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A Moveable Harvest: An investigation into using mobile platforms for picking apples[[1]](#footnote-2)

Alexandria Sinnetta\*, Bill Malcolma, Robert Farquharsona and Thiagarajah Ramilana,b

a The University of Melbourne

b Massey University

\* Corresponding author, a.sinnett@unimelb.edu.au

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**Abstract**

Farm businesses producing fruit for the fresh fruit market require significant amounts of labour, especially for harvesting. In other agricultural industries, like cropping, the reliance on labour has reduced because machines have replaced labour. At the moment, machines do not replace labour for horticultural businesses supplying the fresh fruit market, consequently the labour cost is significant. However, machines, like a mobile platform, may improve the efficiency of labour or reduce the need for particular skills. Mobile platforms are not new and have been a consideration for fruit growers since the 1970s, but rising costs of labour has increased interest in investing in them. Research in the United States, Europe and South Africa into the benefits of mobile platforms has found, in some cases, that using a platform can improve productivity and occupational health and safety, but the findings are inconclusive. The aim of this investigation was to identify the labour needs for Australian growers supplying apples to the fresh fruit market and to investigate and form a view about the role a mobile platform has against other tools that can be used by growers to assist labour. This study has found that the ‘best’ combination of equipment, machinery and labour to use to assist in the main production tasks of horticultural businesses depends on the many and varied characteristics of the business, the segment of the market the farmer sells into, the operator and the skills and cost of labour.

*Key words*: horticulture, labour, mechanisation, cost, management

#### Introduction

Australia’s apple industry has an annual gross value of production around $550 million (APAL, 2017).

Labour is a major input and one of the main costs of horticultural businesses supplying the fresh fruit market. The cost of labour is approximately 30 per cent of total cash costs for horticultural businesses (Valle et al., 2017). The availability and quality of labour are the greatest workforce challenges facing horticultural businesses over the next five years (Valle et al., 2017). Harvesting apples and pears requires labour to hand-pick the fruit because of susceptibility to bruising. Picking is done in the relatively short times when quality is optimum. Labour is also required for pruning and thinning trees.

Equipment and machinery, such as ladders, power-ladders or mobile platforms (Figure 1), are needed because of the height of trees in apple orchards. Orchardists decide which form of machinery and equipment to use with their labour supply based on the one that best suits their system. Most growers use a mix of power-ladders and ladders and a few growers use mobile platforms (pers.comm. O’Conell, 2017).

**Figure 1. Different means to harvest, thin and prune fruit: ladder, power ladder and platform**



*Source*: case study farmers

Rising costs of production has prompted growers to consider investing in a mobile platform for picking apples, but the case is not clear-cut. Research into the net benefits of mobile platforms is inconclusive.

Research, mostly in the United States, Europe and South Africa, has considered the decision of investing in mobile harvesting platforms over ladders and found that the choice of harvesting aid depends on orchard design and cost (as discussed below). The choice of harvesting aid affected productivity, occupational health and safety, and the workers. Gallardo and Brady (2015) surveyed 316 apple farmers (of which 11 per cent used platforms) and identified why some operators used platforms and why others did not (Table 1). They found adoption of mobile platforms was limited because of orchard design and cost. They also found that there is an expectation that worker productivity will increase when using a mobile platform. This was not always the case (Gallardo and Brady, 2015).

**Table 1 Reasons why farmers choose to adopt or not to adopt mobile platforms**

|  |  |
| --- | --- |
| Reasons why farmers adopted mobile platforms | Reasons why farmers did not adopt mobile platforms |
| * increased worker productivity
* improved worker safety
* improved the quality of work
* easy for workers to operate
 | * orchard architectures were not suitable
* cost of purchasing platforms was too large
* steep slopes in orchards unsuited to platforms
* repair and maintenance costs expected to be high
* platform not expected to improve worker productivity
 |

*Source*: adapted from Gallardo and Brady (2015)

Baugher et al. (2009) and Wells (2017) found that using a platform can increase labour efficiency for the tasks of thinning, pruning and tree training compared with a ladder. Schupp et al. (2011) found that labour efficiency at harvest increased with a platform, reporting that time to harvest the apples improved by 10 per cent, and potentially as high as 49 per cent depending on the apple variety picked. Hornblower (2015) found that picking efficiency increased by 15 to 30 per cent when harvesting was mechanised, because of fewer movements to the bin and up and down a ladder. Zhang and Heinemann (2017) found that harvest labour efficiency increased by 29 per cent when using a platform instead of ladders. Schupp and Baugher (2017), in their trials of a platform versus a ladder to harvest fruit, found that four harvest workers on a platform could simultaneously pick a bin of apples quicker than workers picking apples using a ladder (depending on variety, this represented a 15 per cent to 33 per cent time saving).

Contrary to these findings, Van der Merwe (2015) found that the gains in labour efficiency might not be as great with a mobile platform due to the height of the trees and the tree structure. Van der Merwe (2015) and Elkins et al. (2011) found that orchard design and the restrictive nature of the platform meant that using a platform during harvest reduced potential picking rates. Wells et al. (2017) found that, of five trials, three resulted in efficiency gains of 13-17 per cent and two resulted in no gains in labour efficiency. They explained that, in the trials where gains in labour efficiency were observed, the workers had experience with using the machines and working as a team, and in the trials where there were no efficiency gains, the workers had little experience working on platforms.

