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New Red-blushed Pear to Boost Grower Profitability[1]

Kerry Stott[a], Mark O'Connell[b], Ian Goodwin[b], Susanna Turpin[b] and Bill Malcolm[c]

[a] Agriculture Victoria Research, Department of Economic Development Jobs, Transport and Resources (DEDJTR), Centre for AgriBioscience, 5 Ring Road, La Trobe University, Bundoora.
[b] Agriculture Victoria Research, DEDJTR, Tatura Centre, 255 Ferguson Rd, Tatura.
[c] Department of Agriculture and Food Systems, University of Melbourne, Parkville.

Abstract

A discounted net cash flow (NCF) model incorporating Monte Carlo simulation was developed to quantify the net benefits and risks of growing the new red-blushed pear cultivar 'ANP-0131' (Deliza®) on a representative orchard block in Victoria's Goulburn Valley. Results were compared to those for retaining a traditional low-density (343 trees/ha) planting of 'Packham's Triumph'. 'ANP-0131' was grafted to Quince A rootstock and trained on Open Tatura trellis at densities of 1,481, 2,222 or 4,444 trees/ha; these are three of the training system x rootstocks x tree spacing combinations currently being investigated at Agriculture Victoria's experimental orchard in Tatura. The trees in the experimental orchard are currently in their fifth year of a potential life-span of 30 years and have been fruiting for the last three years. Hence, the analysis is prospective and based on crucial assumptions concerning pack-outs, prices and yields. From 10,000 simulations it was found that growers could invest in the new 'ANP-0131' pear system with confidence. Subject to the law of diminishing returns, the most profitable planting was 2,222 trees/ha, for which the mean Net Present Value (NPV) was $258,471/ha evaluated over 30 years using a discount rate of 4.5% real. The Modified Internal Rate of Return (MIRR) was 10.9 per cent, beating the real nine per cent return on Australian equities. The payback period ranged from 7 to 11 years from best to worst case scenarios. The relative advantage of the new planting over the existing planting of 'Packham's Triumph' was clear; the mean annuity of the NPV for the new planting was $15,835/ha p.a., the NCF for the existing planting was a modest $4,595/ha p.a. and there was a 20 per cent chance that it would lose money in any one year.

Key words: Red-blushed pear, 'ANP-0131', Deliza®, Open Tatura, high density systems, orchard economics.

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Introduction

During 2016, 104,928 tonnes of pears worth $91 million were produced across Australia (ABS, 2017a, b) with Victoria's Goulburn Valley accounting for about 86 per cent of the total. In the decade from 2005, national production was on a downward trend; levels are now more stable, but production remains 30 per cent below the 147,688-tonne peak. Various factors contributed to the decline including a high $A that reduced export competitiveness and drove import penetration, as well as reduced intake of canning pears by local processors.

Today, growers are adjusting to the difficult trading conditions by replanting old blocks of traditional, European style pears, such as 'Packham's Triumph' and 'Williams' Bon Chrétien', with higher value fresh cultivars, such as 'Corella' and new club varieties. The commercial development of new cultivars is one of the key strategies of Apple and Pear Australia Limited (APAL) to revitalise the Australian pear industry.

Supporting this varietal shift, scientists working at Agriculture Victoria Research's (AVR) Tatura site are carrying out management experiments on the red-blushed pear 'ANP-0131' to determine the combination of rootstock, training system and planting density that will maximise the precocity, yield and quality attributes of this new cultivar. Bred out of the Australian National Pear Breeding Program and marketed by APAL as Deliza®, 'ANP-0131' is one of three new red-blushed pears that offer the opportunity for Australian growers to produce a range of high quality red-blushed pear cultivars that can have a clearly defined marketing advantage internationally.

Complementing the management experiments, AVR has conducted an economic analysis to answer the following questions:

1. Would new plantings of the red-blushed pear 'ANP-0131' grown in a modern, high-density orchard system be more profitable than continuing to produce traditional European-style pears using conventional practices?
2. How risky is the new planting compared the traditional planting? and,
3. What is the financial feasibility of investing in the new planting?

The economic analysis focused on 'ANP-0131' grafted to Quince A (QA) rootstock (with a 'Beurré Hardy' interstem) and trained on Open Tatura trellis (OT) with multiple leaders at three densities of 1,481, 2,222 or 4,444 trees per hectare. The lower density plantings had 8 leaders per tree, whereas the medium and high-density plantings had 4 and 2 leaders per tree, respectively. OT is a variation of the Tatura Trellis, it is 'open' because a narrow strip about 500 mm wide separates the diagonally planted trees within each row. Quince stocks are now the stocks of choice for most new plantings in Australia because of their dwarfing abilities (Hankin, 2015); they also reportedly improve blush development through lower skin chlorophyll (green) and carotenoid (yellow-orange) concentrations (Roberts *et al.,* 2008).

Potential advantages of the new plantings include more fresh fruit marketed at premium prices, earlier production, and efficiencies in production and harvest operations at full bearing (APAL, 2014). Production from increasing planting density is subject to the law of diminishing returns (Robinson, 2011); so, coupled with higher establishment costs, it was hypothesised that the most profitable new planting would not necessarily be the densest.

At the time of writing, the trees in the experimental orchard were in their fifth year of a potential life-span of 30 years and had been fruiting for the last three years. Hence, the analysis is prospective and based on crucial assumptions concerning pack-outs, prices and yields.

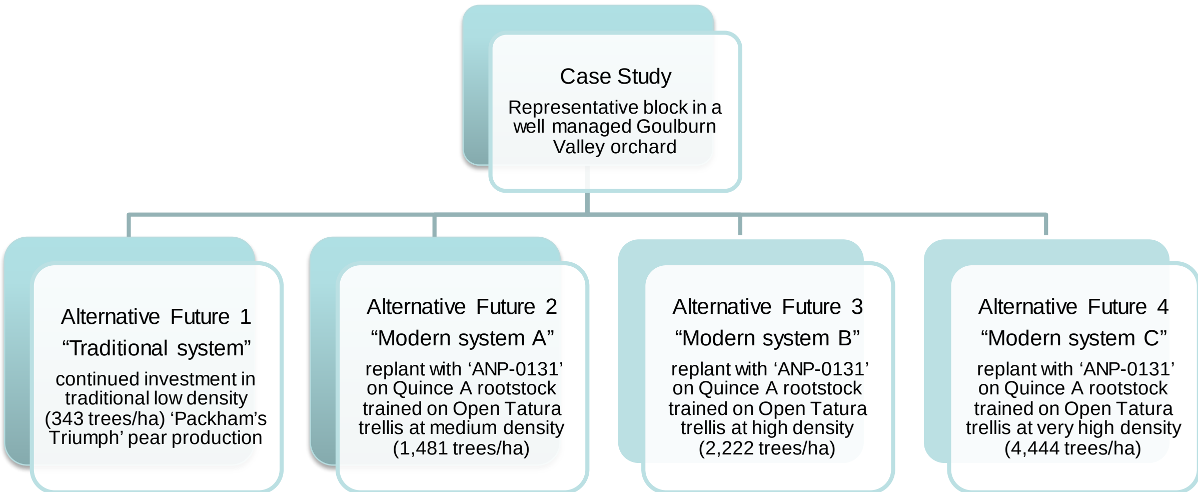
Method

The economic analysis used a participatory case study method comprising several key elements. First, a case study orchard considered typical of a well-managed orchard in the Goulburn Valley. Second, close involvement of AVR's Pear Field Laboratory Advisory Committee to test assumptions and help identify alternative futures for the representative block. Third, the development of a discounted net cash flow (NCF) model incorporating the Monte Carlo simulation technology of @Risk. The model was used to evaluate the economic and financial performance, and risks, associated with alternative futures for the representative block. @Risk is an add-in to Microsoft Excel that allows uncertain variables, such as yields and prices, to be described by probability distributions (Palisade Corporation, 2018).

