Project title:	Update of 2017 AHDB survey ‘An assessment of current access to and future aspirations for automation and robotics in UK horticulture’
Project number:	
Project leader:	Dr. Becky Turner, HortSolutions
Report:	Final report, June 2021
Previous report:	Final report, October 2017
Key staff:	
Location of project:	
Industry Representatives:	Dr. Phil Morley Martin Emmett
Date project commenced:	February 2021

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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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Director

HortSolutions

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[Name]

[Position]

[Organisation]

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GROWER SUMMARY

Headline

- UK growers want to invest in automation and robotics, the main drivers being the cost and availability of labour
- The biggest barrier to investment is the lack of equipment or technologies, where there is automation and robotics available, the biggest barrier to investment is cost

Background

In 2017, AHDB commissioned a survey to establish the current access to, and future aspirations for automation and robotics in UK horticulture (AHDB, 2017). The resulting report provided valuable information which has been used by AHDB to help steer the automation and robotics activities within SmartHort. Due to the speed at which technology is developing, the survey needed revisiting and updating to ensure current activities meet the need and requirements of the UK horticultural industry. The outcomes of the survey will be used to inform future AHDB SmartHort and Defra activity on automation, robotics and new technologies.

Summary

1) Grower demographic

Forty businesses who had previously been surveyed about automation and robotics in 2017 were reinterviewed. A further ten growers were interviewed for the first time, one grower completed an online survey. These 50 growers proportionately represented the spread of levy income by sector. The telephone and online data were combined giving a total survey size of 51 UK growers.

2) Automation usage

Figure A shows the percentage of growers mentioning each category of automation that had been updated in the last four years. Grading of products for harvest was most frequently mentioned, with 37% of growers having invested in some element of their grading systems, this included; preparation of the product, optical graders, filling of the product into sleeves, pots, or bunches, trimming, multihead weighers, traffic light system weighers, generally improved process flow of grading the product. Twenty-seven percent had automated the packing of product with faster packing machinery, pack sealing kit, box makers, automatic wrappers, and new packhouse facilities.

Twenty-seven percent also had some form of system change which could include a complete change of cropping, or a change of how the crop was grown.

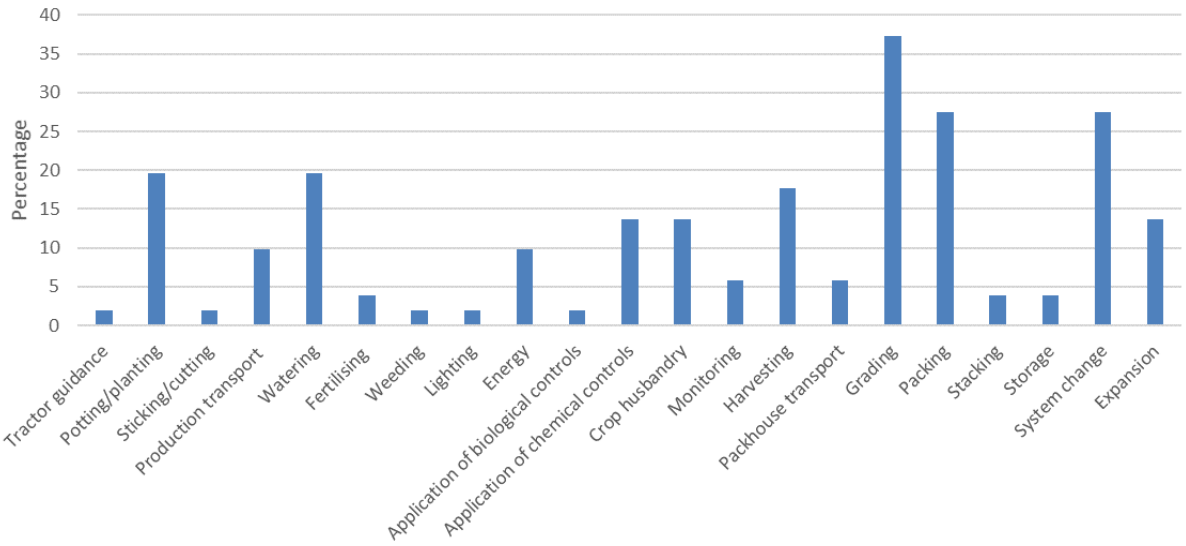

Figure A. Percentage of growers mentioning each category that had been updated in the last four years

3) Robotic usage

Twenty-two percent of growers said they had some form of robotics or robotic technologies in their growing system, the specific areas mentioned are shown in Figure B.

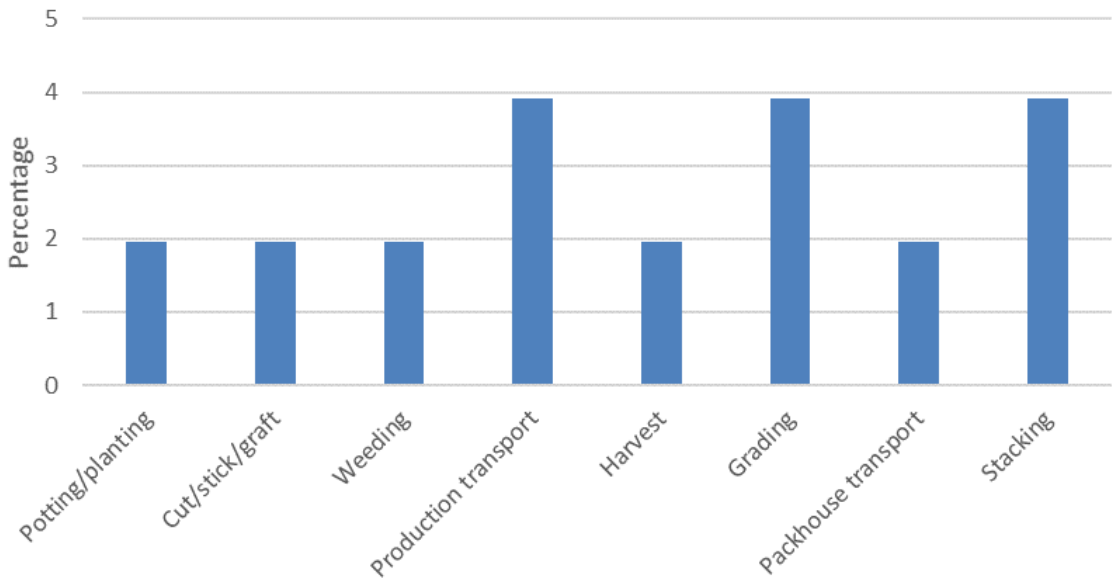

Figure B. Percentage of growers mentioning each category when asked where they had robotics in their system

The main usage was for transport of the product, grading and stacking. It is likely this figure is a little higher as some cutting-edge technologies a few years ago, are possibly not thought of as robotic now, e.g., weeders. Also, where third party companies use robotic technologies on behalf of growers, it may not have been mentioned e.g., drones. It may also be that growers have refined their understanding of 'robotics' for example growers previously mentioning robotic sprayers in glasshouses in 2017, now interpreting these as automated.

4) Grower perceptions

Ninety-four percent of growers thought automation or robotics would reduce the casual labour requirement for their business in future.

