Farm Automation, Robotics & Intelligent Systems (Veg)

An Industry Talent Initiative PMA A-NZ Career Pathways Project

Farm automation and advances in robotics and intelligent systems will shape how we produce, harvest, process, ship and control quality for fresh vegetables in the future.

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Executive Summary

This report has been produced to give an overview of farm automation, advances in robotics and intelligent systems that are currently being trialled in the vegetable sector. These advances will help shape how we produce, harvest, process, ship and control quality of fresh vegetables being produced particularly by Australian and New Zealand growers. Information on these technologies have been cited from selected articles, direct communication with growers who attended PMA Fresh Connections 2014, webpages, and the Plenary Session that was presented by Professor Salah Sukkarieh (University of Sydney) on the topic of Farm Automation: Robotics and Intelligent Systems that will shape the fresh produce industry in the next decade.

Both Australian and New Zealand growers have adopted forms of automated technologies and advances in robotics into their farm businesses. Those technologies that are favoured in the vegetable industry are mainly forms of automated equipment. The use of Global Positioning System (GPS) that provides auto-steer of tractors and auto-guidance of machinery is favoured significantly among vegetable growers. The use of GPS is to optimise overall efficiency and productivity. The use of GPS allows accurate farm practices to be carried out along with reduced fuel and labour costs, as high skilled labour is not required to operate the system. Longer hours of work can be carried out as operator fatigue, concentration and stress is minimised due to the “hands-free” operation. The use of GPS can also be incorporated with other management practices such as cultivation, chemical and fertiliser applications; and harvest. Using GPS during these practices increases accuracy of inputs, while reducing over-lap and tractor passes. This ensures vegetable crops are only being applied with the correct amount of units (fertiliser, Agri-chemicals, etc.), reducing crop damage from excessive passes. This promotes overall quality and yields of the potential crop.

Intelligent systems used for production and post-harvest practices are also favoured by many Australian and New Zealand growers. The ability to monitor a crop in “real-time” has changed the way growers can now produce vegetable crops. Real-time data can be collected from in-field crop sensors, providing growers with information about the current growing environment and whether actions need to be carried out to minimise pest and disease issues that may decrease crop yields and quality. Post-harvest intelligent systems such as automated packing and grading lines are one of the most important assets that a pack-house can have. With the presence of this technology, growers and pack-houses are able to grade product more consistently using computerised vision technologies such as infrared and high-resolution cameras. This is allowing consumers to receive product that is virtually “perfect” in quality. These technological systems grade produce on appearance, shape, size, colour and texture. Although the systems work very well on onion and tomato products, potatoes that are destined for the
brushed and washed markets have had difficulties in determining inherent defects due to the attributes of the tubers. However, with the use of this technology, consistency in quality requirements can be achieved for particular markets. Pack-houses that have invested in intelligent grading and packing systems believe the investment is worthwhile because the volumes and consistent pack-out is allowing them to reach markets earlier in the season to capture the premium returns.

Advances in robotics are slowly making their way to the commercial vegetable sector. As labour costs are increasing significantly in Australia and New Zealand, growers are now starting to look for alternative options. By minimising staff, growers are able to focus on looking at advances that will compensate for the high rising costs of employment. A key robotic system that will be valuable for leafy vegetable growers is the investment of The LettuceBot field robot. This robot is designed as a crop thinner. Lettuce growers that produce product lines such as “fancy lettuce” varieties will be able to take full advantage of this robot as it can minimise labour by up to 12 units when it comes to thinning practices. However in saying that, the commercial vegetable sector will not see robotics for another 10-20 years as robotics that are currently available are only designed for organic and small scaled enterprises.