A decline in occupational health and safety problems is a benefit of a mobile platform for harvesting and tree operations. Isaacs and Bean (1995) found that the physically demanding nature of harvesting apples using ladders makes apple pickers prone to occupational injuries. Gallardo and Brady (2015) found orchardists had invested in platforms because they believed it improved worker safety. Schupp and Baugher (2017) found that, compared with using ladders, using a platform removed the awkward activities associated with using ladders. Platforms reduced the time spent in awkward postures from 65 per cent to 43 per cent. Earle-Richardsonet al. (2006) found using harvest-assist technology instead of a ladder significantly reduced occupational injuries for apple pickers. Lewis (2015) found platforms mitigated the risk associated with ladder injuries and medical claims. Wells (2017) found platforms lowered injury rates because fewer workers spent less time up ladders and fell off them less often.

A cost of using a mobile platform or power ladder can be a loss of fruit quality. Schupp and Baugher (2017) found bruising of fruit increased 2.5 per cent and 7.9 per cent with pickers on a platform instead of being up a ladder, depending on variety of apple. West et al. (2012) found the opposite: there was less damage to fruit and a higher-class fruit when a mobile platform was used for harvesting.

This brief review of the literature suggests that there is still debate over the benefits of a mobile platform for an apple grower. This study sought to provide greater understanding about the role of mobile platforms for apple growers. This was an investigative study into labour and the different machines growers can use to assist labour.

#### Method

This research used the case study method. The case study method is appropriate when an in-depth investigation is required about a current phenomenon. It is used when the researchers want to answer how and why questions (see Sinnett et al., 2020; Yin, 2018).

The research questions investigated in this study were:

* how do labour needs change over a typical year;
* how do different machines affect the efficiency of labour;
* how do different machines affect quality and occupational health and safety; and
* how do the costs of a mobile platform compare with a power ladder?

The focus of this study was on Victorian apple growers who were supplying the fresh fruit market.

Three apple growers were selected as case study farmers for the project. The criteria for choosing these businesses were that the operators have experience using a mobile platform on-farm and

have used other harvesting methods in the past.

The case study farmers were interviewed and data about the costs (tangible and intangible) of different methods to harvest, thin and prune fruit was obtained. The case study farms varied in location, size and in the time that the operators have owned and used a platform in their business (Table 2). The case study farmers were unable to quantify all the benefits associated with each machine, in particular, any effects of harvesting method on quality of the fruit harvested. For this reason, the focus of the study was on the calculating the annual cost of a mobile platform compared with power ladders, to harvest fruit of equal quality. Any benefit of improved quality of harvested product from either method of harvesting, the occurrence of which the growers were not sure happened, would be an added benefit if it was to occur. The decision criterion is to choose the machine with lowest cost to harvest the same quality of fruit.

**Table 2. Details of each case study farm**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Case study 1 | Case Study 2 | Case Study 3 |
|  Orchard area (ha) | 70 ha apple and pear orchard  | 26 ha apple orchard | 135 ha apple and pear orchard  |
| Location relative to Melbourne | Approximately 1 hour north east of Melbourne | Approximately 1 hour east of Melbourne | Approximately 3 hours north of Melbourne |
| Apples varieties produced | Kanzi, Jonathan, Pink Lady, Granny Smith  | Royal Gala, Golden Delicious, Fuji, Granny Smith, Fern Gold | Royal Gala, Pink Lady, Granny Smith |

Using the data from the three case study farms, the cost of owning and operating the two machines used by growers was evaluated. There are three categories of costs for farm machinery: annual ownership costs (fixed costs which occur regardless of whether the machine is used), operating costs proportional to its use (variable costs), and timeliness costs (which are the costs associated with failure to perform operations in timely ways) (Malcolm et al.,2005). (See Appendix 1 for more about these three categories of costs). In addition to these costs, an additional cost was included, associated with a decrease in apple quality or an increase in occupational health and safety incidents depending on the harvesting method used. The value of this cost was based on the case study farmers’ experience and on pertinent literature. To evaluate these costs either the Net Present Total Cost (NPTC) or the annual costs can be calculated (Makeham and Malcolm, 1996). To calculate the NPTC, the total costs expected over the life of the machine is calculated, which are then discounted (Equation 1).

$$NPTC= \frac{initial capital cost+operating costs \left(fixed costs excluding depreciation and variable costs\right)+timeliness costs -salvage value}{(discount rate)^{no. of years}}$$

Net Present Total Cost can be expressed as an amortised annual cost, an annuity whose present value is one, of the stream of costs over time. This is the annual sum which, if incurred each year for the life of the machine, is equivalent to the stream of all costs, including opportunity interest cost, which sum to the NPTC. In this analysis, the operating costs of a machine or a piece of equipment are incurred each year. The amortized capital costs of the machine or piece of equipment are calculated to take account of the life of the capital and annual depreciation, and the opportunity cost, using the capital recovery method of estimating interest and depreciation. The total cost incurred each year is thus the annual operating costs plus the annual fixed costs being the amortized capital cost of the machine or equipment used to harvest the crop and an annual insurance and housing cost – plus any identifiable costs associated with timeliness of operation.

