What is the most profitable way to harvest asparagus in New Zealand?

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CONTENTS

1. EXECUTIVE SUMMARY

As a relatively new asparagus grower, in the Waikato region of New Zealand, I am interested in exploring opportunities within this industry. The harvesting costs in an asparagus business are a significant portion of the total expenditure, so any efficiency gains would provide a direct contribution to profitability.

There are currently several different methods for harvesting asparagus, all of which involve manual picking of the spears. This project looked at which of the current methods was the most profitable for the New Zealand asparagus industry. Variations include paying staff a 'per hour' rate, a 'per kg' rate, or combinations of both. Picking methods vary from individuals walking along a row in their own time, harvesting into a bin or container carried on their person; to a team of pickers walking behind a tractor with a 20 metre boom, loaded with crates that they place the spears into as they pick.

The highly manual nature of the harvesting raised the question of what automation options have been considered or attempted in the past, as well as what the potential for this may be in the future.

The interviews held with existing asparagus growers provided a wealth of information regarding the picking process, as well as the potential for automation. The lowest cost system currently in use amongst the interviewees involves paying the pickers $0.87/kg through the entire season. The next lowest cost involved paying pickers a 'per kg' rate that varied from $0.85/kg at the start of the season, through to $1.20/kg at the end of the season when volumes were lower. The most costly system paid the pickers $18.00/hr, plus a $0.20/kg bonus for all 'Class One' graded asparagus. These costs were adjusted to reflect the wastage through the grading process, and therefore provide a more accurate actual cost per kilogram of saleable product. The results then saw the lowest net cost at $1.31/kg.

Although this assessment clearly showed the lowest cost, the determination of their relative profitability from a long term perspective was much more subjective. This was because each business had a number of unique considerations to incorporate into their decision making process around harvesting costs, for example the age and productivity of a block, access to labour and the typical profile of the labourers.

The interviewee's perspective on the potential for automation was explored and their opinions varied widely, from highly unlikely to occur, to highly likely to occur.

The potential for further study regarding innovative harvesting techniques, by incorporating automation, is significant. The challenge will be in balancing the needs of the growers for a cost effective and easy to use solution, with the research and development costs required to provide that as an appropriate solution.

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3. INTRODUCTION

This project was undertaken as part of the Kellogg Rural Leadership Programme. The intent was to understand and analyse the current methods of harvesting asparagus in New Zealand and identify which of these is the most profitable method. Achieving this would offer an opportunity for asparagus growers in New Zealand to potentially adapt their operations to improve their profitability.

Following the example of other horticultural crops; the natural progression is to consider the potential for increased automation in the industry, particularly in the harvesting and packing space. This was also discussed with the interviewees in detail.

The New Zealand asparagus industry involves approximately 60 growers (NZAC, 2014) with a total planted area of around 820 hectares of land, spread over both the North and South Islands. The main growing region is the Waikato (459ha), with other significant regions including Hawkes Bay, South West North Island, and Canterbury. The asparagus industry is a comparatively niche industry in New Zealand horticulture – compared with the 11,233 hectares of kiwifruit in production; the 8,566 hectares of apples; or the 10,329 hectares of potatoes (Fresh Facts, 2015). Global asparagus production covers some 202,000 hectares, with China by far the largest producer with a 39% share (EuroFresh, 2016).

Currently, asparagus in New Zealand is typically harvested manually by seasonal employees, from September to December annually. Historically, the picking process has been conducted by the individual visually selecting appropriate spears to harvest, cutting them with a knife, then placing them in a bucket/bag carried on their person. This container would then be emptied into crates which are then transported to the packing facility. A number of variations to this process have been trialled to try and reduce the highly physical aspect of harvesting, for example: the pickers lying face down on a tray, transported by a tractor and picking the spears as they pass underneath; pickers walking behind a rig/boom, picking the spears and placing them straight into crates on the boom.

The main issue with the current harvesting method is the high reliance on physical labour and the seasonal workforce. Alongside this, the challenge of securing a picking team, the direct costs of remunerating the workforce, maintaining quality and maximising yield are also significant considerations.

4. AIMS AND OBJECTIVES

The first aim of this project was to identify and understand the different asparagus harvesting techniques utilised by some of the major growers in New Zealand. Having achieved this, the second aim was to conduct analysis of the different methods to determine which of these had the highest profitability to the grower.