Alternative futures for case study block

The costs, benefits and risks from retaining a traditional planting of Packham's on a representative orchard block in the Goulburn Valley (Figure 1, alternative future 1) were compared to those of re-planting with 'ANP-0131' in one of three modern orchard systems (Figure 1, alternative futures 2-4).

Figure 1. Alternative futures for the case study orchard block



The traditional planting was considered typical of a long-established (25-year old) block of 'Packham's Triumph' in a well-managed orchard. The case study orchard was Plunkett Orchards' home farm in Ardmona; and the representative block of 'Packham's Triumph' was planted at 343 trees/ha on the *P. calleryana* D6 rootstock (Table 1). Trees were large (4 metres), free-standing, and vase shaped. Irrigation water was purchased on the temporary market and applied at a regular 6-7 ML/ha every year using a micro-irrigation system. No netting was installed, as the lower crop returns did not warrant the investment, and the crop was at higher risk to hail and sun damage.

The modern planting systems have trees planted 1.5, 1.0 or 0.5m apart within rows 4.5m wide. These alternative futures correspond to planting densities of 1,481, 2,222 or 4,444 trees per hectare, respectively. The lower density plantings had 8 leaders per tree, whereas the medium and high-density plantings had 4 and 2 leaders per tree, respectively. Tree size was smaller (3 metres) than the 'Packham's Triumph' due to the higher planting density and the dwarfing QA rootstock.

Table 1. Alternatives for the representative pear block in the Goulburn Valley

Item	Unit	Traditional planting (alternative future 1)	Modern plantings (alternative futures 2-4)
Scion cultivar		Packham's Triumph	'ANP-0131'
Rootstock		*P. calleryana* D6	QA
Architecture		free standing, vase shape	OT trellis
Tree density	trees/ha	343	1,481, 2,222 or 4,444
- Distance between rows (row spacing)	m	5.4	4.5
- Distance between trees (intra-row spacing)	m	5.4	1.5, 1.0 or 0.5, respectively
- Leaders per tree	no.	n/a	8, 4 or 2, respectively

Performance measures

The measures used to evaluate economic performance of the alternatives were the net present value (NPV), the annuity of the NPV, and the modified internal rate of return (MIRR). Financial performance was assessed for the new plantings (alternative futures 2-4) using the payback period, i.e. the time required for the investment of additional capital to break even.

The NPV was calculated for the new plantings by summing the discounted stream of annual gross income at the orchard gate less variable costs (NCF) over a 30-year time horizon, that being the productive life of the trees. Benefits and costs were in 'real' terms, i.e. no inflation affecting costs, prices and opportunity cost discount rate. A profitable investment is defined as one that has a positive NPV for the nominated discount rate (see section on the discount rate and risk, below). The new planting with the highest NPV is the most profitable, as it adds most to grower wealth over the planning horizon.

The annuity of the NPV was calculated to allow the grower to compare the returns from the new plantings with those from the traditional system (alternative future 1). A new planting of 'ANP-0131' is more desirable if its annuity is greater than the NCF of the traditional system in a 'steady-state' year, i.e. at full bearing.

The MIRR is the internal rate of return for the investment modified to account for the difference between the investment return and the re-investment rate. It is the discount rate which equates the present value of future benefits to the present value of future costs. The MIRR for the new plantings was compared to the potential returns from investing the same capital in some other use to determine desirability.

Financial performance requires nominal values and was assessed using the payback period determined from the cumulative NCF with inflation. Inflation rates on prices of inputs and outputs were assumed to be identical and a constant 2.4 per cent (ABARES, 2016). Historically inflation rates for prices of farm inputs have been higher than for sale prices of outputs, and it might reasonably be expected that this trend will continue. The implicit assumption is that the 'cost price squeeze' is being dealt with by productivity gains other than those arising from the investment under investigation.

Income and Costs

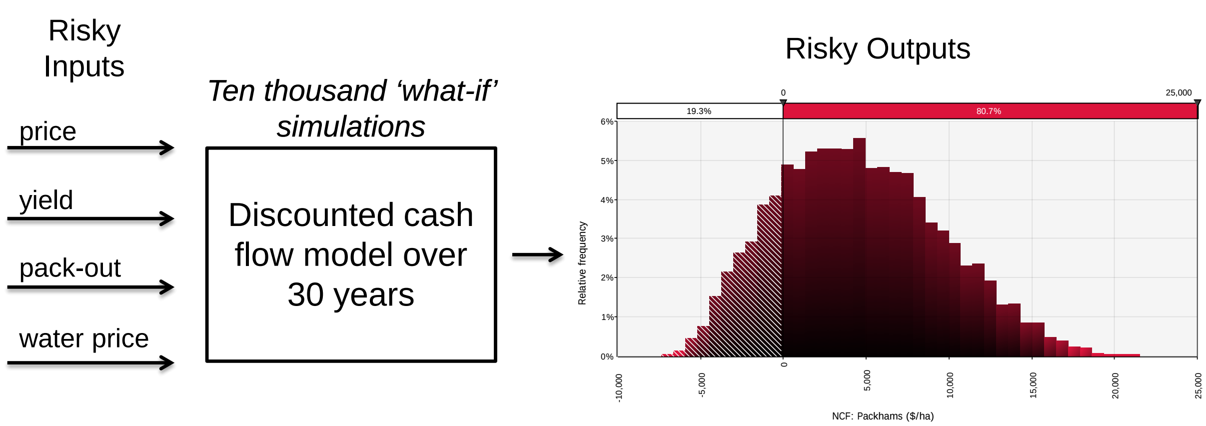
Gross income at the orchard gate was calculated by multiplying the quantity of fruit meeting class specifications (the 'pack-out') by the price for the class at point of sale (that being the pack-house) and subtracting costs for packing, packaging, cool storage, freight to market and grower levies. The three quality classes were 'Class 1' for fruit of premium size, shape and absence of defects (blemishes, bruises, spots etc.), 'Class 2' for less perfect fruit and 'Juicing' for small, misshapen and damaged fruit.