By introducing farm automated technologies and advances in robotics, available labour units for Australian and New Zealand vegetable growers will decline. The industry is already experiencing a shortage of skilled labour where current numbers of qualified people are on a decline. It was seen in 2010 that 789 qualified people were involved with the horticultural industry and in 2012 this number had dropped to 667 (Ministry of Business for Innovation and Employment, 2013). There are labour units available that have qualifications and skills, however growers are looking for labour units with past experience. In New Zealand, there is a shortage of skilled labour that hold past experience and due to this, a decline of qualified people coming through the industry is seen. If farm automation and advances in robotics is integrated completely, there will be a severe shortage of skilled labour available which will become a serious issue within the next 10 years. Growers believe labour will always be required for farm management practices. Therefore with the integration of farm automation and robotics to a certain point, growers will still require skilled labour. With this addition of skilled labour, efficiency and productivity in production will be increased allowing overall quality and yields to be optimised.
Australia and New Zealand vegetable sectors

Australia and New Zealand have a high reputation of producing high quality vegetables for the market supply. The import and export relationship between the two countries has been controversial over the years due to biosecurity and, supply and demand issues. The two-way relationship in trading of frozen potatoes was considerably high in 2013 compared to previous years. $52.2 million in frozen potato exports was distributed by New Zealand followed by $18.5 million of frozen potatoes distributed by Australia in that same year (Aitken. AG & Hewett. EW, 2013).

Australia

Australia has approximately 4,200 commercial growers producing fresh vegetables on approximately 126,500 hectares (AUSVEG Ltd, 2012a). There are seven main regions where fresh vegetables are produced. These regions are New South Wales, Queensland, Victoria, South Australia, Western Australia, Tasmania and Northern Territory. Most vegetable growers produce more than one crop to fulfill crop rotations and maximise returns with a variety of products (AUSVEG Ltd, 2012b). Between 2011-2012 approximately 2.5 million tonnes of fresh vegetables were produced, generating a gross value of $3.3 million (Ottesen, 2013).

Table 1. Key vegetable crops produced in Australia

<table>
<thead>
<tr>
<th>Type of vegetable</th>
<th>Number of growers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>1054</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>780</td>
</tr>
<tr>
<td>Lettuce</td>
<td>541</td>
</tr>
<tr>
<td>Capsicums</td>
<td>451</td>
</tr>
<tr>
<td>Broccoli</td>
<td>432</td>
</tr>
<tr>
<td>Melons</td>
<td>384</td>
</tr>
<tr>
<td>Onions</td>
<td>378</td>
</tr>
<tr>
<td>Carrots</td>
<td>255</td>
</tr>
</tbody>
</table>

Note: Growers produce more than one crop that are listed above. Grower numbers for each crop therefore fluctuate.

New Zealand
New Zealand has approximately 2,500 growers that produce fresh vegetables on approximately 50,000 hectares. The main regions of production are Pukekohe, Waikato, Gisborne, Hawkes Bay, Manawatu, Horowhenua and Canterbury. In 2013 approximately 1.4 million tonnes of vegetables were produced with 500,000 tonnes going to exports (Aitken. AG & Hewett. EW, 2013). Export vegetable products from New Zealand include tomatoes, pumpkin, squash, onions, carrots and frozen (processed) potatoes. Produce that is exported usually generates a higher return compared to vegetables sold on the domestic market. This is due to a larger market size available for New Zealand growers. Key export destinations for New Zealand fresh vegetable products are Europe, Asia, USA and the Pacific Islands (Ministry for Primary Industries, 2013).

Table 2. Key vegetable crops produced in New Zealand

<table>
<thead>
<tr>
<th>Type of vegetable</th>
<th>Number of growers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>200</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>150</td>
</tr>
<tr>
<td>Broccoli</td>
<td>150</td>
</tr>
<tr>
<td>Cabbage</td>
<td>150</td>
</tr>
<tr>
<td>Pumpkin/ Squash</td>
<td>150</td>
</tr>
<tr>
<td>Sweetcorn</td>
<td>150</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>120</td>
</tr>
<tr>
<td>Onions</td>
<td>110</td>
</tr>
<tr>
<td>Lettuce</td>
<td>70</td>
</tr>
<tr>
<td>Silverbeet/ Spinach</td>
<td>50</td>
</tr>
<tr>
<td>Kumara</td>
<td>45</td>
</tr>
<tr>
<td>Carrots</td>
<td>40</td>
</tr>
</tbody>
</table>


Note: Growers produce more than one crop that are listed above. Grower numbers for each crop therefore fluctuate.
Whole-farm automation in the vegetable sector

Whole-farm automation is the ability to automate farm practices that will result in improved efficiency and productivity. The integration of farm automation has an aim to produce fresh vegetables at a more accurate and consistent rate, while ensuring supply and profits are maximised. Farm automation is a combination of precision (automated) equipment, robotics and intelligent systems.