Fifty-one percent of growers thought there were no further current automation or robotics available for their system. Where machinery or technology was available, the main reasons for not using it were; too expensive, not confident, doesn't fit their system.

5) Grower drivers

Labour cost and availability were the main drivers for using automation and robotics. The most frequently cited answer was labour cost, with 54% mentioning this as the main factor. Seventeen percent mentioned labour availability. A more positive 88% believed automation was in development for their crops.

6) Grower innovation

Thirty-one percent of growers said they were developing their own in-house solutions to automation and robotic needs. Thirty-nine percent of all surveyed were involved in automation or robotics research projects. Twenty-five percent had applied for funding or been involved in funded research in the last four years.

Ninety percent of growers said that they would, or maybe would, like to be involved in research projects investigating automation or robotics in the future.

Figure C shows the percentage of growers mentioning each category when asked where their priorities for automation investment were.

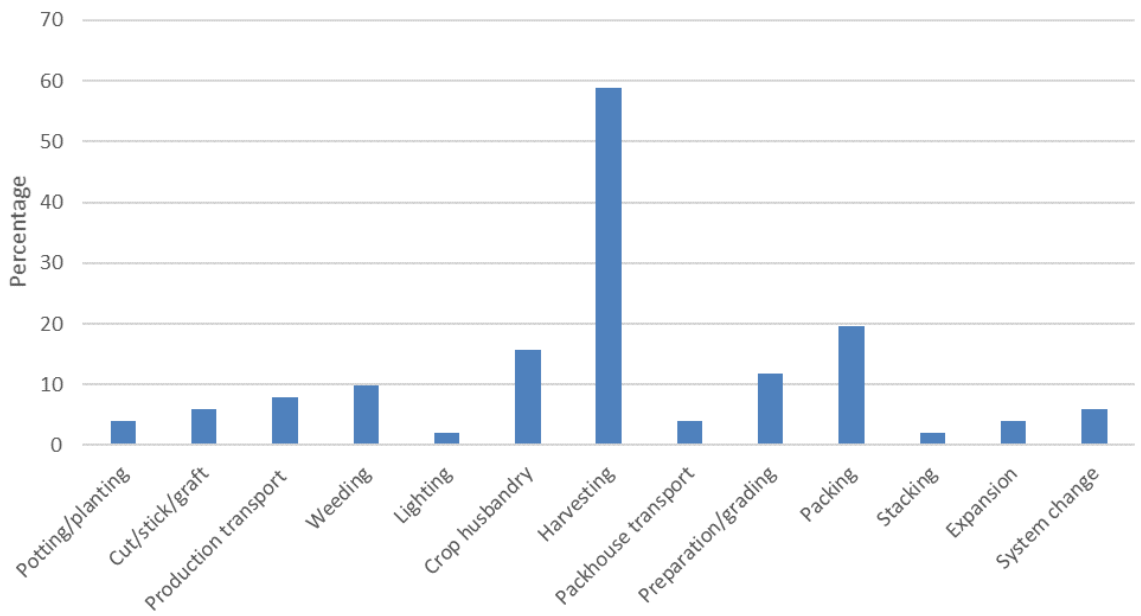

Figure C. Percentage of growers mentioning each category when asked where their priorities for automation investment were

Fifty-nine percent said picking/harvesting was their priority for automation or robotic investment. Twenty percent would spend on packing, with grading, stacking and packhouse transport also mentioned at that end of the system. Crop husbandry tasks were important for 16%. Ten percent specifically mentioned a weeding need.

7) Grower investment

Ninety-four percent of respondents said they were going to invest in automation. Twenty-four percent could see their businesses investing within the year, 24% by five years and 29% by ten years. So, in total 77% would have made investment within the 10-year timeframe.

Growers were asked about how much they might invest in automation or robotics. Forty-three percent had a go at estimating spend, the most frequently suggested spend, a quarter of those responding, was 1-5% of turnover. Twenty-one percent thought 5-10% and 20-50%, with 17% estimating 0-1% of turnover. Eight percent were estimating the 50-100% of turnover spend level.

How would this investment be funded? Most mentioned a mix of options including internal investment, a financed option and grants. Almost two-thirds said they would need external finance and 37% mentioned looking for grant funding.

Forty-one percent of growers said having a working, economically viable product that they had confidence in, would speed their investment. Twenty-two percent wanted to see more R&D into automation.

The impact of Covid-19 or Brexit on investment plans was questioned. Forty-one percent said their investment in automation and robotics had been affected by Covid in some way. Where details were given, it was mainly that investment had been slowed; by travel restrictions – unable to see machinery working or meet with companies/scientists/trade shows, by cost of materials rising, by expenditure implementing Covid regulations.

Thirty-one percent said they had been affected by Brexit similarly, mainly through slowing down investment timeframe as they dealt with Brexit issues. It was taking greater resource (time, paperwork and therefore money) to get casual labour, plants, produce and machinery in and out of Europe.

8) Autonomous automation

Growers were asked if they were concerned about the public perception of autonomous automation? A resounding 94% were not concerned about the public perception, but they still had some thoughts on barriers to use, such as; safety for other workers, the view by staff it would be putting people out of jobs or they would be losing money, overcoming the legislative barriers and H&S regulations, getting insurance, ensuring the messaging around usage was on point so that the public understood why they were being used, the likelihood of getting the machines stolen, the concern about machines going out of control in an environment where they could do a lot of damage. The positives of replacing repetitive, difficult or more hazardous labour tasks were also mentioned.

9) Grower information sources

Growers were asked ‘Where do you get your information on automation and robotics?’. Forty-five percent mentioned online with just slightly less mentioning commercial companies. Around a third mentioned visits both in UK and overseas. The use of AHDB’s programme of SmartHort resources was questioned. Fifty-three percent of respondents had made use of the resources. Data was further examined for those 53%; the Lean package of work was the most popular being used by a third, a quarter of those using SmartHort had attended or watched a conference.

10) Comparison of 2017 and 2021 survey

There was a comparison of the same questions asked in 2017 and 2021. There is reduction in the use of robotics reported, 32% to 22%. There is a more positive outlook on whether automation will reduce the need for casual labour, from 88% to 94%. There is a slight reduction in the perceived availability of automation and robotics, from 56% to 49%, but a slight increase in knowledge of what is in development, from 80% to 88%. Around the same percentage were developing in-house solutions, now 27% vs 31%. Again, around the same

percentage were taking part in research trials was 32% now 39%. A greater proportion, 94%, said they would now invest in automation and robotics compared with 88% four years ago.

In summary the survey shows:

- The need to get cost-effective automotive/robotic solutions to the marketplace is the main priority to advance automation
- Growers are continually automating and looking for automation and robotic solutions
- Investment in the last four years has been focussed on grading, packing and new growing systems
- Growers are highly confident automation and robotics will reduce casual labour in future
- There is a clear desire to invest in automation and robotics from growers
- The main drivers for automation and robotic investment were labour costs and availability
- The biggest barrier to investment is the lack of equipment or technologies
- Where there is automation and robotics available, the biggest barrier to investment is cost
- Growers are very keen to be involved in research projects to find automation and robotic solutions
- The clear priority for automation and robotic needs is harvesting

The findings of this survey suggest activity needed by AHDB is to:

- Provide information for researchers and commercial companies on grower automation and robotic needs
- Provide information on grant funding
- Support lobby groups working with policy makers on financial support
- Provide reliable, up to date information on automation and robotic R&D and marketplace products and technologies
- Demonstrate R&D and marketplace technology

SmartHort has delivered some of these needs, but would have to be resourced going forwards to continue, and expand the programme, to address all requests. If not funded, another barrier to automation uptake will be created.