**Table 3. Costs of machinery**

|  |  |
| --- | --- |
| **Ownership costs** | **Unit** |
| Capital recovery cost (depreciation & opportunity interest cost) | $/machine/year |
| Insurance and housing | $/machine/year |
| 1. ***Total ownership cost per year***
 | *$/machine/ha/year* |
|  | (adjusted by the annual area used) |
| **Operating costs** |  |
| Total accumulated repairs | $machine/ha/year |
| Fuel cost | $machine/ha/year |
| Lubrication | $machine/ha/year |
| Labour cost | $machine/ha/year |
| Other (quality cost, occupational health and safety cost, extra labour cost) | $machine/ha/year |
| 1. ***Total operating costs***
 | *Sum operating costs* |
| 1. ***Timeliness cost***
 | *Quantity of fruit harvested late valued at the price penalty for late harvest fruit* |
| **Total costs** | **A + B + C** |

*Source*: adapted fromMalcolm et al.(2005)

In addition, as discussed in the brief literature review, there may also be costs that cannot be valued and therefore cannot be included explicitly; these costs are identified and discussed.

#### Results

**Labour requirements and wage rates**

For the three case study growers, labour demand fluctuated through the year (Figure 2). Labour was needed for activities ranging from thinning, pruning and picking. Each case study business had a core team of full-time staff providing the skilled labour input. In addition to the full-time employees, every year new people were employed in the business for a short period of time to help with activities on farm (mainly harvesting). These intermittent workers, generally, have not worked on an apple orchard before and do not have experience or skill in driving a tractor or operating a power ladder.

**Figure 2. Case studies 1, 2 and 3 labour needs over a year**

(Th: Thinning; H: Harvest; P: Pruning, T: Tree training)



To help with reliability and consistency of skills, Grower 1 employed the same group of contractors for nine months of the year for harvesting, pruning and thinning. All three orchards employed an equal mix of women and men, and all seasonal workers were visa holders.

**Table 4. Labour details for each of the case study farms**

|  |  |  |
| --- | --- | --- |
| Case study 1 (70ha pome fruit) | Case study 2 (26 ha apple orchard) | Case study 3 (135 ha apple and pear orchard) |
| 9 Full-timers (paid an hourly rate)16-18 contractors (paid an hourly rate, except at harvest, some prefer to be paid pieceworker rate)20 backpackers (paid pieceworker rate) | 3 Full-timersUp to 17 casuals at various times(all paid an hourly rate) | On average across the year 60 people are employed to work on the orchard3 Full-timers plus casuals at various times (all paid an hourly rate) |

All three case study growers reported that they did not have difficulty finding workers to employ. They attributed this to:

* They paid their staff properly (that is, they paid the award rate and entitlements);
* Two out of the three provided accommodation for their seasonal employees;
* Two out of the three orchards were located within an hour of Melbourne.

Employees can be paid an hourly rate (either as a full-timer or a part-timer or a casual) or at a pieceworker rate (see Table 5 and 6). As seen in Table 4, Grower 1 paid some employees an hourly rate and others at a pieceworker rate; Growers 2 and 3 paid all employees an hourly rate. All three growers agreed that employees have to be paid an hourly rate when working on a mobile platform because workers operate as a team. Grower 1 stated that the platform is generally only used on weekdays as the penalty rates for labour on weekends are too great to justify using it beyond the standard 40 hour week. A challenge for Grower 1 was that skilled labour preferred to be paid pieceworker rates at harvest, but he needed them to be managing a team, including unskilled labour, on the mobile platform.

A piece rate is where employees are paid by the piece (or bin for fruit workers). An employee on a pieceworker rate must earn above the minimum hourly rate as determined by the Fair Work Ombudsman (FWO, 2017). Farrow (2014) explained that ‘a piecework rate … would allow the average competent employee to earn at least 15 per cent more per hour than the relevant minimum hourly rate in the award, including the casual loading for casual employees’ (see Table 5).

**Table 5. Adult hourly full-time/part time rates and casual rates and the equivalent hourly pay rate when an employee is on pieceworker rate**

|  |  |  |  |
| --- | --- | --- | --- |
| Classification | Full-time/part-time hourly pay rate | Casual hourly pay rate | \*\*Equivalent hourly pay rate when an employee is on pieceworker rate |
| Level 1 | $18.29 | $22.86 | $25.60  |
| Level 2 | $18.81 | $23.51 | $26.34  |
| Level 3 | $19.36 | $24.20 | $27.10  |
| Level 4 | $20.09 | $25.11 | $28.12  |
| Level 5 | $21.29 | $26.61 | $29.81  |

*Source*: Adapted from Fair Work Ombudsman (2016) and (2017). \*\* Using the Fair Work Ombudsman method for calculating the equivalent hourly rate when an employee is on pieceworker rate (see Appendix 2 for details). Note that there are higher rates for public holidays, afternoon shifts, night shifts, overtime, working through meal breaks.

A difficulty in determining the pieceworker rate (the dollars per bin) is defining what output an average competent employee could achieve. Grower 3 estimated an average picker could pick 3 to 3.5 bins per day. According to ProPicker (2017), a picker starting out would pick around 3 to 4 bins per day on an average day of work; after a month, an average picker could reach 5 to 7 bins on good days; and, after a couple of seasons, they could fill 8 to 10 bins of apples in a day’s work. In practice, however, a typical picker, who has not had seasons of experience, would pick around 4.5 bins per day. To meet the expectation that a pieceworker earns 15 per cent above the hourly rate, the pieceworker rate should be as much as $65 per bin or as low as $28 per bin (this is dependent on the amount an average picker could pick in a day, see Table 7).

