A Nuffield Farming Scholarships Trust Report

Award sponsored by

Studley College Trust

Intensive Horticulture – man versus machine

Bruce Harnett

December 2015

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NUFFIELD FARMING SCHOLARSHIPS TRUST (UK)

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A Nuffield (UK) Farming Scholarships Trust Report

"Leading positive change in agriculture. Inspiring passion and potential in people."

Date of report: December 2015

Title	Intensive Horticulture – man versus machine
Scholar	Bruce Harnett
Sponsor	Studley College Trust
Objectives of Study Tour	To understand the reasons for and inhibiting factors against the implementation of technology versus more manual production methods in horticulture. Establish the key opportunities and threats from technological advancement and the significance of the production decisions taken, as well as potential future developments for the UK ornamental plant industry.
Countries Visited	Japan, Israel, Holland, Belgium, Germany, USA and Canada

Messages

- Technological advancement is just one of several critical, interrelated factors that horticulture should not ignore.
- Labour issues and efficiency are key drivers towards technological advancement in production processes.
- Logistics and the finance required are principal barriers to investment in mechanisation.
- The advancement of technology will be rapid for horticulture over the coming years.
- Understanding a business, its position, finances and costings is essential before making decisions to incorporate technology.
- The future is not necessarily "Man versus machine" but a suitable balance of "Man in harmony with machine".

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DISCLAIMER

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**Figure 1: Sonic bloom -
Pacific Science Centre, Seattle WA (USA, April 2015**

Nuffield Farming Scholars are available to speak to NFU Branches, Agricultural Discussion Groups and similar organisations.

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1.0. Executive summary

The advancement in technology is just one of a host of interrelated factors which is bound to influence the activity and decisions we make within our businesses. My perception was that those who understand and anticipate the existence and implications for a factor such as this, will be more likely to survive and thrive. My intention, when embarking on my journey, was to be one of those who understood the reasoning and implications surrounding this key subject.

I visited a diverse range of over 90 organisations in Japan, Israel, Holland, Belgium, Germany, USA and Canada. The choice of countries was based on the desire to witness a variety of different global markets and cultures whilst exploring production within and outside of my immediate, typically labour intensive, industry: the ornamental plant sector of horticulture.

My aim, by means of interviews, surveys and general discussions was to gain an understanding for the reasons, advantages, disadvantages and barriers to implementation of technology versus more manual production methods. By technology I infer mechanisation, automation, robotics and information technology. I wanted to anticipate the opportunities and threats likely to shape our future that will emerge from the technological arena. I also endeavoured to try and understand the consequence of the actions and choices taken in production. Finally, I attempted to process the fountain of information collected and make some predictions and recommendations for my industry.

In addition to all preconceptions I previously held regarding the reasoning for, or against, the decision to employ technology, I realised there was even more besides: the key overarching reasons being within the scope of labour and efficiency, of course. Restrictions to mechanisation were usually associated with finance, production limitations, perception of quality and cultural factors. I uncovered a whole host of opportunities and threats, such as breeding innovations and developments in producing plants within enclosed environments. Opportunities cited will allow some businesses to progress whilst others simply weather the storm.

Although there is significant consolidation and increasing competition within my industry, I feel that there can be room for everyone who does sit up and take notice of their surroundings. Develop an appropriate business strategy and production system to suit whilst placing emphasis on marketing and customer focus.

I completed my travels with little doubt in my mind that the tide of technological advancement will continue to surge. It will simply wash over us if we do not look to enhance its power. We shouldn't view the prospects negatively, but be prepared to pounce on the opportunities it is certain to bring. Technology will reduce the reliance on labour in many sectors of horticulture. Often these are repetitive, low-skilled and sometimes strenuous tasks that few will relish in future. Technology is likely to create job opportunities faster than they are eliminated by its advance. Indeed, people and their skills will be more important than ever for businesses. Rather than man **versus** machine, it will be a case for harmonisation of man **with** machine.

2.0. Personal introduction

Figure 2: With my family in Cornwall (August 2015)

I was born in 1975 and now live on the site where I grew up at Kernock Park, Cornwall. I was the youngest of four children with two brothers and a sister. I wasn't considered academic in my younger years. In fact, my parents (Richard and Jan) and teachers at my primary school were a little concerned as to what to do with me. Following some early success in establishing a plant nursery, Kernock Park Plants in the mid 1980s, my parents somehow scraped together the money to send me and my older three siblings to Kelly College, Tavistock. I enjoyed the sport, the cadet force and led a couple of "Ten Tors" teams around Dartmoor as part of the extra-curricular activities. I started to do a little better academically with a new-found interest in sciences and geography and left school with some decent A' Levels. Onward I went to study at King's College, London University. With little idea of what I wanted to "be" I read Applied Environmental Science under the premise that it encompassed all my A' Levels, and which I quite enjoyed. I also knew I had an option to take a "sandwich year" in the third year. With that, I wrote to the professors at the Riverine Ecology department at the University of the Witwatersrand, Johannesburg. They kindly invited me to work there for a year studying the effects of rural developments, particularly damming on riverine environments of South Africa.

In my final year of university I was bouncing some potential options about my post graduate life with my Dad and he cunningly suggested that I should apply for a graduate placement scheme at University of Plymouth. Funded in part by the government, it was an opportunity to work alongside the family business at Kernock Park Plants but in conjunction with the university, whilst undertaking a part-time Masters in Business Studies and Management of Technology. Well, it seemed like a pretty good offer at the time, but I was quite clear that there should be no strings attached as far as taking on the business in future. I always knew, however, that Dad was quietly considering this as a succession opportunity! As a boy I was the one out of all my siblings who was most keen to earn a few pounds in the nursery during summer holidays, although looking back I am not sure how useful I actually was? I recall getting a bit of a grilling after weeding out some beautiful plants and leaving some lovely willow herb in the pots!

Things progressed from my post-graduate studies and placement and, a few years afterwards, I made the decision that I would indeed take on the company that is now Kernock Park Plants Ltd. It's

now my job to manage the growing business together with a management team which includes my wife, Jo. As I say, we live on site and have a young family. My son Isaac was recently 6 and my daughter Gwen is 3 years old.

Kernock Park Plants has just over 4Ha (10 acres) of protected growing area and produces over 13 million young plants each year: selling mostly to customers within the United Kingdom and Ireland, but also exporting to the European mainland. We offer over 1200 varieties spanning several areas of ornamental plants such as seasonal, herbaceous perennial and hardy nursery stock. The business employs approximately 55 full time equivalents, rising to over 70 in the peak production season.

In a "normal" year, apart from work, I enjoy spending some quality time with my immediate and extended family and catching up with our friends. When I do manage to sneak a few hours for myself (hopefully more frequently in the coming years) I might be found on the golf course. I try to sneak the odd trip to go skiing or snowboarding and recently have been learning to play the drums and guitar.

Figure 3: With my Dad, Richard Harnett, at Kernock Park Plants (December 2015)

3.0. Acknowledgements, Thanks (and Apologies)

Acknowledgments traditionally go at the back of a report like this, but I felt that there were so many credits due, that I should voice them before we start, rather than risk them being overlooked at the finish.

So, firstly many thanks of course go to both Studley College Trust for their invaluable sponsorship and the Nuffield Farming Scholarships Trust who posed the opportunity. Together they allowed me to make this happen, so I am exceedingly grateful for their support. I hope I can begin to repay them from this point onwards. Thanks also have to go to my Dad, Richard Harnett. It was he who made me aware of Nuffield, well informed by his friend Chris Older (NSch 1981). Dad suggested I apply as he was keen that I do as he has done during his years in the business: to go and travel, seek and bring back ideas.

Figure 4: Me in an apple orchard, Washington State, April 2015

I am also indebted to those who provided suggestions of countries and organisations that I should visit and helped establish the crucial contacts. Of course thanks have to go to the many hosts who contributed their time and thoughts, hosting me whilst on my travels. There are too many to mention, but you will know who you are. The proponents opened the doors that I did not know were even there, the facilitators let me go inside and the resulting report that follows is really just a culmination and interpretation of what I saw and heard from those I visited, so once again, thank you.

It seems that most Scholars not only have to thank their families for their support and encouragement, but apologise for not being there as much whilst embarking on the "journey" that is a Nuffield Farming Scholarship! So my sincere thanks and apologies go to Jo and my lovely kids Isaac and Gwen. They are a constant and increasing support for me, so unparalleled thanks go to them. You already know that I will try and be here a bit more over the coming years!

Before starting, I feel I should make a small confession for those who are about to read this report. The initial intention was to be brief and whilst I try to make the report succinct and to the point, missing out large swathes of detail, I realise now that I probably saw almost too many people and organisations, over 90 in total. I also realised the far reaching nature of the topic, so found it virtually impossible to chop bits out that I felt were crucial to include. I hope it is thought provoking and you stick with it to the end. I welcome your comments. Enjoy!!

4.0. Study background and tour

4a. Why Nuffield?

I'm sure I'm not the first potential Nuffield Farming Scholar to have been asked the following question at interview stage: "Why not just go and do it under your own steam?" I replied with something along the lines of - "… for the anticipation of amazing experiences and engaging with a lifetime network of influential people etc. etc....". I imagine this to be a stock answer amongst candidates, but it was only after being awarded a Nuffield Farming Scholarship and after being introduced to some of these people mentioned that I actually understood what Nuffield could do more specifically for me. I am aware that I'm essentially a second generation "farmer", managing a successful business over the past 10 years that my parents started from nothing over 30 years ago. I therefore feel some pressure to navigate the business through the next decade or two (or three) without messing it all up! I might take some solace in reading Jamie McCoy's (NSch 2013) Nuffield Farming Report "Opportunities for the small family farm", that it is usually the third generation that stuffs it up, so I will leave that honour to my children!

Without dwelling on this potentially gloomy vision, it was my intention to use this Scholarship to open my eyes as wide as possible, get my feet out from under my desk and go further afield than I would normally venture. Initially I wanted to try and understand where I and my company fit, now and in the future. I hoped that this would then assist me to make sound business decisions and help ensure that I can indeed navigate myself and my company through the inevitable ups and downs to ensure our success.

4b. Ticking clocks

Something that Rob Napier said during the Nuffield Contemporary Scholars Conference[1] (2014) in Sydney, Australia, resonated with me. Rob, a Director of Napier Agrifutures, a firm specialising in strategic planning for agriculture and agribusiness, said: "*Luck is where opportunity meets pre-emption.*" I interpreted this to imply that we can help to engineer our fate by understanding what is happening around us and make informed decisions based on our assessment of the landscape.

The way I see it is that there is a whole plethora of potential opportunities and threats for all businesses and industries. Let us imagine them as lots of ticking clocks, some with particularly "alarming" factors and influences, like mines that are set to "go off" at some point in the future. Broadly speaking, for the horticultural industry, I think these issues can be loosely grouped into the following generic areas:

- Political factors (national and global)
- Legislation/regulation
- Environmental factors
- Economic factors
- Human resources

[1] A week long "briefing" which all Nuffield Farming Scholars, internationally, appointed in the current year, attend.

- Social factors
- Technological advances
- Supply chain forces
- Consumer influence
- Competition

Clearly these broad categories will not be completely independent of each other; indeed interacting in a series of complex relationships. There are so many of these issues already at play, or waiting in the wings. The factors at play are usually far too large for most companies to be able to stop or manipulate in any way, certainly alone. We may be more sensitive to some factors than others, but all have the potential to significantly impact what we do in business. It is for business leaders such as myself to firstly try and anticipate which "clocks are ticking" and understand their potential repercussions on the business. Avoid the pitfalls and run with the opportunities. Don't be left behind.

Figure 5: The minefield, Arava – Israel-Jordan border (November 2014)

Figure 6: The ticking clocks analogy

It was interesting to stumble across a report (*NFU Public Affairs, 2002*) derived from a survey of horticulture commissioned by the NFU in 2000. It said that according to the survey, the indications were that that there was an abundance of challenges facing the horticultural industry at the time: such as increased competition from imports, continued restrictions on pesticides, waste regulations and reduced government support. Despite these obstacles more than 60% of growers surveyed at the time said they were confident about their trading future. This was reflected in the fact that they were embracing new, environmentally friendly practices, the organic movement and funding their own research to adopt new technologies. Many of the challenges it seems are still the same today, 15 years after that survey, and some of those who acted positively are probably amongst the strongest in their field.

4.b.i. My chosen "ticking clock"

You will notice that technological advance is one of those "ticking clocks" that I mention above. The sort of technology that I touch on will refer to many aspects of production including harvesting, general processing, logistics and growing of crops.

Technology is, as we know, moving apace in every aspect of our lives and I felt it essential to try and understand firstly where we are, in our horticultural industry, with regard to technology. To comprehend the motivations for certain businesses who chose - or are able - to employ more automated or technological practices than others; the pros and cons of employing different methods; the barriers, constraints and opportunities of either route; to recognise the best practice being utilised now and trying to get a glimpse of potential future developments. Further to this, I attempt to understand the potential implications that these decisions could have on the businesses themselves, the supply chain and of course the end-consumer who will buy the products that are manufactured as a result of the choices that are made up the chain.

During my initial visits I realised that I would need a way of recalling key points in an attempt to explain in a brief sentence or two what I was hoping to achieve during my Nuffield Farming travels. So, I wracked my brains one car journey in the Westland region of Holland for an appropriate acronym. I came up with **"RADIOS".** In a nutshell my main focus could then be recited by the following:

The Title "Intensive Horticulture – man versus machine"

Just to avoid any potential confusion, it is worth pointing out that my chosen title is not meant to be literal and is a play on a fairly common saying when referring to low-technology pitted against high-technology .

"Man" of course refers to Mankind or perhaps more specifically in my case **MAN**ual labour. "Machine" refers to technology, or artificial intelligence of almost any kind.

- **R**easons (for, or against technology)
- **A**dvantages
- **D**isadvantages (of employing certain strategies)
- **I**nhibitors (barriers to technology)
- **O**pportunities (and threats surrounding the issues)
- **S**ignificance (of the decisions taken)

Considering I chose my project title way back in July 2013 when applying for a Scholarship, not even knowing if I was going to be successful, I was glad that I had given it some thought at the time and it remains as applicable, if not more applicable today as it was then. This is not to say that I didn't and won't refer to other surrounding issues. I will, but technology and its implications was my central focus during my travels and will be at the core in this "melting pot" of discussion through this report.

4.c. My travels

I soon realised that the question of where to visit was not going to be an easy one to answer. When the world is your oyster, initial thoughts of visiting all sorts of dream destinations come to mind: South America, Africa, China, India - all were on the mental pin board. Subsequent to that were thoughts on how to start making the contacts in these countries. Who I would see and "*How are these places relevant to my study*?" I canvassed people I met at trade shows as well as work colleagues and friends in the industry with good knowledge and links. I realised that I simply could not visit everywhere with a time restriction of approximately eight or nine weeks travel in total. So I

started to concentrate on countries where I had the best leads: the ones that interested me most and those that I felt would fill the brief best.

A rough plan evolved into a more detailed one as I started to secure visits. The result was the following itinerary:

Figure 7: My travel companions – my son's Moshi Monsters!

Visit Date	Countries	Motives for choice
June 2014	The Netherlands	Where better place to start and "cut my teeth" on my Nuffield Farming journey! Holland is arguably the most progressive horticultural country in the world with a vast array of different types of producer in such a relatively small area.
September 2014	Japan	I was easily convinced to go to Japan after speaking to world renowned plant breeder Ushio Sakazaki. He described not only the horticulture, but the diverse Japanese culture and methods of industry in general. This is what I intended to go and discover.
November 2014	Israel	Israel has been a world player in fresh produce for decades. Primarily I wanted to see both ornamental horticulture and fruit and vegetable production in a challenging setting such as Israel, with constant battles in regard to water shortage and desertification.
February 2015	The Netherlands, Germany and Belgium	I realised as soon as I left The Netherlands in June 2014 that I would have to return to see just some of the companies I had missed. Now with more of a focus back on my sector of horticulture I wanted to see some leading Dutch facilities as well as delving into both Germany and Belgium which also have well-documented histories in horticulture.
April 2015	USA & Canada	North America, just as Europe, has a very well developed horticultural industry. I have been to see nurseries in the USA before now, but with this new found focus I selected a sample of some of the best production nurseries on the continent to try and understand their perspective on the matters in question.

4.d. The topic in context

In order to provide some perspective, here is a brief overview of the garden market in the UK and Northern Ireland and, more specifically, the ornamental plants sector of horticulture. I also provide a bit of background on my company, Kernock Park Plants Ltd, in order to understand what sort of business I manage and to gauge my viewpoint.

4.d.i. The market – ornamental plants

The literal Latin translation of "horticulture" is garden cultivation (*hortus cultūra)*. Horticulture is thought to account for approximately 9% of the UK's £25.8 billion worth of agricultural production. There are several sectors to horticulture including the cultivation of fresh produce such as soft fruit, protected edibles and field grown vegetables. The market that I live and work within can be grouped under the banner of ornamental plants which, broadly speaking, includes protected ornamentals; hardy ornamental nursery stock (HONS); bulbs and flowers. These represent approximately 20% of horticulture, so if I assume horticulture in the UK is worth approximately £2.32bn, then I deduce that the wholesale value of the ornamental segment would represent in the region of £464 million. I will of course refer to other sectors, industries and markets around the world, some with distinct similarities, others quite different to my own, but in an effort to be as succinct as possible, I will try to bring the relevance back to UK horticulture, sometimes more specifically the ornamental plant market.