Costs included variable costs for hired labour, water and other agronomic expenses. Fixed costs were not considered, as the budget is a 'partial budget' drawn up to estimate the effect on profit of a proposed change affecting only part of the orchard. Establishment costs (materials, irrigation infrastructure and labour) were included in the development stage of the new investment. Tree pull costs were included at the end of the productive life of the trees. To approximate the annual average tax rate, $0.10 was paid for every extra dollar of the real annual NCF from production.

Discount rate and risk

The economic analysis used discounting at the cost of capital borrowings. The real discount rate was 4.5 per cent[2] (or 7 per cent in nominal terms) - the average rate paid on business debt in the farming sector over the last 10 years (ABARES, 2016). A higher real discount rate, such as a real 9 per cent reflecting returns and risk premiums for investing in Australian equities, was not used. Instead, the risks were captured in probability distributions for risky variables embedded in the NCF model using @Risk (Figure 2), bolstered by sensitivity analysis and scenario testing (Malcolm, 2006).

Figure 2. Discounted net cash flow method using Excel and the @Risk Monte Carlo simulator



Risky variables were yields, pear prices by class, packout by class and prices paid for irrigation water. Each risky variable was given an @Risk distribution profile which required prior experience or in the main: the best-case estimate, the most likely estimate and the worst-case estimate (Appendix A, Table A.1). The @Risk model then calculated distributions for the economic performance metrics from 10,000 Monte Carlo simulations, with each simulation using a different set of input variables drawn at random from their respective probability distributions. Tornado plots, which are the graphical output

[2] The real discount rate was calculated from the nominal rate (i) using an inflation rate (j) of 2.4 per cent as follows: (1+i)/(1+j) – 1.

of a sensitivity analysis generated by @Risk, were used to illustrate which risky inputs have the greatest impact on the economic performance measures.

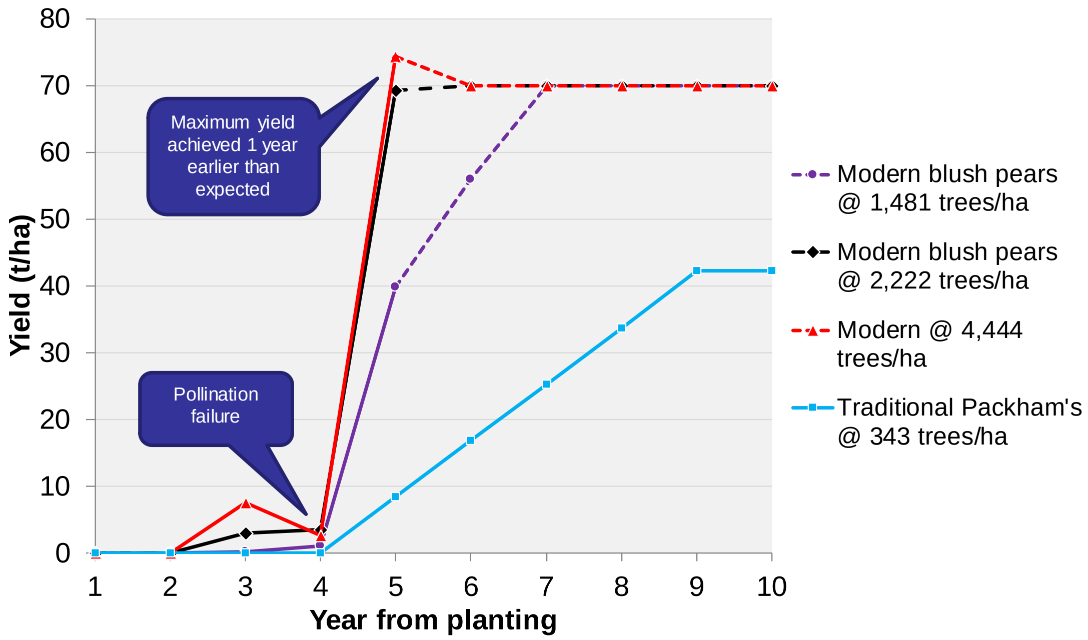
Data used in the analysis

Primary data used in the analysis were obtained from the case study orchardist, records kept by AVR on activities in the experimental pear orchard at Tatura, experimental observation and from expert opinion. Secondary industry data compiled by AgFirst (2008, 2010-2016) were also used extensively to fill information gaps and define probability density functions for the risky variables and correlations.

Yield curves

A piecewise linear production function was used to relate hypothetical marketable yield to tree age for each planting system. The hypothetical yield curves are defined by the parameters: years to begin fruiting, years to full bearing and marketable yield at full bearing. Year-to-first-crop and year-to-full-bearing were earlier for the higher-density modern systems than for the traditional 'Packham's Triumph' system, and the yield-at-full-bearing was higher for the modern systems (Figure 3).

Figure 3. Expected yields over 10 years for red-blushed pear 'ANP-0131' grafted to Quince A rootstock trained as a multi-leader system on Open Tatura ('modern' systems) at three planting densities (1,481, 2,222 or 4,444 trees/ha) v. traditional low-density planting of 'Packham's Triumph'. Actual experimental yields shown for the modern high-density systems for years 1-5 (solid lines). Expectations to year 10 indicated by dashed lines



AVR scientists expected yields for the modern systems to increase rapidly to reach a maximum in year six or seven. Due to the varying number of leaders per tree, yield at full bearing was expected to even out at 70 t/ha (in the range 43 - 97 t/ha). This is much higher than for traditional plantings of 'Packham's Triumph' that yield 42 t/ha (in the range 31 - 52 t/ha).

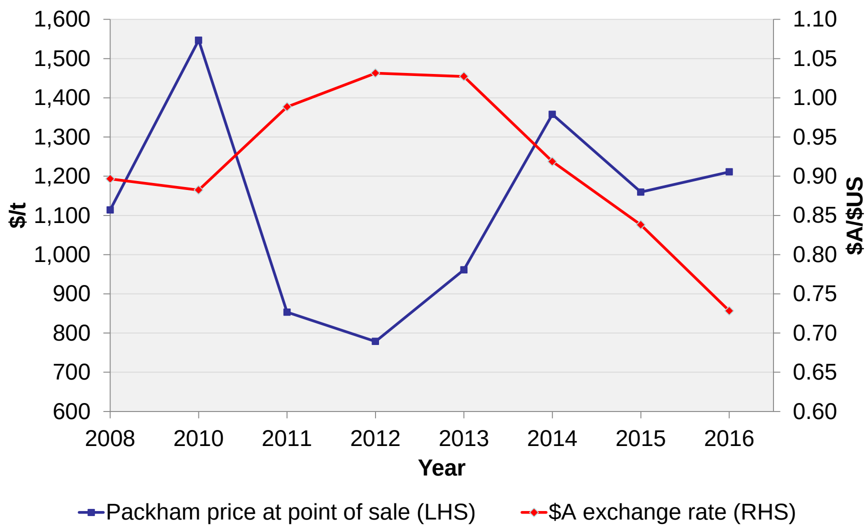
Actual experimental yields were used for the modern systems rather than hypothetical yields as they became available (solid lines in Figure 3). These showed that the red-blushed pears began fruiting in year three as expected; actual yields in year four were very much below expectations due to pollination failure brought on by a wet spring and inactive bees; and excellent yields were achieved in year five suggesting that plantings of 2,222 and 4,444 trees/ha had reached full production one year earlier than expected.