Automated equipment is diverse and is seen throughout the vegetable sector with many well-developed products available. Both on and off-field equipment is widely used by many vegetable growers throughout Australia, New Zealand and other key agricultural/horticultural producing countries.

Key forms of automated equipment include:

- Auto-steer tractors (GPS systems)
- Auto-guidance machinery (GPS systems)
- Automated cultivators, planters, drills, fertiliser spreaders, chemical sprayers and harvesters (precision machinery)
- Automated grading and packing lines for both brushed and washed products (computer controlled)

Robotic systems are new innovations that have been introduced to the vegetable sector. Robotics have only emerged in the industry within the last 10 years with proto-type models being trialled from the year 2001 (Gacia-Alegre MC, 2001). Key robotic systems that have been recently developed for the vegetable sector are The Ladybird, The HortiBot and The LettuceBot. These field robots have the ability to operate on a pass-to-pass (row crop) pattern by using GPS, lasers, sensors and vision (infrared and optical) technologies. These features are helping growers to assist with accurate pest and disease control; weed and nutrient management; and harvesting practices (Sukkarieh, 2014).

Intelligent systems that are currently being used in the vegetable sector are crop sensors and computer vision (camera + infrared) grading systems. Crop sensors are a system of integrated sensor units that are placed within a crop, data on the plants health, soil, and environment is collected and sent to a central hub where growers can interpret the data to see what current conditions are within the crop environment. From here, growers can make informed decisions on inputs that are required by the crop for optimal yields and increased quality. There has been an increase in integrated grading systems introduced to many growers and pack-houses throughout Australia and New Zealand. Integrated companies that were in attendance at PMA Fresh Connections 2014 had many integrated laser and optical vision grading systems on digital display. Products such as the Compac InVision 9000 Blemish, MAF RODA Agrobotic GlobalScan 5; and the Newtec Celox XT
optical grading machine were very popular among growers. Many vegetable growers throughout Australia and New Zealand have invested in systems like those that are listed above. This is because growers aim to only supply produce that is high in quality to meet specific market requirements. As growers invest in these intelligent systems, pack-out rates are increased as efficiency and productivity are also increased, resulting in higher market returns (Compac Sorting Equipment Ltd, 2013b). By incorporating forms of automation to the farm business, growers have the opportunity to produce vegetables that are higher in yields and quality compared to conventional methods.

Automated Equipment

The most common form of automated equipment used in the vegetable industry is the use of GPS tractors and machinery. The use of GPS equipment in the vegetable sector is to maximise land use, increase productivity and increase efficiency while reducing running costs, labour costs and operator fatigue. Large companies such as John Deere, Trimble, Fendt, New Holland and Case IH are market leaders in GPS technology (Yule, 2014). A New Zealand based vegetable grower who was in attendance at PMA Fresh Connections 2014, Bharat Jivan of Jivan Produce Ltd has been using John Deere GreenStar™ (GPS auto-steer) on his tractors for approximately 9 years. The use of GPS has allowed Mr Jivan to establish straight and correctly spaced rows that is particularly important when it comes to using wide machinery. For instance, when Mr Jivan drills his onion crops, he uses a 3-bed onion drill. By having correctly spaced rows, the outer seed lines remain within the seedbed, preventing individual seed lines from being planted into the wheel tracks. To operate a GPS equipped tractor, the driver doesn’t have to be particularly skilled as the tractor is “self-driven” (hands-free). The system is able to form 3 rows from one pass, increasing productivity and efficiency. The incorporation of GPS, particularly John Deere GreenStar™ allows Mr Jivan to collect data as planting, chemical application and harvest is carried out. This data provides traceability and planting records that are required for Food Safety Accreditations. The use of this GPS product on Mr Jivan’s farm has promoted longer hours of work to be carried out as auto-steer technology has significantly reduced operator concentration, fatigue and stress (Jivan, 2014).