SCIENCE SECTION

Introduction

Horticulture is an important area of agriculture with an estimated farm-gate value of around 3.75 billion (Defra, 2020a). It produces a high value commodity per area cultivated, delivering almost 20% of agricultural value from less than 2% of the UK farmed area (Defra, 2020b). It is also a growing sector with the value of vegetable, fruit and ornamental production increasing between 2018 and 2019 (Defra, 2020a). There are opportunities to increase production further, by increasing the use of automation and robotics for many stages of the growing system. The drivers for automation can be a reduction in labour, energy or materials with a potential increase in productivity, quality, accuracy, consistency and sustainability.

A major driver for automation currently is concern over access to, availability and affordability of labour which is relied heavily upon in many sectors, particularly at key times of the year such as planting or harvest. The UK horticulture industry employs approximately 40,000 permanent workers, plus 70,000 seasonal workers each year (EFRA, 2020). The labour intensity (number of jobs per hectare) is by far the greatest in horticulture (0.24) compared to all other farming types, for example cereals (0.02) or mixed farming (0.03) (Devlin, 2016).

Human labour accounts for between 30% and 70% of total variable production costs in horticulture (AHDB, 2017a). The National Living Wage is driving labour costs up substantially at a time when margins are under strong downward pressure from retailers. In the past five years, 2016 to 2020, the basic hourly wage rate has risen from, £6.50 to £8.72, a rise of 34% (Pelham, 2020), rising again in 2021 to £8.91. Current government predictions are a rise of 5.7% for 2022 to £9.42, this still under consultation by the Low Pay Commission (Defra, 2021a). This increasing labour cost has been compounded in 2020 by Covid-19 and issues with; worker availability and recruitment, training, accommodation, transport and logistics operations, with costs rising up to 15% (Pelham, 2020). It is therefore critical that the UK horticulture industry looks forward to incorporate new technologies, including automation and robotics, to existing practice to reduce labour costs where possible.

A House of Commons report recognised “It is apparent that the statistics used by the Government are unable to provide a proper indication of agriculture’s labour needs” (House of Commons, 2017). A 2018 Defra consultation paper acknowledges the need for allowing seasonal workers but emphasises “for the longer term we want to work with industry to encourage more domestic workers to enter the profession and attract the engineering, manufacturing, research and other STEM skills necessary for an increasingly sophisticated

food and farming industry" (Defra, 2018). To necessitate the need for higher skilled roles growing systems will need to be more automated.

The lack of labour is frequently publicised in the horticultural press (e.g., Da Silva Marques, 2019; White, 2020; Evans, 2021). The NFU Seasonal Supply of Labour survey found that in 2017, Britain had a 10% drop in the number of seasonal workers coming from Europe (NFU, 2017), in 2018 the drop was higher at 13%. The UK is around 10,000 to 15,000 seasonal workers short each year. In response to the labour concerns the Government introduced a seasonal workers pilot scheme to provide 2,500 workers (Defra, 2021b). This operated in 2019 but shortages were still experienced. In November 2019 it was announced the scheme would be extended to 10,000 workers for the 2020 season (Malnick, 2019). The impact of labour shortages was captured by the NFU's Horticulture Seasonal Worker Survey 2020, it was completed by 244 horticultural growers, recruiting over 30,000 people, just under 50% of the workforce. It found UK residents made up only up to 11% of the 2020 workforce. Vitally, it was also found that first-time UK resident workers stayed for nine and a half weeks on average, compared to just over 14 weeks for first-time non-UK workers and 18 weeks for returnee non-UK workers (NFU, 2021).

In a bid to enlist more UK workers Defra and AHDB launched a 'Pick for Britain' campaign in 2020 with a central website where growers could connect with potential workers (Pick for Britain, 2021). AHDB ran the Horticulture Labour Barometer, which provided information on real time labour requirements from a sample of edible horticulture producers in England and Scotland, from the end of May to the end of September 2020 (AHDB, 2021). Of the 39 companies who provided data, 23% said that they were unable to recruit a sufficient amount of labour this season to meet their productivity targets. Sixty-four percent said that they had employed more local workers in 2020, compared with previous seasons, and 90% of companies said that local labourers were less productive than overseas workers (AHDB, 2021). The AHDB edible skills survey (AHDB, 2020) highlights that the industry is not importing unskilled labour for the most part but takes advantage of high levels of experience and skill in its returning seasonal workforce.

On 22 December 2020, the government announced an extension to the seasonal workers pilot for 2021 only, with an expanded quota of 30,000 places (Defra, 2021b).

A study by Lincoln Institute for Agri-food Technology (Korir *et al*., 2021) of 19 UK horticultural businesses aimed to analyse the current and emergent impacts related to Covid-19 and Brexit on UK fruit and vegetable production. The results suggest that a very substantial majority of producers either plan to scale back production in 2021 (47%) or have been unable to make plans for 2021 because of uncertainty (37%). In addition, the data supported broader

evidence that the sector had experienced profound labour supply challenges, with implications for labour cost and quality. It also concluded that currently, automation plays a limited role in contributing to the UK's horticultural workforce shortage due to economic and socio-political uncertainties.

In 2017, AHDB commissioned a survey to establish the current access to, and future aspirations for automation and robotics in UK horticulture (AHDB, 2017). The resulting report provided valuable information, which has been used by AHDB, to help steer the automation and robotics activities within their SmartHort programme. Due to the speed at which technology develops, AHDB commissioned this survey to ensure current activities meet the need and requirements of the UK horticultural industry, and to establish the need for activity in the future. This piece of work was initiated in March 2020, due to Covid-19 and the AHDB Horticulture ballot it was not possible to start the survey until February 2021.

Materials and methods

This project relied on survey data which was collected in two ways:

1. Telephone survey
2. Online survey

A standard set of questions for both surveys was produced (Appendix 1), in collaboration with AHDB, Defra and external parties. Some questions duplicated those asked in 2017.

A sample of 40 growers from the previous 50 contacted in 2017 were resurveyed some four years on. Ten new growers were contacted which produced a total telephone survey size of 50 growers. The numbers contacted represented the proportion of levy income from each horticultural sector; Field Vegetables (FV), Soft Fruit (SF), Protected Edibles and Mushrooms (PEM), Protected Ornamentals and Bulbs & Outdoor Flowers (POBOF), Tree Fruit (TF) and Hardy Nursery Stock (HNS). A spread of business size was also taken into account. Each grower was asked the standard set of questions requiring qualitative and quantitative responses, comments were recorded by hand and summarised into an Excel spreadsheet. All data was kept anonymous.