The key outcome desired was to be able to provide opportunities for participants in the industry to potentially improve their profitability if the results showed capacity to do so. Alongside this was the potential for 'normalising' the harvesting process within the industry – which would enable better support or integration between growers.

The final aim was to explore how automation has played a role in past harvesting techniques and to give consideration to what future options for increased harvesting automation (particularly robotics) in the industry might look like. This was to be approached from the perspective of how the increasing development of harvesting automation may positively influence profitability in the future.

5. LITERATURE REVIEW

There is very little literature available that compares the types and profitability of asparagus harvesting techniques. None could be found pertaining specifically to the New Zealand environment.

Given that the current harvesting techniques are so reliant on manual labour, this lack of literature is an interesting point when considering the responses in a recent New Zealand horticultural survey (Halliday, 2016). In this survey, 83% of respondents from the asparagus industry rated the availability of seasonal labour as having had either 'some impact' or 'a significant impact' on their business over the last five years. This would suggest that further study into the harvesting of asparagus in New Zealand would be well received by industry participants.

Washington State University, USA, has completed a number of papers looking at levels of automation within the industry, and also conducted some comparison between costs of manual and automated harvesting systems. The primary piece of work done in this area relates to the Geiger-Lund OR-24 selective asparagus harvester (Clary et al, 2006). They explained the economic considerations required to determine the commercial viability of a mechanical harvester. These included picking acceptable quality spears; picking all available spears; and finally, achieving this in a profitable manner.

Another Washington State University study (Cembali et al, 2004) simulated a comparison between mechanical and manual harvesting, using a locally developed harvester. They determined that based on the harvesting results achieved by the mechanical harvester, it would only need to harvest 73.55% of what the manual pickers harvest, in order to be economically comparable. They also outlined the potential to increase yield because the mechanical harvester could operate at additional times, or constantly, throughout the day. This enabled it to cut a spear as it reached the desirable length, thus causing the crown (root system) to divert energy to growing another spear, rather than adding unsaleable length to the freshly harvested spear.

The most interesting recent development for horticultural harvesting automation in New Zealand is the autonomous kiwifruit harvester (Scarfe, 2012). This robotic system incorporates a base unit with a picking unit. The base unit, or Autonomous Multipurpose Mobile Platform (AMMP), is responsible for the ground movement, using GPS to navigate via directional control mechanisms. The picking unit incorporates specifically designed software and technology to identify, assess and select the fruit. It harvests the fruit with robotic arms, before then placing the fruit into bins on the AMMP. This system has a lot of potential for conversion to the asparagus sector and is considered to have the most promising potential.

6. METHOD

The information for this report was gathered from interviews conducted face to face with existing New Zealand asparagus growers, all in the North Island. The growers interviewed, combined, are responsible for approximately 55% of the New Zealand industry. The interviews were carried out during the 2016 harvest season.

The growers were interviewed by the report writer, with the same eight questions asked of each. This was done to ensure consistency of information provided, thus enabling relevant comparisons to be drawn. The final question was included to allow consideration of the unique factors pertaining to each property, for example: area; property layout; infrastructure; crop maturity.

The interviews were loosely structured around these questions, which enabled natural conversation to flow more easily. This resulted in numerous other aspects of their individual operations, and the industry in general, being discussed during the interviews, which added to the value of the interactions.

These were the questions:

1. What method do you use to harvest asparagus?
2. Why do you use this method?
3. How do you remunerate your pickers?
4. What quality control measures do you have in place?
5. How do you source your labour force?
6. What other costs are directly involved with the harvesting?
7. What are your thoughts on the use of automation in the picking process?
8. Do you have any other comments relevant to this topic?

The interview results were then dissected and analysed to identify matching themes as well as areas that were persistently unique. The financial results were converted to a standard measure, 'picking costs per kilogram of asparagus sold', to enable appropriate comparisons to be made across the range of payment methods.

The direct financial results were not the only consideration assessed in the determination of 'profitability'. Other relevant components such as crop impact, reliability of staff, quality of product sold, were also considered integral components of on-going operations and profitability for these businesses.