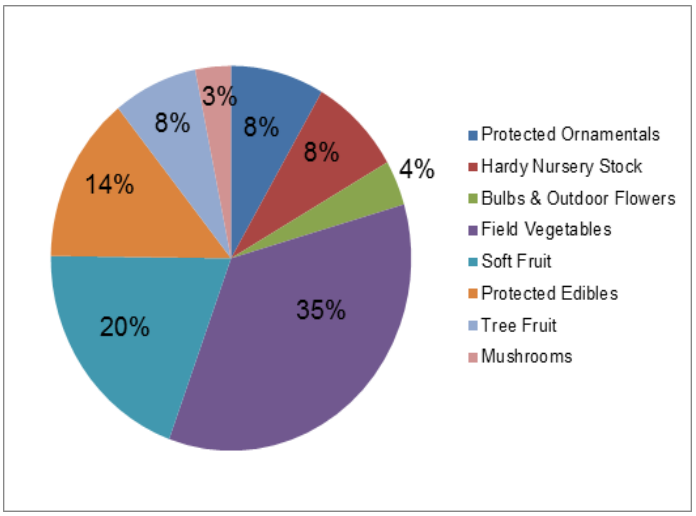

Figure 8: An indication of horticulture sector proportions based on AHDB levy fee apportionment (*Source AHDB, 2015)*

4.d.i.1. The garden market

Referring to the retail side of the industry that the ornamental plant market supplies, "the garden market" in the UK is one of the largest of its type in Europe. The UK has a long history and tradition of gardening being a passion and popular pastime for many. Currently valued at around £5 billion at consumer level, including the landscape and amenity sector, the garden market has been growing steadily over the past year by an estimated 8%. According to a recent garden products report from AMA Research (*AMA Research, 2015*), it is predicted to continue this underlying growth over the next 5 years. Ornamental plant sales represent about 25% of the retail value for this market. Other key product sectors, which will typically account for anywhere between 10% and 20%, are garden buildings, sundries, leisure, equipment and chemicals.

4.d.i.2. The retail arena

DIY multiples are the main outlet for garden leisure and equipment. The internet and progression from traditional mail order catalogue sales, is of course a growing channel for sales in this area, now accounting for 10% of the market. Grocery multiples such as Tesco, although only holding a relatively small market share in ornamental plants, have undoubtedly captured a larger slice of the market in recent years. Garden centres are still thought to account for a fifth of all garden trade and thus remain the principal outlet for living "green" products. Some retail centres have adapted to the modern consumer needs in recent years by increasing range and appealing to their audience by means of "destination" centres.

The emergence of "discount" supermarkets is not only polarising the UK grocery market, but retailers such as Aldi, Lidl and B&M are becoming increasingly stronger in offering "value" plants for impulse purchase whilst out shopping. This, I can only assume, will directly compete with the more traditional DIY store offering mentioned above. Also, the likes of upmarket grocer Waitrose are making a stamp on the impulse market as a perceived convenient alternative to garden centres. The well-known UK retailer Next has sights set on the garden market with development of its "Home & Garden" stores over the past four years to capture a corner of the garden and leisure market. Only time will tell as to whether home furnishings and garden products are really suitable together in the shoppers' trolley.

4.d.i.3. Weather

Garden sector sales have always been heavily dependent on the unpredictable prevailing weather in any given year, particularly in the key spring and summer gardening periods and more specifically the public holiday weekends and celebration days of Easter, Mothers' Day and May "bank holidays". The weather had a devastating impact during the summer and autumn of 2012 with excessive rain followed by extreme cold in early 2013. The industry in general seems to have bounced back from this period, with some casualties of course, but I think it is fair to say that whilst weather is absolutely critical, sales are also affected by a multitude of other factors.

4.d.i.4. Housing and demographics

It is not just the overall state of the housing market that will affect plant sales, the landscaping market in particular, but also the shifting demographic of those owning their homes and reduction in those that have a garden. This has been outlined as a particular concern by the Horticultural Trades Association (HTA) in recent years. Citing a report from the HTA, the Financial Times *(Chris Tighe, 2014*) highlighted the fact that there are now just 16.8 million people under the age of 45 who have a garden or allotment today. That equates to approximately 2.3 million fewer people in 2014 compared to 2007. This has been offset somewhat, by nearly 1 million more over-45s with outdoor space over the same period. Those in rental properties spend on average 55% less on their gardens than those who own their homes. Younger consumers don't always view their garden as somewhere to actually "garden" or relax, but see them more as a children's play area and place to socialise. Added to that, there is an increasing number of people with limited, or no, garden at all. Increasing numbers of the population living in flats and the shrinking gardens in suburbia following the popularity of paving over gardens to create parking spaces or reduce garden maintenance, are all

perceived as threats for the industry. Forecasters predict that these factors could impact the potential spend on gardening by up to £87 million per year by 2023, when the younger band of consumers reach the “core gardening” age group of 35 to 65 years old.

4.d.i.5. Consumer trends

On the flip side, although appearing more recently to have lost their momentum, initiatives such as "grow-your-own" have had a positive impact on plant sales over the past few years and exterior design trends such as the "Ground Force" were hugely influential in the late 1990s, a time of increased home ownership and economic prosperity and associated higher disposable income. Through this period and into the early 2000s the biggest economic factor for gardening seemed to be linked to pressure on the leisure pound and more focus on price point. Before this time, the ornamental sector was traditionally less price sensitive than that of fresh produce for example, but that trend has clearly infiltrated the ornamental plant arena in recent times.

4.d.i.6. Economics

No market can escape the effects of the economy and the garden market is no different. In particular hard landscaping and “big ticket” items such as trees and shrubs are often dictated by the number of new builds. The garden market has typically been quite sheltered from the brunt of economic downturns and it has been assumed that this is due to the fact that most people still want to “do up” their garden to a certain degree each year. Also, the trend for “staycations” in times of recession was thought to encourage expenditure in exterior decoration at home. In addition to this, the current ageing population has assisted the expansion of the consumer audience for garden products.

The garden market was estimated to have grown by 7% in 2014 compared to the previous year. Growth is expected to continue, but slow down, in part due to the fact that much of the recent growth was due to pent up demand deferred during recession and following those poor weather years, but also due to the assumption that many product sectors are in a phase of maturity. However, recent growth areas such as permeable paving, artificial grass, solar lighting, vertical gardening and garden rooms are predicted to allow for some anticipated modest growth.

4.d.i.7. The supply chain

The well renowned nature of the garden market in the UK has of course attracted importers, predominantly from the European continent, but horticulture in total provides employment for an estimated 40,000 people in the UK, many of those jobs of course in rural areas *(Chartered Institute of Horticulture, 2015).* This industry in turn sustains many supporting industries such as agrochemicals, sundries suppliers and processing companies. The structure of the supply chain in the ornamental plants sector is still relatively diverse compared to that of the fresh produce sector, for example. Wholesale production of any scale can be likened to manufacturing. There are primary producers contributing inputs (cutting, seed, bulb, tissue culture, multiple or young plant), and

subsequent value-adding processes by one or more intermediate producers before the plants are ready for retail or the amenity market.

The wholesale ornamental plant production industry that supplies the garden market is a very complex and fragmented industry made up of an abundance of relatively small and medium, often family, concerns operating on a fairly local scale. The most common and visible of these smaller enterprises to the general public will be the grower-retailers who produce finished plants from seed or cuttings, or purchase "young plants" to grow on and sell directly from the nursery. The ornamentals sector is experiencing the same pressures seen in more mature sectors of horticulture in terms of supply chain forces applied from both customers and competitors, which is likely to lead to further consolidation and streamlining in the supply chain. Horticulture in general has not had the level of government support often enjoyed by more mainstream agriculture with schemes such as the Common Agricultural Policy (CAP), which you could argue has prompted a survival instinct for many involved in horticulture over the years.

No single company would have more than 5% of the UK wholesale market share and the larger primary producers are more likely to have export business. The largest grower-finishers will procure seeds, cuttings and young plants and grow them to a finished state for the retailers. The intricate nature of the industry is further muddied by the fact that there are so many imports of young (pre-finished) plants as well as "finished" plants; particularly from countries such as The Netherlands, Denmark, Belgium and Germany, the latter having the largest domestic garden market in Europe.

4.d.ii. Kernock Park Plants – where do we fit?

To help you understand my perspective at Kernock Park Plants compared to other companies mentioned within this report, we are a young plant propagator producing and selling in the region of 13 million young plants per year across a range of more than 1200 different varieties. Kernock offers many unit size and specification variations and the range is broad including many ornamental seasonal/summer patio plants, herbs, alpines, perennials, grasses, woody shrubs and more besides.

Figure 9: Kernock – A wide range of product

Figure 10: Kernock Park Plants Ltd. - Pillaton, Cornwall

So, the site has been built up as we have grown since my Mum and Dad established the company in the early 1980s. We produce on four hectares (10 acres) of glass and polythene-protected growing area, split into blocks, each of them levelled on construction, but "dotted" around our sloping 7-hectare site. It always makes me smile that Dad would advise people on the ideal siting of a glasshouse nursery as an ADAS advisor. One of the first things he would recommend was to start with a nice, flat site. It's a shame he did not take his own advice!

We are amongst the largest ornamental plant propagators in the UK, but in comparison to some continental European producers we could be considered fairly small. I cannot be completely sure, but simple calculations indicate that our production accounts for approximately 0.85% of the ornamental plant production in the UK, but there are of course significant imports from outside the UK which contribute to the plants part of the garden market mentioned above.

As far as implementing technology to assist our production, we have always tried to introduce systems which aid production efficiency and quality. Due to the limiting factors of batch size, variability, timing and topography, we are relatively low-tech compared to many of the largest global producers. I would say that we have good, but fairly standard environmental control. For example, we measure light, heat and irrigation for certain crops in greenhouse locations. We have a couple of potting machines, tractors and towing devices. The nursery is heated by two biomass boilers, which combined produce 4 MW of heat. We have some supplementary lights, mostly sodium lamps, but are also currently trialling LED alternatives in various departments. We have a comprehensive, bespoke-designed nursery management database system which uses barcode scanners and manual input to help run the nursery processes from production forecast to invoice. We remain highly reliant on labour and labour costs are in the region of 34% of our near £4 million turnover.

This labour comes in the form of approximately 55 full time equivalent employees, including production and administration/management personnel. This rises to about 75 in the peak season mostly from overseas staff who live in on-site accommodation between December and June. This is augmented by local agency labour which can be called upon at short notice.

Whilst I have tried to be objective in my questioning around the subject and will try to represent all views, I make no apology for the fact that I will inevitably be somewhat biased towards trying to understand what the future may bring for me and my business: a small/medium primary producer of a diverse range of ornamental crops.

5.0. The RADs - Reasons, Advantages and Disadvantages

One of the first questions I wanted to get straight in my mind was: why do certain producers choose to employ some level of technology as opposed to people? I knew what I "thought" but I wanted to start afresh and prove or disprove any preconceptions. So essentially in this chapter I will talk about the "**RAD"** part of my **RADIOs** acronym…. the **R**easons, or at least the benefits and **A**dvantages as well as the **D**isadvantages of chosen production methods whether they be more manual or technological. It is impossible to separate them completely as they interlink in a complex mesh, so I will attempt to simply group the **RAD**s as I go along.

5.a. Labour

I start intentionally with labour because as soon as I mention my project title with anyone, before being able to explain in any detail, the first assumption will often be that I am an advocate for automation of all procedures that are currently undertaken by manual labour. The first question I was asked on visits was often: "*Do you want to see the machine that helped me eradicate XX people from my process*?" Now whilst the machines in the shed, yard or glasshouse were really interesting and will form a key part of this report, I was also interested to understand if the decision to mechanise is as fundamentally based on labour as I may have assumed. In order to answer that, I needed to understand a little about the perceptions and realities of labour in the market.

There are of course many regulations enforced by governments and other ruling bodies that affect the status of labour in all countries. National regulation will encourage or discourage potential employees (both indigenous and immigrant), to seek employment within a country and/or within a specific industry. Government policy clearly influences the availability of labour for business. Legislation can also dictate the appeal and ability for those businesses to actually employ available labour and I suggest that the costs involved for various labour options are one of the key factors in their appeal.

5.a.i. Availability and cost

In many parts of the world the availability and lure of other industries is currently hampering the efforts of the horticulture industry to attract potential employees. Whilst travelling, it seemed that many of the most successful horticultural countries have often based their competitiveness on the availability of a reliable stream of relatively cheap labour. I will mention them in this section, but first I start with a UK context.

5.a.i.I. The UK context

In the UK it seems that the initial fears in horticulture following the termination recent of the Seasonal Agricultural Workers Scheme (SAWS - a scheme that allowed growers to employ migrant workers from Bulgaria and Romania), have not yet been realised to the devastating extent that some commentators had predicted. British Growers Association (BGA) chief executive James Hallett back

in 2013 urged ministers not to terminate the scheme, but those calls fell on deaf ears (*James Hallett, 2013).* There is, however, continuing uncertainty regarding the future access to an adequate supply of reliable labour with particular reference to seasonal migrant labour. The perception for some is that there are insufficient workers to be found here in the UK to help meet the growing demand for British produce and to enable growth that will support the investment that is required in the industry. There are therefore calls from many bodies such as the BGA and National Farmers Union (NFU) for the introduction of a successor scheme to SAWS. These bodies feel this would make seasonal agricultural work in the UK more accessible to foreign students (*Philip Case, 2014).*

NFU president Meurig Raymond also advocates a change in the culture of how "agri-business" is portrayed. He feels that many people in the UK perceive horticulture to be an old-fashioned, menial, hard, dirty and uninviting career choice. Whilst nobody will deny there is certainly a large proportion of manually intensive, often repetitive tasks in agribusiness, Raymond argues that there are "*lots of highly skilled jobs in the industry, with good career progression opportunities*". Unfortunately, I share the concerns regarding the negative image conjured in many people's minds when considering horticulture as a career. The reluctance for many people to even get dirty hands whilst working in heated greenhouse conditions is a challenge for our horticultural industry. Horticulture faces stiff competition from the potentially more attractive and growing service-based industry; even other production-based, factory or warehouse work appears to be more appealing to many prospective employees.

It seems that, with a newly enforced national "living wage" coming into effect at a rate of £7.20 per hour from April 2016 (compared to £6.50 in April 2015), and schemes such as "auto-enrolment" pensions, UK horticulture will be forced to be more aligned with other industries, at least as far as wages are concerned. I cannot pretend to understand all the consequences of this legislation for the future of intensive horticulture. But if we want to really encourage more people to choose horticulture as a career, I feel we need to offer enticing job opportunities and remind people of the vital role that horticulture plays in enriching the environment and promoting health and quality of life. Part of encouraging people into horticulture will be to educate the educators in all levels of academia and provide courses of excellence. It seems that many teachers providing career advice lack the depth of awareness of the job opportunities in agribusiness and are more likely to steer school leavers and potential apprentices away from horticulture as a career path: only choosing agriculture and horticulture as a last resort! The fact that agribusiness can be wholesome, often outdoor, work involving research and development of new technologies to green or feed and enrich the world is often overlooked. In the meantime, some businesses are making arrangements to address their potentially untenable dependence on labour.

5.a.i.2. Japan

Minimum wage in Japan is variable depending on VISA status but usually within 600-900 Yen (£3.25-£4.90). Some immigrants will come into Japan on agricultural VISAs and it is possible to pay below the minimum wage. Consequently this is often used as a loophole by employers in some sectors to enable them to employ workers from countries such as China, Thailand and Indonesia. Unemployment is currently at less than 4%. With an ageing and reducing population this is set to reduce further and, anecdotally, some employers suggest it is harder to find good, skilled labour. The

government still appears to be trying to crack down on immigrant labour, as having too many migrant workers in Japan is seen as a social issue.

Figure 11: Taka Nakamura, apple farmer (Japan, Sept. 2014)

Yuki Watanabe of the Clema Corporation, a clematis and hellebore grower situated at the foot of Mount Fuji, said that it's not very easy to get good staff and train them. Some staff has been with them for over 30 years and there is a danger of a vacuum being left as they retire.

Mr Takanobu Nakamura (Taka), the president of Azumino Family Agri-Products, an apple farmer in Japan near Nagano, suggested that the availability of labour for him, however, was not such an issue. His labour accounts for 50% of turnover, but he takes on travelling "wannabee farmers" and said that they are not too hard to find. The Japanese youth also seem to want to get closer to nature, almost bucking the trends of the techno age. I was given the impression by others as well, that many younger people in Japan are prepared to work voluntarily in agriculture and will sometimes pay to get experience in land based industry such as horticulture.

5.a.i.4. Israel

In Israel the rate of pay is apparently similar to equivalent industry in Central America and Portugal: approximately 25 Shekels (£4.20) per hour for a standard worker. The minimum is 23 Shekels per hour for imported labour. Many workers in Israeli operations seemed to be women, particularly in the highly dextrous tasks, often coming from the Bedouin community. At Cohen Propagation Nurseries in Kfar Ha'nagid, for example, owner Asaf Cohen told me that they employ up to a maximum of 540 staff in the peak of the season and that included 170 Philippine students in recent years, which apparently cost a little more than standard labour but are usually ultra-keen.