The opportunity to take part in the online survey and register for the telephone survey was emailed to all AHDB Horticulture levy payers who were registered for the monthly news update. The online survey questions were the same as the telephone survey, the survey was live between 10th March and 20th April 2021. There was also the opportunity to leave details and be contacted by telephone.

Results

The diversity of British horticultural growing systems produces a complex set of requirements for any research and knowledge exchange topic. Automation and robotics are no different and needs are specific to different sectors, different crops within them and even the same crops grown on different grower holdings. Responses have been collated across all sectors for each question with highlights for specific sectors picked out.

1) Grower demographic

Forty businesses who had previously been surveyed in 2017 were recontacted and agreed to participate for a second time. A further ten growers were interviewed for the first time. The 50 telephone surveys were carried out between 18th February and 29th March 2021. One online survey was filled in. The online data was combined with the telephone data giving a total survey size of 51 UK growers. The levy paying demographic was replicated by the survey as shown in Figure 1.

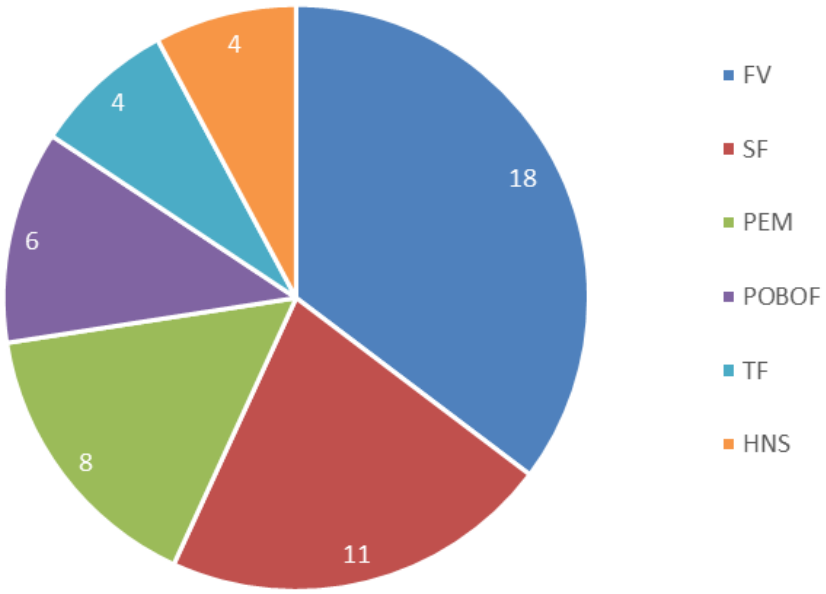

Figure 1. Split of horticultural sectors represented by growers taking part in the surveys

The split of business size surveyed is shown in Figure 2. Figure 3 shows the further breakdown of business size by sector.

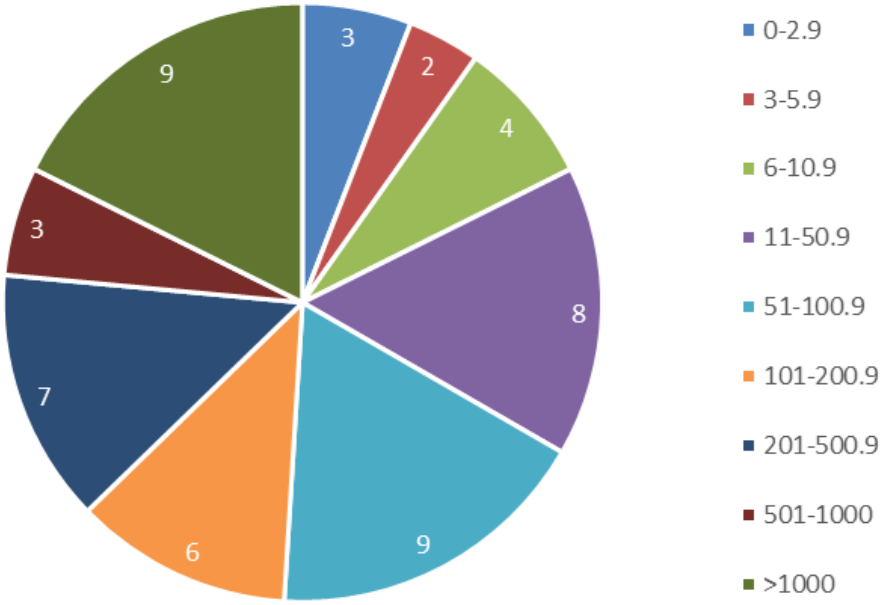

Figure 2. Split of business size (ha) represented by growers taking part in the surveys

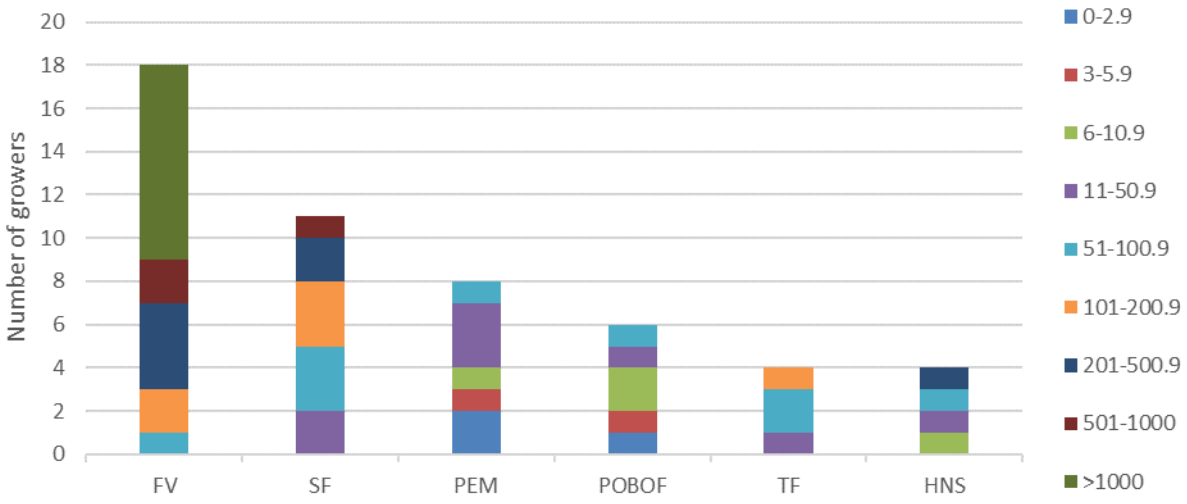

Figure 3. Split of business size (ha) per sector represented by the growers taking part in the surveys

Figure 4 shows the split of business turnover per sector from the surveys to give a further idea of business size involved.