Automated machinery such as precision cultivators, planters, drills, fertiliser spreaders, chemical sprayers and harvesters are being used in combination with GPS and GIS systems. Precision machinery attachments such as John Deere iTEC™ Pro and Autotrac™ provide greater accuracy and efficiency when it comes to carrying out a range of farm practices. With the use of products like these, growers are able to carry out productive tasks such as preparation of a uniform seedbed; accurate planting densities using precision systems; accurate nutrient and chemical applications using
electromagnetic (EM) mapping (Yule, 2013); and controlled harvesting techniques such as laser level cutting for lettuce and brassica crops (Hari, 2014).

Automated grading and packing lines have become an important asset to vegetable growers. Once a vegetable crop has matured, the main focus for growers is to harvest and dispatch the product out the farm gate as soon as possible to ensure quality and shelf life is maximised. State of the art grading and packing lines have been available for the past 10 years. They are used by many commercial vegetable growers as they provide accuracy and efficiency when it comes to sorting produce (Compac Sorting Equipment Ltd, 2013b).

Market leading companies such as Compac Sorting Equipment Ltd and Wyma Engineering (NZ) Ltd have developed automated grading and packing lines that vegetable growers across the world are incorporating into their businesses to ensure only quality produce is leaving the farm gate. This ideally allows the product to reach supermarket shelves quicker, providing a higher quality product for consumers, while maximising the potential shelf life of the product. Kiran Hari of R C Hari & Sons Ltd believes automation is going to be a necessity in moving forward as the costs of labour and compliance in New Zealand is significantly increasing. In Mr Hari’s case, his company currently has 8-9 labour units processing lettuce. He believes by simply adding an automated wrapping machine, labour can be reduced down to 5-6 units for this particular part of the processing stage. By investing in automation this will allow the company to focus on moving labour units who are currently working in the pack-house to other areas of the business (Hari, 2014).

Robotics

The theory and development of robotics have been occurring in the horticultural industry since 1997. The first form of robotics was the development of guidance and weed detection systems to make more effective use of herbicides and pesticides (Tillett, 1998). In 2001 agriculture robots that were smart and autonomous were developed based on agronomic, economic and environmental requirements. They were developed to carry out practices specific to crop establishment, plant health and selective harvesting (Blackmore, BS, 2004).
The Ladybird field robot

Professor Salah Sukkarieh (The University of Sydney robotics expert) and associates developed The Ladybird field robot. The Ladybird was developed specifically for the vegetable sector with an aim to carry out autonomous farm practices such as surveillance, mapping, classification and detection of weeds. The Ladybird robot was developed to minimise inputs that are now becoming a high expense. The Ladybird is used to maximise outputs and increase efficiency. The Ladybird has been designed for a range of broad-acre crops and is solar-electric powered. The robot is controlled by a selection of sensors that detects plant growth and pests and disease activity using detections of colour, texture and shape. The Ladybird consists of a mechanical arm that is used to physically remove weeds if required. The mechanical arm has a spray nozzle for spot spraying of weed species, providing greater accuracy and minimised foliar damage. The mechanical arm also acts as a “hitch-point” where equipment such as fertiliser applicators and harvesting tools can be attached. The fully autonomous robot can travel to speeds of up to 5km/h and has all-wheel steering capabilities to prevent soil compaction and drag. The robot uses lasers, sensors and hyper spectral cameras to operate on a row crop (pass to pass) pattern. There is still a large amount of research to be carried out on this particular robot but Professor Salah Sukkarieh believes the future of farming will see the fully developed field robot being an important asset for vegetable growers (Sukkarieh, 2014).