The restriction for this system is that workers need employment for 11 months and Cohen's peak is usually 6 months on their ornamental unrooted cutting facilities. Temporary Thai workers are commonplace around the farms of Israel, but visa restrictions can be onerous as the government is tightening up on the quantity of imported labour depending on crop and farm area. They earn in the region of 170 Shekels (£31) per eight hour day including accommodation, electricity and food requirements. Some companies I visited in Israel also had experience of migrant labour from countries such as Kenya and Eritrea, but anecdotally the work ethic was often not suitable for such an intensive industry.

I heard about new employment tax laws for foreign workers in Israel that were to be implemented at the start of 2015. These new rules may affect the attractiveness for migrant employees to come to Israel for work. In Israel most local people are apparently less interested in horticulture as a career - as is the case for many developed countries around the world. The overall feeling I took away from Israel however, was although there seemed to be plenty of labour options, government intervention and diminishing employer rights and associated administration required for human

resources within the business was the least appealing factor for employment of staff, driving some organisations towards a mechanisation response. Otherwise, attention on technology was still relatively limited.

5.a.ii.5. North America

A preconception that I took to the USA is that the Americans would be “Mexicanised” more than mechanised. Having visited many companies in and around my field of interest, it’s true to say that although there were similar pressures for some in finding suitable labour, in the main, there is a plentiful supply of reliable, reasonably low cost labour, not just from Mexico, but also from elsewhere such as Africa, The Philippines, Burma, Vietnam and other Hispanic regions of Central and South America. Having said that, as with all countries visited, there were still perceived challenges for some businesses to find an adequate supply of suitable labour.

Figure 12: "Mexicanisation” – (USA, April 2015)

Terri McEnaney, president of Bailey Nursery Inc., wholesale grower and finisher of a wide range of ornamental plants and trees based in Minnesota, USA, suggested that one of the biggest challenges for the future as far as she is concerned is the labour force. She perceives there to be less people in the labour pool and even fewer people who are happy to do the work. Many of the current workforce are happy to work in greenhouses or on tree nurseries whereas they perhaps used to work farmland. Now less people are working the land and the next generation, both locals and immigrants, are no longer keen to work in horticulture. Her question is: where is the next generation of willing workers coming from?

Add to this the fact that in the USA in particular, the verification procedure for recruiting new employees, even on the guest worker schemes, is apparently cumbersome, due to the extent of illegal migrants with fake details seeking employment. Some statistics state that up to 50% of the agricultural labour in America is "undocumented". Many believe that the true scenario could be significantly higher than this. Federal laws on immigration, known as Comprehensive Immigration Reform, are attempting to legalise the current undocumented workers, whilst trying to restrict the flow of new immigrants. Van Belle nurseries, near Abbotsford, Canada, mainly finish flowering shrubs and perennials. Vice President Devonne Friesen cited the increased regulation south of the border as a motive to at least future proof themselves when considering future technology when constructing their new glasshouses, even though the availability of staff is not an issue for them at present.

I met Manoj Karkee, PhD Assistant Professor at Washington State University IAREC (Irrigated Agriculture Research and Extension Center). Dr Karkee leads a research program in the area of agricultural automation and mechanisation at WSU CPAAS (Center for Precision & Automated Agricultural Systems), with particular emphasis on machine vision, sensing and control technologies for agricultural automation. He has been working on numerous sponsored projects in this field,

including apple crop load estimation, field robotics including apple and cherry harvesting; fruit tree and berry bush pruning; hop wire tying; weed detection and treatment in vines and agricultural system; modelling, simulation and control, such as water and nutrient stress-monitoring in potato crops.

Manoj told me that the State of Washington alone produces an average of 10 billion apples a year, each one picked manually. This is equivalent to 60% of American apple consumption: enough apples to go around the world 20 times! He believes that *"In 10 years, because of decreasing labour supply and increasing labour cost, it will be inconceivable to think that people will be moving their hands 10 billion times or more to harvest apples for the US market."* Manoj showed me that they were digitally mapping the canopy of vertically grown apple trees to capture the size, mass, quantity and precise 3D location of the fruit. Developers at the university were attempting to replicate the human hand action using a robotic hand, an "end effector" with 3 fingers. The current model is about one year away from commercial prototype.

Figure 13: Dr Karkee demonstrating an apple load mapping prototype (USA, April 2015)

Monoj said that more and more products such as asparagus are now originating from Chile and other importing countries due to labour cost. In his view, there remains a questionable future for the citrus, berry and apple industries in America. More perishable crops have some protection from the import invasion. Cherries for example are best grown and sold locally, as transit times should ideally be short as they do not last for more than 15-30 days in optimum condition once picked. If cherries are going to be consumed in the American summer, they need to be produced in close proximity to America. If labour availability is reduced and/or becomes more expensive, as is almost inevitable, then the price of cherries will have to follow the increased production cost. The other possibility is that prices will be maintained, at least in part, by advancement in technological practices such as mechanical harvesting. The current method of agitating the canopy to harvest soft fruit apparently needs improvement to prevent such high wastage in order to make it acceptable practice in future.

5.a.ii.6. Europe

In mainland Europe, my first impression was that it didn't appear that labour was in short supply especially where there was a good source of reliable, specialist agency labour. It was suggested, however, that if salaries in Eastern Europe start to match Western Europe there will be less appeal for migrant labour to seek work in the west. It is this disparity in wage, often enforced in western countries by minimum wage legislation, which can draw labour, thus affecting its availability. Manfred Heekeren of Jacob und Heekeren Staudenkulturen, a perennial plant producer, told me that until recently the minimum wage rates in Germany were nearly one Euro less per hour than in neighbouring Netherlands. This had an effect on the draw of businesses - such as his - being so close

to the border in Rheurdt. Many workers were seeking work just 20km away in Venlo and took home at least €200 more per month in their pay packet. This disparity has closed now and both are in the region of €8.50 per hour, so the draw to cross the border for work he assumes will be less in future.

It was also apparent that most people questioned on my European excursions felt that local labour, even the unemployed faction, is not generally interested in pursuing careers in manual horticulture. Just as for Israel and USA, I heard examples where dealing with personnel issues was a major factor in pushing some producers towards automation, regardless of costs and availability of labour. I got the feeling that, in some circumstances, business leaders were using systems and mechanisation to actually take the "power" away from the employees. I'm not suggesting that they were disregarding the ability of the workforce, but perhaps felt that they did not want to rely too heavily on the staff in case of potential change of circumstance which they might not be able to control.

I spent a thoroughly interesting afternoon with John Bijl the founder of Vitro Plus located in Burgh-Haamstede, Holland. John manages a very successful laboratory fern production facility that he started from his bathroom 25 years ago. The company produces 80% of the world's commercially produced ferns. John explained that in the early days, as the costs and percentage of labour increased for the business, his business partner wanted to move to Eastern Europe to take advantage of the lower labour costs. John was defiant and resisted this temptation as he wanted to stay in Holland. John was forced towards automation enabling them to increase consistency of their product, but more significantly reduce the pressure of labour costs and compete by lowering the sales price to their customers.

Figure 14: John Bijl, founder Vitro Plus (Holland, June 2014)

If, for whatever reason, horticulture is not attractive, or the labour pool is limited, I gleaned from my travels that businesses around the world were more likely to look towards technological advances to reduce their reliance on manual labour.

Perhaps the more critical factor in this decision was based on costs. I heard evidence of governments across the world increasing the onus on employers and employees to help balance their Treasuries' finances and this fact was implied to be significant when considering the reason to mechanise as opposed to employing labour.

5.b. Other labour factors

Just as I intimated in the market summary on previous pages, the UK ornamental plant sector is a diverse and complicated industry. The labour situation in horticulture is similar to that in other forms of agriculture and is therefore equally as complex. Businesses are often family run, particularly in the medium to smaller end of the scale, which means that some owners and employees work in the business as a part-time vocation. Time devoted to the business may vary during the year and owners and employees alike may have supporting streams of income. The seasonal nature of horticulture clearly affects all sizes of business. Large numbers of workers are required for varying periods of time. Sometimes these periods can be very short, just a few days or weeks for certain tasks, but more typically a few months.

Whilst travelling I also heard some concerning statistics regarding the age of owners within agriculture in general. In Holland I understood 50% of farmers are over 45 years of age. In the USA the average age of farmers is 65 years old and, for every farmer under the age of 25, there are seven above the age of 72! In Japan, 40% of farmers are over 60 years of age. In Israel the average farm owner is 61 years old and in the UK, the average age is in excess of 58. Whatever the statistics, the assessment is that those running global agribusiness are an ageing group of people, some of which are losing the enthusiasm to continue in their roles. As described above, new entrants into horticulture, just as for agriculture, are not in great supply in many of the countries mentioned, particularly for management level.

So it appears that the lack of time to be able to devote to the business, the constraints of seasonality for consistency of labour, ageing owners, managers and lack of succession are just some other labour factors that I feel may push business towards employment of technology as opposed to people.

5c. Efficiency

“Efficiency” is a fairly broad term. In production, being lean and efficient can be defined as the conversion of minimal inputs to create a desired output of an appropriate quality, with the minimum of resources - whether these be materials, energy, labour or finance for example. Most of the technological examples that I saw in operation on my travels were designed with overall efficiency in mind, but I feel it useful to try and identify the underlying aim for implementing technology or manual labour rather than banding the motives into the overarching “efficiency” bracket.

5.c.i. Speed and endurance

Speed certainly came top of the list, when asking people why they had implemented their various technology strategies. It is often assumed, but not necessarily the case, that companies who employ technology want to reduce labour as described above, but many are actually more concerned with increasing proportional output, particularly in an industry such as ornamental plants where the season is condensed into such a short period of time.

In view of the fact that the act of inserting cuttings into their rooting cell is an activity where most time is spent in my own nursery, I couldn’t conceivably research my topic without visiting one of the

forerunners of those who have implemented propagation technology into their facilities. Deliflor, located in Maasdijk, Netherlands act as one of the main rooting stations for Beekenkamp which is based just up the road. They propagate items such as cut flower chrysanthemum and dahlia. Cuttings are imported from mother stock locations, often in Africa where they are pre-treated with hormone powder. When they arrive at the nursery they're sorted and placed on belts that feed 28 separate ISO "sticking" machines on the site I visited. The machines can stick 3500 cuttings per hour which is at least 20% faster than the fastest people in the company, and 40% faster than the average worker. This speed can of course be sustained over a longer period of time by robots, with shifts normally operating from 5am to 9pm. Before the machines, there were 70 people employed in this area, now there are just 10 permanent staff and up to 20 more from agency sources who generally stick the smaller batches of cuttings below - 10,000 pieces - as these are less viable to put through the machine due to changeover downtime. The payback time for a machine costing in excess of €80,000 is calculated to be 5-6 years.

Figure 15: ISO insertion machines - Deliflor (Holland, Feb. 2015)

Figure 16: Vibrating belt and pickers – Deliflor (Holland, Feb. 2015)

Wim van der El, R&D Manager at ISO Group, the company that makes many of the sticking machines in operation, told me that there were several companies around the world that are employing this technology and it is no longer restricted to large cuttings like I saw at Deliflor. Dianthus and even small, relatively soft Calibrachoa cuttings are being inserted at certain locations in Europe. The current limiting factor for the varieties that can be inserted in this manner is that they need a long enough stem, or "leg", below the last leaf node. This currently rules out sticking plants where the stem is not long enough as the machines find it hard to pick them up and insert them appropriately.

Although much of the robotic technology that I saw in action was clearly faster than an equivalent person, I realised that many proponents of automated options were not actually referring to the like-for-like speed of the activity, but the consistency of a well set-up mechanical alternative which, like the ISO machinery, does not tire and theoretically can go on indefinitely if supplied with the input units required.

There is also the fact that some jobs are simply too physically demanding for people to carry out for any length of time. Whilst in North America, I saw two nurseries which were able to demonstrate

their HV 100s, known as “Harvey’s”, from Harvest Automation, a material handling company based in Boston, Massachusetts. Harvest Automation is focussed on agriculture in order to solve what they perceive to be an acute labour crisis across the sector. They cite labour availability, tightening employment law and environmental regulation as key reasons for creating solutions to reduce the reliance on manual labour, but also mention the benefits on health and wellbeing of the workforce. Harvest has served over 20 nurseries that have employed HV 100s. These are essentially pot plant moving robots which normally work in groups under supervision and can be set to space and re-space pots as they grow. They’re guided by magnetic strips that are laid down in the locations and can sense their location according to these strips, using sensors on their body. From what I witnessed, Harvest robots seem to be pretty practical for the customer to use, reasonably easy to programme, flexible and easy to deploy. There was little need to change existing infrastructure or workflows. They cost is in the region of $28,000 per robot.

Terri of Bailey Nursery, mentioned earlier, had purchased 4 HV100s and nicknamed them after Top Gun characters: “Goose”, “Maverick” etc. Terri says that the robots are not necessarily faster than a human and are not suitable for uneven ground situations, but just keep going at a constant speed, avoiding physical exertion for their staff and releasing labour to other areas of the business. Maintenance of the robots can be challenging, but she says Harvest Automation is excellent at assisting the induction and continued maintenance of the robots.

I also saw these robots in action at Altman Plants’s Perris site in Southern California. Altman Plants is America’s second largest ornamental producer, that offers a huge variety of cacti, succulents, annuals, perennials, shrubs and other specialty plants. Jim Hessler, the general manager for the region, told me they have nearly 700 hectares (1700 acres) across 20 sites in 6 states of America. There were 10 million plants sitting on the Perris site when I visited and they despatch 20-30 million plants from this site alone. Seeing the HV 100s working in a group of five, I could really see their effectiveness. Altman’s small herd of robots, each given names such as Batman, Robin and Wall-E, needed constant supervision as they spaced pots of garden roses. Left to their own devices they couldn’t handle pots that had fallen over; pots would become stuck in their grippers and obstructions or other robots would appear to stun them into inactivity. Why do the pots need to be “spaced” you might ask? Well, in addition to the more obvious reason that spaced product occupies more area, which may not be available at the time of planting, laying newly potted plants pot thick, or "can tight" as I often heard it referred to in the US, reduces the heat loss from the bed and encourages optimal root growth. So once they are more fully grown and have rooted out sufficiently, they need spacing to increase light around the canopy.

Whilst viewing the robotics in action, I asked Nicholas - who was supervising the team of robots - to show me how he would have done this job manually. He picked up two of the 2 gallon (9L) rose containers in each hand and laid them according to the spacing pattern desired. The ones I saw had just been watered and I estimated that they would have weighed about 6 kg per pot, so at least 12kg in each hand held by a few fingers. Imagine repeating that hundreds of times a day and I can completely understand why the workers don’t relish the task.

Jim, said that the Harvey’s are approximately the same speed as one person going flat out, but the key is that they are doing a job that is incredibly strenuous for long periods of time, a job that

nobody really wants. Barring technical issues, they do the job with the same precision and accuracy on the last pot that they did with the first. The robots are occupied for up to 11 months of the year on this site and payback for Altman was in the region of 15 months. HV 100s can move pots as small as 1 gallon, but as the pot size decreases, of course it is harder to justify the time spent using the robots compared to a person who can pick two, or even 3 smaller pots in one hand.

Figure 17: HV100 robots in action – Altman Plants (USA, April, 2015)

Figure 18: The manual method (USA, April 2015)

5.c.ii. Quality

I realise that quality can be subjective. In my field, quality will often relate to factors such as reliability, uniformity and consistency within and between batches of plants.

Whilst in Israel I visited the Hishtil Nurseries sites. The Ashkelon site provides over 20 million seedlings and grafted young plants to growers. Alon Perry told me that as far as Hishtil were concerned, mechanisation has many benefits, not least the fact that it decreases the risk of transferring infection caused by manual handling of the product. In this trade, reducing the risk of virus contamination is key. Watermelons for example are unlikely to yield viable fruit if infected by certain viruses. Alon spoke about machines that have been developed for grafting but said that the significant cost of the machinery on the scale required and the large variation of product counted against this automation decision, particularly as labour costs are not so high that they are prohibitive. I saw similar grafting machines that were sitting unused around the world such as at Plantenkwerkerij Vreugdenhil B.V. and was informed that the current machines at their disposal do not produce a high enough quality output: the wastage is too high and downtime excessive.

Again, whilst in Israel I saw machines used in the harvest for shaking dates into a net, and effective use of a new image-based sorting system for both dates and peppers at Kedma packaging centre in Arava. In this case it allowed a 50% reduction of labour for that particular task. One of collaborative owners of the packing centre told me that of course these advances helped to save labour, but more importantly it enabled them to make the harvest on time for the optimum quality and yield.

5.c.ii.l. Precision and uniformity

The choice for technology against manual labour was high on the agenda when I visited Jordan Valley Herbs. Lori, owner and son of the founder, agreed that the cost of employment was not yet a determining factor in Israel, but precision was key. He believes the quality of hand prepared herb product is often superior to what can be achieved by machinery when referring to the precision required for choice of stem length or leaf size for example. He saw the advantage of utilising machinery for packing, so purchased a machine for packing bunches of herbs. I saw the machine packing tarragon to a specification known as "cut 19" destined for the UK market. These are 19 cm long cuts, 30-35g in each bunch and packed 32 per batch. The machine saved just one person in the process, but with a far more uniform output enabling him to service high-end customers and once it is more refined Lori hopes for more savings.