**Table 6. The piece worker rate required to earn 15 per cent above the minimum casual rate, depending on the average number of bins filled**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | If average number of bins was 3.5 | If average number of bins was 4 | If average number of bins was 5 | If average number of bins was 6 | If average number of bins was 7 |
| Level 1 | $56 | $49 | $39 | $32 | $28 |
| Level 2 | $57 | $50 | $40 | $33 | $29 |
| Level 3 | $59 | $51 | $41 | $34 | $29 |
| Level 4 | $61 | $53 | $43 | $36 | $31 |
| Level 5 | $65 | $57 | $45 | $38 | $32 |

In practice, the pieceworker rate is around $35/bin. This figure is supported by industry data which show that strip picking is usually paid at between $28 to $33 per bin, whilst colour picking is usually paid at around $33 to $36 per bin (and for Pink Ladies it can be up to $40 - $42 per bin). Using the Fair Work Ombudsman formulas, the expected daily rate for an employee at level 2 and dividing by the industry dollars per bin, the expected number of bins for these different rates are:

* if a picker is getting $30 per bin, they need to pick approximately 6.5 bins per day; or
* if a picker is getting $35 per bin, they need to pick approximately 5.5 bins per day; or
* if a picker is getting $40 per bin, they need to pick 5 bins per day.

If the employee was picking only 4.5 bins per day (as expected) and the dollar per bin was between $30/bin and $40/bin, the hourly rate of employees would be lower than what the Fair Work Ombudsman would expect (compare Table 5 to Table 7).

**Table 7. The equivalent daily and hourly rate if the typical industry $/bin was paid and if the number of bins per day was 4.5**

|  |  |  |  |
| --- | --- | --- | --- |
| Dollars per bin | Bins per day | Dollars per day | Dollars per hour |
| 30 | 4.5 | 135 | 17.8 |
| 35 | 4.5 | 157.5 | 20.7 |
| 40 | 4.5 | 180 | 23.7 |

The FWO admits that a pieceworker may get paid less than a worker being paid an hourly rate“Nothing in this award guarantees an employee on a piecework rate will earn at least the minimum ordinary time weekly or hourly wage in this award for the type of employment and the classification level of the employee, as the employee’s earnings are contingent on their productivity” (Fair Work Ombudsman, 2020, 16.9). The case study farmers felt that, for farm businesses that are set up for pieceworker rate, and which have employees who prefer pieceworker rate, this could be a significant factor against adopting a mobile platform on farm.

In the analysis of the costs of a mobile platform and power ladders, different scenarios were considered to account for the variability in the equivalent hourly rate paid, depending on how employees are paid:

* the casual labour hourly rate of $23.51[[2]](#footnote-3);
* the pieceworker hourly rate of $26.34 (if the pieceworker is being paid approximately $45 per bin and picks 4.5 pins a day);
* the piecework hourly rate of $20.70 (if the pieceworker is being paid $35.00 per bin and picks 4.5 pins a day);
* the piecework hourly rate of $17.80 (if the pieceworker is being paid $30.00 per bin and picks 4.5 pins a day).

**Labour and mobile platforms**

The case study orchardists agreed that an advantage of the platform is that it can be used with unskilled workers (provided there was a skilled operator managing the team). They made the following observations about labour and mobile platforms:

* Staff prefer working on a platform, because working conditions are more comfortable. For example, through using a platform for pruning employees are not standing in wet ground;
* A mobile platform gave the case study farmers the ability to provide alternatives to employees at the time of harvest who were too slow for pieceworker rate on ladders or power ladders.

Grower 2 explained that a platform required fewer skills of casual employees and removed the need to train them in power ladder operation. The platform can have a more experienced full-time employee as the operator of the platform and the other three to five can just begin working, whereas a power ladder requires someone to be trained in how to use it; this training can take up to a week.

**Machinery details of each of the case study farm businesses**

The three case study orchardists use mobile platforms as well as power ladders (Table 8). They found that a mobile platform can replace four power ladders, but they still needed to have power ladders to reach heights that the mobile platform could not reach and to give employees who prefer pieceworker rate that option, and also for those parts of the orchard that were not suited for use of a mobile platform.

**Table 8. Machinery details for each of the case study farm businesses**

|  |  |  |
| --- | --- | --- |
| Case study 1 (70ha pome fruit) | Case study 2 (26 ha apple orchard) | Case study 3 (135 ha apple and pear orchard) |
| 18 power ladders3 platforms (2 older ones used for pruning and thinning and 1 new one used for pruning, thinning and harvesting) | 5 power ladders2 platforms (1 new one, and 1 older one) | 6 power ladders 4 platforms (all within 5 years of age) |

The case study orchardists reported that there is an initial learning phase involved with using the mobile platform. Grower 1 said that, although the marketing information claimed it could be used with six to eight people, he believed it was more efficient with fewer people on it. He sometimes had six workers on it, but much of the time it had four people on it. Further, the type of mobile platform influenced how people could use it. Grower 1 had an older platform and it was necessary to be sure people had mastered how to use it; he would put less-skilled people on power ladders rather than on the harder-to-use platform. Grower 2 had recently purchased a platform that drives itself, using sensors to move along the row, and is self-levelling. This means that the staff on the platform can focus on the task without needing to operate the machine. This grower also has an older-style platform on which apples are picked and put into a bin. With the latest platform, apples are picked and put on a conveyor belt and gently released into the bin.

Grower 3 had the most experience working with platforms. They originally purchased a platform as they could see that you could have four people on one machine, instead of needing four machines for four people. They have found that a platform could be used with between two and six people depending on the task. They use the platform with people working on it and people working on the ground, putting the fruit on the conveyor on the platform rather than in a bag. This slows the overall efficiency of the machine but delivers higher quality fruit.

