2567	0.2292	0.2046	0.1827	0.1631	0.1456	0.1300
Discounted industry benefir	0	0	0	0	0	3	12	43	109	239	409	647	866	1,026	1,090	1,128	865	1,580	608
Present value of industry benefit ($'000)			8,624																
APAL Costs ($'000)	300	300	300																
Discont Factor	1.0000	0.8929	0.7972																
Discounted Costs	300	268	239																
Present value of APAL Costs ($'000)			807																
Benefit cost ratio			**10.69**																
Mean NPV($'000)			7,817																