Figure 19: Herb trimming and bunching machine, for high end precision cut herbs - Jordan Valley Herbs (Israel, Nov. 2014)

Seeing the indoor pot rose production at Nolina, based in Woubrugge, Netherlands, it could clearly see the uniformity of the crop - created predominantly by machine. The process of production is a cyclical, first-in-first-out system where the roses are grown on automatic moving tables that transit through the nursery through different climatic zones. The pot crops are trimmed during their life and the trimmings are collected, sorted, clipped and stuck by robots into their new pots ready for rooting. Once the pots are flowering and ready, they reach the end of the line and are prepared for despatch. As well as the quality factor, Marcel, the owner director, told me that the system's constant production enables them to retain their best staff all year round.

It is also clear that certain technology such as lighting during pot production of campanula, for example, is key for some producers such as Piet Keuvenhoeven owner of R.C. Keuvenhoeven en Zoon, finisher of pot grown campanula and hellebore, located near Poeldijk, Netherlands. He believes that if he didn't use supplementary light for his campanula crop as he does, not only will the quality and uniformity not be up to standards expected, but he would simply miss the peak sales window that begins in February, compared to a naturally grown pot plant. He is also confident that the price that he is paid reflects the energy he invests in the crop. There is an argument that some treatments such as artificial lighting, or growth regulation, both in common practice around the world for many ornamental plant finishers in particular, may produce a fine looking finished crop to help increase the impulse sale off the bench, but may not be of long term benefit for the crop and therefore the eventual consumer.

Figure 20: Remaining campanula at Keuvenhoeven en Zoon, (Holland, Feb. 2015)

Streamlining the offer to fit a certain lean production system may also limit choice for the consumer in the end. This is something to be aware of as technologies develop. Not only will the methods and techniques change, but certain crops will be selected to suit these production techniques, rather than consumer needs: varieties of fruit that are more suitable for robotic harvesting, or plant varieties that can be mechanically rather than manually handled, for example.

5.c.ii.2. Reactivity

During my travels, it was clear that the owner's or operator's viewpoint was often that they could not do what they do without the system that they have in place. For example, Van Lint is a nursery in Holland that finishes shrubs and perennials. Patrick Struik showed me around his impressive 9ha nursery. It was a relatively low-tech facility but Patrick was convinced that the only way they could react to prepare a large despatch in a short period of time is due to the fact that they can throw large amounts of labour to the job. They pay agency labour a set fee per item for all tasks required. So as long as the assessment of what work will be required on the crop in its lifetime on the nursery is accurate, i.e. potting, maintaining, cleaning and preparing for despatch, then it does not matter if they put 30 staff on one day in one area to shift 30,000 hydrangea for a supermarket in the UK for instance. This provides an incredible level of flexibility to do jobs, as and when required, and is not dictated by the speed of machinery. This of course assumes that obtaining enough staff at short notice for such a brief period is achievable. That certainly doesn't seem to be a limiting factor for Patrick at the moment.

Figure 21: Van Lint Hydrangea crop (Holland, June 2014)

A similar picture was relayed to me by Mollie Hoare, Operations Manager at Skagit Gardens Inc. Her division produces retail-ready plants for garden centres and landscapers, as well as pre-finished plants sold to growers and brokers all over America and into Canada. Mollie said that, at Skagit, they are extremely customer service oriented, responding to last minute orders immediately, often despatching within the same day as order receipt. This inevitably drives the labour percentage up, but Mollie says "This is who we are. It gives us a point of differentiation". She does recognise that this philosophy, whilst very attractive to the customer, does inhibit some decisions that would otherwise be made to increase efficiency such as streamlining processes and possible implementation of mechanisation.

Conversely in a nursery such as Nolina, mentioned above, they are doing a very similar job as these nurseries, but with their high-tech, fully automated facility. Marcel would indicate that they could not output the volumes required in the time frame allowed, at the cost expected, without the automated systems they have in place. Nolina can't significantly increase their output per hour by sending in the troops to pull the product through the system, but with extended or additional shifts

and with the consistent high speed at which the machinery can work, the nursery can respond to nearly any peak that is required of them. Marcel reckons that this system with its consistent speed also reduces the stress and upheaval on the staff.

Figure 22: Pot rose bench system at Nolina (June 2014)

So it is true that both manual and machine based producers can cope with the variable supply and whilst they achieve this through different means, a common theme between the best examples that I saw is that they all have a great understanding and control of their costs. They know with a high degree of accuracy how much each unit costs to produce and this fact endorses either approach.

5.c.iv. All of the above!

As you can no doubt appreciate from the above, even when I recount an example of a motive either for, or against implementing technology, it is clear that there is usually a collection of reasons for the decisions that leaders and operations managers make in this area. Omer Hochberg, the owner of Hochberg Export Ornamental Plants Ltd, in Moshav Bitzaron, Israel, could see the potential for mechanisation in the preparation and washing of whips and bare root material. The machine that he purchased in recent years cost in the region of €85,000 and he reported that this reduced the labour required for this task from 8 to 2.5 people. It also increased the speed and helped to "drive" the workforce at a constant pace. He suggests that this productivity boost also helped to improve reliability, quality and profitability of the resultant product.

It is worth noting that with automation and streamlined production often comes inflexibility. This is why it is critical to have strong relationships with suppliers, to ensure that the input supplied fits the system. If this is not the case, it can cause unnecessary inefficiencies caused by downtime and increased wastage of product and time.

I also assume that a by-product of increased efficiency and productivity is the reduction in the quantity of resources of all kinds (water, energy etc.) so presumably less impact on the environment. This is assuming that the manufacture and utilisation of the new technology itself is not more harmful to the environment than the previous, more manual process.

See case study on next page

The Toyota story

During my time in Japan I was very kindly hosted by Hakusan Trading Co. Ltd, a floriculture production company in the Aichi Prefecture. The company had investment interest from Toyota Motor Co. and due to these links I was fortunate to be offered a chance to take a tour of the Motomachi manufacturing plant in Toyota City. It was such an interesting visit and demonstrated many reasons for the implementation of both man and machine, I feel it is worth a piece of its own.

The Motomachi Plant was commissioned in 1959. It was the first passenger car plant in Japan in a city now known as Toyota City. Today the factory is referred to as the mother plant of Toyota. 35,000 of the 200,000 people in Toyota City are employed in some way by Toyota. Motomachi is 75,000m^2 in area and produces 120,000 cars each year from this plant. It is primarily reserved for production of Toyota luxury models such as the Lexus GS, Estima, Crown and Mark X manufacture. The manufacture line, unlike the traditional Henry Ford standardisation approach, can handle multiple models at any time. In total, Toyota produces 300,000 variations across their range of models. The process at Motomachi involves "stamping" the sheets of metal to form body parts, welding 400 body parts together with 3500 spot welds, washing and coating with four coats of paint, assembly of 30,000 parts for one car. Finally a 1500 point inspection is carried out before shipping.

Many of the well-known "lean" manufacturing principles are in evidence at the plant. A "Just-in-time" production system is one of the key elements. Once a part is used in assembly, the Kanban inventory control system is set in motion. The onus is on the supplier to have a small inventory and the Kanban instruction is sent up the line so there should never be a shortage of parts. 10% of the 30,000 parts used are made in-house. 80% of external suppliers are less than 2 hours away by road which assists the Kanban.

The well-renowned "Andon" chord system is in place as a means of calling for help. It has recently been replaced by call switches that are easier to reach for the assembly workers. The Andon board lights up to request a team leader to respond with corrective measures. A yellow flashing light will go red if the issue is not solved before the next section, thus stopping the line. Team leaders must have at least 10 years' experience of manufacture in order to help to solve any problems as rapidly as possible. The shifts on assembly are 6am to 3pm and 4pm to 1am. In each shift there is a margin of 15-20 minutes of down-time. If the shift doesn't achieve 96% of the expected production, then the shift needs to be extended. Another key lean principle, "Kaizen", the practice of continuous improvement, is used to keep improving all methods, in terms of their efficiency and flexibility.

What can we in horticulture learn from Toyota? Well, some of these practices can, and have been, implemented into horticulture, with initiatives such as "lean meets green". Whilst some principles are workable, the variabilities such as the environmental factors, shelf-life and often scale as mentioned in the next chapter can throw "spanners" in the works for the lean champions.

Overall however Toyota employs what they call a "Jidoka" way of thinking: "Automation, but with a human touch". 96% of the work in the stamping and welding shop for example is performed by 760 robots, but there are over 8000 engineers that work on the factory floor, predominantly in assembly and inspection. This appears to be a great mix of Machine dovetailed together with "Man" to achieve what is often heralded in manufacture to be a great success story of efficiency, speed, precision and quality at a reasonable price.

(See photos overleaf)

Figure 23: Motomachi manufacturing plant, Toyota City (Japan, September 2014)

Figure 24: Spot welding robots, Toyota (Japan, Sept. 2014)

Figure 25: Kanban system in evidence, Toyota (Japan, Sept 2014). Comfort in "Status Quo"

5.d. Comfort in "*Status Quo*"

It is not just by chance that some farms or practices that I saw were not larger, capitalising on the potential benefits of economies of scale, possibly of automation. Many farmers of course do not wish to grow out of their comfort zone in terms of size or production.

Daichi Miura is primarily an egg producer near Gifu, Japan. At Kikusei Farm he specialises in producing organic fertilised eggs which have a higher protein level and, in his opinion, are tastier than normal unfertilised eggs. Together with his mother and father, he runs the farm of 1700 hens as well as rearing a handful of Japanese Black in a beef herd. He also farms rice, something that seems to be the pastime of many in Japan, even if it consists of just a few fragmented plots around the house. They are currently planning a new building to house up to 2500 hens, but don't feel it necessary to automate as they are happy with the way they do things and generally Daichi doesn't want to over-invest as he wants a certain scale of business that is manageable for his family without having to employ more farmhands.

This is just one example I saw where it had been a choice rather than a forced decision to remain at a certain size and utilise manual labour rather than employ technological solutions.

6.0. Inhibitors – barriers to automation

I have already started to allude to reasons why certain organisations might choose not to implement technology in place of manual labour, but in this chapter I will refer more to the actual and physical barriers to automation. Just as there are reasons for or against technological solutions, there are equally as many inhibiting factors which may deprive the decision maker of the "automated" options even if they wanted to. Conversely, when these restricting factors were not in evidence, I saw that a business was often more likely to adopt technological strategies.

6.a. Money, money, money

In many cases "it's all about the money" when it comes to investment in new technology: whether the actual availability of money or the future confidence for income streams to make a return on the investment. There are many interrelated issues that can affect producer confidence including weather and factors such as consumer buying attitude as mentioned in chapter 4. In Japan for example, the future economy was a concern that was mentioned several times. It appears stable at the moment, but there is apprehension that the recent increase in consumption tax (VAT) from 5% to 8%, even though this is relatively low compared to many other nations around the world, will have a long-lasting impact on consumer buying. This may in turn affect the ability, or attitude, of a producer to invest in technology if they are uncertain about the future demand.

6.a.i. Return on investment

It's not surprising that the return on investment (ROI) term was quoted several times during the course of my visits. At Hishtil Nursery's Nehalim site in Israel, production manager Alon Wallach told me that the general rule of thumb within Hishtil is that investment in capital machinery needs to be paid back within one and a half years or less to be viable. They have seeding machines for their bedding and pepper plants which had met the target. Alon demonstrated one machine that had beaten target by more than 6 months: a machine procured to attach the handles to their pack bedding trays. They used to employ 10 people all year round for this task and now just 3 are required for the same job.

Figure 26: Hishtil Nurseries: handles attached to packs by machine (Israel, Nov. 2014)

At Plantenkwerkerij Vreugdenhil B.V., production manager Cock Groenendaal said that decisions on investment were all based on payback. The company produces ornamental and vegetable young plants: much is contract grown specifically for Syngenta. Their production is strongly dictated by their largest customers, so decisions made within their company will require some assurances by these key accounts.

Eric Moor, the owner of Sion Orchids in the Netherlands was quite clear that ROI should be at the forefront of the decision to invest in technology. He has seen a rapid increase in the size of his indoor orchid business from a turnover of €11 million 6 years ago to €32 million in 2014. Since 2008 he has made incredible investment in automation right through the production process whilst acquiring a young plant business to augment and supply his finished crop business. He has had a keen eye on the return for what has required some serious financing over the years.

6.a.ii. Finance and funding

Funding has been key factor in the decision making process for many of the companies I visited, when considering investment in technology. In Japan, Masatoshi Togura, President of Okura Engei Nurseries Ltd, an ornamental plant producer near Chiba, described a type of government loan that enables investment at 0.3% interest rate, but with a very strict application procedure. He was one of six producers in Japan that took advantage of funding available and invested in a machine that produces a "glue-type plug", costing 9 million yen (£50,000) to implement.

Larger growers of rice and tea in Japan are allegedly being supported more by the government than the smaller ones, particularly in the northern areas where harvest yields are lowest. Funding is available for initiatives relating to efficiency and innovation, such as advancements in harvesting or processing. Northern areas are now often more efficient than their southern equivalents. The investment being encouraged by the government is apparently benefiting the larger growers, whilst forcing many of the smaller growers out of business. The dominant growers commonly purchase the failing facilities from the smaller growers and start again, often with funding up to the tune of 90% from the government to encourage redevelopment and entrepreneurial spirit. Organisations from outside horticulture are now capitalising on funding available, viewing it as an investment opportunity.

It seems that whilst financial assistance is heavily relied upon by certain industries, having it taken away or reduced can mean the death of the struggling organisations. Many tea producers in Japan for example have quit growing primarily due to declining tea prices, but the final "nail in the coffin" for many was the termination of financial aid from the government, which had been afforded to them following the earthquake and tsunami of April 2011. Compensation was offered to many growers as there was a perception from both within and outside Japan that crops, particularly in the north and west areas would be affected by radiation from the Fukushima nuclear plant.

In Israel, whilst it was apparent that most businesses were not focussed on making technological advances, due to the apparent abundance of labour, in many cases it was also a fact that finances required to mechanise were simply not available, especially considering the extensive ROI. The Israeli government is providing approximately 25% funding for investment on machinery known to save on labour, but unfortunately new machines are often not yet listed. So there is no funding unless the company can prove the case for the unlisted machinery. This government rationale is designed to reduce the number of foreign workers in agriculture. Other schemes aimed at reducing migrant labour include providing a permit for a designated number of foreign employed workers, based on crop production and area. Unfortunately, the more machinery that is funded, the more government also enforces a linked reduction on this foreign labour permit.

In Holland the government has a history of rewarding innovation with payback schemes and reduction of tax on profits. From my brief perspective, whilst there is more scrutiny than there used to be on proposed lending from the Dutch banks, they still seem keen to invest in well-structured business propositions and have been doing so even through the difficult years of global economic recession. I heard an unbelievable anecdote about funding from about 15 years ago in Holland, where a completely new 5ha site was developed with substantial government assistance, but the site was never actually used as the grower who instigated the development decided to move to Ethiopia in order to take advantage of the climate there instead!

6.a.ii.1. Attitude to borrowing

Whilst on my travels I saw that there were three different types of borrowers: those that don't; those that do; and those that do, but don't really like to. Some borrowing attitudes of course change depending on experience and wealth. Sion Orchids' significant investment mentioned above was almost entirely funded by borrowing and Eric tells me that he had to go through a few years of making losses with extortionate interest rates on his borrowings, but now the level of interest is much more acceptable and the company is happily making good profits year on year. Many Dutch producers in particular seemed at ease with borrowing, often citing the fact that whilst interest rates were so low, it seems like a sensible option to borrow whilst maintaining a stable cash flow.

One company I visited that would prefer to remain nameless, had an owner who came into the family nursery business. With his father's backing, but with considerable trepidation, he invested hugely to transform the internal logistics. He was so worried about the extent of borrowing and the fact that it could ruin the company if the investment didn't work, that he made sure that his insurance policy covered suicide! So, it seems to me that borrowing money from banks, or other lending bodies is all about managing the risk. Whilst conservative spenders will think otherwise, some believe that the higher the investment the lower the risk. Whatever the case, any decision on the risk being taken has to be a conscious one.

Figure 27: Winding roads of Route 198 California (USA April, 2015)

I suppose an analogy could be drawn between the way we drive our companies and the way we drive our cars: "fast and furious" or "slow and steady". Some will feel that "getting there first" is the key to success, giving the benefit of time and experience. Others are more conservative, risk averse, possibly fuelled by fear of failure or the fact that the owners do not wish to be too conspicuous - to raise their head above the parapet only to risk being knocked down.

See case study overleaf.

The Emsflower story

Emsflower is an incredible company that I visited early in 2015. Its main site is nestled near the town of Emsbüren, Germany, but close to the Dutch border. I will refer to this company a handful of times through this report and the visit shed light on several key areas for me: so I think they are due more of an introduction than I can afford for all the other brilliant companies I saw! The original company was founded by a Dutchman, Jan Kuipers, in the Netherlands in 1954. In the beginning he mainly grew potatoes and cucumbers. Jan's son, Bennie, was 18 when he started to work in the company. Jan encouraged Bennie to travel before becoming too involved. Meanwhile they joined an emerging cooperative movement of ornamental plant producers and moved away from vegetables.

Bennie travelled to the USA in 1977 and witnessed the "law of the large numbers" driven by retailers such as Home Depot. They seconded growers and farmers to grow bedding plants to satisfy their needs. Bennie came back with immense inspiration and was looking forward to expanding the family business back home in a similar vein to what he had seen in the USA. Land was relatively expensive in The Netherlands, so he saw the potential in East Germany once it had started to open up in 1989. He bought a 17 ha plot in Fretzdorf, near Berlin. The company initially produced far more than the actual demand that was there.