Fruit quality, prices and premiums

Specialty and club varieties achieve a significant premium over commodity lines, and orchard-gate prices for the blushed pears were assumed to be higher, and fruit quality on average better and more uniform compared to the 'Packham's Triumph'.

Industry data highlight the considerable year-to-year variation in prices and in price differentials between classes. With the exchange rate unlikely to revisit the historical highs of 2012 (Figure 4), prices received for 'Packham's Triumph' at the pack-house were expected to average a more encouraging $1,170/t in real terms over the planning period. This average masks substantial price differentials between classes: $1,590/t for Class 1 fruit, $610/t for Class 2 fruit and $110/t for Juicing quality fruit. Subtracting post-harvest costs totalling about $570/t (Appendix D, Table D.2), prices received at the orchard gate were expected to average about $600/t.

Figure 4. Packham pear prices at point of sale (2016 dollars) v $A exchange rate. Prices are averages expressed in 2016 dollars weighted by packout. 'Year' refers to financial years (2008=2007/08)



Sources: AgFirst (various issues), ABARES (2016)

Consumer preference evaluation between 'ANP-0131' and 'Packham's Triumph' confirmed consumers' willingness to pay a premium for 'ANP-0131' and for most to purchase it in addition to other pear and apple cultivars (Turpin *et al.,* 2016). Considering these findings and observed retail price premiums for the parent cultivar (Corella), a conservative 10 per cent price premium was assumed for the blushed pears.

With protection from the elements and good-sized fruit (above 180g), the packout of Class 1 plus Class 2 fruit for the blushed pears was also assumed to be better, totalling 90 per cent compared to less than 80 per cent for Packham's.

On balance, orchard gate prices for the blushed pears were expected to average about $810/t compared to $600/t for the Packham's.

Establishment and tree training costs

Ground preparation, infrastructure and planting costs for the modern system were estimated from records held by AVR on actual costs incurred to establish the experimental pear orchard at Tatura. Tree prices were as reported by a local nursery (Taylor, 2014).

Establishment costs were highest for the higher density plantings, due to the additional cost of a greater number of trees and higher planting costs (Appendix C, Table C.1). Netting for sun and hail protection was included bringing total establishment costs for the planting of 2,222 trees/ha close to $90,000/ha. Tree pull at the end of an orchard's productive life was estimated at around $3,000/ha (Durham, 2013).

The labour associated with tree training, tree support, leader management, winter pruning, tying down, thinning and summer pruning were high in the early years (Appendix C, Table C.2). Valued at about $23/hour based on the Horticulture Award, these costs come to about $4,000/ha.

Variable costs at full bearing

Total variable costs at full bearing for growing 'Packham's Triumph' amounted to about $20,052/ha on average (Appendix D, Table D.1). Wages comprised 58 per cent of this total, with machinery costs a further 24 per cent. Water costs were a modest two per cent of the total, on average, but could approach 20 per cent when scarce.

For the high-density systems, harvesting costs at full bearing were higher because of the higher marketable yield (136 v 95 bins/ha). Conversely, pruning costs were assumed lower (120 v 170 hours/ha), using information reported by van den Ende *et al.* (2003) as a guide.

Rather than having capital tied up in water entitlements, the case-study grower relies on being able to buy water from the allocation (temporary) water market as needed. Water costs were expected to average about $70/ML over the review period, but approach $500/ML in times of water scarcity. These prices were inflated considerably (by about 120 per cent[3]) from the historical average to allow for a 30 per cent (2,750GL) water 'shock' under the Murray-Darling Basin Plan.

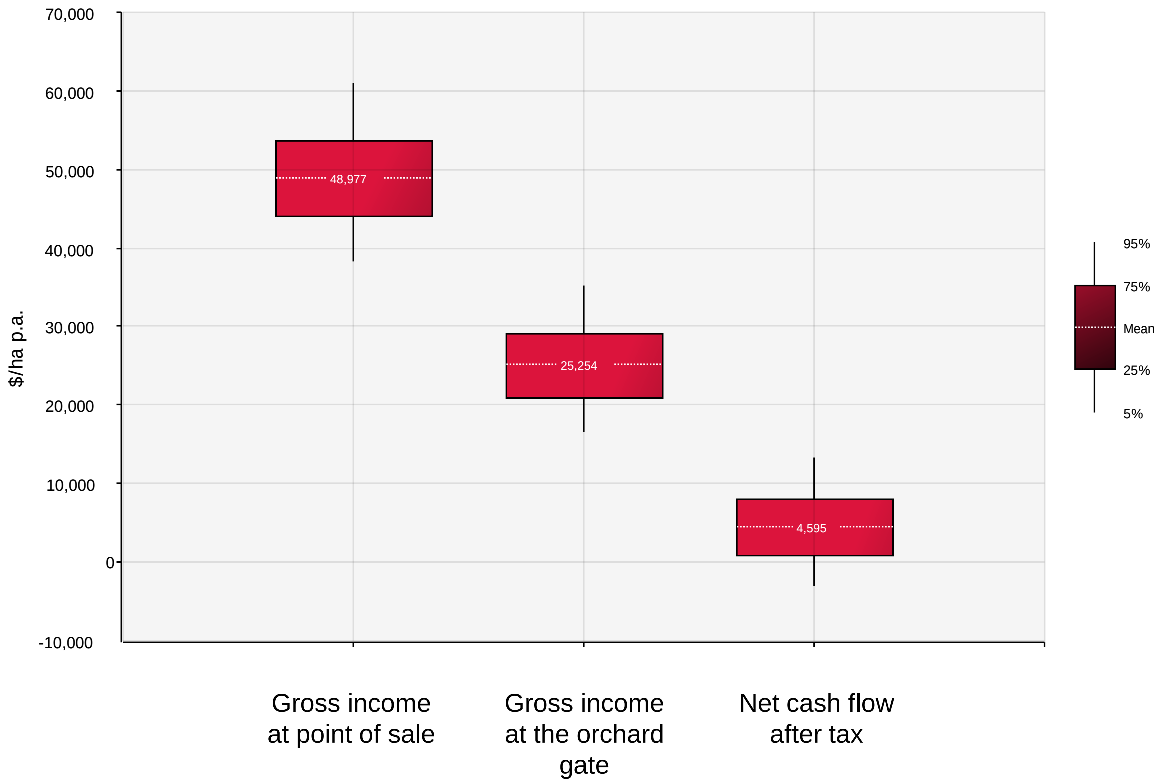
[3] This increase assumes a price elasticity for water allocation demand of about -0.25 and a price flexibility of -4 (derived from the relationship reported by Stott (2014, p.8) for water allocations during the millennium drought in south-east Australia from 2001-2009 and its immediate aftermath). Hence the water price would be expected to increase by a more than proportionate 120% (=4*30%), on average as a consequence of the 30% water 'shock'. The price elasticity assumed in this analysis is considerably more inelastic than the short run elasticity of -0.52 and long run elasticity of -0.81 reported by Wheeler *et al.* (2008) for water allocations over the period 1997 to 2007.