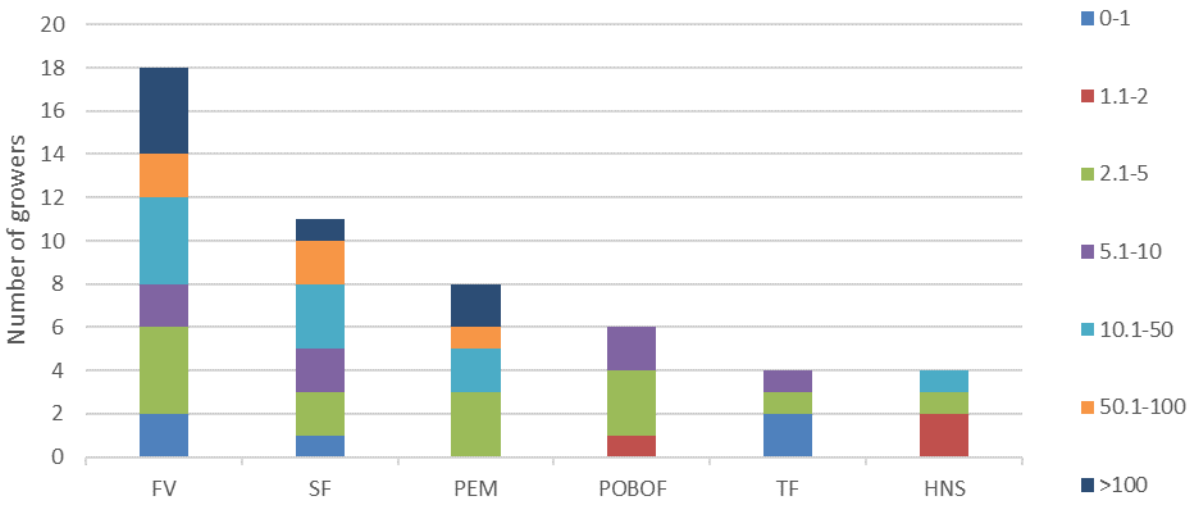

Figure 4. Split of business turnover (£ million) per sector from the surveys

The total horticultural land area covered by the survey was 45,209 ha, approximately 27% of the UK horticultural land area – 166,000 ha (Defra, 2020c).

2) Automation usage

Growers were asked 'What has been automated in the last 4 years?'. Figure 5 shows the percentage response for each category.

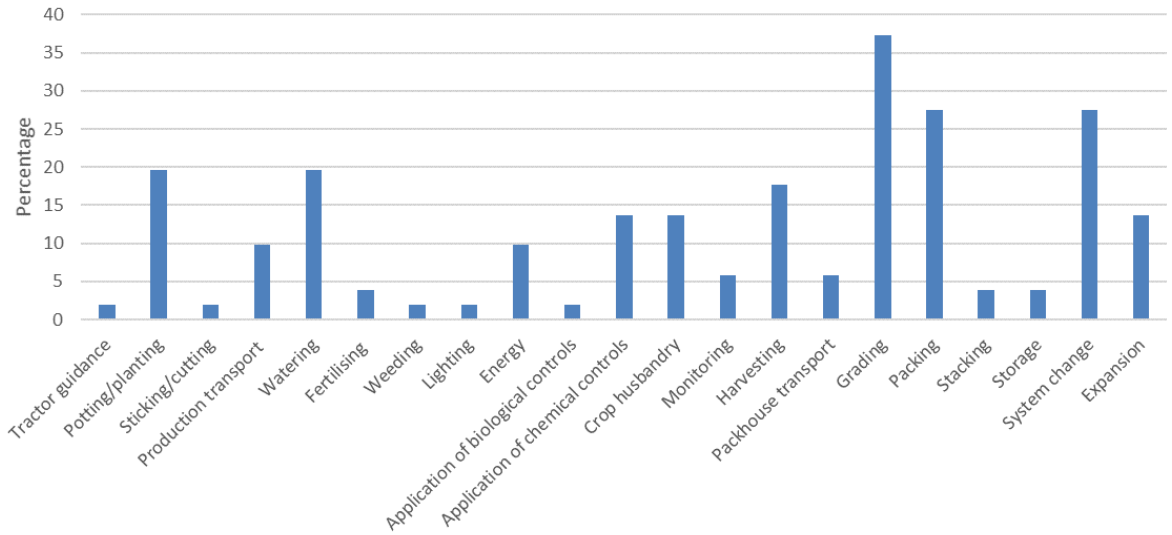

Figure 5. Percentage of growers mentioning each category that had been updated in the last four years

Grading of products for harvest was most frequently mentioned, with 37% of growers having invested in some element of their grading systems, this included; preparation of the product (for example getting the crop one step further along before moving to a processor or one stage further on the harvesting rig), optical graders, filling of the product into sleeves, pots, or bunches, trimming, multihead weighers, traffic light system weighers, generally improved process flow of grading the product (e.g., redesign of lines, automated conveyors). One grower mentioned a moving away from specialised premium lines to fulfil discounters wanting basic product in bulk, resulting in widening of product specification, so less labour or technology needed for grading.

Twenty-seven percent had automated the packing of product with faster packing machinery, pack sealing kit, box makers, automatic wrappers, this category also included new packhouse facilities (some required due to space needed for social distancing).

Twenty-seven percent also had some form of system change which could include a complete change of cropping, for example adding another crop (asparagus was most commonly cited) or a change of how the crop was grown (mainly moving from soil-based production to a hydroponic system, but also smaller things like improved bed design for labour efficiency). New crops allowed the most up to date systems to be purchased and less automatable crops tended to be the ones dropped. Fourteen percent mentioned expansion, which in itself is not an automation upgrade but is a method to incorporate greater automation in new cropping, or facilities, for example new tunnels now with automatic doors and vents saving on staff management time.

About 20% of those interviewed spent money updating potting or planting machinery (more automated planters, driverless planters), the watering system and crop harvest. Updates to the watering systems meant less labour was needed to move irrigation around, also mentioned were; Bluetooth control of watering gantries, improved mechanisation on misting systems. Harvesting machinery updates included technology investments such as the ability to interact with the harvester through a mobile phone via Bluetooth. Harvest machinery upgrades which incorporated grading systems had allowed packing straight from the field to pallets, to the retailer, instead of the extra step of moving product from field to packhouse. There was mention of harvesting improvements such as improved facilities for workers for example better hygiene facilities (some driven by Covid-19 regulations).

Fourteen percent mentioned crop husbandry improvements such as use of crop sensors, powered trimmers for crop pruning or machinery to take growing media out of bags. Fourteen percent also mentioned further improvement to application of chemical controls mainly

through larger, more efficient sprayers. One grower summed things up by saying ‘we’ve done everything where a motor can replace a person’.

There was also comment about the need to automate each step of production, and this was further explained that there needs to be balance across the production season. Field workers who, for example, help with planting, then fleecing, then weeding, then harvesting have jobs for a whole season, taking an element out of the cycle leaves workers without jobs for a period of time and creates worker retention issues. One grower felt strongly that to help automate there must be use of gene editing technologies to give growers the best chance possible to automate (for example getting more uniform stands of crops, maturing at the same time, ease of crop detachment and making the crop more resistant to mechanical harvest). Another commented on the need to redesign growing systems starting with automation/robotics rather that retro-fitting into systems designed for humans.

In terms of sector specific investment, FV had concentrated equally on harvesting, grading and packing. SF had seen by far the most whole system change of all sectors and that was the most frequently cited automation upgrade for them followed by husbandry upgrades. PEM was also concentrated on grade and pack investment, whilst POBOF mentioned watering systems and product transport upgrades the most often. TF invested in spray application and grading, HNS had mainly upgraded propagation, planting and potting.