Each of the case study orchardists preferred not to use ladders. The reasons were to do with low productivity of workers on ladders, the occupational health and safety implications, and adverse implications for quality with ladder-picked fruit.

A mobile platform is a significant capital investment. The cost of one platform is approximately $90,000. A platform can replace four power ladders. The decision to replace power-ladders with a platform depends on the perceived relative costs and benefits of the alternative methods.

 Grower 2 had five power ladders ranging in age from 6 to 20 years. The annual repair and maintenance costs did not increase with the age of the machine, with regular servicing and housing of them. The older power ladders are slower to move around the orchard than the newer ones; but once they are in the row they perform as well as the other machines. Grower 2 preferred using the power ladder for pruning, thinning, harvesting and tree training. However, with the available labour pool, he felt that a platform would increase their efficiency and the quality of their work as it left less room for human error.

Grower 1 also felt that power ladders are more efficient than ladders: they can be used anywhere on the farm and they can be operated by one person, provided the operator is experienced. Quality suffered a little because of damage that occurring when the bucket on the power ladder is emptied into the bin; the case study farmers were not able to quantify the impact.

Grower 3 noted that an advantage of the platform is that it removes the carrying of bags from a machine. Operators of power ladders need to lift a bag and empty it into the bin.

**Market supplied**

All three businesses aimed to produce high quality apples with more than 50 per cent of their fruit grading as class 1. Grower 1 explained that the variety of apple determines how it will be picked. Pink Lady apples are susceptible to bruising so they did not use a power ladder to harvest this fruit. Compared with other methods of harvesting the fruit, an advantage of the platform was that there is less bruising and fewer stem punctures associated with harvesting the fruit. Essentially, anywhere staff had to use a bag for the picked fruit, the quality was affected negatively. Thus, fruit picked with a platform would be a higher quality than fruit picked using a power ladder. Grower 1 estimated that using a platform would result in 10-15 per cent more class 1 fruit in the fruit harvested with a platform. Grower 2 explained that there are price incentives for quality. He gave an example to illustrate the price difference of higher quality fruit: ‘At the moment, Fuji apples are being sold to the supermarkets for $28 per box, but the fruit and vegetable shops will pay $45 per box for higher quality’.

**Productivity**

All three case study orchardists felt that productivity, measured through the amount of fruit picked per person, was greater on a platform than when using a power ladder or ladder (Tables 5, 6 and 7).

**Table 9. Productivity of different classes of employees, case study one**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Bins/day if using power ladder | Bins/day if on pieceworker rate on a ladder | Bins/day on the platform |
| Full Timehourly rate | 4 bins per day per person when on an hourly rate | 2 – 2.5 bins per day per person when on an hourly rate. These workers are colour picking and size picking for market and they are picking on younger trees | 5 bins per day per person on an hourly rate4 people usually work on a platform (Total from the platform: 20 bins per day)  |
| Contractor hourly rate |
| Contractor pieceworker rate | 4 to 5 bins (and some 6 bins) per 8-hour day per person when on pieceworker rate(Note: they work 6 days a week) | 3 – 3.5 bins per day per person when on a pieceworker rate | Unable to pay pieceworker rate on platform |
| Pieceworker | Unable to pay pieceworker rate on platform |

\*\* note these workers are picking for colour – thus slower because they have a different objective

Grower 3 explained that the productivity from platforms is 10 per cent to 15 per cent higher than for power ladders. He also believed that, once the stand of trees has an even canopy, even greater productivity gains are achievable, possibly another 10 per cent. He also noted that when there is not consistency in the canopy of the trees, the power ladder may be the better option. Using a platform for thinning the fruit trees also had promise with one person able to thin two rows in a day whereas on the power ladder one person could only thin half a row a day. The case study farmer attributed this to the fact the platform was constantly moving, pushing the efficiency of the slowest worker to increase.

**Table 10. Productivity of different classes of employees, case study two**

|  |  |  |
| --- | --- | --- |
|  | Bins/day if using power ladder | Bins/day/person on the platform\* |
| Full Time (hourly rate) | 3 bins per day per person | 5 bins per day per person  |

\*Note: this is based on another grower who has a similar platform. They have only just purchased the new model platform and have yet to go through a harvest with it yet.

**Table 11. Productivity of different classes of employees, case study three**

|  |  |  |
| --- | --- | --- |
|  | Bins/day if using power ladder | Bins/day/person on the platform |
| Full Time (hourly rate) | 4 bins per day per person | 4.5 bins per day per person  |

The greatest constraint for a platform is the labour needed to manage the handling of bins and the time that labour is idle whilst bins are being replaced. One of the case study farmers explained ‘the bins have to be loaded on to the trailer; once a bin is full it needs to be ejected another bin is moved into place on the platform’. It took two minutes to change a bin when using a platform. Grower 3 explained:

The more people you have working with the platform, the more people who are sitting idle whilst the bins are changed. If there are four people picking four bins a day then, over a day, 16 bins of fruit are picked. This equates to two bins of fruit being picked per hour (for an 8-hour day) – there is a four minute delay every hour. If there were eight people picking four bins a day, then over an 8-hour day 32 bins would be picked, and this would be equivalent to four bins per hour, which would amount to nearly 10 minutes every hour to stop and change the bins.

Grower 2 attributed the productivity gains of a platform over a power ladder to an increase in the efficiency of the slowest worker. Grower 2 said “it slows down the best worker, but this is more than compensated by increasing the efficiency of the slowest worker”. He believed this was because the platform is continually moving with a team of up to eight people working on it, whereas a power ladder has only one person working on it.