Results and Discussion

Economic performance of the traditional low-density planting of 'Packham's Triumph'

NCF after tax at full bearing for the representative block of 'Packham's Triumph' averaged about $4,595/ha (Figure 5), and there was a 20 per cent chance that it would to lose money in any one year. The poor economic performance of the traditional low-density block of 'Packham's Triumph' highlights the importance of boosting the profitability and reducing the risks of pear production in the Goulburn Valley through initiatives such as the commercialisation of the new red-blushed pear varieties and the adoption of modern high-density orchard management systems.

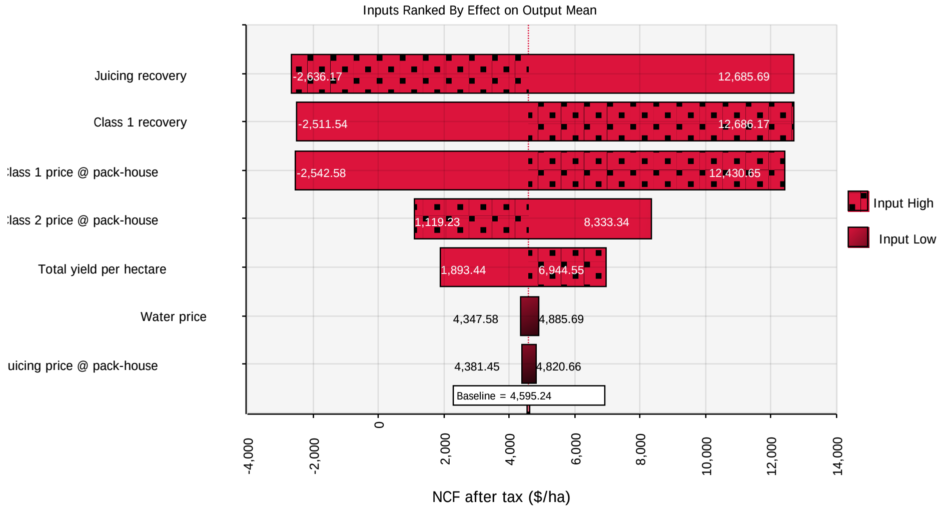
Figure 5. Mean and key percentiles for gross income and net cash flow at full bearing for representative block of Packham pears planted at 343 trees/ha



The profitability of the traditional pear planting was most affected by the pack-out and market pricing, with year-to-year variation in packout percentages and the price received for Class 1 fruit having the largest effect (Figure 6). The low influence of the water price belies its importance in irrigators' thinking, with the pain associated with uncertainty and regulation being a major stressor for irrigators in the southern Murray Darling Basin (Adamson *et al.,* 2016).

The increase in NCF at full bearing as a result of reducing the amount of fruit in Juicing from the maximum of 25 per cent to the minimum of 10 per cent (and thereby increasing Class 1 and Class 2 packout percentages) would be about $15,300/ha. This result suggests that the key management goal for a grower to achieve a positive NCF is to ensure that the amount of fruit going into juicing is minimised. This may entail detailed pruning to optimise fruit size and prevent limb-rub and other damages, but according to the case-study farmer, low crop prices and high labour costs are such as to make this a low priority activity on traditional vase-shaped tree configurations.

Figure 6. Tornado plot for annual net cash flow (NCF) at full bearing for a representative orchard block of Packham pears planted at 343 trees/ha



Economic performance of the new high density planting of red-blushed pears

For all three planting densities examined, both the NPV and the MIRR indicated that growers could invest in the new blushed pears with a high degree of confidence (Table 2). Subject to the law of diminishing returns, the most profitable planting density was 2,222 trees/ha, for which the NPV averaged $258,471/ha over the 30-year time horizon, with a 95 per cent confidence interval of $210,641/ha to $307,256/ha. All of the high-density scenarios examined achieved an MIRR exceeding the real nine per cent return on Australian equities.

The profitability of the planting at 2,222 trees/ha was most affected by the variability in Class 1 recovery, Class 1 price, and total marketable yield (Figure 7). In particular, a maximum Class 1 packout of 74 per cent could see annual NCF at full bearing reach $47,876/ha; conversely a minimum Class 1 packout of 57 per cent could see NCF fall to $15,740/ha.

Figure 7. Tornado plot for annual net cash flow (NCF) at full bearing for 'ANP-0131' planted at 2,222 trees/ha grafted to QA rootstock and trained on OT

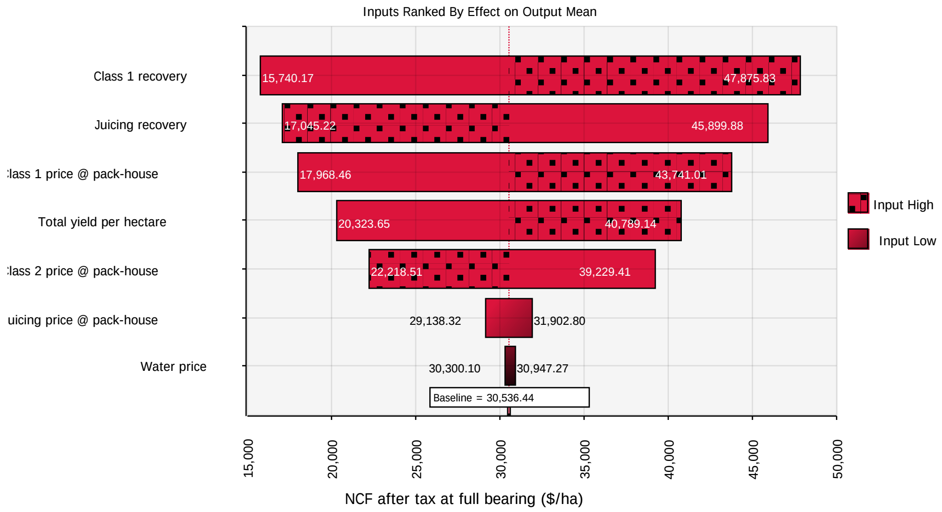


Table 2. Economic performance measures for 'ANP-0131' planted at densities of 1,481, 2,222 and 4,444 trees/ha grafted to QA rootstock and trained on OT. The 5th percentile (P5), the mean and the 95th percentile (P95) are described