3) Robotic usage

Twenty-two percent of growers (11 separate businesses) said they had some form of robotics or robotic technologies in their growing system, the specific areas mentioned are shown in Figure 6.

The main usage was for transport of the product, grading and stacking. The sector with the greatest robotic use was POBOF where two thirds of growers questioned were using robotics, whilst TF and HNS did not report any usage.

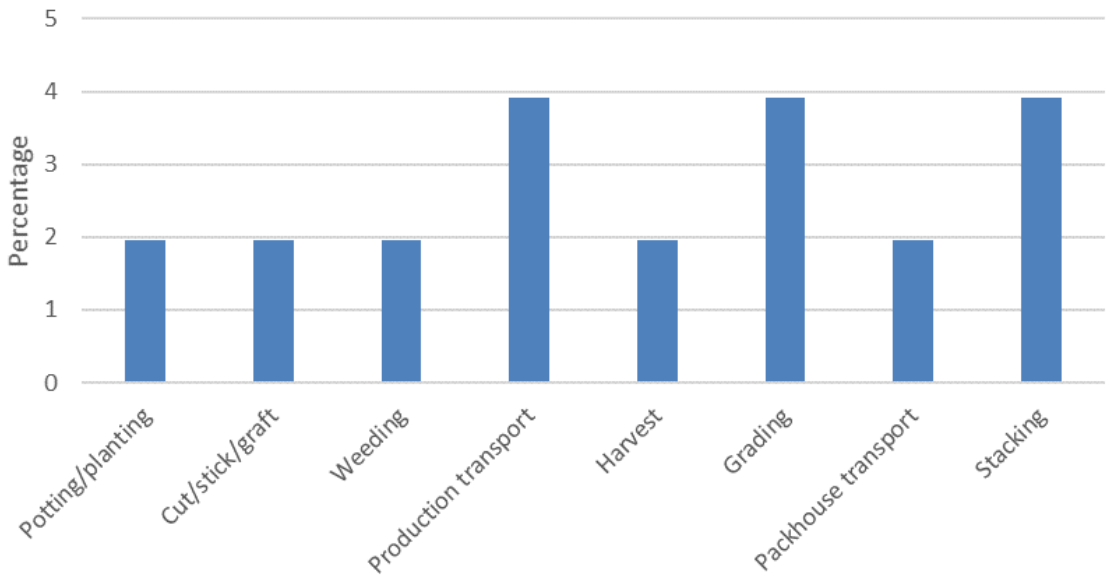

Figure 6. Percentage of growers mentioning each category when asked where they had robotics in their system

The potential use of robotics was more frequently mentioned than actual use. Growers were investigating the use of; robotic arms (the main feature holding back investment was lack of ability to multitask or field suitability), robotic sensors, robotic movers, robotic autonomous vehicles and robotic harvesters. A few were involved with research companies, a few about to go into active trials, a few about to invest. The main comment being repeated was lack of flexibility was hampering investment, to be cost effective they need the machinery to be able to do more than one thing. Several growers commented that whole growing systems needed changing, one saying to fit around the robots not the other way round.

4) Grower perception

Growers were asked if they thought automation or robotics would reduce the casual labour requirement for their business in future, a resounding 94% said it would. Those that didn't, were two growers who were as automated as possible already, and one that didn't see a future for British horticulture.

It was a 49:51 percent split of growers who thought automation or robotics was currently available for their system to those who thought it wasn't. Growers were asked why they weren't using the currently available kit. The main reasons for not using the machinery or technology are shown in Figure 7.

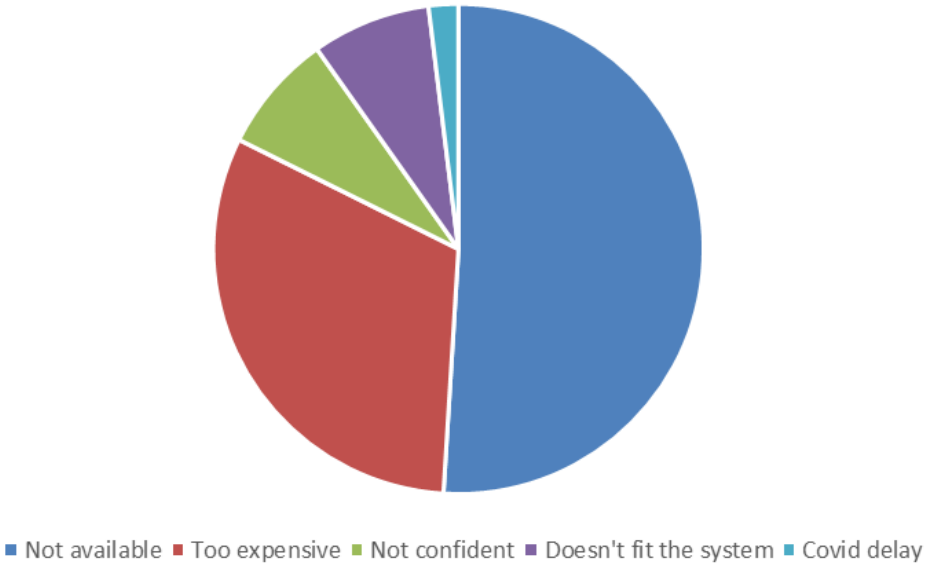

Figure 7. Split of grower main reasons for not having automation/robotics in place

As mentioned, fifty-one percent said there just wasn't any available automation or robotic solutions. This was fairly evenly split across sectors, with slightly fewer than average for FV and SF growers, and slightly higher for PEM. Thirty-one percent said what was available was too expensive (even split across sectors with the exception of HNS who didn't mention cost), eight percent were not confident to invest in what was available and eight percent did not think it would fit their system. Those not confident to invest or didn't think it would fit their system were very keen to see some machinery working in a real-life situation. There were several comments about how YouTube videos could be misleading and that anything could look like it was working but actually, in reality, it didn't perform as required. There was also mention of waiting to see that the product or technologies persisted in a fast-changing marketplace, particularly with systems that were not software cross-compatible. There was an even spread of responses across the sectors with cost being key for delaying investment in available solutions.

A more positive 88% believed automation was in development for their crops, with three sectors 100% positive; SF, PEM and TF. Some growers from POBOF, HNS and FV were not aware of anything in development for their crops.

5) Grower drivers for automation and robotics

Growers were asked what are the drivers for using automation/robotics? The most frequently cited answer was labour cost, with 54% mentioning this as the main factor. Seventeen percent mentioned labour availability. Efficiency, consistency and quality were other reasons.

Although this survey is focussed on automation not labour, this question often prompted growers to explain about labour issues, concerns and worries for the future. One grower in the POBOF sector who had been through 2021 harvest prior to the survey reported labour availability had not been sufficient to meet his needs this year, leading to crop wastage. The ornamentals sector described being particularly grieved that the Government focus was on fruit and vegetables, rather than flowers and ornamental plants. They did not have access to the seasonal workers pilot (SWP) scheme and there were not enough overseas workers with settled or pre-settled status to fill their labour needs.