All the growers agreed that picking with the platform was quicker than a non-powered ladder. They also said that some of the women employed would find working on a ladder difficult and they would struggle to pick a single bin in a day using a ladder. This same demographic would work well on a platform or even on the ground.

**Orchard design**

All three orchardists explained that to maximise the efficiency of a platform, the orchard needs to be set up in a particular way. Grower 3 had been preparing for a platform for a number of years. When renovating a block, they ensured that the orchard design best suited a platform and not a power ladder. They designed the orchard as single wire, single leader and a tree every metre. Such a design would be very inefficient with a power ladder – as they would spend a considerable amount of time moving the machine. The orchard needs to be designed such that the width of the tree is an arm’s length on either side. He estimated that only about 10 to 15 per cent of the farm is not suitable to be used with a platform. Grower 1 explained that a platform can only be used on trees planted with trellis.

All the case study orchardists agreed that to use a platform most efficiently when harvesting fruit there had to be an even canopy. If the crop load is uneven, there is more fruit on one side than the other which results in half the crew being idle.

Another change that had to be made when using a platform was to trim the height of the trees; or otherwise use the power ladders to reach the areas of the farm that the platforms could not reach.

**Cost of power ladder and platform**

A key factor in considering a platform over a power ladder is how many power ladders can be replaced with a platform. The three case study orchardists were firmly convinced that one platform could replace the work of four power ladders. Thus, the cost of one platform is compared with the costs of four power ladders. Further, given that there is debate in the literature about whether platforms increase labour efficiency (even though the case study farmers reported that they did), two scenarios were considered:

* Scenario 1: it was assumed no additional labour savings between a power ladder and platform;
* Scenario 2: it was assumed a 10 per cent labour saving for a platform compared with a power ladder.

The cost of using four power ladders versus one platform is shown in Table 12 for the two scenarios. Under both scenarios, a platform is expected to have a lower annual total cost compared with a power ladder. The assumptions (based on the information from the case study farmers) are:

* Four power ladders are replaced by one platform;
* To complete the tasks of pruning, thinning, harvesting and tree training a total of 800 labour hours per hectare are required; 400 labour hours/ha are spent above the ground on a ladder, or a power ladder, or a platform;
* No timeliness costs;
* No difference in occupational health and safety outcomes for the different machines;
* Platforms required eight litres of diesel per day;
* Power ladders required eight litres of petrol per day;
* Repairs and maintenance costs averaged $1,000 for a power ladder and for a platform;
* The economic lives of the platform and the power ladder were 10 years;
* The trade-in value was 50 per cent of its purchase price;
* Employees were at level 2 standard of operating;
* Employees working on a platform were only paid an hourly rate;
* Employees working on a power ladder were paid either an hourly rate or pieceworker rate;
* Contractors who had their own power ladder were paid an additional $3 per hour.

The cost comparison indicates that the annual ownership and operating costs of using the alternative types of equipment are 7 per cent lower for one platform than for four power ladders if there are no improvements in the efficiency of labour. The annual cost is approximately 17 per cent lower for one platform than for four power ladders when the labour efficiency improvement is included.

**Table 12. The annual ownership and operating cost ($/ha) of either four power ladders or one platform, under the scenario of either no improvement in labour efficiency or with labour efficiency**

|  |  |  |
| --- | --- | --- |
|  | Four power ladders | One platform |
| Total costs scenario 1 (assuming there is no difference in labour efficiency for a power ladder or a platform) (all employees on an hourly rate) | $10,580 | $9,892 |
| Total annual costs scenario 2 (assuming tasks take more time to complete with a power ladder compared with a platform) (all employees on an hourly rate) | $11,525 | $9,892 |

In Table 13 the results of the analysis using different wage rates are presented. If workers are paid piece-work rates on a power ladder and hourly rates on a platform, then a power ladder could have a lower annual total cost (Table 13).

**Table 13. The annual ownership and operating cost ($/ha) of either four power ladders or one platform, under scenario 1 or scenario 2 and assuming that employees working on power-ladders are on pieceworker rate**

|  |  |  |
| --- | --- | --- |
|   |   | Casual hourly rate and equivalent piecework hourly rate |
|   |   | Platform: $23.51/hour Power ladder: $26.34/hour ($45/bin) | Platform: $23.51/hour Power ladder: $20.70/hour($35/bin)  | Platform: $23.51/hour Platform: $17.80/hour ($30/bin) |
| Scenario 1 | Power ladders require 400 man-hours to prune, thin, harvest  | $11,717 | $9,460 | $8,300 |
| Platforms require 400 man-hours per hectare to prune, thin, harvest  | $9,892 | $9,892 | $9,892 |
|   |   |   |   |   |
| Scenario 2 | Power ladders require 440 man-hours to prune, thin, harvest  | $12,770 | $10,289 | $9,013 |
| Platforms require 400 man-hours per hectare to prune, thin, harvest  | $9,892 | $9,892 | $9,892 |

This analysis does not include some benefits or cost of platforms which could not be quantified. The costs of platforms that could not be quantified are:

* A reduction in labour productivity because of uneven canopy;
* Employees idle whilst waiting for a full bin to be replaced;
* One of the case study farmers found because he could not pay workers on a platform piece-work rate there was no incentive for employees to pick at a faster rate; and
* There is an adjustment cost when a platform is first used on the farm. This could be a cost in learning how to make the best use of the platform, or it could be a cost in making adjustments to orchard design to make sure it is most suitable for a platform.