Scenario	Tree density (trees/ha)	Year full bearing achieved	Yield at full bearing (t/ha)	Estimate (mean)	P5	P95
(1) Medium density planting	1,481	7	70			
- NCF at full bearing ($/ha)				30,522	16,297	47,168
- NPV ($/ha)				244,361	203,168	286,346
- Annuity ($/ha p.a.)				14,971	12,447	17,543
- MIRR (%)				10.8	10.3	11.3
(2) High density planting	2,222	6	70			
- NCF at full bearing ($/ha)				30,536	14,663	49,697
- NPV ($/ha)				258,471	210,641	307,256
- Annuity ($/ha p.a.)				15,835	12,905	18,824
- MIRR (%)				10.9	10.3	11.4
(3) Very high density planting	4,444	6	70			
- NCF at full bearing ($/ha)				29,999	13,956	49,167
- NPV ($/ha)				220,813	172,962	270,188
- Annuity ($/ha p.a.)				13,528	10,596	16,553
- MIRR (%)				10.0	9.5	10.6

Scenario testing on the blush pear planting at 2,222 trees/ha suggested that even for a pessimistic scenario involving no price premium over 'Packham's Triumph' and a lower yield of 60t/ha at full maturity, the blush pears are a profitable investment at the nominated discount rate (Table 3).

Comparison between alternative futures for the representative orchard block

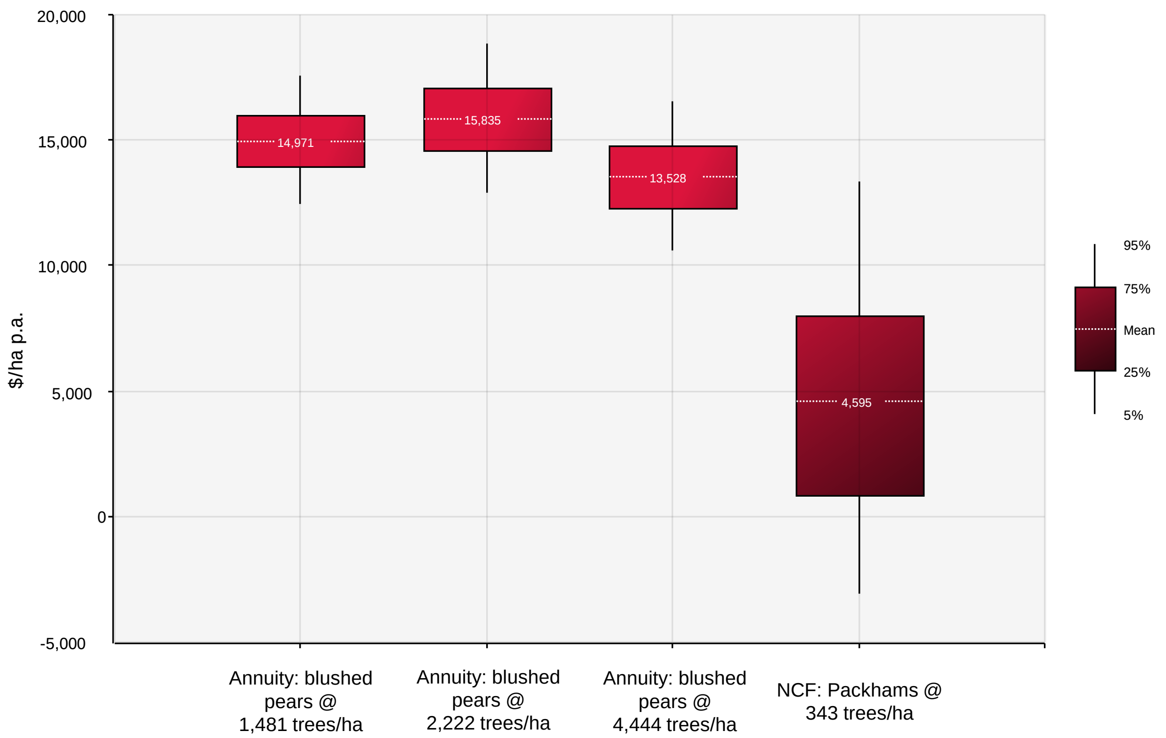
The relative advantage of replacing a traditional low-density planting of 'Packham's Triumph' with a high-density planting of the new red-blushed pears is clear (Figure 8). The annual return for the traditional system was a modest $4,595/ha p.a. on average, and there was a 20 per cent chance that it would lose money in any one year. By contrast, the annualised return for each of the new systems, determined from 10,000 simulations, was strongly positive; in the order of $15,835 p.a. for a tree density of 2,222.

Table 3. Sensitivity of economic performance measures for 'ANP-0131' planted at 2222 trees/ha grafted to QA rootstock and trained on OT to changes in assumptions regarding the price premium for red-blushed pear and yield at full bearing (estimates are means)

Scenario	Price premium (%)[(a)]	Yield at full bearing (t/ha)	NCF at full bearing ($/ha)	NPV ($/ha)	Annuity ($/ha p.a.)	MIRR (%)
(2) 2,222 trees/ha ('base')	10 ($810/t)	70	30,536	258,471	15,835	10.9
(4) Higher price premium	20 ($934/t)	70	38,428	359,639	22,033	11.8
(5) No price premium	0 ($683/t)	70	22,639	157,253	9,634	9.8
(6) Higher yield at full bearing	10	80	36,766	332,982	20,400	11.5
(7) Lower yield at full bearing	10	60	242,89	183,933	11,289	10.1
(8) Optimistic (higher price premium and higher yield at full maturity)	20	80	45,796	447,660	27,426	12.4
(9) Pessimistic (no price premium and lower yield at full maturity)	0	60	17,487	96,143	5,890	8.9

Notes: (a) Price premium for red-blushed pear compared to 'Packham's Triumph'. Absolute values in brackets.

Figure 8. Box plots for the NCF of the traditional 'Packham's Triumph' system, and the annuity of the NPV for the modern red-blushed pear system at 4.5 per cent real for 30 years