Many growers reported the increasing difficulty of sourcing labour. This added pressure and stress to the 'day' job. Labour costs are increasing and price pressure from multiples was driving down product value, it was repeatedly mentioned that costs must be cut, and labour tends to be a very large proportion of costs and a priority area to target. A soft fruit grower commented, in practice, real costs in the last twenty years had constantly risen, but sale prices in shops for consumers had remained static, in a sector that had invested heavily in automation, it was questioned how much longer growers could absorb this inequality. There was very little 'fat' left in growing he said. This is supported by (Pelham, 2017) which states "the value of their [soft fruit producers] produce has remained static, with prices in 2015 little changed from 1996".

6) Grower innovation in automation and robotics

Thirty-one percent of growers said they were developing their own in-house solutions to automation and robotic needs. The most innovative sector was PEM where half of the growers questioned said they were involved in finding their own solutions, no-one from POBOF said they were, other sectors had an evenish split.

Thirty-nine percent of all surveyed were involved in automation or robotics research projects. The most active sector being SF (64% involved), several were in producer organisations (POs) who had a dedicated research programme. The least active sector was POBOF where no-one said they were involved in research on this topic.

Around a quarter of growers had received some element of funding for work on automation or robotics in the past four years, this was fairly evenly split across sectors.

Figure 8 shows the percentage of growers who would like to be involved in research work on automation and robotics in future. Seventy-eight percent said they would, with a further 12% being slightly more cautious and agreeing to 'maybe'. Ten percent did not want to be involved. Some were very clear they were prepared to put the time and effort into a research project,

particularly if there was grant funding available, some felt it was part of an unwritten, embedded company ethos to be innovative and of course they would be involved. One commented if you don't drive the research it doesn't happen.

Those who had previously been involved with research stressed the value of applying for funding with companies or institutions that had experience of the particular funding stream. The 'maybe's' and 'no's' had growers who had previously been involved, but had not seen a great enough return on time and resources. Another believed their cropping was too specialised to have a chance of receiving funding and would 'piggyback' on greater acreage crops of a similar type. Others reasons for not taking part were; already committed to other types of research, would only get involved with 'known' partners, the desire to be early adopters not innovators, not working on anything that involved academics.

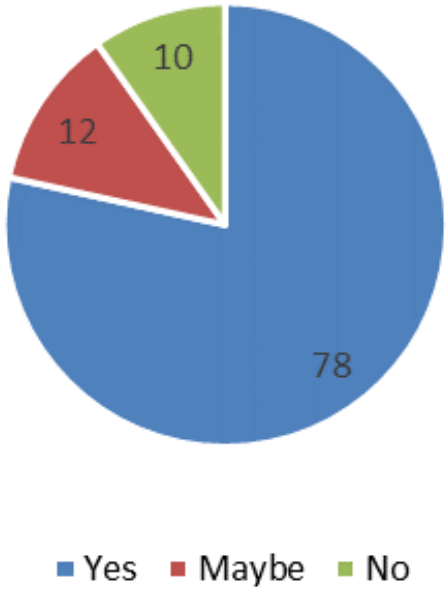

Figure 8. Percentage of growers who would like to be involved in research work on automation and robotics in the future

7) Grower investment in automation and robotics

Growers were asked 'What are your priorities for automation investment?'. Figure 9 shows the percentage of growers mentioning each category when asked where their priorities for automation investment were.

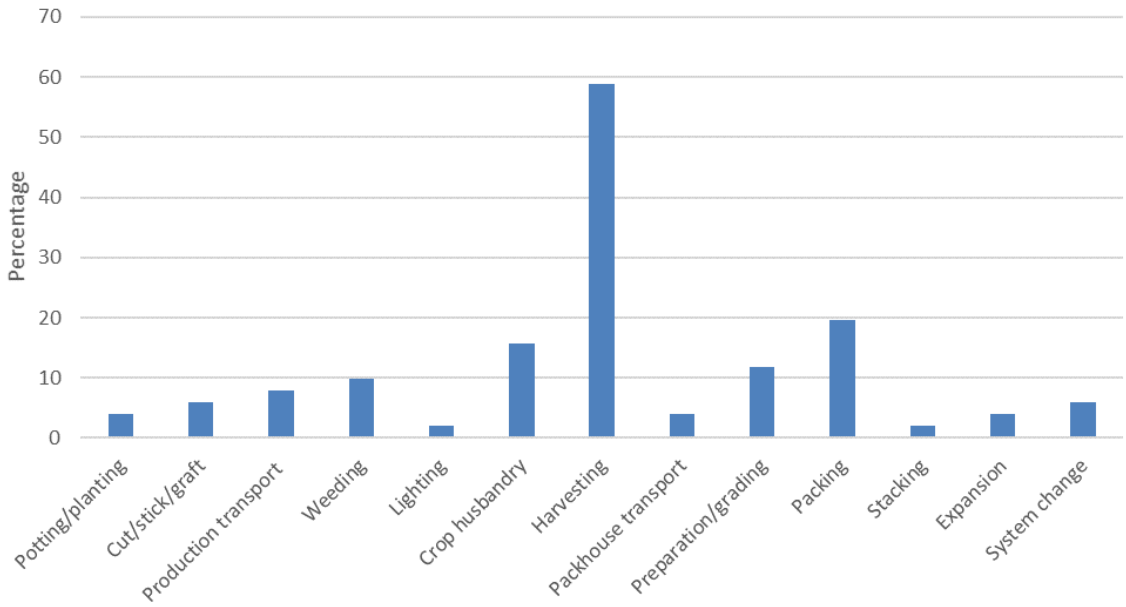

Figure 9. Percentage of growers mentioning each category when asked where their priorities for automation investment were

Fifty-nine percent said picking/harvesting was their priority for automation or robotic investment in the future. This was consistently the main request across all sectors with the exception of HNS, their need focused on automating the transport of product around the nursery. Twenty percent would spend on packing, with grading, stacking and packhouse transport also mentioned at that end of the system. Crop husbandry was important for 16%, particularly for PEM, SF and HNS with high labour costs in this area.

Ninety-four percent of respondents said they were going to invest in automation, the only exceptions were; two growers as automated as possible and couldn't see a need, and one that felt there wasn't a future for horticultural produce at their business.

Participants were asked when they were planning on investing in automation or robotics and Figure 10 shows the timeframe responses for each grower. Twenty-four percent could see their businesses investing within the year, 24% by five years and 29% by ten years. So, in total 77% would have made investment within the 10-year timeframe.