The benefits of a platform that could not be quantified are:

* Increased fruit quality because employees using a platform do not need to use bags, rather apples are placed on a conveyor belt and gently placed in the bin;
* Labour benefits as employees do not need to be trained how to drive the platform, rather there can be one experienced operator on the platform and three inexperienced operators (whereas with a power ladder each employee needs to know how to use the power ladder);
* A platform offers a more comfortable way of picking; and
* A platform can be more efficient than a power ladder. One case study farmer explained that because a platform has a team of people it can result in the team encouraging the slowest worker to pick to their pace. However, it can slow down the fastest worker.

**Concluding Discussion**

Labour is a major input cost for orchardists. This study has shown that adopting a platform to assist labour can be a lower cost alternative to using four power ladders. If there are no efficiency gains from using a platform, instead of a power ladder, the platform is still expected to have lower annual costs. If there are efficiency gains, which all three case study orchardists expected there would be, then the platform is a lower cost alternative to the four power ladders. This result accords with other research findings. Baugher et al. (2012) found that harvesters could be profitable, but it depended on the system. They found that it was profitable to use a harvester (platform) to harvest fruit in a production system that was efficient to pick. Further, they found that for all other jobs, too, the harvester can be profitable. Zhang and Heinemann (2017) found that a platform can result in a net benefit when it is assumed that a platform resulted in a 29 per cent time saving for harvest and a 50 per cent time saving for pruning, training and thinning. Wells et al. (2017) also found that investing in a platform would result in a cost saving when the following assumptions are applied:

* 13 per cent increase in labour efficiency at harvest;
* 30 per cent labour efficiency increase in pruning;
* 40 per cent increase in efficiency in hand thinning.

Sazo et al. (2010) found it was profitable to use a platform instead of a ladder for trellis wire installation and tree tying, dormant pruning and hand thinning.

A constraint to the adoption of platforms is that the orchard design must be in a two-dimension (2D) tree structure which is relatively narrow, such as Tatura trellis or the wall system. In addition to the tree structure, all three case study orchardists explained that orchard design is critical to achieve the potential efficiency gains from a platform. A platform requires that the trees are not the traditional structure; that the trees need to be a certain height, if they are too tall then a power ladder will be required to reach those heights; and, most importantly, all the case study farmers explained the importance of an even canopy. An uneven crop distribution reduced harvest productivity with a platform because individual pickers did not have the same amount of fruit to pick. If one picker has more fruit to pick than others, he/she then would slow down the whole team because all the pickers are restricted to the progress of the platform. These findings accord with past research that found that orchard design effects the productivity improvements achieved using platforms (Elkins et al., 2011). Van der Merwe (2015) found that misalignment between orchard and machine design limited the picking rate a picker could achieve, thereby reducing the possible productivity gains.

This study has also explored the annual cost for a platform and a power ladder under piece-work rates and hourly rates of payment of labour. The orchardists explained that employees working on a platform need to be paid an hourly rate as they are working in a team rather than individually. On a power ladder, given that employees are working independently, they could be paid piece-work rates. If the pieceworker rate equates to less than the recommended equivalent hourly rate (which could be the case for some businesses), then the hourly rate of labour is cheaper on the pieceworker rate, and this makes a power ladder the lower cost machine. At the award rate, a mobile platform is the lower cost machine.

A benefit of the platform that was not able to be quantified in this study is the improvement in quality of fruit that can arise from using the platform. The three case study orchardists explained that, when a bag is used to hold fruit as it is being picked, quality is adversely affected. Using a platform to assist with harvesting does not require the pickers to use a bag; rather, fruit is placed on a conveyor belt that transfers it to the picking bin and quality is less affected.

Most employees in the horticultural industry are seasonal workers. An advantage of a platform over a power ladder is that employees do not need to be trained to operate the platform. Only one person on the platform needs to be experienced in the operation of the machine. With a power ladder, being a single person machine, the employee needs to be trained in how to operate the machine, which the case study farmers estimated could take up to two weeks. Gallardo and Brady (2015) found that orchardists invested in platforms as they were relatively easy for workers to operate.

Past research has found that businesses that used platforms were a preferred employer (pickers preferred the use of platforms), and they had access to a larger labour pool (Wells, 2017; Lewis, 2015; Elkins et al.,2011). Baugher et al. (2009) found platforms reduced worker fatigue and increased worker comfort. The case study orchardists observed that, in many respects, especially comfort and safety, employees would prefer using the platform to any form of ladders. However, because workers had to be paid an hourly rate on a platform, using a power ladder was the preferred choice as they could earn at piece-work rates and take home higher pay.

Another consideration, aside from the costs of the mobile platform is the financing aspect to the decision. A mobile platform costs approximately $90,000 and more than one platform are usually needed to achieve the greatest efficiency gains from platforms. This investment could have implications for a farmer’s balance sheet. Zhang and Heinemann (2017) argued that the cost of platforms may be prohibitive to smaller-sized orchards. Hornblow (2015) believed the capital cost can be prohibitive to the use of platforms and only orchards of a particular size that have a suitable orchard area that can be used with platforms will be best placed to use them.

Unsurprisingly, this study also supports the almost universal conclusion that there is no one system that is right for different operators and different systems. The answer to the question about whether an orchardist ought to invest in a platform or not, is, ‘it depends’. This study has shed light on the things ‘it depends’ on, i.e. the conditions that make adoption of a platform an attractive option, or not. Helpful information is provided for someone who is considering the potential role of this technology in a horticultural business.