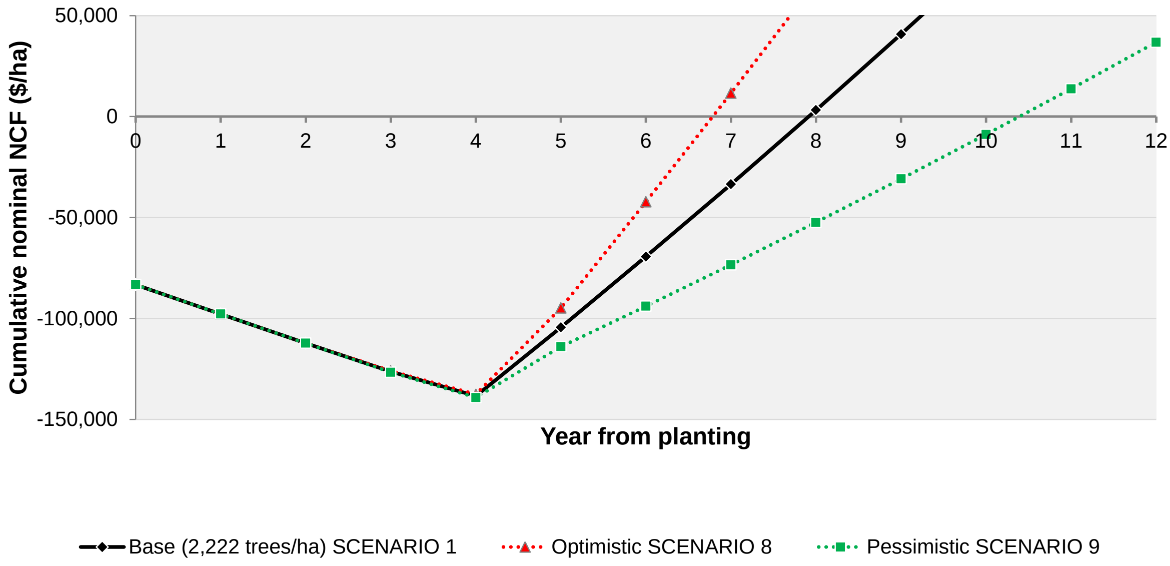


The worst-case conditions that would alter the conclusion that the red-blushed pear is more profitable than the traditional variety (i.e. to return a mean NPV of less than $4,595) include the following: a price discount relative to 'Packham's Triumph' of 0.92 per cent; or an average yield at full bearing 45.6 t/ha, or a discount rate of 11 per cent real.

Financial feasibility of investing in the new planting

Taking inflation into account, debt peaked for the 2,222 trees/ha 'base' scenario at $138,356 in year four, and the investment broke even by year eight (Figure 9). The payback period ranged from 7 to 11 years from best to worst case scenarios. By contrast, should it be planted today, our low-density planting of 'Packham's Triumph' would break even in year 18. These results are consistent with Elkins *et al.* (2008), who showed that high density plantings of 1,594 trees/ha came into production sooner and recovered establishment costs in year 10 compared to standard spaced plantings of 797 trees/ha, when the pay-back period blew out to 21 years.

Figure 9. Pay-back period for establishing a block of 'ANP-0131' grafted to QA rootstock trained as a multi-leader system on OT at a density of 2,222 trees/ha: base (10 per cent price premium, 70t/ha at full maturity), optimistic (20 per cent price premium, 80t/ha at full maturity) and pessimistic scenarios (no price premium, 60t/ha at full maturity)



Conclusions

A discounted NCF model incorporating Monte Carlo simulation technology was constructed to quantify the net benefits and risks of replacing a traditional planting of 'Packham's Triumph' with 'ANP-0131' on dwarfing QA rootstock trained on OT trellis at 1,481, 2,222 or 4,444 trees/ha.

Advantages of the new plantings included more fresh fruit marketed at premium prices, earlier production, and efficiencies in production and harvest operations at full bearing. Subject to the law of diminishing returns, the most profitable planting density was 2,222 trees/ha. For this system:

- The NPV (i.e. addition to grower's wealth over 30 years), evaluated using a real (inflation adjusted) discount rate of 4.5 per cent, averaged $258,471/ha.
- The MIRR was 10.9 per cent, beating the real nine per cent return on Australian equities.

- Debt peaked at $138,356 in year four, and the investment broke-even by year eight. The payback period ranged from 7 to 11 years from best to worst case scenarios.

The relative advantage of the high-density planting of the new red-blushed pears over the traditional low-density planting of 'Packham's Triumph' is clear. Where the mean annuity of the NPV over 30 years for the new planting at 2,222 trees/ha was estimated at $15,835/ha p.a., the NCF for the low-density (343 trees/ha) planting of 'Packham's Triumph' was a modest $4,595/ha p.a., and there was a 20 per cent chance that it would lose money in any one year.

At the time of writing, the trees in the experimental orchard at Tatura were in their fifth year of a potential life-span of 30 years and had been fruiting for just three years. Hence, the analysis is prospective based on crucial assumptions concerning pack-outs, prices and yields.

References

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) (2016), *Agricultural Commodity Statistics 2016*, Australian Bureau of Agricultural and Resource Economics and Sciences, December, Canberra. Available at: http://www.agriculture.gov.au/abares [Verified 27 March 2018].

Australian Bureau of Statistics (ABS) (2017a), *Agricultural Commodities, Australia*, 2014-15, Cat. no. 7121.0, Australian Bureau of Statistics, Canberra. Available at: http://www.abs.gov.au [Verified 27 March 2018].

ABS (2017b), *Value of Agricultural Commodities Produced, Australia*, 2014-15, Cat. no. 7503.0, Australian Bureau of Statistics, Canberra. Available at: http://www.abs.gov.au [Verified 27 March 2018].

Adamson, D., Lock, A., Wheeler, S., and Conner, J. (2017), 'Submission to the Standing Committee on Agriculture and Water Resources inquiry into water-use efficiency in Australian agriculture', Centre for Global Food and Resources, University of Adelaide. Available at: https://blogs.adelaide.edu.au/global-food [Verified 27 March 2018].

AgFirst (2008, 2010-2016), 'Australian Pomefruit Industry Orchard Business Analysis', reports prepared for Apple and Pear Australia Ltd.

Apple and Pear Australia Limited (APAL) (2015), 'Levies'. Available at: http://apal.org.au [Verified 27 March 2018].

APAL (2014), 'Intensive pear production'. Available at: http://apal.org.au [Verified 27 March 2018].

Durham, J. (2013), 'Submission to the Productivity Commission Inquiry into imported processed fruit', Apple and Pear Australia. Available at: http://www.pc.gov.au [Verified 27 March 2018].

Elkins, R.B., Klonsky, K., DeMoura, R. and DeJong, T.M. (2008), "Economic evaluation of high density versus standard orchard configurations; case study using performance data for 'Golden Russet Bosc' pears", *Acta Hortic.* 800, 739-746.

Hankin, M. (2015), 'AP10016: pear rootstock trial', final report to Apple and Pear Australia Limited. Available at: http://apal.org.au [Verified 27 March 2018].

Horticulture Industry Network (HIN) (2016), 'Planting system experiment'. Available at: http://hin.com.au [Verified 27 March 2018].

Palisade (2018), 'Risk analysis using Monte Carlo Simulation'. Available at: http://www.palisade.com [Verified 21 March 2018].

Roberts, S.C., Steyn, W.J. and North, M.S. (2008), "Effect of rootstock on red colour of bi-coloured 'Forelle' pears", *Acta Hortic*. 800, 625-630.

Malcolm, B. (2006), "Investigating net benefits from alternative uses of resources", in Pannell, D.J. and Schilizzi, S. (eds.), *Economics and the Future: Time and Discounting in Private and Public Decision Making*, Edward Elgar, Cheltenham, UK and Northampton, MA, USA.

Robinson, T.L. (2011), "High density pear production with *Pyrus communis* rootstocks", *Acta Hortic.* 909, 259-269.