(University of Sydney, 2014)

Figure 1. The Ladybird field robot in action on a beetroot and spinach crop in Australia.
The HortiBot field robot

Rasmus Jorgensen and a team of Danish scientists developed The HortiBot during late 2009. The HortiBot is an autonomous platform that consists of hardware and software structures that are designed to collect data on weeds, and most importantly pests and disease activity (Sukkarieh, 2014). The robot has individual wheel controls using hydraulic motors and a DC (direct current) motor for steering, speed and wheel angle control. The engine is run using a control module that also controls the lift arm. The HortiBot system includes a tow hitch that allows an implement to be attached to carry out selective field practices, specifically those relating to weed, pest and disease issues. The HortiBot is still under development but a trial was carried out on an organic onion and shallot crop in Denmark, the robot was able to function by operating autonomously using a row detection system but researchers believe further development is required for operation on uneven topography and in different environmental conditions. The developers of The HortiBot believe cost in weed control can be reduced by 35% and studies show the robot has potential to become more economically viable in the near future compared to conventional tractor operated weeding systems combined with manual weeding (Swain KC, 2009).

The main features of The HortiBot are:

- 24-hour automatic function of repetitive farm practices for row crops with minimum use of Global Positioning System (GPS).
- DC and hydraulic driven motors.
- Agracom row detection vision.
- Provides high precision of selected farm practices.
- Efficient in that it uses minimal power for operation.

(Sorensen CG, 2005)

Figure 2. The HortiBot robot system developed by Rasmus Jorgensen and fellow Danish scientists.
The latest robot to be developed for the vegetable sector is The LettuceBot. An American company called Blue River Technology that is based in Mountain View, California has developed this model. The company formed in 2011 and by 2014 they had developed a fully functional robot system that recognised distinct plant types. The LettuceBot is a precision thinning system that provides growers with more control on yields and quality potential. The LettuceBot is currently used on lettuce, corn and soybean varieties. The robot uses a computer vision system to visually characterise each seedling on shape, size and colour. Calculations are made to identify which seedlings are to be kept to optimise yield. High concentrations of fertiliser are then applied at a desired spacing rate. The fertiliser is applied over the seedlings that are not wanted, also removing double planted seedlings and those that the robot believes will cause competition within a seedbed. The highly concentrated fertiliser burns the foliage of the lettuce seedlings by applying a band of spray. The fertiliser then remains in the soil profile for soil-enrichment. The LettuceBot is only feasible on lettuce crops that have been sown from seed rather than those that are transplanted. This is because transplanted seedlings (eg, iceberg lettuce varieties) are planted using cell planters that have selectable spacing rates that are usually accurate whereas a seed drill sowing fancy lettuce varieties can sometimes sow “doubles” causing competition and yield reductions. Large commercial growers in America state the investment is expensive but is worth it, as the robot optimises yields and overall quality (Blue River Technology, 2014).

![LettuceBot robot in action](image)

(Blue River Technology, 2014)

Figure 3. LettuceBot robot in action- Figure shows concentrated fertiliser spots are those seedlings that will be eliminated.
Intelligent Systems

Intelligent systems have been a major contributor to how we produce vegetables and how we get the end product along the supply chain in the shortest amount of time. Key intelligent systems seen in the vegetable industry are those mainly used during production (planting to maturity) and post-harvest stages.

Production Intelligent Systems

During the production stage, crop sensors are installed within a crop to gather information on soil moisture, temperature, humidity, wind, and plant health (leaf wetness). These crop sensors are connected to a main hub using wireless connectivity. The data is collected and analysed, providing growers with accurate information to make required steps to improve the overall quality and yields of the desired crop. This is important because most crop sensors systems are equipped with sensors that indicate leaf wetness and therefore with combined data categories, predictions are made on pest and disease activities, providing growers with reliable information on whether spray applications are required (John Deere, 2014).

Large companies associated with the agricultural and horticultural industry are collaborating together to develop intelligent systems that will be of important use to vegetable growers in the near future. Bayer CropScience have teamed up with John Deere to incorporate both company’s values and products to form one powerful solution. The cooperation has carried out intensive research and development with agronomic systems allowing them to form a digital tool that will assist growers to maximise yield potentials and overall profitability on each hectare produced. The performance of the crop can be interpreted using the digital tool and crop data that is collected by the combined use of products such as John Deere Field Connect (crop sensor) and overhead drones that use infrared technology can be analysed to indicate crop health, how the crop is currently growing and whether steps in irrigation or pest and disease control are required (Bayer CropScience AG, 2014).