7. RESULTS

1. **What method do you use to harvest asparagus?**

   Grower A: A team of seasonal workers are employed to harvest the spears. Approximately 40% of these pickers are RSE workers (Recognised Seasonal Employer - definition on Immigration NZ website). All produce is picked by hand (Figure 1). Each picker carries a long handled 'knife' to cut the spears just below ground level, and they wear a bucket attached to their hip via a belt as an intermediate storage container for the spears. They individually select and cut the spears as they work down a row. The picking crew will work their way across the block, covering all rows over the course of the day. This process is typically repeated daily (less frequently at the start or end of the season), though a row may be picked by different people each time. Each picker will cover approximately 1-1.5 hectares over the course of the five or six hour day.

Figure 1.

The pickers then empty their buckets into crates located at strategic positions around the field (Figure 2). It will take several bucket loads to fill a crate, depending on the volume picked in each bucket, and the volume the picker considers to be a full crate. As the picker fills a crate, they attach their individual identifying number to that crate. This is done to ensure that the crate load of asparagus is allocated to them at the packhouse; this is important because they are paid on a weight basis. A couple of times each day, these crates will be collected by another employee (via ute and trailer, or small truck) for delivery to the packhouse.

Figure 2.

Grower B: A contractor is engaged to provide a team of seasonal labourers to harvest the asparagus. These labourers are all New Zealand residents. As with Grower A, all asparagus is harvested by hand, with each picker selecting and cutting individual spears as they work along a row. However, they do not pick into buckets carried on their person.

This grower utilises a tractor with a 20m boom attached to the three point linkage. The boom is loaded with crates and the pickers harvest by hand into the crates (Figure 3). This method requires around 20 people; 14-16 to cover the rows (1.4m spacings), three roaming behind to harvest any spears that have been missed, plus a tractor driver. The tractor will typically travel around 2km/hr, which equates to 4ha/hr.

Early in the season, there will be one tractor and picking crew operating. Once the yield starts to increase, there will be two of these rigs operating over the property, each with an 18-20 person crew. As production winds down towards the end of the season, they will reduce back to one tractor and crew. The tractor will follow the same path each day, thus minimising the damage done to the asparagus field whilst also ensuring all rows are harvested evenly.

Figure 3.

Grower C: A team of seasonal employees are utilised to harvest the asparagus, with 95% of the workers coming from overseas via the RSE programme. The pickers manually harvest the crop in a very similar manner to that of Grower A, individually selecting and cutting spears, placing them into a bucket attached to their person, then transferring the spears to a numbered crate. However, the pickers are each allocated a one hectare block that they are responsible for picking each day. The one hectare block is set up to maximise the efficiency of the pickers, it is split into four portions, each is 12 rows wide (1.4m spacing) and 150m long. Once they have finished their allocated area, they may move on to help others if required. This will typically take four to six hours.
All pickers then move into the packhouse and pack the product they have harvested that morning.

2. How do you remunerate your pickers?

Grower A: All pickers are employed directly by the grower. The grower pays their picking staff $0.87/kg for all asparagus harvested (weighed on arrival at the packhouse). Additionally, all RSE workers have half of their return airfare (approximately $400), and their work visa (approximately $200), paid for by the grower.

Grower B: A labour contractor is engaged to provide a workforce, hence the payment is made directly to the contractor, who then pays the individual. The payment from the grower is $18.00/hr, plus $0.20/kg of Class One graded asparagus. This payment for quality is based on the weight of product graded through the packhouse, tallied and paid at the end of each month.

Grower C: Pays $0.85/kg to their picking staff during October and November. This rises to $1.00/kg in December and rises again to $1.20/kg in January. This reflects the declining yield as the season progresses. The pickers agree to have the bulk of their wages sent back home to their families, with the grower only paying a small weekly allowance into their New Zealand bank accounts. As with Grower A, Grower C is required to meet the additional RSE costs of approximately $600 per person (the work visa and half the airfare).

3. Why do you use these harvesting and payment methods?

Grower A: It provides an incentive for staff to earn more by picking more. They have freedom to move at their own speed, which means they can manage the quality of their picking better – they are not rushing to keep up with someone else, or conversely, waiting for someone else to keep up with them. Given that the yield in different rows can vary, it is important to have this flexibility to minimise unproductive time. Rig type systems have been tried in the past, but are not considered by this grower to be as cost effective as the manual system currently in use.

The RSE portion of costs is a requirement of the system.

Grower B: This property has a large area of asparagus crop, with rows up to 1.1km long. This method enables the pickers to pick continuously as they move down the length of the rows. There is no requirement to move back and forward from the rows to the crates in order to empty their buckets into the crates. The bulk of the crates are then co-located when it comes time to transport them to the packhouse, thus reducing the time and effort to load them for transport. Furthermore, given they are co-located, there is no need for tracks across the field, so the number of plants per hectare is higher than a similarly planted block with tracks for internal access.