Stott, K. (2014), 'The economic impact of groundwater SDLs on irrigated agriculture in the northern Victorian MDB', Agriculture Research technical report, Victorian Department of Environment and Primary Industries, Carlton.

Taylor, A. (2014), 'Valley Trees Nursery: Winter 2014 tree list'. Available at: http://www.valleytreesnursery.com.au [Verified 27 March 2018].

Turpin, S.R., Stefanelli, D., Jones, L., Norton, J., Probst, R., Konings, J. and Langford, G. (2016), "Perfect pears for the next generation of consumers", *Acta Hortic.* 1120, 507-514.

van den Ende, B., Nardi, D. and Pottenger, J.H. (2003), 'AP96053: Productivity and profitability of growing Packham pears', report to Horticulture Australia Ltd. Available at: http://apal.org.au [Verified 17 May 2017].

Wheeler, S., Bjornlund, H., Shanahan, M. and Zuo, A. (2008), "Price elasticity of water allocations demand in the Goulburn–Murray Irrigation District", *Australian Journal of Agricultural and Resource Economics* 52, 37–55.

Appendix A. Probability Density Distributions for Risky Inputs

Table A.1. Summary of the probability distributions used for yield, packout, fruit and water prices ($A 2016 values) for a representative pear block of 'Packham's Triumph' and hypothetical replanting with modern high-density plantings of red-blushed pears. Distribution types: (PER) = Pert, (EXP) = Exponential, (PAR) = Pareto. The 5th percentile (P5), the median (P50) and the 95th percentile (P95) are described for each Exp and Par distribution, and the minimum (Min), the median, and maximum (Max) values for each Pert distribution

Variable	Unit	Dist. type	P5/ Min	P50	P95/ Max	Source
Yield						
Traditional system						
- Maximum attainable yield per hectare at full bearing	t/ha	PER	31	42	52	Case study orchard and AgFirst (various issues)
Modern system						
- Maximum attainable yield per hectare at full bearing	t/ha	PER	43	70	98	Authors' estimates
Packout						
Traditional system						
- Class 1 recovery	%	PER	54	65	70	Case study orchard and AgFirst (various issues)
- Class 2 recovery	%					Balance of class 1 and juicing.
- Juicing recovery	%	PER	10	19	25	Case study orchard and AgFirst (various issues)
Modern system						
- Class 1 recovery	%	PER	57	70	74	Authors' estimates
- Class 2 recovery	%					Balance of class 1 and juicing (total=100%)
- Juicing recovery	%	PER	5	10	13	Authors' estimates
Price @ point of sale						
Traditional system						
- Class 1 price	$/t	PER	1288	1615	2082	AgFirst (various issues).
- Class 2 price	$/t	PER	415	600	726	AgFirst (various issues)
- Juicing price	$/t	PER	79	110	141	AgFirst (various issues)
Temporary water (allocation) price	$/ML	PAR	53	62	102	Stott 2014

Appendix B. Probability Density Distributions for Observed Yields in the Experimental Orchard

Table B.1. Summary of the probability distributions used for actual yield for 'ANP-0131' grafted to Quince A rootstock and trained on Open Tatura trellis at densities of 1,481, 2,222 or 4,444 trees/ha. Distribution types: (U) = Uniform, (EXT) = ExtValueMin, (EXP) = Exponential. The 5th percentile (P5), the median (P50) and the 95th percentile (P95) are described for each EXT and EXP distribution, and the minimum (Min), the median, and maximum (Max) values for each U distribution

Variable	Unit	Dist. Type[(a)]	P5/ Min	P50	p95/ Max	Source
First crop (year 3)						Turpin, pers. comm.
- 1,481 trees/ha	t/ha	EXP	0.01	0.10	0.45	
- 2,222 trees/ha	t/ha	EXP	0.16	2.12	9.15	
- 4,444 trees/ha	t/ha	EXP	0.38	5.19	22.41	
Second crop (year 4)						McClymont, pers. comm.
- 1,481 trees/ha	t/ha	EXP	0	0.6	2.8	
- 2,222 trees/ha	t/ha	EXP	0	2.2	10.4	
- 4,444 trees/ha	t/ha	EXP	0	1.7	8.0	
Third crop (year 5)						McClymont, pers. comm.
- 1,481 trees/ha	t/ha	U	11.7	38.3	64.9	
- 2,222 trees/ha	t/ha	EXT	32.7	72.7	95.2	
- 4,444 trees/ha	t/ha	U	39.8	72.7	102.3	

(a) Fitted to actual yields for individual trees using the @Risk distribution fitting feature.

Appendix C. Establishment and Tree Training Costs

Table C.1. Orchard establishment costs for OT planting systems ($/ha)

Tree density	Ground preparation (a)	Trellis/ supports (a)	Netting (a)	Additional drip irrigation and fertigation infrastructure (a)	Trees @ $14 each (b)	Planting (labour and materials) @ $2.15 per tree (a)	Total establishment costs
1,481	4,100	8,400	38,000	3,100	20,734	3,185	77,546
2,222	4,100	8,400	38,000	3,100	31,108	4,777	89,509
4,444	4,100	8,400	38,000	3,100	62,216	9,555	125,398

Sources: (a) AVR records (b) Taylor (2014)

Table C.2. Average time/ha (hours) for all tree training tasks, OT planting system by tree density

Tree density	Leaders per tree	Tree training times/ha (hours)		
		Year 2	Year 3	Cumulative
1,481	8	211	157	368
2,222	4	163	212	375
4,444	2	106	250	355

Source: AVR records

Appendix D. Variable Costs at Full Bearing

Table D.1: On-farm variable costs for Packham pears at full bearing

Item	Unit	Quantity	Total $/ha	Sources
Labour				
- Hand harvesting	bins/ha[(a)]	95 bins @ $52/bin	4,891	Case study orchardist (Shields pers. comm.)
- Pruning	hours/ha	170 hours @ $23/hr	3,903	Case study orchardist (Shields pers. comm.)
- Other wages	ha	1	2,838	Case study orchardist (Shields pers. comm.)
TOTAL WAGES	ha	1	11,632	
Water	Ml/ha	7.0 @ $68/Ml	476	Author's estimate
- Weed, pest & disease control	ha	1	2,513	Case study orchardist (Shields pers. comm.)
- Fertiliser & lime	ha	1	656	Case study orchardist (Shields pers. comm.)
- Machinery	ha	1	4689	AgFirst (2016)
- Pollination	ha	1	87	AgFirst (2016)
TOTAL OTHER	ha	1	7,945	
GRAND TOTAL	ha	1	20,052	

Note: (a) Full bin = 440kg.

Table D.2. Post-harvest costs ($/kg)

Post-harvest costs	Value
Packaging and packing[(a)]	0.36
Cool storage & freight (cool store to market)[(a)]	0.19
Levies[(b)]	
-Domestic pears	0.021
-Processing pears	0.0059
-Juicing pears	0.00295
Total	0.57

Sources: (a) AgFirst (2016); (b) APAL (2015)