Figure 4. John Deere Field Connect crop sensor installed in a vegetable crop.
Post-harvest Intelligent Systems

Post-harvest intelligent systems that the vegetable sector currently use and are seeing further development in are automated grading and packaging lines commonly used for brushed and washed produce.

Compac Sorting Equipment Ltd who were present at PMA Fresh Connections 2014 are market leaders in producing intelligent grading and packing systems. During the 1980’s Compac Sorting Equipment Ltd developed the first automated grading system for fruit. Due to this success, in 1997 the company released an automated grading system specifically designed for vegetables such as potatoes and onions. The automated intelligent system is used to sort vegetable produce by weight, size, colour, shape, density, blemish, defects and internal characteristics by using various forms of automated and computerised technologies (Compac Sorting Equipment Ltd, 2013a).

Wyma Engineering (NZ) Ltd also developed intelligent systems that are automated and highly sophisticated. The company currently develops automated sorting equipment that is used to clean and sort a range of vegetables particularly potatoes, onions, carrots, beetroots, broccoli and parsnips. In 1995 Wyma Engineering (NZ) Ltd developed a rotary brush washer for potatoes and carrots. Following this prototype model, in 1999 the company sold its first carrot-washing model to a grower based in the North Island of New Zealand. From this on-going success, in 2008 and 2009 the company released the largest washing and polishing machine in the world, the Mega-Polisher (Wyma Solutions, 2014).

Post-harvest intelligent systems are becoming very popular for growers in both Australia and New Zealand as the computerised features provide automation; simple functionality; efficiency and increased productivity in that the systems do not require labour for operation (Compac Sorting Equipment Ltd, 2013a). Mr Jivan of Jivan Produce Ltd believes post-harvest intelligent systems are and will be a very important asset for vegetable growers as efficiency and pack-out is optimised. Although fully developed models have been available for a relatively long period of time, Mr Jivan believes the technology needs to develop somewhat further to ensure inherent defects not seen by the human eye are removed during the packing stage. Mr Jivan stated that current equipment that is available does not handle brushed...
potato lines very well, brushed potatoes are a major product line for New Zealand based growers and Mr Jivan would like to see further development on this particular issue as he believes this will be of benefit. It is experienced in New Zealand that increasing costs in labour are a key liability for vegetable growers. Growers in New Zealand like Mr Jivan all believe rising costs in labour is going to have a relatively large impact on efficient running of businesses and that growers will soon move to automation such as post-harvest intelligent systems (Jivan, 2014).

Intelligent grading and packing line systems are providing vegetable growers with the ability to pack-out large volumes of product in a shorter period of time as manual labour has been removed. These intelligent systems ensure only quality produce is being sent out the farm gate. This is achievable through the efficient use of these systems. The ability to pack-out more volume is evidently the most important component for growers, as their main source of income is through sold products. Therefore growers with a high pack-out rate tend to generate a higher return on income due to the ability to supply quality produce to markets on a regular and consistent basis (Compac Sorting Equipment Ltd, 2013b).

Figure 5. Compac Sorting Equipment Ltd autonomous grading line.
Quality control of vegetables

Quality is one of the most important components of produce supply. Consumers require produce that is appealing, safe to consume and affordable. Produce that displays freshness; cleanliness; uniformity in shape, size, colour, and health (no physical damage) are all quality attributes that consumers look for in vegetable products, it is these product attributes that generate premium returns for growers.

Quality Standards required by majority of all New Zealand retail stores:

- **Freshness**
  - For majority of leafy vegetables, consumers look for produce that shows quality attributes of the product being bright in colour, cool, crisp, firm, hydrated (turgid), tender and young.

- **Cleanliness**
  - All vegetable produce must be free from dirt, dust, chemical and insect stains, and other foreign materials.