In the year 2004, four years after Bennie first saw the piece of land available in Emsbüren, he acquired 100 hectares, right next to a planned autobahn development. The locals thought he was crazy to buy such a large piece of land, but he paid attractive farmland prices, rather than industrial prices. The only restriction was that they could only construct a maximum 60 ha of greenhouses. It took two years to build 20 ha of glasshouse and now they have 40 ha of glass. Their core products are "pack bedding", about 200 different varieties of traditional bedding plants including pansies, bellis, fuchsia and pelargonium. In total they produce in the region of 500 million plants, 350 million of them on the site in Emsbüren. They also produce and grow vegetables such as tomatoes and mini cucumbers, mainly in the summer months and sell predominantly to the local German market based on "home grown" appeal.

Their largest customers include the likes of Aldi and Lidl. These retailers are apparently attracted by the size and possibilities that Emsflower can provide. It has to be said that, aside from anything else, the location of the site is perfect for the considerable German market, but with great links to the rest of Europe and the associated advantages for quality of delivered product that this proximity brings.

I met with Tom Kuipers, the son of Bennie, who oversees operational and financial aspects of the company. He told me that the company was supported heavily by a 32 million euros investment, in particular by Rabobank. Bennie said that when he borrowed his first million in his earlier years, he couldn't sleep at night, but once he had borrowed over 30 million euros he slept just fine! Tom seemed to have an excellent grasp of his costings and finance and was quite frank when he said that in order to pay the company loan interest and avoid creating more debt he could not afford to lose more than 5 million euros in any year. Fortunately the company was turning a healthy profit, even on their relatively tight margins. Borrowing money was clearly not a concern for this company and indeed it appeared that money borrowed had enabled huge investment in current technology.

(See photos overleaf)

Figure 28: Emsflower HQ (Germany, Feb. 2015)

Figure 29: One of 20 x 1.5ha glasshouse blocks – Emsflower (Germany, Feb. 2015)

Figure 30: Emsflower 60ha site including 40ha glasshouse area (Germany, Feb. 2015

Figure 31: Tom Kuipers, son of Jan – Emsflower (Germany, Feb. 2015)

6.b. Production and facility limitations

I would say that the second most significant limitation to financing technological development within production situations lies within the realms of logistics and production scale. The principal limiting factors that I noted in this area will be covered in this section.

6.b.i. Site logistics

It is difficult to rank the most typical reasons for being unable to automate certain processes in a production facility, but certainly site size and layout, crop format (size and orientation) and topography were common themes around the world. Japanese growing areas and facilities I visited were often built on hills with many discrete units, not unlike my own nursery. These sites do not traditionally lend themselves to high-tech possibilities. Even in The Netherlands, which I would say is probably the most technologically advanced country that I visited as far as horticulture is concerned, there were logistical restrictions based on size or regularity of glasshouse structures.

Figure 32: A "slope" in Holland as described by Jim - van Son & Koot (June 2014)

Figure 33: A slope in Japan – tea plantation (October 2014)

When looking at field production as I did in Washington State with Dr Karkee he illustrated that the challenges in the field are fundamentally cost based, but affected by the variable conditions of the environment. In factories where robotics has been employed for over 50 years, robotics usually operates knowing the location and orientation of the object. In the field the actual process performed is often less complex, but the situation including the environment, location and structures are so variable. Delicacy, accuracy and speed are key, so this presents many challenges to attain practical viability of robotics. Currently, constructors of state-of-the-art apple picking machinery have reported harvesting speeds of 5 seconds per apple. An average human picker can harvest one apple every 2 seconds. It is simply not viable to employ two robots per current person in the field. The cost, logistics and maintenance are currently unimaginable, even though a robot can have extended shifts. The solution might be to have one machine containing expensive software, but with multiple hands. Also, it is likely to see the technology develop to increase the harvesting speed.

6.b.ii. Production scale

From what I witnessed around the world, it is often the scale of the farm, nursery or production facility which stifles potential mechanisation. The investment required to implement a high degree of technology often requires a significant throughput of product or needs a large enough area to be viable. The main barrier to increasing the size of the operation was commonly due to availability, or high value of the adjoining land.

Some of this reasoning in reality is due to the fact that there is limited perceived advantage to automation, and the ROI for technology is unacceptable. Sometimes, the set-up and downtimes are simply too long to entertain, particularly when accounting for the logistics of moving the product to the machine, or machine to product. This setup time is particularly apparent with smaller scale operations, where throughput is not enough to regain lost downtime between batches or areas.

Units of area?

I have to say that I hadn't realised that everywhere I would travel around the world would have their own measure of area. In Israel a dunam was originally like an acre, equivalent to the area that could be ploughed by a team of oxen in a day. The modern dunam is now equivalent to 1000 m^2. A tsubo in Japan is approximately 3.3m^2. Feet and acres in America and of course metric units in Canada and throughout Europe are the common units of area.

It is not only a case of how large the site is at this point, but whether it has been, or will be, broken into more blocks in the future due to family succession. The apple industry in Japan for example dates back more than 150 years. Whilst orchards used to be larger, many apple growers in Japan have just one, possibly two, hectares as the land has been fragmented when passed down through the generations from parents to multiple siblings.

Some production facilities that I visited were large, yet logistically fragmented, so that it was equally difficult to imagine high levels of mechanisation due to the practicality and distance involved in transporting machinery around the sites. Hochberg Export Ornamental Plants Ltd in Israel was one example of such a company. They produce mainly ornamental trees such as Acer, Wisteria, Cercis and Hibiscus as bare-root plants, "whips" or cuttings. The nursery is approximately 60 ha, split into sections, approximately 2-3 ha on each site. This, Omer Hochberg felt, was a limiting factor to the introduction of future technology.

Figure 34: Emsflower Despatch area (Germany, Feb. 2015)

An example of where large scale does allow for high levels of automation was at Emsflower, Germany, discussed earlier. To give a flavour of the scale of production from their 40 ha greenhouse site, Tom Kuipers told me they have minimum orders for bedding plants in the region of 3000 "CC trolleys" (transport containers). This is based on the amount of bedding packs that will fill just one of their 1.5 ha discrete environmentally controlled units. Here, many production processes are fully automated such as the transplanting and transport of product around the site. There is a massive 3ha logistics area designed with future-proofing in mind, anticipating a potential 60ha site at some point in the future. On peak weekends they will see 1000 trucks docking at their 34 docking bay despatch area!

6.b.iii. Diversity and batch size

The parameters of diversity and batch size could arguably be dealt with independently but, almost without exception, where I saw excessive variability that prohibited mechanisation, there were also issues of down-time that would be associated with relatively small batch sizes. I felt that this factor was certainly amongst the most prevalent reasons for not considering automation as a viable option.

I mentioned Omer Hochberg above and referred to some machinery that he was able to employ on his tree nursery in Israel for the preparation of whips and bare root trees. He also told me that he was looking for mechanical assistance with his sorting and packing operation, but as yet has not found a machine that can cope with the complexities of his product variation and specification. Manfred Heekeren, a grower of perennial plants near Rheurdt, Germany, said that it was the diverse nature of crops, over 1500 varieties and many different pot sizes, which stifle mechanisation options available to him. Like so many nurseries on my visits around the world, he had a transplanting machine virtually redundant due to the variation and relatively small batch size that he has to put through the machine. "*Changeovers kill the system*", he said.

On the American continent I hardly saw an automatic tagging/labelling machine in operation. These machines insert point-of sale-labels into, or onto, plant pots in preparation for retail. Maybe I just happened to visit the wrong places, but it was often stated that there were simply too many label types and sizes and a plethora of different containers, unmanageable for current machinery to entertain. I went on to see John Van der Ende, Managing Director of Burnaby Lake Greenhouse Ltd, based in Surrey BC, Canada. The company finishes plants for retail, specialising in indoor plants, but also producing a whole selection of other planters, bulbs, pot roses and cut flowers on their 18.5 ha greenhouse site. They have a wide product portfolio with several thousand crops and even more variations (skews) on offer, typical of what I saw in Northern America.

Figure 35: Plethora of containers offered – Bergens (USA, April 2015)

Diversity of product mix is the main restriction to mechanisation as far as John is concerned. It is not that he doesn't see the benefit in specialisation. They certainly see efficiencies from automation and economies of scale when they dedicate, say 50,000 square feet to single crops such as mini-roses or pot chrysanthemums. It is the fact that the market in Canada, with its relatively low and diluted population, is simply not large enough to support numerous specialised producers, each producing significant volume of a narrow product range.

Market distance and concentration can dictate diversity

It is not just the total market size, but often the concentration of the population and distance between markets that will dictate the capacity, number of producers and production style to a degree. It was abundantly clear to me that in the USA and Canada transport distance often dictates strategy. For products such as finished plants, that are usually too bulky to be sent viably by air, the only alternative is to transport by road. The distances are incredibly long, thus the time and costs are significant, restricting the potential catchment area for finished plant producers. The size of the market (demand) within a particular transport "catchment area" will therefore dictate how many producers can be supported. Where there are few producers, those producers will inevitably offer a wide product range in order to satisfy the market. Specialisation is difficult even if the producer wished to do so. So taking advantage of certain automation and associated economies of scale is often not realised in these situations.

Some of the largest producers work around this to a certain extent by having satellite growers based throughout the country with central hub and/or use brokers who consolidate the supply and service massive geographical areas. Also, even some of the largest retailers split the production of certain products across several vendors wanting them to be "one-stop-shops" due to the proximity to the distinct retail areas. The advantage to the producer for this can be that different products can often dovetail well together. When products such as bulbs and summer baskets - offered for spring and summer - wane, autumn and Christmas products such as poinsettia take over, thus optimising the space and workforce available. In Europe, where the market is often far more concentrated into smaller geographical areas, a large retailer would generally try to rationalise procurement of one product from just one or two suppliers.

A visit to Chiba Nursery, the second largest ornamental plant propagator in Japan, producing 56 million plants each year, surprised me a little. Even in a nursery of this scale the majority of its irrigation was being conducted by hand. There was some boom irrigation in a couple of greenhouses, mostly where poinsettia were grown as plug plants in the heat of summer. Most of the time, however, Mr. Tamura, production manager for the Chiba site, situated in the lowlands near Tokyo, said that watering by hand is preferred due to the variability of the crop requirements. Having in excess of 10,000 varieties in 500 category types, and relatively small batch sizes, forces this approach in order to deliver the right amount of water to all the different varieties and trays within the plant batches.

I discussed some forms of automation with Sander Hamer, third generation in the family company now known as Florensis, based in The Netherlands. They have many forms of mechanisation including seeding and transplanting machines, but they also have a despatch system which is the envy of many a young plant producer. Up to 40,000 trays per day are semi-automatically collated with minimal potential for error. The setup involves a complex network of conveyors that resembles Heathrow's Terminal 5 baggage handling system! CC trolleys and pallets are made up manually, or by machine with shelves inserted at precise levels based on a pre-calculated product height. All product is then semi-automatically processed onto the trolleys. QR codes on each tray are scanned through a portal as a final check before official despatch. In the peak of the season they have two consecutive shifts of 10 hours each.

Figure 36: Florensis collation & despatch system (Holland, Feb. 2015)

Figure 37: Non discrete cells, more difficult to handle by machine – Florensis (Holland, Feb. 2015)

Even on their considerable scale however, producing over 900 million plants per year including cut flowers, the fact that they have over 5000 different articles on their system dictates that some batches are simply not large enough to employ certain mechanisation options. It is fair to say that high levels of mechanisation will often be developed to process a relatively small band of product variation. I often noted that where there was variability, there were always products that were not deemed possible to process mechanically, even within the most automated facilities. For example image based, plug transplant machines will identify viable plants for grading or potting, by means of canopy cover or pigmentation photography. Where cells are reasonably discrete, this is fairly straight forward, but where there is significant overlapping of foliage from one cell to the next, the automated approach has to be far more complex. So, often it is not viable to pursue this route for certain crops, especially where batch sizes and total volumes are relatively small.

With both product variation and small batch size often comes higher proportional wastage. Although modern automation can sort waste and grade products quite adequately with imaging technology and associated hardware, the current technology is normally most suitable for larger batches with relatively small losses. Lewis Gerten, Gertens Greenhouses and Garden Centre said that as far as he was concerned most mechanised systems dealing with seedlings require almost 100% success. Providing 100% in his case, requires that he sow double the seed to ensure 100% germination, so he prefers lower sowing rate and manual handling of the product with higher losses. Setup and downtime involved with small batches having higher waste proportions usually extinguish any advantage in time savings during operation, so investment is irretrievable.

6.b.iv. Hygiene

When I visited Cohen Nursery in Israel many years ago they had invested in a cuttings collector system. Several individual tram-type trolleys would constantly travel around the facility's various houses on a rail loop collecting the "cuttings" which the employees were taking and bagging. This offered a significant reduction in the movement of people and increased the speed of cuttings to cold storage. Visiting the same facilities in 2014, I noted that this system had been decommissioned due to hygiene issues.

Cohen has developed into a specialist producer of unrooted cuttings, particularly in Solanaceous crops (e.g. Petunia, Calibrachoa). These are part of the tomato, potato and tobacco family and have had a chequered history in commercial horticulture since the 1990s with several virus pandemics. Hygiene has been increased to such a level that employees who work in certain parts of the nursery's "elite" (virus clean) facilities, must be non-smokers. Tomatoes, even in salads or sandwiches, are not allowed on the site. In each of the houses, there is a holding chamber with air blowers to avoid any unwanted pests entering the greenhouse that could transfer disease. They couldn't therefore risk their high level sanitation protocols with the cutting collectors making a circuit through all the various greenhouses, so had to revert to runners manually transferring the cutting boxes.

Figure 38: Cohen Nurseries, typical high level hygiene (Israel, Nov. 2014)

Also in Israel, I met a grower of cut herbs including basil, mint, Rucola and rosemary. Rafi told me whilst walking through his polythene tunnels that labour was a significant cost for him at around 40% of turnover, but cutting by hand into 70-80g per bunches is not only quicker than by using current available machinery, but he suggested that there is less chance of cross-contamination of viral or other diseases by using his manual method. They can clean knives more frequently than current mechanical options.

More photos overleaf

Figure 39: Rafi Cohen herb nursery – "It's cleaner by hand" (Israel, Nov. 2014)

Figure 40: Typical split greenhouses in hot climates (Israel, Nov. 2014)

6.b.v. Temperature regulation

Many greenhouse growers across the world experience soaring summer temperatures, so need to have more isolated growing units as opposed to creating a consolidated block. Discrete blocks aid air circulation, ventilation and cooling of greenhouse air temperatures far more effectively than large blocks. The common standard distance between greenhouses in hot climates I visited, such as Israel, Japan and parts of America, is approximately 1.5 times the height of the greenhouse. Automation, particularly in current formats, often lends itself to larger consolidated blocks as mentioned above, so this separation requirement clearly inhibits moves towards mechanical solutions. *(see photo above*).

6.b.vi. Unpredictable market

It was most apparent whilst in North America that the fear of an ever-changing market and product demand was one of the main reasons for avoiding implementation of technology. Lew Gerten, mentioned earlier, said that he wasn't originally prepared for the trend for baskets, a US phenomenon that has recently exploded for them. Unfortunately, they had just invested heavily in a system based on production of four inch tubs on "ebb and flood" irrigation flooring and they had to ditch that and adapt the system to cope with the increased production of baskets.

Figure 41: Making the product fit existing production systems – Gertens (USA, April 2015)

Bergen's Greenhouses reported a similar issue where there is a diminishing demand for small pots and packs of bedding. The consumer now wants instant gratification with large and varied baskets and containers. Once again, old infrastructure developed for the "pack bedding" heyday is often redundant, or needs to be adapted to accept the new wave of products. This fear of implementing new technologies only for them to become obsolete due to a changing market trend is a clear argument against technological development in the production area.

6.b.vii. Relocation unrealistic

If mechanisation is perceived to be required or desired for future growth and success, then relocating and transferring the business, or part of the business, to a more favourable location can sometimes be an answer to permit appropriate development. Of course it's not as easy as simply "upping sticks" and dropping them down in another plot. Quite often the value of the developed land being left behind will not match the value of the undeveloped green, or brownfield, site that might be acquired. Not a problem of course if sufficient borrowing is a possibility, but where it isn't, certain companies may find themselves stuck in a "rut" with nowhere to go. The only option in this case is to make the best of what you have. Make more minor improvements, possibly technological advances, but also strategic decisions to ensure optimal use of the space that is available. Have a strategy and produce a product suitable for the situation and continue to review the situation.

6.b.viii. Automation options unavailable

Although, in some cases, it was only perception rather than reality that mechanisation was not feasible, in many cases the perception is of course true. Plant breeding for example is one area where many of the tasks require highly complex dexterity. Bart Kuijer of Varinova based in Bleiswijk, Holland, said that the many delicate methods involved in plant breeding - for example - are extremely variable, often like surgical operations. Similar can be said for mother-stock producers that I visited, where they need to take cuttings from locations across the facility that involve high levels of dexterity and a series of complex decisions in order to take appropriate cutting material.