To conclude, based on the situations of the case study orchardists, a platform is expected to have lower annual total costs compared with a power ladder. The possible reduction in costs ranged between 7 per cent and 17 per cent. Whether a platform is the right tool for an apple grower depends on the hourly rate employees are paid; it depends on the orchard design; it depends on the terms of those employed (full time, part time or seasonal workers); it depends on the size of the farm; and it depends on the market in which they are selling their fruit. It would be worthwhile for a future study to complement this initial project with data from a field trial that: (i) examines the labour efficiency of a power ladder and platform; (ii) measures the fruit quality implications of a power ladder and platform; and (iii) considers whether there is a timeliness issue with either a power ladder or platform.

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#### Appendix 1. Machinery Costs

**Ownership costs (fixed costs)**

Ownership costs are the sum of capital recovery (which is the cost of depreciation and interest) and insurance and housing.

To calculate depreciation and interest the capital recovery method was used (see Makeham et al. (2005), Edwards (2015), Chisholm and Dillon (1971). The capital recovery is the total depreciation and interest cost of owning the machine:

$$Capital recovery=\left(total depreciation × capital recovery factor\right)+\left(salvage value × interest rate\right).$$

Here:

$$Total depreciation=purchase price-salvage value$$

$$Capital recovery factor=\frac{i \left.\left(1\right.+i\right)^{n}}{\left.\left(1\right.+i\right)^{n}-1}$$

$$Salvage value=current list price × remaining value factor$$

The capital recovery factor (Chisholm and Dillon, 1976) is the annuity (for a given time period and discount rate) whose present value is unity.

Insurance and housing are grouped together as one per cent of the average value (Edwards, 2015), so that:

$$Insurance and housing=0.01 × \left(\frac{purchase price+salvage value}{2}\right).$$

**Operating costs (variable costs)**

These are the costs associated with the direct running costs of using the machine (repairs and maintenance, fuel, lubrication, and labour). The assumptions for each are:

* The repairs and maintenance cost were provided by the case study farmer;
* The average fuel usage per hour will be estimated by the farmer. This figure will be multiplied by the fuel cost per litre to calculate the average fuel cost per hour;
* The fuel cost per hour was multiplied by 15 per cent to estimate total lubrication costs (Edwards, 2015);
* To cost the labour associated with each different machine was the total man hours using the machine multiplied by the casual hourly rate. Further, Edwards (2015) argued that actual hours of labour usually exceed field machine time by 10 to 20 percent, because of moving the machine, lubricating and servicing the machine. To account for this, we multiplied the labour wage rate by 1.2 (as suggested by Edwards, 2015).

**Timeliness cost**

Khairo and Davies (2009) explained that a timeliness cost is an increase in costs caused by an operation not being completed within the optimum time. To calculate this, the optimum time to harvest, thin and prune fruit was obtained from the case study farmers. Then the expected time to harvest, thin and prune fruit using the different systems was discussed. If there was expected to be a loss in quality because fruit is not harvested in the optimum time, then that cost was included.

#### Appendix 2. Piece Rates

#### Source: https://www.fairwork.gov.au/pay/minimum-wages/piece-rates-and-commission-payments#1607-1623)

An employee can enter into a written agreement to be paid pieceworker rates under the Horticulture Award. If an employee doesn't have a written agreement, then they can't be a pieceworker. This agreement has to be genuinely made without coercion or duress.

A pieceworker isn't guaranteed a minimum hourly or weekly rate that applies to the type of work they do, or the national minimum wage.

The piecework rate has to allow the average competent employee to earn at least 15 per cent more per hour than the relevant minimum hourly rate in the award. Casual employees also get a casual loading.

There are many factors that affect what an average competent employee is. There's no standard across the horticulture industry.

Factors that should be considered in a piecework agreement include the:

* crop involved
* plants involved
* terrain
* particular harvest
* picking requirements
* size and sophistication of the business
* packing shed
* harvesting or pick data.

### Example: Calculating piecework rates

Webber and Sons Orchards plan to enter into a piecework agreement with Fiona, an adult casual picker. The piecework rate for Fiona is calculated as follows:

* Weekly wage rate level 1 (see clause 14): $694.90
* Plus 25 per cent casual loading: $173.73 ($694.90 x 25 per cent)
* Plus 15 per cent piecework loading: $104.24 ($694.90 x 15 per cent)
* Total: $972.87
* Daily wage rate: $194.57 ($972.87 ÷ 5 days)

The daily rate is then divided by the bin or kilogram rate per day that an average competent pieceworker can achieve to determine the piecework rate.

For example, if an average competent pieceworker can pick 15 bins of fruit over a daily picking shift of 7.6 hours (approximately 2 bins per hour) the piecework rate is:

Daily wage rate ($194.57) ÷ 15 bins = $12.97 per bin.

If 2 bins are picked per hour by an average competent pieceworker, this is effectively $25.94 per hour. This is higher than the award hourly rate + (25 per cent casual loading + 15 per cent piecework loading) ($25.60).

Use the [Piecework agreement template (DOCX 41.3KB)](https://www.fairwork.gov.au/ArticleDocuments/766/Piecework-agreement-horticulture-award.docx.aspx) to make a piecework agreement under the Horticulture Award.

1. Funding for this study was provided by the Innovation Seed Fund for Horticulture Development. [↑](#footnote-ref-2)
2. <https://calculate.fairwork.gov.au/findyouraward> [↑](#footnote-ref-3)