Given the crop was only planted two years ago, the yield is lower that it will be once fully established. As such, it becomes more time consuming for the pickers to harvest as they typically have to move further between spears than they would if the crop was at peak production. Given the lower yields of the current crop, an hourly rate avoids any concerns around whether the staff are picking sufficient volume of product to meet the minimum wage requirements in New Zealand. Putting all staff on an hourly rate reduces their focus on maximising the volume picked, which means they can focus on picking good quality spears instead.

The extra $0.20/kg of Class One graded asparagus ensures there is a focus on ‘best practice’ picking to improve efficiency, reduce damage and maximise the volume of high quality spears harvested.

Engaging a contractor rather than directly employing the staff is a convenience decision given the owners of this block all have interests outside this business, as such are not able to commit the time to managing staff through the picking process.

Grower C: Property has been split into individual blocks for each picker. This allows them to have a consistent approach to harvesting their particular block and gaining a familiarity that could be advantageous. This approach also allows the grower to conduct more accurate analysis, if desired, around the volume yielded by the individual area, or the quality of the harvesting being completed by that picker.

Given the spears decrease in diameter as the season progresses, and yield reduces, varying the income through the season enables the pickers to secure a consistent level of income across the time they employed. This is important because Grower C continues to pick asparagus into mid or late January, after the typical season has finished. This is due to different climatic conditions (they also start later, usually early October rather than early September).

It can often be challenging retaining pickers at the end of the season as there will start to be some cross over of harvesting different seasonal crops, such as apples. Some pickers may want to move on to picking these seasonal crops that may pay better, be easier work, or simply be a variation to their workload.

4. What quality control measures do you have in place?

Grower A: Each crate of field picked asparagus is assessed at the packhouse with direct traceability to the harvester via their picking number. If it is discovered that quality is below requirements, remedial training is provided. The pickers will be docked a crate of asparagus if the poor quality continues. This typically results in an increased focus on, and delivery of, quality.

Grower B: Incentive payment for the volume of packed asparagus. The roving pickers behind the rig will provide feedback to individual pickers if they are missing too much product. Also, given the close proximity of the pickers to one another, there is an element of cross checking the work of each other.

The packhouse will also make an assessment of quality when the crates arrive. However, there is no method for distinguishing which crates came from each rig or crew.

Grower C: The pickers also pack the asparagus, and are again paid on a weight basis. Hence if they have to spend too much time grading out the poor product they picked earlier in the day, then they earn less at packing time.

Additionally, the pickers are each allocated a one hectare block to pick, which enables the grower to conduct an assessment of the quality and provided subsequent remedial training if required.

5. **How do you source your labour force?**

Grower A: Recognised Seasonal Employer (RSE) status, which enables recruitment of overseas employees to harvest. This must be done in conjunction with an Agreement To Recruit (Immigration NZ website). Approximately 40% of their pickers are Samoan RSE workers, with the balance being local (New Zealand) Samoan groups. A church leader in Samoa is engaged as the local recruiter of potential employees. The potential employees must be making a contribution to their communities and commit to utilising the skills they learn in New Zealand to improving their home villages.

Grower B: Sources staff via a contractor who liaises with Work and Income New Zealand (WINZ) to link job seekers with this seasonal employment opportunity.

Grower C: Utilises the RSE scheme to source workers from Vanuatu. Approximately 95% of employees are RSE workers. The balance are locals who help with the logistics of the operation, as well as other jobs. A small number of local employees are employed via WINZ, as a requirement of the RSE scheme, though they typically don't remain in the job past their training period.

6. **What other costs are directly involved with the harvesting?**

Grower A: Additional costs to access RSE staff include paying half of their return airfare (approximately $400) and their work visa (approximately $200).

Grower B: Leasing the tractor that carries the rig for the pickers. The tractor costs $45/hr to lease, including diesel. Several 'portaloo' units are hired during the picking season at a cost of $49/week.

Grower C: RSE costs of $600 per employee (as per Grower A). Picking buckets.