6.c. Perception of quality

When I was in Japan I was really interested in delving into the Japanese culture and heritage and commercial production in unfamiliar, non-horticultural territory. There were many things I wanted to see, one of which was a Sake brewery: sake, of course, being such an iconic Japanese drink. I was recommended to visit Iwamura Brewery Inc. just down the road from Kikusei Farm, Gifu prefecture. My incredibly helpful host and translator, Masashi Fujiwara, and I, stumbled hopefully into the brewery after six o'clock in the evening. After explaining to the lady in the front shop about my visit to Japan, we were fortunate enough to be given an excellent, yet impromptu tour of the brewery by the president and CEO Mitsuteru "George" Waterai. They produce their branded Onnajoshu (lady of the castle) sake, a premium sake produced in Iwamura Castle, built in 1185, and the highest castle in Japan at 721m. The brewery, now a family concern, was founded in 1787 during the Edo era and has always operated under a policy of producing premium sake with crystal clarity and aroma. The mineral water used to make the sake springs from a 400 year-old well and the rice that is used in the brewing process is sourced locally.

Figure 42: "George" Waterai, Iwamura Castle (Japan, Sept. 2014)

Perception is particularly relevant in a traditional premium industry like this and even though George has some mechanised stirring machines, it is critical not to damage the fermenting rice with the paddles, so most stirring is still done diligently by hand. Similarly the washing and polishing process that removes as much as 70% of the protein coat to produce the highest quality sake could be more mechanised, but George insists that the human eye can detect subtle colour changes and see the water content, that a machine wouldn't be able to detect. This is a **critical process in order to achieve the quality** that he is striving for. They're able to command a premium price due to this process and constituents. It is George's intention to maintain a similar volume of production, but increase the profitability by producing a more polished, higher clarity, sake.

In horticulture, I saw this perception of higher quality by man in evidence time and again. Yuki, of the Clema Corporation did not place a great deal of importance on technology as most of the workers ("ladies") are better than the machines. She feels that they are fast and keep a high level of quality. There were some examples of technology in the nursery, for example a fairly standard potting machine, but I was told it wasn't used much as Hiromi, the director of the company, considered that the machinery was not suitable. They felt that the clematis plants produced are far too sensitive for handling at the speed of the machine. Lewis Gerten of Gertens Greenhouses and Garden Centre, Minnesota, also told me that they had invested in a transplanting machine for potting plug plants, but mechanical damage caused by the machine persuaded him to side-line the machine in preference to a few unskilled positions that were not too hard to fill and train.

Figure 43: Tea harvest by machine (Japan, Oct. 2014)

Kenichi Yokoyama told me that a human eye can detect all quality aspects when picking tomatoes for his restaurant business in Japan. Colour, size, and ripeness are all critical observations that he doesn't feel a machine could account for. Just 1% of all tea produced in Japan is hand-picked. The remainder is machine cut, four - or possibly five - times, between April and October. Picking by hand is typically better because a skilled picker can take only the finest quality tips and less woody tissue. Also, machine-cut tea has more cut leaf edges which can lead to unwanted and more imbalanced fermentation. Hand picking however is reserved only for the freshest "virgin" tips of the first cut in April. Much of the earlier cuts will be

prepared for fresh green tea whilst later cuts are destined for the soft drinks market. Just some of the finest tea leaves are also processed completely by hand which is perceived to enhance the flavour to such a degree that some of the most expensive tea can fetch 1 million yen (£5500) per kilo! It takes several hours to process just a few kilograms of tea.

I mentioned earlier that the move towards harvesting cherries mechanically by agitation needs some perfecting. Dr Karkee of Washington State University told me that more than 80% of cherries harvested by machine will currently be collected without a stem. Just as for the cork-versus-screw-cap debate on wine bottles, public perception is generally that cherries with stems intact are somehow superior quality to those without stems. I suppose they feel that the cherries must be more natural, or organic, with stems, but the fact is that cherries are actually better picked and packed without the stems. Stemless cherries have a longer shelf life with less risk of botrytis from stem dieback. Also the absence of stems avoids unnecessary bruising in the packaging. So, if technology is the only way that America can remain competitive against the import of cherries from other nations, then it appears there will be some public education required to demonstrate why harvesting without stems is actually beneficial for the cherry. The alternative is to develop robotics to harvest *with* the stem, or charge more for the cherries *on* the stem. Let the consumers decide if they want to buy American grown cherries with stems in preference to imported cherries!

6.d. Culture

I would say that the culture of a country and of course the business people in it has a part to play in the likelihood of technology being implemented. Most people's perception of Japan for example would typically be of a nation technically advanced. That is certainly true for many industries, but in agriculture (including horticulture), it is fair to say that most facilities I visited were in the mid-to-low end of the spectrum of technological advancement. The Japanese people appear to be incredibly hard working. Standard holiday allocation nationally is approximately 20 days, but I was told that most people don't take their holiday entitlement as it doesn't look good to be away from work! Teruo Takatomi intimated to me that small family agricultural concerns do not include their own time and labour costs when calculating their prices. This is a fact not restricted to Japan of course - a common trait in agriculture worldwide, but it is certainly apparent that in Japan some continue farming the land as a tradition regardless of whether they actually turn a profit. I heard of business owners working incomprehensible hours. One owner of a young plant company told me he worked 17 hours a day in the peak season performing almost all the tasks in the company!

Professor Kozai of Chiba University reckoned that Japanese culture derives from the fact that ancestors in the Asian Pacific rice countries have a history of working all the time. Conversely, western societies originate from a hunting background and are used to working hard, only when they actually see food. Hiroaki Ozeki, owner of an OZ farm that primarily produces and processes green tea, felt there are two different Japanese mentalities: the "Toyota thinker" and those with the "old farming" mentality. Even the younger generations in Japan can be categorised by these mentalities, with some more interested to protect and conserve the land rather than thinking of the land primarily as a business and financial opportunity.

Although I assumed that a culture of spirituality and tradition was likely to be evident in Japan, I didn't realise to what extent this would spill over into business practices. That is not to say that technology was not being developed in agricultural circles of Japan. I heard of unmanned helicopters spraying rice fields and robotic strawberry pickers being developed in cooperation between Miyazaki University and Kyoto University. The opinion of Naomi Takami, Izumi cyclamen nursery, is that Japanese horticulture in general, though, is not moving with the times. They need to adapt to the changing circumstances presented to them. Mechanisation is a possibility, but he feels that the perception that manual tasks are good for the body, mind and soul could be blocking progression in this area. *"Being happy is more important than technology".* My question was then: "Are most Japanese people only happy when they are working hard in the business?" His answer – "*Yes!*"

Figure 44: The hard work ethic - Izumi Cyclamen nursery (Japan, Sept. 2014)

Figure 45: The image of Japanese high technology (Japan Oct. 2014)

6.e. Limited benefit

Another key barrier to automation comes from the perception that mechanisation will bring such limited benefit as suggested when discussing ROI. You could argue that this could come under the "Reason" chapter (chapter 5) and I agree it fits somewhere between the two. The perception for limited benefit can be seen in both low-tech production as well as highly automated situations. For example at Nolina in the Netherlands, it was Marcel's perception that placing another automated pot sleeve machine was unnecessary as the person at the end of the line is not fully

Figure 46: Nolina - pot sleeve machine – no need for more than necessary (Netherlands, June 2014)

occupied by the task of overseeing his two machines. During the slack time available, they would sleeve pots with no time or cost implication.

Sometimes, where it is the perception that the technological route chosen has shortcomings, or limited benefit, operators will make manual adaptations, or bypass automated options available altogether. Occasionally these perceptions are correct, but more often than not, they're influenced by the apparent resistance to change, particularly when change involves mechanised strategies. Sometimes it is simply a poor understanding of the new systems. In other instances it is because the new procedures being implemented don't have the necessary forethought required to predict the practical implications. A typical example of this for ornamental horticulture is moving benches. "Transit" bench systems are perfect in a situation where the product is made, processed and despatched in whole blocks, but doesn't work where it is produced, processed and then separated into different locations and despatched over an extended time frame. In some nurseries you will see employees hurdling over metal bars and ducking under benches to reach a table in the middle of a house to collect a few trays of product which are required before the table reaches the "end of the line".

Equally, I witnessed situations when new procedures, or methods, were implemented with the right foresight, but the operators didn't realise that sometimes they would have to "break the rules" to be efficient. For example, a forklift that picks up to 200 pots at a time is great when there are 200 full pots to pick. But when the batch has already been picked through and is sparse, it may be time to deviate from the ideal system, get out of the cab and move them by hand, or reposition the pots for a more efficient collection and transfer.

Figure 47: Shula and the Aloe Vera crop (Israel, Nov. 2014)

Whilst in the Arava Valley, Israel, I visited Shula, a producer of Aloe vera products. Together with her husband she has 6 dunams (approximately 1.5 ha) of outside aloe plantation and can harvest the leaves of aloe once they reach maturity at two and a half years. Each year, a plant provides about 10 leaves. The process of extracting the Aloe vera from the harvested and peeled aloe leaves is simply to squeeze them as you would an orange. Other processors of Aloe vera around the world will typically have a far more technological extraction process. Often the entire leaves including skin and pulp are fed into a pulping machine, then filtered physically and chemically. Shula was under the impression that the only reason these other Aloe vera producers would do this is due to the fact that there was less polysaccharide available per kilo of their raw material. She estimated that there was twice the concentration of polysaccharide in her aloe compared to other growers around the world due to the high temperatures and lack of available water in her fields.

7.0. Opportunities and threats

During my travels I noted many potential opportunities and equally as many threats within the area of technology. Some have been hinted at already in this report, but there are a few others within and surrounding the technological debate that I feel it appropriate to mention.

7.a. Breeding innovation

A major area for technological development for the future will surely be in genetics. Breeding in ornamental horticulture has been particularly prolific in the last 25 years. This brought many advances in variety selection for new/novelty flower and foliage colours, earliness to flower, habit traits and resistance to certain diseases and temperature tolerance, for example. Some producers such as Florensis feel that where there is high pressure on commodity lines such as primula the only way to remain both competitive and profitable is to expand up the chain by breeding their own varieties and contract the seed production. Indeed it is in this area of breeding for improved seed-raised ornamental varieties that I feel there is both opportunity and threat to vegetatively-produced alternatives. Seed forms of product are sometimes thought inferior to cutting-raised products, but that is unlikely to be the case in the future as breeding techniques develop. The fact is that seed produced varieties are often cheaper due to the source cost and production system, particularly for large producers set up for high volume. I feel this is an area to watch closely.

In recent years, laboratory based breeding with techniques such as “embryo rescue” and induced mutation have assisted traditional plant breeders by increasing the speed in realising new and improved characteristics. Genetic modification has been extremely limited in its implementation in the ornamental plant sector, mostly due to the costs involved, but also because there are so many more developments to conventional breeding still to be fully utilised. It appears to me that the breeding revolution will continue with the onset of bio-informatics, and quantitative genetics such as marker-assisted breeding to further increase the accuracy of traditional breeding.

The ability to tag the genetic sequence of traits such as storage root formation, drought tolerance and cold tolerance, and disease resistance of sweet potato, has been one focus of work being carried out at the North Carolina State University. Dr Craig Yencho and his team at the Department of Horticulture aim to speed up the breeding and selection time by understanding genetic sequences, in order to predict the likelihood of certain characteristics being exhibited in a chosen cross. This technology is primarily focussed on edible crops, but at the university they also have an eye on ornamental traits as well. Just as for genetic modification, this is not a cheap process, so there would need to be the funds available in ornamental horticulture if this sort of sequencing is to be possible. Also, the speed of this sequencing is not a fast process, so ground can be lost to more conventional breeding, particularly in the initial research phases. It is only after many years that the benefits of mapping, crossing and selection may be reaped.

Genetic modification potentially has a future in the development of new ornamental varieties, but aside from the financial implication as mentioned for the above, it has many other perceived barriers to overcome such as the theory of the “super weed” and “Frankenstein” fears. A significant level of communication to convince a sceptical public would be needed for this to be conceivable in future.

7.b. Crop control restrictions and developments

So many active ingredients for pesticides, herbicides and fungicides are being taking out of circulation: often due to reassessment of their suitability or lack of investment in keeping their licences active. There is fear within agriculture and horticulture that we will face significant issues in the near future where there simply are no control options for certain pests, weeds or diseases in certain circumstances. Neonicitinoids, oxadiazon and glyphosate were amongst chemicals that were mentioned, during my trips, where growers have concerns regarding suitable replacements.

We have had to and will need to continue to look towards and promote the development of new, environmentally-responsible active ingredients and control methods with crop management specialists such as Koppert, Bayer and Syngenta. I was lucky enough to have a meeting with Paul Koppert, Managing Director of Koppert, who provided an insight into the history of the company and the strides that they have made to bring in new biological methods of pollination, pest and disease control, and various techniques regarding their application in a fully integrated manner, over the past 50 years. Seed companies such as Rijk Zwaan and Syngenta are also playing their part by developing new technologies for disease control and resistance through processing the seed rather than the plant requiring subsequent control. This is I assume, an area of significant development for the future. There is also likely to be an increased requirement to breed less sensitive - or more tolerant - species that require less pesticide application or irrigation.

Although some of the newly enforced regulations present major challenges to producers and exporters, there are some potential opportunities for those that are able to embrace these challenges. Mr Nakagawa of Kenmin company, Japan - a processing, packing and distribution company for drinks and foodstuffs, such as tea soft drinks and rice noodles for major clients such as Suntory - said that the stipulations on trace chemical levels in tea sold in Japan have curtailed a proportion of Chinese imports of tea, which has helped to increase the volume of home grown tea grown and sold. Also, the higher level of regulation has positively affected export to countries around the world including Taiwan. So where there are challenges, there are also potential opportunities - at least in the short term - whilst others get themselves into position to supply under the new regulations.

7.c. Lighting and enclosed environments

Although I knew a fair bit about lighting of crops before my travels considering we at Kernock have been embarking on some commercial trials of LED lighting in various areas of production, it became increasingly evident to me that lighting and the principle of growing crops in virtually self-sustaining environments is going to be an area of massive development in the coming decade. Mr Toyoki Kozai, Professor of Chiba University and Chief Director of Japan Plant Factory Association, was kind enough to take a very wet Sunday afternoon in October to escort me around the campus of Chiba University. Within the campus sits what he refers to as an indoor “plant factory”: an enclosed, multi-layered, artificially lit and environmentally controlled production facility. The facility enhances CO_2 at 4-5 times that of natural levels (1600-2000ppm) and of course “fertigates” on a hydroponic type system, which provides water and nutrients just as required - no more, no less. The plants are grown in tiers, sometimes as many as 15 tiers, each with their own LED lighting, 12 months of the year.

Figure 48: Chiba University plant factory (Japan, Oct. 2014)

Figure 49: Professor Kozai (Japan, Oct. 2014)

The project was initially set up, subsidised 50% by the Japanese agricultural industry and 50% from private investment. Principally it was established as a learning facility, but is also a shop window to help provide knowledge. He calculates that they can achieve a between 10 and 100 times increase in productivity of salad leaves, micro-carrots and radishes, for example, compared to natural production in more traditional facilities. The enclosed system also has advantages of reducing the pest and disease potential in the crops, therefore reducing wastage and improving quality and cleanliness, something that many high-end retailers and consumer are increasingly demanding.

We discussed Spread Co., the largest indoor vegetable production facility in Japan, reputed to produce over 8 million heads of leafy greens in their production facility near Kyoto. It is Professor Kozai's vision, though, that it will not just be large commercial facilities like this that produce the world's vegetables in future, but smaller community, micro-plant factories in urban areas that don't require vast amounts of space, situated in residential buildings, restaurants, schools, commercial and hospital buildings for example. It is envisaged that these facilities will produce food in the vicinity where it is required, using these "indoor" principles that are being honed in private and academic situations. Due to the costs of production, the system is currently most suited for short, fast growing, high value crops. But if the capital investment required for the lighting and infrastructure becomes more accessible, energy costs reduce as we become more self-sufficient, I see vertical, enclosed production as being a critical development area for both small and large scale production for a much wider range of crops in the future.

I witnessed lighting used in many facilities, often LED lighting due to its energy efficiency with lower heat emissions and extended bulb life. Varying spectra, day-length and intensity was used to increase the speed of growth, reduce or increase flowering and supress losses in production. Niels Kreuk of Maatschap Kreuk in the north of Holland was using LED lighting successfully for forcing tulip bulbs in his warehouse. Following several poor years with unacceptable losses in this process, in 2014 he invested in a three tier system using both natural light and LED light on the different levels to help increase the success of his bulb forcing.

Figure 50: Vitro Plus laboratory shelving (Holland June, 2014)

Vitro Plus, Holland have developed a new system for growing their ferns to a larger size in enclosed conditions. Owner John Bijl initially saw tissue culture as a way to meet his goals in his fern crop production when he started the business. He was a self-taught technician and once read a study about increasing CO_2 in tissue culture by using breathable/perforated film on sealed units. From this knowledge he developed a new system that he called "VIVI" using both agar and more traditional, but sterile, glasshouse growing media such as peat and coir in a system that produces a more advanced product than traditional lab/tissue culture material. This enabled them to sell further down the supply chain than was previously possible from the lab. With clear advantages in quality and less pest and disease issues, John feels that this is the way greenhouse production will progress in the future.

There are also other potential benefits that lighting could bring, some of which we don't yet understand. I recently spoke with Phil Davis, Applied Photobiologist at Stockbridge Technology Centre and mentioned that I had read about some recent research into varying light spectra to affect the behaviour of certain pests. Although there is limited evidence of the effects at this time, he agreed that this was an area that could hold significant benefit for growers.