- **Shape**
  - The shape of produce must be uniform and typical to the variety produced.

- **Size**
  - The size of produce must be consistent to the market requirements. Leafy vegetables must be able to fit into a container while onion and potatoes must be above a specific diameter (e.g., >20mm or <20% variation).

- **Colour**
  - Colour must be uniform and true to variety. Consumers look for produce that is bright and attractive.

- **Health**
  - All produce must be free of physical damage (i.e., bruises, cuts, machinery damage and splits). Consumers look for produce that is healthy and attractive in appearance, therefore produce health is of significance when it comes to overall quality.

  (Turners & Growers, 2010)

The Australian vegetable sector believes meeting quality standards on all vegetables produced is very important as this influences food safety and premium market returns. This is mainly due to many supply markets being very strict on quality standards. Growers who produce top quality produce have the potential of supplying large supply markets. Growers who produce good quality produce tend to supply those markets that have leniency in quality.
standards and because of this, growers tend to receive lower returns for their produce. Important systems that regulate the supply of acceptable vegetables in Australia is run by Australian Quality Assurance Pty Ltd. This organisation puts systems in place to ensure consumers acknowledge that they are receiving produce that is safe to consume, high in quality and has been produced under a sustainable and controlled environment. Australian Quality Assurance Pty Ltd follows the HACCP (Hazard, Analysis, Critical, Control, Point) system. This system ensures shelf life; temperature; nutrition; product acidity; product handling and; potential pest contamination measures are controlled. By following the HACCP system, risk for food safety is reduced. Australian consumers are ensured they are receiving produce that is:

- Safe to consume
- Free of biological pathogens (fungi, bacteria, viruses, algae)
- Free of physical pathogens (glass, wood, stones, insects, Agri-chemicals, heavy metals and food additives)
- Has been produced in a sustainable and controlled environment

(Australian Quality Assurance, 2009)

Quality control of Australian produced vegetables is crucial. By following the HACCP system, the Australian vegetable sector is ensuring only healthy and safe products are supplied to consumers who are the drivers of the industry. Without these systems put into place, quality could not be defined and there would be an outbreak of food safety scares on a global scale. Growers who follow the HACCP system and other food safety accreditation programmes have the ability to supply large supply markets such as IGA, Woolworths, Coles and Aldi. Growers who are able to supply these large supply markets tend to generate a higher return than those growers who do not have the ability to supply large markets like those stated due to not meeting accreditation requirements (Australian Quality Assurance, 2009).

The New Zealand vegetable sector also follows strict protocols of quality control. The New Zealand government through AsureQuality provides food safety and biosecurity services on a global scale. The NZ vegetable sector also follows the HACCP system. NZ GAP and GLOBAL GAP are the two key auditing systems put in place for New Zealand growers (AsureQuality, 2014a).

The HACCP system is very similar for NZ vegetable produce handlers as seen with Australian produce handlers. Risk mitigation and identifying hazards are expressed to ensure only safe and high quality vegetables are supplied to consumers.

NZ GAP (New Zealand GAP) is a quality assurance programme that is owned by Horticulture New Zealand. AsureQuality carries out audits on growers on an annual basis. This system provides traceability and accountability for consumers for the produce that they are consuming. The purpose of this
programme is to reassure consumers that the produce being supplied is meeting quality standards of food safety. The programme ensures that good agricultural practices (GAP) have been followed. All major New Zealand retailers and fresh produce wholesalers support NZ GAP. If growers are not NZ GAP accredited, they do not have the authorisation to supply major retailers and wholesalers such as Progressive Enterprises, Foodstuffs, Turners & Growers and MG Marketing. Being NZ GAP accredited provides consumers with proof that the suppliers (growers and retailers/wholesalers) are providing acceptable produce (AsureQuality, 2014c).

GLOBAL GAP is the pre farm-gate standard set in place by Europe’s leading food retailers to provide their customers with assurance of food safety. Only growers that are certified can supply these European retailers. GLOBAL GAP certification allows New Zealand based growers’ access to the European markets because the certificate provides evidence that those certified growers are meeting GAP (good agricultural Practice) standards. Annual audits by AsureQuality are carried out on New Zealand growers for renewal of their accreditations (AsureQuality, 2014b).