Aside from the above, growers incur a small cost for harvesting tools (knives), picking buckets, and picker number labels; though this is considered negligible given the total costs over the season.
The cost of 'freight' to collect and transport the crates from the field to the packhouse are relevant considerations, but this is considered to be a consistent cost for each grower, so has been excluded from this analysis.
Other factors, such as the capital costs or depreciation are beyond the scope of this project.

7. **What level of wastage occurs from the field to the packed product?**

   Grower A: 32% of picked product is discarded at packing. This is weighed and recorded continuously at the packhouse. The wastage is nearly exclusively in relation to trimming spears to the desired saleable length from the field picked length.

   Grower B: 36% of picked product is discarded at packing. Details as per Grower A.

   Grower C: 12% of picked product is discarded at packing. This is a more subjective assessment given the highly manual nature of the packing business for this grower. The level of wastage is not weighed, but is estimated as the difference between the typical harvest length and the trimmed length for sale – for example, a 27cm spear is trimmed to 24cm, therefore 11% wastage. A small, one percent, extra allowance for wastage of poor spear quality is included to reach 12%.

8. **What are your thoughts on the use of automation in the picking process?**

   Grower A: There will be a huge level of change over the next 10 years. We are currently involved as the commercial partner with a PhD automation project being completed at the University of Waikato.

   The workplace will see some step changes as automation becomes an effective tool in the process. The picking and packing will need to adapt. What we consider to be boundaries will need to be reassessed to provide capacity for some of the potential that automation could bring.

   Grower B: Various options have been tried in the past, but none of them worked effectively and were too costly. Unlikely to consider automation options in the future. Happy with the current model of manual harvesting.

   Grower C: Likely to see increasing use of some form of automation to capture efficiency gains. Will need to adapt workforce to incorporate this. Very interested in watching developments in this space.

9. **Do you have any other comments relevant to this topic?**

   Grower A: The focus is on building a community environment with the team, especially the RSE staff who may not have previously travelled internationally, and are a long way from their usual communities. This business has committed a huge amount to building a strong relationship with the workforce, and this is reflected in the trust they have with their employees. Having the flexibility of

straight manual harvesting means the pickers can switch between blocks easily. This is important given there are several blocks in the district, at varying maturity ages, which require different approaches.

Grower B: Sourcing labour has been a challenge for this relatively new business. The current method will be reviewed at the conclusion of the 2016 picking season. The biggest factor contributing to the adoption of an hourly remuneration system has been the concern around meeting the minimum wage levels for staff. The relatively 'hands off' involvement of the owners means there is a requirement for someone else to manage the labour aspect, hence the contractor.

Grower C: Relative isolation provides challenges for this business. An accommodation unit has been built to house the employees, but an effort is made to take them into town once a week to experience another part of the New Zealand culture. The packhouse and staff accommodation are both located in the middle of the asparagus field, which creates some efficiency gains that other growers may not have.

8. ANALYSIS

Given the volume of wastage that occurs at the packhouse, where harvested spears are trimmed to the desired saleable length, or graded down if poor quality, this needs to be taken into account to determine the net picking cost for each operator.

Grower A pays $0.87/kg and incurs 32% wastage. Accounting for this wastage, the picking cost is $1.28/kg. There is also a cost of $600 for each RSE worker (airfare and visa). Assuming they pick 9,000kg, after wastage (comment from grower), over the season (equivalent of 1.5ha), this cost would be equivalent to $0.07/kg. However, only 40% of the workforce are RSE, so averaging this cost across all pickers would see it reduce to $0.03/kg.
There are some other minor costs, such as providing buckets, picking knives, or picker identifying labels; that also form park of the harvesting costs. However, these are considered to be negligible in the scale of the business.
Therefore, given the allowance for wastage and RSE employment costs, the net picking cost for Grower A is $1.31/kg of saleable asparagus.

Grower B pays $18/hr and incurs 36% wastage. They also pay a further $0.20/kg of Class One graded asparagus. The yield and wages figures (including incentive) provided for the 2016 season were 51,611kg and $113,160 respectively. The cost to harvest was calculated from this to be $2.19/kg. With the additional costs of leasing the tractors at $45/hr, this came to a further $0.29/kg. The portaloo hire adds a further $0.01/kg
Therefore, the net cost of harvesting for Grower B was $2.49/kg.