7.d. Alternative energy sources

There has been a trend over the past decade in horticulture to employ alternative energy sources to provide heat and sometimes energy, particularly for the energy intensive glasshouse "protected" edibles and ornamentals sector. Growing poinsettia into December, for example, typically requires temperature lifts of up to 20 degrees. Energy is commonly one of the highest input costs in management accounts, so this fact, coupled with incentives such as the renewable heat incentive (RHI) in the UK, has promoted investment in alternative energy provision such as biomass boilers, photovoltaic capture, wind farms and combined heat and power (CHP) plants. The incentives seem likely to diminish for future developments, but the long term benefits still appear to be able to provide a return on investment, particularly as cost of the hardware reduces.

One of the most significant examples of new energy provision that I saw on my travels was in Germany. In 2012, with the lure of subsidies in Germany for renewable energy, Tom Kuipers of Emsflower opted to build a 10MW wood chip fired combined heat and power plant. It provides heat for the 40ha nursery and also contributes both heat and electricity to the local area. The plant has an incredible 3000m^3 accumulator tank and emissions are relatively clean as they have both a cyclone filter and a 15,000 Volt electrical filter to extract the finest particles from the emissions. Investment in this plant alone required 6 million euros.

7.e. Water capture and treatment

More effective capture, storage and treatment of available water and irrigation is clearly an area of development for many within agriculture, particularly in times of water shortage. There was current and historical evidence of developments in this area in each country I visited. Half of the world's natural water resources have apparently been depleted over the past 50 years and regions such as California are experiencing more frequent water stress. So, with diminishing availability, increasing demand and subsequent regional regulations in countries such as Israel, it was unsurprising there were many examples of water capture, storage and treatment by slow sand filtration, iris, or reed bed treatment and UV used to help clean water ready for use on the production facilities. Jim Hessler of Altman Plants, California, conveyed how they reduced water consumption on the nursery by 50% through changes to their irrigation system and subsequent training of the staff: changing the mentality of the irrigator's mind-set that more water is not necessarily better. Now, they plan to recycle water to save a further 150 million gallons, equivalent to another 40% water saving. Rudy Raes, young plant producer in Belgium, like most producers collects rainwater from glasshouse runoff. He stores 4 million litres in a reservoir outside, but also due to restriction of area on his nursery, had a 1 million litre storage sited under his glasshouse.

Figure 51: Drought issues in California (USA, April 2015)

Israel – The water story

Although some coastal, central and northern regions of Israel can see an average in excess of 700mm or more per year, the southern and more eastern arid extremes of the country often receive no more than 50mm per year. It is not just the lack of water and droughts which have been challenging to both domestic and industrial quarters, but also the fact that so much of the limited fresh water supplies such as the Sea of Galilee are contaminated by sea water and saline water bodies. The Jordan-Dead Sea Rift Valley, human pollutants and also the dissolution of soluble salts that naturally exist in the bedrock all contribute to the salinity. Two billion cubic metres of water are used each year in Israel and only approximately 1.1 billion m^3 of that is potable, with chloride content of below 600mg/L. Whilst some water is naturally potable with as low as 10mg per litre of chlorides, other groundwater sources, I was told, provide water in excess of 1500mg/L.

Figure 52: Sorek desalination plant (Israel, November 2014)

Figure 53: Sorek reverse osmosis (Israel, November 2014)

(..continued on next page)

Israel – The water story – (continued from previous page)

This poses an incredible challenge and expense to the well renowned horticulture industry of Israel and much emphasis is put on attaining a constant supply of water. A colleague of mine was kind enough to organise a trip to Sorek desalination plant, 15km south of Tel Aviv.

This is the largest desalination plant in the world and the newest in Israel, commissioned in 2013. The plant processes 150 million m^3 of sea water each year - up to 624,000m^3 per day - extracted from the sea 2km west of the site and contributes water to the national carrier. There are many stages in the process, starting with an initial crude filter of the largest matter followed by coagulation of particles, acid injection, slow sand filtration and ultimately reverse osmosis. This is the key process of applying hydraulic pressure along hundreds of metres of vertically mounted tubing with internal membranes to drive the mineral content from the water. Ironically after the process is complete, they dissolve calcium carbonate into the water to bring the water to the right alkalinity to avoid pipe corrosion and for body health. The resultant water is leaving with EC of 0.25 and Ph of 8. Processed water is blended with ground water and water from the Sea of Galilee. This plant caters for 20% of the country's demand for potable water, so clearly the Israeli government has a vested interest to encourage developments of plants such as Sorek, and therefore encourage agricultural producers to purchase water from the "grid" at discounted rates.

Everywhere I visited in Israel, water was on the agenda. Most production facilities have water capture and storage in conjunction with their own desalination plants. Even the water delivered by the grid can be too variable for precision horticulture. I was often told by growers that water was their largest cost, often ahead of labour. Some areas of Israel such as in the Arava Valley are not even yet on the water network. Locals told me that they expect to be connected in 2018, but in the meantime farmers have to be completely self-sufficient, often drilling up to 1500 metres below ground for a water source with an EC level still in excess of 3. The air in Arava is apparently so salty that when it rains, the crops often get salt burns as the salt is deposited on the leaves and fruit.

It is not surprising, then, with such importance placed on water that much of the irrigation systems that are in use today around the world were brought from Israel. I went to see Ami Charitan, the chief agronomist at Netafim, a global company based near Be'er Sheva. They design and manufacture irrigation systems including drippers, connectors and tubes. Netafim was created due to issues of lack of water in this dry area in the south of Israel (100-200mm rainfall per year) and salinity problems mentioned above. The ancient systems of collecting water, conceived over one thousand years ago, kept people alive for centuries. Those in agriculture, for example apricot growers, were trying to leach salts from the soil and water to facilitate its use. But this was often ineffectual for consistent crop production year after year. In 1965 the mechanism of drip irrigation was invented: pipes with a specific hole size and resistance designed to disperse water to the root zone of crops at an appropriate rate, without clogging the hole, or losing too much water. Now with many patents long expired, Netafim relies on its reputation around the world, delivering irrigation systems even where water is not a limiting factor in countries such as Brazil. Netafim's research suggests that yields are often enhanced by 20-30% in typical scenarios, but by as much as 10 times in certain situations by employing their precise delivery systems, including "fertigation/nutrigation" and application of herbicides, pesticides and growth regulants in some instances. The additional advantages are of course reduced water consumption, leachates, methane emissions (in traditional paddy situations) and increased quality and resultant price of the products.

7.f. …and so many other areas!

I realise that there are so many other areas that I could mention in this section regarding perceived opportunities and threats, but in the interests of brevity I will make some cursory observations:

- Inevitably, due to the restrictions of automation mentioned, many of those I visited around the world were more focussed on enhanced IT systems to help improve performance in logistics, customer liaison, accuracy and speed of communication, forecasting, reduced speculation, traceability, cost allocation and control. These are just some of the ways that I see that will help reduce wastage and improve the offering, as well as the profit margins.

- Improved rooting media technology including the incorporation of peat alternatives, I assume, will not only meet targets set by the government for the future, but improve growing speed and efficiency.

- Imports of ornamental plants are likely to continue to be key even though the phytosanitary regulations for imports into the UK and bio-security borders are likely to remain rigid. The emerging markets of Eastern Europe continue to develop their export capacity alongside the more traditional European plant producers. One of the key factors that could continue to hamper imports on a greater scale from further afield, such as Africa and China, particularly for low value, bulky produce, is the *volume* of the shipments. Time and distance in transit for perishable products and, of course, the cost of fuel, are also inhibitors in this area. Although oil prices are relatively low at the time of writing, I assume that fuel prices are set to keep rising in the longer term as oil reserves are depleted. Perhaps though, this price issue as far as transportation is concerned will be circumvented through the more efficient use of fuel, increased development of alternative fuels and increased speed of the transportation. Advances in this area could provide a significant boost for imports and of course have a potentially negative impact on local production.

8.0. Significance and general observation

There are many points regarding the significance of the above observations that I would like to touch on. Some have clear links to the core subject regarding the advancement of technology and other major surrounding issues in the industry today.

8.a. How to exploit the market?

8.a.i. David v Goliath

I don't see the situation of the "big boys" against the small or medium operators in a David versus Goliath type contest. I see that we should all be able to operate in the same market, but we have to be vigilant of what is going on around us and operate within our agreed limitations. Usually, there is little point for a mass producer to attempt to produce for a small, niche market, that can be catered for by smaller, more specialist players. Likewise small and medium producers may well be able to produce volume, but not usually at the price of the big guy who has the size, scale and technology to keep costs down. Glenn Andersen, owner of Nordic Plants in Abbotsford, Canada, figured that there is only so much cost you can drive out of the production of a commodity product without larger volume. This is not to say that smaller companies cannot compete in a volume market if they choose to, but from what I see, these opportunities usually emerge where price is not the only driver. Smaller producers can be flexible and offer some added value or unique service, which perhaps alternative, larger companies may not be able to entertain.

It is true that most producers have rationalised their A-Z offerings in recent years in a bid for efficiency, but it is the selection of specialist crops that are not serviced by the more major players that could reap benefits. The ability to be more flexible to offer smaller quantities, or a "just-in-time" service, could win business. There is also likely to be some stratification of the market to offer "good, better and best" options as is common for groceries, thus providing potential for all producers to supply their niche. Some customers and consumers may shy away from the "giants", or products that they perceive to be mass produced in corporate-style supply chains. Whatever the scenario, I feel confident that there will always be "scraps from the table" of the larger producers that provide a feast for smaller producers. So, as long as there is future demand in our market we can assume there will be plenty to go round for producers that are prepared to "step up".

8.a.iii. Marketing focus

To "supply niche" or develop "added value" offerings is, of course, more easily said than done. Firstly you have to work out what is "niche" or consider what added value options will take focus away from price, then fathom how to service those specialist markets. Where branding is involved, there is a significant amount of forethought, time, money and effort required to realise a successful promotion. I witnessed heaps of examples on my travels where producers were successful in this area. Azumino Apple Farm, Japan, has the largest Pink Lady™ orchard in Japan with 1500 trees (1.5 ha), but the president Taka was always looking for other apples and markets to exploit. It is Taka's intention to plant more 'Granny Smith'. This is not a popular apple in Japan, but Taka sees the

potential for this more profitable line and wants to seize the market. Also, whilst in Japan I saw that a 200g bag of shiitake mushrooms will fetch 650 yen (approx. £3.50), up to 10 times more than standard mushrooms. This is a great example of a niche that has been created through the perception of a premium product, in this case produced through traditional processes involving labour intensive, back breaking methods.

We need to be savvy when selecting and marketing plants we wish to produce. The many and varied benefits of each product need reiteration. Whilst impulse-led purchase, purely on aesthetics, colour, shape etc., is still vital, many consumers shop for plants like they shop for other goods, with a little research. This is where demonstrating provenance, ethics, low plant miles, wildlife-friendly, or multifaceted use of novel plants pays off. I witnessed this sort of smart selection and marketing on several occasions around the world with breeders, producers and retailers. Jeroen Star, sales manager at Schoneveld Breeding in Twello, Holland, said that their general breeding policy and marketing focus was to select garden plants that can be used in both indoor and outdoor situations. It was his desire that new varieties had "stories" that come with them creating more marketing potential, and higher profitability. In turn, he felt that this could help to increase the price perception of other similar standard ranges. Proven Winners®, a well-known plant brand in North America, is certainly amongst the very best at selecting and marketing their brand. This is why we believe so strongly at Kernock that branding - using a brand such as Proven Winners® - is so important in order to engage the consumer and encourage them to repeat purchase.

Figure 54: Schoneveld, primula breeding (Holland, Feb. 2015)

Figure 55: Proven Winners branding – Monrovia (USA, April 2015)

8.a.iii. Customer centric

It is not simply a case of understanding the market, but also understanding that the customer is key. So many times on my travels I heard the phrase "*the customer must come first*". Again, easy to say, but harder to carry out in practice. A business following this sentiment will essentially place the customer at the centre of their decision making process. Decisions will not be moulded by ego and perception, but based on the perceived experience of the customer. Of course there are going to be compromises that have to be made on occasions due to viability - that is key. But as long as the

ultimate decisions are made with the customer at the heart, then I feel that this admirable intent will stand that company in good stead. If companies do not follow this mentality, then I can only assume that the customer will vote with their "purchase order" and go elsewhere if they are not happy. The customer and consumer are king and they will ultimately drive the requirement.

John Bijl, owner of Vitro Plus, gave me an insight into the fern market and issued a sort of warning shot when he said: "*You cannot let your production dictate your strategy and offer. You need to be customer focussed*". John recounted the fact that he had five or six competing tissue culture fern producers 10 years ago. Some were specialised and had excellent production models that worked superbly for the facility, but the output was not customer focussed. These processes were hard to change and now there is just one other specialist fern laboratory that has the remainder of the fern market. Jim Koot, director of van Son & Koot, a shrub plant specialist based near Kaatsheuvel, Netherlands, said that he aligns his company absolutely with the customer. He has no desire to expand unless his clients demand and support him to increase his capacity.

Marshall Dirks, director of marketing for Proven Winners® in the USA, was referring to both consumers as well as customers in business when he said: "*it is now all about the customer*". Product differentiation is increasingly difficult. Improved genetics, providing great quality, and products with great impulse at the point of sale are some of the ways that we can differentiate the offer. But, he believes: "*it's all about how the customer feels, not necessarily about what they think*". We need to ensure we recognise, listen, value and care for our customers. It is not necessarily technology that will assist in this area, but there are several technological developments that Marshall cited that Proven Winners® and other brands are using to elevate the customer experience. Real time availability of retailers and automatic communication to consumers in the catchment area is just one method to improve the consumer experience. He also cited examples such as delivery.com who are winning the race to ultimate customer service. They've delivered food to addresses for years, but will now bring a packed lunch of your choice to a GPS location according to your phone, whilst in Central Park! This is a reminder that we have to think smart and will have to deliver more than just the goods.

8.a.iv. Diversify

Diversification is a word often used in agriculture, less so in horticultural circles, but I have to say I saw some great examples of diversification in horticulture, used as a prop for the core business. On so many of my visits, I went expecting to see one thing and I would end up seeing many strings to the bow. Producers around the world like to keep several fingers in several pies, even branching into unfamiliar territory. Some will diversify upstream, downstream and sideways within the same sector. These are good strategies designed to spread risk.

I said I would mention them a few times, and I have … Emsflower, Germany, was a nursery like no other I saw. Not only were they looking to expand upstream in their supply chain in a bid to have more control of production, but they have also broken into the retail side of the market. Tom Kuipers, showed me around his garden centre, just across the road from his nursery. Named Gartenwelt it was opened on 01 April, 2014. It is an incredible 24,000 m^2 area dedicated purely to retail sales, 50% of that dedicated to plants, set on a site with a total area of 80,000 m^2. Trying to be

Figure 56: EmsbÜren Gartenwelt (Holland, Feb. 2015)

like a large Dutch garden centre, the retail area is at least double the size of the largest UK garden centre equivalent. It is truly XXL! Perhaps even more novel and impressive than the garden centre, is the fact that Emsflower have opened their nursery up as a tourist attraction. Twenty tour guides are employed to show 300,000 visitors each year through their facilities for a price of 8 euros per adult. Visitors can see demonstration growing areas, walk through tropical and butterfly houses, have an opportunity to see the heart of the nursery logistics area on a suspended bridge, eat in cafés and restaurants, and their children can use the play areas that are available. This was a complete eye-opener to the possibilities that could be explored by a conventional production facility and surely a way to engage the public and inspire a future crop of horticulturalists.

8.a.v. Creating demand

I mention clearly the need for marketing awareness, and customer focus, and suggest possible diversification into alternative areas, but what of the consumer demand for ornamental plants in the future? I discussed earlier in the UK market analysis that demand is not increasing. If the market is to have confidence into the future, we collectively need to encourage gardening, particularly amongst the gardening youth. We need to create more reasons to buy plants. Perhaps more "indoor gardening" opportunities: gardening programmes on TV clearly help the cause. Could there be more special celebration days associated with gardening, to encourage the plant purchases? Campaigns such as "Love the Plot You've Got" and "It Starts with a Pot" initiated by the HTA aim to blow the cobwebs from the potentially confusing gardening arena and popularise it amongst consumers of 30-45 years of age. They're designed to excite this age group who often see gardening as a chore, a hard work pastime of "older people": to engage them and encourage enjoyment of the outdoors regardless of garden size, or gardening knowledge, and promote the benefits of gardening.

8.b. Supply ≠ Demand

It did occur to me whilst visiting various production facilities around the world that more automated systems are commonly churning out product over and above the actual demand. This is why pot roses, for example, are less than a third of the retail price in December compared to Mother's Day and Valentine's Day. The supply is not matching the demand. I wonder if this affects not just the perception of price on the pot rose example, but also other similar products, even if they are not produced in the same way. Perhaps, addressing the oversupply to the market will help to reverse this trend of diminishing profits. Jim Koot of van Son & Koot was not the only person on my travels who agreed with the need to decrease capacity in the market and focus on the quality and marketing of product in order keep prices sensible.

Producers need to strike a balance between supplying volumes required and forcing products towards commoditisation. Plants, or product areas, that become commodities are unlikely to return to specialty crops in the future. One challenge is that there are always suppliers that are prepared to sell for less than others, either through enhanced efficiency, or acceptance of lower, even negative profit margins. This I felt was certainly true in situations where there was significant investment in technology, and this needs to keep rolling to ensure any sort of return on the investment made.