The GLOBAL GAP standards include:

- Food safety
- Minimal impact on the environment
- Minimised use of Agri-chemicals
- Improved efficiency use of natural resources
- Improved efficiency of labour health and safety

As mentioned above, the quality control of vegetables by both countries is extremely important in that the final consumer is guaranteed to receive produce that meets quality standards, is safe to consume and has been produced under a commercial and sustainable environment.
Future trends and aspects

The future is set for efficiency and innovation. There is currently a large range of technologies that have and are being developed for the future of vegetable production. The reasons for these future trends are due to the reluctant increases in labour costs and labour productivity. Labour costs have increased significantly over the past 5 years and as a result, it is becoming more difficult for growers to seek quality labour that hold the required skills (Hari, 2014). Due to this, steps towards farm automation are currently being seen and many growers have already incorporated forms of autonomous technology into the farm business.

With the increase in labour costs, high compliance costs and lack of employment, the industry will soon see the introduction of fully developed commercial robots that will have the capability to carrying out various production, process and logistic practices (Jivan, 2014). New Zealand and Australia have experienced significant increases in labour costs. With current economic trends it is seen that future costs of labour will increase significantly due to a rise in numbers of enrolled agriculture and horticulture students who will be seeking career roles in the next 3-5 years. With an increase of skilled labour about to come through the industry, costs of hiring these qualified people will also increase due to added demand. Therefore looking at alternative options will be of significance for growers in the near future (Ministry of Business for Innovation and Employment, 2013).

Actions/ Recommendations

From analysing the information, Australia and New Zealand are well established in the vegetable sector. The sector is stable with large numbers of growers who remain active. Quality produce is being supplied to many large retailers both on a domestic and international scale. Qualified people are also increasing in numbers, which is going to promote demand for employment opportunities. This however will be beneficial as the industry, particularly the vegetable sector is lacking. If automation and robotics over-ride growers businesses due to increased costs in labour and compliance, qualified people are going to look for alternate industries to pursue their careers. It is recommended that Australia and New Zealand based growers need to carry out actions that will:

- Utilise autonomous technology that will enhance product quality and yields throughout the production, process and logistic stages (ie, GPS technology and intelligent packing lines).
- Utilise autonomous technology that will enhance efficiency and pack-out rate (ie, intelligent packing lines).
Utilise farm technology and robotic advances to a point where profits will be optimised but labour input will still be required (GPS technology).

Utilise autonomous technology in that it will reduce carbon emissions and overall impacts on the environment (ie, GPS technology, intelligent crop sensor systems, intelligent packing lines).

Conclusion

In conclusion, farm automation; advances in robotics and intelligent systems were always going to be introduced to the vegetable sector sooner or later. This generation is revolving at a rapid pace and technology is becoming a very important part of life as it is providing growers with the ability to digitally carry out a range of farm practices. Increasing efficiency while ensuring quality and yields remain high are important for growers. It is also important for growers to take into consideration that the incorporation of these automated technologies compared to convectional methods can significantly increase returns, as growers will be able to produce vegetables that have the potential to be higher in quality and higher in yields.

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Designed to attract the best and brightest students to begin a career in the fresh produce industry, the PMA A-NZ Career Pathways program connects the Australian and New Zealand fresh produce industry to future leaders by providing ten university students the opportunity to attend PMA Fresh Connections Conference and Trade Show.

Scholarship students have the chance to network with industry professionals at all levels of their career, at workshops, social events and on the exposition floor. An industry mentor is assigned to each student to answer questions, introduce them to other industry professionals and simply help them embrace the myriad of opportunities and rewards the produce industry has to offer. Students are also given pre- or post-conference assignments to help them prepare for the event and add more value to the learning experience.

The PMA A-NZ Career Pathways program forms part of PMA A-NZ's Industry Talent Initiative. It is run in association with the PMA Foundation for Industry Talent.

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