Grower C pays $0.85/kg in October and November, $1.00/kg in December and $1.20/kg in January. Given approximately 65% of the picking occurs in October and November, 25% in December and 10% in January, with a total yield of 6,000kg per picker, the following applies. 3,900 x $0.85 = $3,315; 1,500 x $1.00 = $1,500; 600 x $1.20 = $720. Total picking wage is $5,535 which equates to $0.92/kg of harvested asparagus. Assuming 12% wastage, this becomes $1.05/kg of saleable product. Add to this the RSE costs of $600. For this grower, it is spread over a lower volume of product, so equates to $0.10/kg.
Therefore, total net harvesting costs for Grower C was $1.15/kg.

The wastage percentage provided by each grower was based on the discarded product measured at the packhouse. For Grower A and Grower B, their packhouses incorporated what the industry would consider to be a high level of automation, with computerised grading machines and detailed analysis. However, Grower C used a manual packing line, where the spears are graded and measured by visual

assessment only. This may have meant the detailed information available to the other interviewees was not realistically accessible for this grower. This is relevant particularly when considering the level of wastage between the harvested volume of asparagus, and the saleable volume. It is possible that without the ability to accurately measure this, it may have been underestimated. This would subsequently distort the analysis of picking costs completed earlier in this section. If this analysis for Grower C was reassessed, using a similar wastage level to Grower A (being at the lower end of the other growers), then the total net harvesting cost would increase from $1.15/kg to $1.46/kg.

The net harvesting cost for Grower B, at $2.49/kg, was significantly higher than the others. Given that this grower engages a contractor to source and manage their labour requirements, it would be appropriate to expect this to be reflected somewhat in harvesting cost. By engaging a third party in this manner, the grower is immediately sacrificing some margin to the contractor, but in return gains greater convenience and the desired skills and support. This aside, the results suggest that paying a harvesting rate 'per kilogram', as was the case with the other growers, appears to be a more cost effective method. This rate is likely to be influenced by the maturity of this crop producing a lower yield in comparison to the other growers. If a similar analysis was completed with this block at full maturity, is would be expected that the costs would reduce. It is considered unlikely that it would reduce to the level of the other growers though.

The speed of harvesting systems is very similar between the systems. With the tractor system covering 4ha/hr with 20 staff, it would take five hours to cover 20ha, the equivalent of one hectare per picker. The other growers, with their systems, achieve a similar area of 1-1.5ha over 4-6hrs.

The interviews conducted, and subsequent analysis, show the lowest cost picking system to be the fully manual harvesting carried out by Grower A. While they paid a higher rate in the early part of the season, this was offset by continuing that rate through the whole season, whereas Grower C increased their rate as volume lowered.

However, the cheapest harvesting method is not necessarily the most profitable from a long term sustainability focus. There are numerous factors that influenced the decision making of the growers with respect to the system they choose to implement, with many of these factors being very hard to allocate a direct financial cost or benefit to. Factors such as age of crop; layout and size of property; access to labour; proximity to packhouse; quality of product picked; volume discarded; etc., are all essential considerations that may influence a decision to adopt a particular system. This is covered in further detail under the Conclusion section.

9. DISCUSSION

The seasonality of many horticultural industries presents a significant challenge for the respective sector, and asparagus is no different. The highly manual nature of harvesting techniques, and the physically demanding work involved, has presented ongoing challenges and risks for participants. The potential to incorporate automation into the asparagus industry presents the opportunity to reduce some of this risk and to concurrently gain a number of potential advantages, including increased yield and improved quality.

An automated kiwifruit harvester has been developed for that industry (Figure 4), with the technology now being expanded to conduct other tasks within the kiwifruit cycle, such as pollination and spraying. The complexities of developing the necessary software and hardware for this robot is more advanced that what would be required for the asparagus industry. With asparagus, the key parameters for spear selection are length and deformities. However, with kiwifruit, this includes size, deformities and ripeness, as well as the ability to select fruit within the vine system (Scarfe, 2012).

Figure 4.

The current asparagus automation options, such as the Geiger-Lund OR-24 can result in reduced saleable yield due to the damage done to adjacent spears at harvesting time. Specifically, the lack of

precision can see harvesting knives slice adjacent spears. However, the use of manual labour can also result in the same type of damage to the spears. In Figure 5, the green butt of the harvested spear can be seen to the left of the remaining tall spear that disappears to the top right of the image. Note the remaining spear has been accidentally sliced during the process of harvesting the adjacent spear. This remaining spear was not long enough to be harvested at the time, but is now wasted as it is beginning to die off from the damage done to it and will be unable to be harvested.