It is also clear that the drive by some increasingly powerful retailers is resulting in a "squeeze" for all producers. Labour and raw material costs continue to increase, so this pressure looks set to continue. Where price has been the main factor in the tender process, rather than quality or specification, growers might cut corners and retailers may have to deal with the consequences of inferior product. The significance of this strategy could be fairly instant, but might equally take several years to filter back whilst the consumer, consciously or sub-consciously, realises that quality of the products they have purchased did not meet their expectations.

8c. The robots are coming!

The first visit that I made, before even organising my other trips, was back to my university, King's College London, to go and see Dr Matthew Howard, a specialist in robotic learning in the Department of Informatics. Matthew was viewing horticulture with the intention of applying for funding for a PhD student to research the possibilities of robotics in horticulture. The visit and discussions reaffirmed my impression that a robotic revolution is upon us. There are, of course, already domestic robotic vacuum cleaners and lawn mowers available, but Matthew talked of robots becoming the norm in the household and doing all our household chores in the future. Industrial production will undoubtedly pioneer the technology required to help enable this sort of advance to occur. So we can expect big movements, particularly in production and manufacture. Robotics is likely to move on from being specific task-based towards more intelligent robotics that can be taught a variety of complex tasks, improving their activity through experience of performing the task, just like humans.

Initially robotics like this will no doubt only be within the grasp of the biggest growers with lower product variability and larger budgets. As technology develops, however, it will conceivably fall into the domain of the smaller producer. Just as for agricultural machinery now, mobile robotics for example may have to be shared in cooperative type systems or privately contracted. Manoj Karkee, WSU, told me that this is happening for Kiwi growers in New Zealand who share harvesting machines. Sharing is however limited by the window of opportunity to harvest the fruit and the number of machines available to exploit this time-frame. In a more compact, manufacture-style greenhouse environment, Manoj believes there will be possibilities for the smaller sized grower in the future. The delicate nature of many tasks will be manageable, especially if the plant, or object that requires work, is mobile. Currently, moving plants around a site is often impractical due to the size of product, or logistics of the site as mentioned previously. So, once again this may present a major hurdle to progress until the problem is overcome.

The sort of research required in this area needs a strong collaborative effort. I was particularly impressed when I visited Demokwekerij Westland B.V. which is a horticultural innovation centre, a

Figure 57: Demokwekerij Westland, horticultural innovation centre (Holland, Feb. 2015)

little like a technical university. They research, demonstrate, and share knowledge. Within the facility there is a robotics department called Techno Centrum Glastuinbouw. It is funded and supported between the knowledge and innovation organisation known as TNO and Delft University of Technology. It aims to bring all the people in the chain, right from top down, to realise technological advancement. Many of the areas of development such as automated pepper picking, tomato vine maintenance and cut flower packing, were on display during my visit. This I feel is the sort of collaborative approach to research that is essential if we in the UK are going to compete in horticulture in the future.

8.c.i. Job elimination or creation?

So, it is true that technology will progress quickly and yes, it is true that in the past decades machines, specifically robotics, computers and software, have been replacing peoples in certain jobs. Deloitte suggest that 800,000 jobs in the UK have been lost to automation since 2001. It is expected that nearly one third of jobs currently in the UK (approximately 10 million jobs) are expected to be eliminated through technological advancement over the next 20 years (*Katie Allen, 2014*). Agriculture is one of the industries that can expect further employment consolidation. In 1871, 6.6% of the workforce of England and Wales was classified as agricultural labourers. That has fallen to just 0.2% today, a whopping 95% decline.

Statistics like these could of course be viewed negatively, but they are only half the story. The fact is, most of the jobs lost to automation have been in the more repetitive, laborious, strenuous, sometimes dangerous and usually lower paid and low skilled positions. These have typically been the jobs that are hardest to fill in recent years because of these unappealing qualities. One way to look at it, said Dr. Karkee, is "*when we look at technological developments, we are not trying to displace workers but merely trying to fill the gap that is there, now or in the future. Just as we can't imagine harvesting corn by hand in the developed world, in the future we will not think anything of harvesting all apples, cherries and grapes by machine*."

Not only have robotics allowed companies to reduce their reliance on manual labour for these tasks, but they have been able to dedicate more time for other alternative, important tasks that can't be performed by robotics and weren't adequately covered previously. History also suggests that whilst many jobs are being replaced by technology, many more are being created due to this technological progress. Deloitte's statistics indicate that in the same period since 2001 mentioned above, there have been 3.5 million jobs created, which is over four times the number displaced. Employing technology requires its own operation and maintenance for example. New opportunities have emerged in the technological sector as well as other unrelated industries, often more highly paid jobs created from the emerging needs of a new generation. Examples would be in the areas of social

media, leisure, service, care and welfare, education and professional service industries. Through these developments, it is thought that the world is likely to become more productive and wealthier.

One of the main adaptations that will need to be addressed in this scenario is the new skillset required by those displaced staff. They will need appropriate training, providing them with new skills required for the new age in their new job roles. This need not be a concern if addressed in the right manner. So, rather than fighting the inevitable advancing tide of technology due to fear of job redundancy, we need to adapt and embrace it. By engaging with relevant partners such as the team at Kings College London, WSU CPAAS, Demokwekerij Westland and similar bodies around the world, we can hope to seize the opportunities and manipulate the advancing technology to our future advantage.

8.d. People are key

This study was never based on a desire to see reduction in staffing levels, but about understanding how to select the most appropriate production methods which utilise the right balance of labour to optimise production and service levels. This might involve investment in technology, but it will also require selection of the right people for the right tasks. Terri McEnaney, from Bailey Nursery, was spot on with her management philosophy in my opinion. She said that she always tries to give opportunities to those people who have the potential to lead. She advises putting people in the right place, investing in them and having faith that they know what they're doing. "*Ensure that you are open to ideas from the team and those ideas that come from the people are recognised and not squashed by the senior managers,"* she said.

Figure 58: Terri McEnaney, Bailey Nursery (USA, April 2015)

These thoughts were echoed by operations manager, Csaba Lippai of Bergen's Greenhouses, producers of annuals, perennials, shrubs and trees. Bergen's is a fourth generation, family-owned business that has been servicing the upper Midwest USA since 1921. He said that the people are the most important factor. He wants his team to be positive and satisfied. His mantra for management is "*don't ask more of them than you would ask of yourself*". He also said that he encouraged his staff to *"think inside the box",* essentially encouraging them to be involved in the decision making process and think for themselves.

People will always be required, but their job roles are likely to change in order to adapt alongside future technological solutions. When making changes, technological or otherwise, I feel it essential to engage, explain and train the operators in the chosen production methods. They will be more likely to adapt and understand the process enough to contribute ideas to improve the process. Remember the principle of "Jidoka" that I saw in action at Toyota - "automation, with a human touch". This is a simple philosophy for any company to follow based on perfect harmony of man and machine.

8.e. The balance sheet rules

In my industry we produce plants and, perhaps like those in more creative industries, sometimes I believe decisions will be made that do not necessarily make complete financial sense. In this increasingly corporate world, I believe that we should maintain some level of emotive decision making. Ultimately though, most strategic decisions in business will be dictated by the promise of profit. “The balance sheet rules” as they say. No matter which production strategy or techniques are chosen, we have to turn a profit to be able to continue in business.

Figure 59: Toyota’s Motomachi plant (Japan, Sept. 2014)

In order to make sound financial decisions, we need a good understanding of our costs. I discussed the subject in some detail with Tom Kuipers of Emsflower, Germany. He told me that shortly after they built 20 hectares of glasshouse in 2005, they were facing a €9 million bill due to damage caused by heavy snow. They weren’t insured due to a discrepancy in the snow weight allowance for the glass. The bank involved didn’t want to lose the €32 million that they had just loaned for the initial construction, so lent another €3 million, and the insurer ended up paying out the remaining €6 million. It took this complete disaster for the bank to impose much stricter scrutiny on their costings. We have the luxury of looking our costs and financial health without suffering such a major disaster.

Ultimately, if producers don’t make money supplying a certain crop, whatever the production method, then they will abandon the crop, or it will abandon them. In 10 years’ time, if the future global labour situation is to be as challenging as is generally expected, then certain crops will be produced with robots, or not at all. It might be that there is some future back-lash to technological methods. People may grow to love the deformed or dirty fruit and veg, or irregular plants on the retail shelves. But I believe that, in the main, the consumer is unlikely to care much for the actual production method in the new techno-age. Many plant purchases in particular are based on impulse, so primarily the produce needs to look good and capture the attention. As long as demand is satisfied and consumers have confidence that production uses morally, ethically, environmentally sound methods, I believe most will be satisfied.

8.f. Understand, adapt, survive and thrive

Rob Napier, whom I mentioned earlier, said that the future of any agribusiness, particularly the small to medium sized, or the family business, will depend on benchmarking and exploring the “sweet spots”. Volatility is a given and opportunities will come and go. When I sat with Lori from Jordan Valley Herbs, Israel, he echoed this perception, when he said: *"Some people feel the rain. Others just get wet."* I understood this to mean that two different people can be having exactly the same experience, but some take the time to understand or can instinctively interpret their experience and use it for some personal gain. Others just carry on getting wet! So the moral of the story is: look up, open your eyes, make sure you question everything, understand who you are, where you fit, realise your USP’s and how they might be threatened, anticipate the sweet spots, get creative, and have courage in your convictions to make the right decisions.

It dawned on me during my travels that in business we shouldn't be looking over our shoulder with concern, or over the fence assuming that the "grass is always greener". We should not complain about competition. We need to take a view of ourselves, develop within our means and align production systems to the situation and strategy we choose to adopt, making the best of the situation. I recall Csaba from Bergen's Greenhouses giving an analogy of the bison and the wolf pack. "*If you are a weak wolf you will not survive the winter. You cannot blame the bison for being too strong and fast: just as the bison can't blame the fit wolves for being too cunning."* We can't expect to sell overpriced, mediocre product. We have to increase quality of product and service and, if that is not possible, or the situation is no longer tenable, drastic change might be required

I do not advocate implementing technology for technology's sake, indulging in some "techno binge" simply because the technology becomes accessible. When speaking to Jim Hessler from Altman Plants, California, in his opinion process improvement was just as important as mechanisation opportunities. Jim told me that they weren't able to get any more money for their plants, so their policy is to produce the same quality, for less cost, i.e. being "leaner". Jim described the implementation of a new method that helped reduce movement of pallets and racks in their despatch area by 75 miles. One of Jim's employees said to him afterwards: "*The new way is a lot harder on the brain, but easier on the body*". I thought this was great recognition of the fact that they were thinking smarter, rather than working harder for overall gain.

So don't change for the sake of change, but also be careful not to fall into the trap of "*if it ain't broke, don't fix it*". This mentality can be an excuse for choosing to ignore new possibilities. Even if technology is not available, or unviable at this point, we need to keep an open mind to the emerging possibilities, continuing to develop knowledge and expertise, so that we are prepared to change when the time comes. It is equally important that strategy should not be dictated by the limitations of production. Don't discount an idea that can aid sales just because it is tricky to implement within the current production system.

Where technology is deemed appropriate, suitable advice needs to be sought and good relationships with the technology provider are vital in order to develop machinery with precise requirements in mind. Appropriate incorporation of technology into the system is the key to driving efficiency. Just because it is on site, the benefit may not be realised without proper understanding of the capabilities and limitations and suitable integration into the process with the key personnel on board. It is also tempting to seek funding streams available to assist with high capital investment of technological implementation. But I feel that if the actual process improvement is not properly assessed, many £s and much time can be wasted in adoption of poorly conceived improvements.

I read a lovely quote relayed by Tom Smith, son of Frank Smith Jr., founder of Four Star Greenhouses (Michigan, USA), who sadly passed away earlier this year. Tom shared a few "Frankisms", one of which was: *"If you're average, you'll be the best of the worst, and the worst of the best."*

Now this may seem pretty obvious on the face of it, but to me it serves as a poignant reminder that no matter what the chosen strategy, we need to try and strive to be the best: aiming to be the most reliable and efficient; offering the highest quality product and service in our class in order to help ensure our future success.

9.0. Conclusions and Recommendations

Compiling key conclusions and recommendations is not an easy task considering I took so much from the Nuffield Farming experience and the project undertaken, but if I were to pick ten key conclusions or recommendations they would be these:

1. Technological advancement is just one of many influential factors that we need to be aware of and should embrace within the horticultural industry.

2. Labour, its cost, availability and the regulations imposed on employers, are the principal motivations behind the decision to adopt more technology in production processes.

3. The aim to increase quality with fewer resources - essentially speaking "efficiency", is another key driver towards technological investment for production facilities. Well-orchestrated mechanisation, in the right environment can often provide speed and endurance unmatched by man.

4. The chief barriers to the adoption of technology in horticulture are the finance required and the logistical difficulties of implementation within certain production situations.

5. The perception of quality, as well as national and company cultures, are significant influencers, often inhibiting the decision to automate.

6. The robots are coming! The tide of technological advancement will continue to surge whether we like it or not. It will undoubtedly reduce the reliance on manual labour within the horticultural industry.

7. Technological advancement in horticulture will not be restricted to mechanisation and automation, but the employment of many other precision information and process improvements that will be key in the future.

8. Precise costings of all the factors involved are an essential precursor to making well informed decisions on implementation of technological strategies.

9. Whilst most should embrace the potential benefits of mechanisation, it is not suited to every production company or process. Careful consideration for the options available is required and 'blind thinking' to capitalise on the technological advances is not the answer.

10. The future is not "Man versus machine" but "Man in harmony with machine". Employing the right people, engaging them and providing appropriate training will be more important than ever when striving for efficiency.

10.0. Personal reflections

Here, I attempt to demonstrate that this Nuffield Farming opportunity has been worthwhile for me. Of course the key people to convince include the Nuffield Farming Scholarships Trust themselves, my sponsors Studley College Trust, my family, work colleagues and contributors. Well ….. I am pleased to inform all of the above that it has made a difference to me and hopefully to others in the future.

10.a. Has it changed me?

The "Hoover" mentality

I started this process without really knowing what I was going to discover. Part way through the trip, I realised that all I was in fact doing was acting like a vacuum cleaner, "hoovering" and collecting as much detail as possible with the intention of filtering and retaining the good stuff. Writing this report has been a case of picking out some of the themes and most interesting bits from the hoover bag. Also, it has been incredibly valuable to take a moment to consider where I have come from, where I am both personally and as a business, and ask myself *"where am I going?"* There is something about committing words to paper that made me consider carefully my views and opinions.

I came to the realisation towards the end of my travels that I was not necessarily going to experience a "eureka moment". On reflection, what I had experienced was a collection of little nuggets that make a sort of cumulative epiphany.

Listen!

I have never found that listening came easy to me. I always remember my French teacher, Mrs. Rowley, saying that if I could listen half as well as I could speak French then I would get an A. For some, listening comes naturally. For me, my mind can wonder, clinging to one particular point during dialogue, especially when taking detailed notes. I was intent on making sure that I didn't simply come away and produce a blog of my own preconceived, possibly misconceived ideas. So I knew that I would have to really concentrate in order to "hear" and make sense of what people were saying. I can't say that I have completely perfected this art yet (my wife Jo will agree), but I have certainly improved through necessity.

Confidence and courage

I remember being at the Contemporary Scholars' Conference in Sydney and getting together with the 60 or so global Nuffield Farming group of 2014 and thinking that this was an impressive group of people. I wasn't sure I belonged. As time went on, I realised that I was making valid contributions and maybe they viewed me as I saw them. That thought gave me a confidence boost, providing me with courage in my convictions to bring a debate or make decisions that I may not otherwise have made. I have already started to implement changes in my business that I have considered for a while, but perhaps before I wouldn't have enacted.

Step back

I already knew that I needed to extract myself from the day-to-day minutiae of work on the nursery. That was one of the main reasons for undertaking a Nuffield Farming Scholarship, but the experience only reinforced that aim. I intend to continue to devolve many of my responsibilities and focus on, rather than in, the business. That is not to say that I won't get involved in some of the detail. I think it is important to understand much of the detail to retain an informed opinion. But in the end, the future of the business depends on me being able to see the bigger picture, take a little time to decipher it and deliver the key messages to those on the ground.

10.b. Make a difference

Getting involved

Over the last couple of years I have inevitably made lots of connections and have been getting involved in a couple of projects. I was happy to assist and back the proposition of a PhD studentship from King's College London, Informatics department. They have now secured funding from the AHDB (HNS PO 194) for a project known as "GROWBOT". Essentially this is preliminary research into the feasibility to develop A GROWer-reprogrammable roBOT for ornamental plant production tasks. I informed Dr. Howard, initial proponent of the project, that I am more than happy to help mentor and provide commercial background for the studentship.

I was also happy to be involved in a proposal coordinated by Dr Jorge Hernández of University of Liverpool Management School. The potential project was known as RUCAPS. Its intention is to develop and implement knowledge-based ICT solutions within high Risk and Uncertain Conditions for Agriculture Production Systems (RUCAPS). Together with over 20 potential project participants we sought funding from the EU H2020 framework for a comprehensive four year programme covering many topics. Unfortunately the proposal has not been accepted at this stage, but I understand there is still potential for future funding for this, or for a comparable project.

Share the experience

At the time of finishing this report, I have already started the process of sharing the knowledge and experiences that I was fortunate enough to gain. I have spoken at a conference recently and have several more presentations lined up, which I welcome and will enjoy since I've got plenty to say on the matter! Hopefully, I can enthuse others by showing glimpses of the people and the organisations I am privileged to have experienced and be able to impart just some of the inspiration that I have encountered.

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Figure 60: A Journeys End - Arava Valley Desert (Israel, Nov. 2015)