Figure 5.

Manual harvesting can also cause damage if the picker pulls too hard on the tip of the spear prior to completely severing the spear, as seen in Figure 6. This image shows the tip of the spear has been pulled off during a failed attempt to harvest the spear. Without the tip, it will not be a saleable spear, and so is wasted.

Figure 6.

So, whilst the current mechanised options can result in reduced yield through a lack of precision, the manual harvesting method is by no means the perfect system. It is, of course, subject to human error. This increases the reliance on training, supervision and skills within the workforce.

Another study in the USA explored the ability of ground penetrating radar to detect asparagus spears and root systems. Achieving this would enable greater precision at harvesting time, thus capturing the maximal spear length (Seyfried and Schoebel, 2016).

Asparagus has a longer shelf life when picked early in the morning (Lill and Borst, 2001), so the option for utilising robotics could enable picking to occur between 0200 and 0800 daily, to maximise shelf life.

Additionally, if spears could be harvested at more regular intervals, for example if the robot continuously operated, then there would be less wastage as spears would be closer to the required length. This would enable the plant to put energy into growing new spears, rather than extending ones already at length, hence saleable yield should increase.

As one grower highlighted, the influx of automation into the asparagus industry over the next 10 years has the power to change the game, and the industry needs to adopt this in a managed way to ensure maximum potential is gained. Further study into this is currently being undertaken at the University of Waikato, though this has only recently begun.

If the right automation system is developed to the potential that it can be, we will see huge profitability gains in the way we harvest asparagus in New Zealand.

Such automation is never a 'finished product'. Continual refinement of systems, along with development of new parameters relevant to the industry will enable ongoing gains to productivity and the availability of picking or plant data. This requires industry participants to be fully engaged in the process and fully focused on growing their industry. This will not suit everyone, as Grower B suggested, but it is considered realistic that enough support for such automation would exist.

It now requires proactive leadership within the New Zealand asparagus industry to engage with the necessary stake holders to see this come to fruition.

10. CONCLUSIONS / RECOMMENDATIONS

While there are a range of variations on picking methods, there is a huge reliance on manual labour. All current New Zealand methods are underpinned by this.

This project has demonstrated the variations in direct costs relating to asparagus harvesting for a selection of growers. The system being utilised by Grower A is the lowest cost at $1.31/kg. The highly physical nature of harvesting asparagus is a widely understood component of the industry. Providing the opportunity for pickers to actively seek employment in this industry and be rewarded for working hard should be reflected in their pay. Providing an incentive based remuneration such as Grower A and Grower C do, enables these employees to maximise their opportunity in the physically demanding industry.

The unique environments, individual strengths and different constraints faced by asparagus growers in New Zealand means that it is unlikely that any one harvesting model will be the 'best' for everyone. As such, it is not considered achievable to normalise harvesting within the industry at this time.

However, the opportunity for integrating automation into this highly manual process is significant and is currently being explored by one grower.

There are a number of facets of the analysis that were difficult to accurately determine during this project. For example, with Grower A, do the RSE workers and the local workers pick the same volume? If not, then the proportion of costs could vary. Similarly with Grower B, is the tractor running for every hour the pickers are paid? Or once the second tractor began, was it used every day?

Further study into incorporating higher levels of automation into the harvesting process is recommended, as this may surpass some of the current unique challenges that make it unrealistic to normalise harvesting as it currently stands, for example, minimising or removing the reliance on seasonal labour.

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12. AUTHOR'S BIOGRAPHY

Tim has a genuine passion for the Primary Industries, which continues to grow with his experiences. Some of the highlights include winning the 2013 Young Farmer of the Year and 2012 Australasian Rural Ambassador titles. He currently works as a Rural Manager for Rabobank, and has business interests in the agricultural and horticultural sectors.

As a relatively new asparagus grower, Tim has enjoyed the chance to immerse himself in a new sector. This project matches the asparagus interest with his interest for innovation.

Outside the Primary Industries, Tim continues his contribution as an Officer in the NZ Army Reserves, as well as maintaining business interests in the retail, service and online space.

As a qualified Scuba Diving Instructor, with a Bachelor of Social Sciences (Psychology major); Tim's diverse range of skills and experiences enable him to make a unique contribution to the commitments he has.

Tim and his wife, Hilary, have recently welcomed their first child, Isobella.