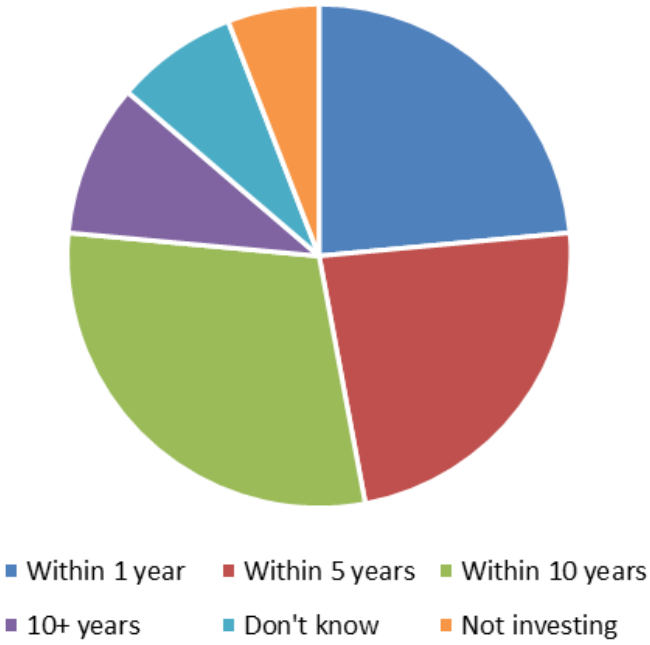

Figure 10. Percentage division of grower's responses to timeframe for investment in automation or robotics

Growers were asked about how much they might invest in automation or robotics. This was a very difficult question, as it required a prediction or guess for most that did not have definite plans. Figures were expressed as a percentage of business turnover. Forty-three percent had a go at estimating spend, the most frequently suggested spend, a quarter of those responding, was 1-5% of turnover. Twenty-one percent thought 5-10% and 20-50%, with17% estimating 0-1% of turnover. Eight percent were estimating the 50-100% of turnover spend level. Those with a lower turnover estimated a higher percentage spend.

Level of investment in automation and robotics was followed by questioning how it would be funded? Most mentioned a mix of options including internal investment, a financed option and grants. Almost two-thirds said they would need external finance and 37% mentioned looking for grant funding.

How to accelerate the uptake of automation and robotics was questioned and grower responses are shown in Figure 11.

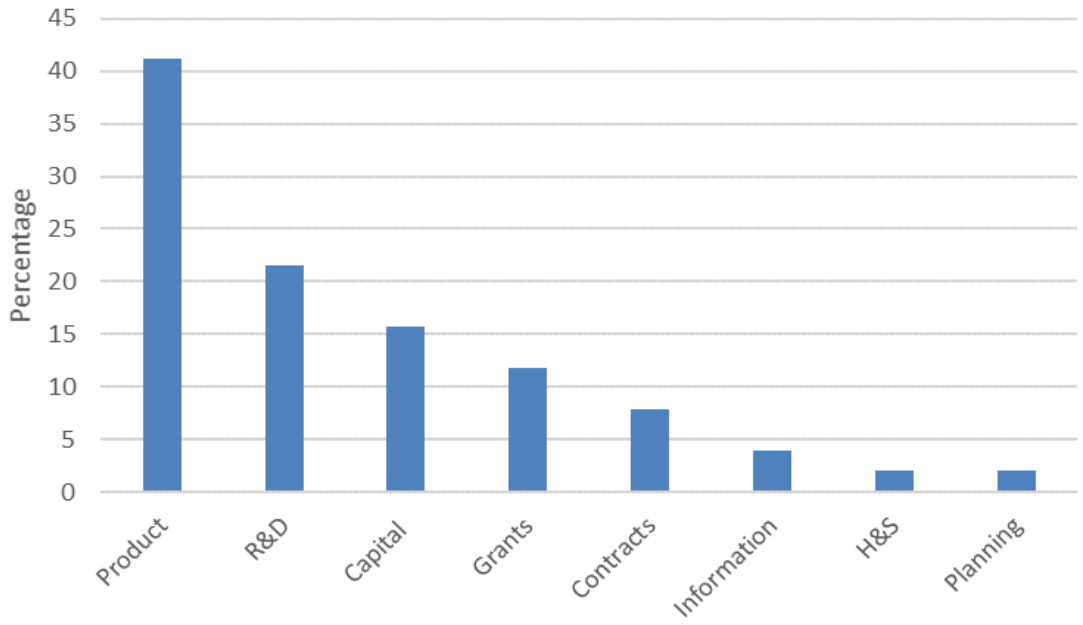

Figure 11. Percentage of growers mentioning each category that would speed up their investment in automation and robotics

Forty-one percent of growers said having a working, economically viable product that they had confidence in would speed their investment, this included growers from all sectors. Twenty-two percent wanted to see R&D into automation. Sixteen percent needed money to be able to invest, mainly from FV and PEM sectors, suggesting product or technology to be available, 12% specifically suggested grants to support investment. Eight percent mentioned the need for retailer contract confidence before investing. Health and safety and planning concerns were mentioned by 2% each.

The impact of Covid-19 or Brexit on investment plans was questioned. Forty-one percent said their investment in automation and robotics had been affected by Covid in some way. Where details were given, it was mainly that investment had been slowed; by travel restrictions – unable to see machinery working or meet with companies/scientists/trade shows, by cost of materials rising, by expenditure implementing Covid regulations. One commented they had seen positive benefits of increased retail sales, as consumer spend has been focused on the multiples rather than service sector. One said the space created in packing for social distancing will allow an easier transition to automation, which tends to require more area to operate and safety space for co-workers. Another mentioned Covid had speeded building expansion and new machinery in the packhouse because of extra space required. HNS sector were most affected, TF sector least.

Thirty-one percent said they had been affected by Brexit (an evenish split across sectors) similarly, mainly through slowing down investment timeframe as they dealt with Brexit issues.

It was taking greater resource (time, paperwork and therefore money) to get casual labour, plants, produce and machinery in and out of Europe.

It was commented that Brexit had accelerated investment for some, as labour was short, automation became a more viable option, investment had been almost forced. A positive effect of Brexit was mentioned that due to the difficulty shipping small loads from Europe customers were buying locally and increasing sales in the ornamentals sector.

8) Autonomous automation

A roboethics question was considered to see if growers were concerned about the use of autonomous automation. The question was 'Are you concerned about the public perception of autonomous automation'. Ninety-four percent were not concerned. Six percent (from the fruit sectors), were concerned about what the public might think of their use.

The question did generate a range of thoughts about autonomous automation in general. Several mentioned it was not a concern they even thought about. Some were a distance away from any public access, or undercover and therefore not concerned. Others felt the public were getting used to autonomous vehicles with trials on roads, so this was similar. One said they believed it was a way off for their sector and more science fiction than real-life. Others thought there would soon be no alternative if they couldn't get people to work in the field, particularly UK labour. The positives of replacing repetitive, difficult or more hazardous labour tasks were also mentioned.

Primary concerns about use (although the question was answered as 'No') were; safety for other workers, the view by staff it would be putting people out of jobs or they would be losing money, overcoming the legislative barriers and H&S regulations, getting insurance, ensuring the messaging around usage was on point so that the public understood why they were being used, the likelihood of getting the machines stolen, the concern about machines going out of control in an environment where they could do a lot of damage (e.g., in a glasshouse). There was a concern that if; the power fails, the satellite communication fails, software is corrupted or machinery breaks down, this will leave growers vulnerable unless there are fail-safes in the system.

9) Grower sources of information on automation and robotics

Growers were asked 'Where do you get your information on automation and robotics?', Figure 12 shows their percentage responses for each category. Forty-five percent mentioned online with slightly less mentioning commercial companies. Around a third mentioned visits both in

UK and overseas. Just over a quarter were accessing AHDB information, and just under using publication such as journals and magazines. There was no distinct pattern for different sectors.

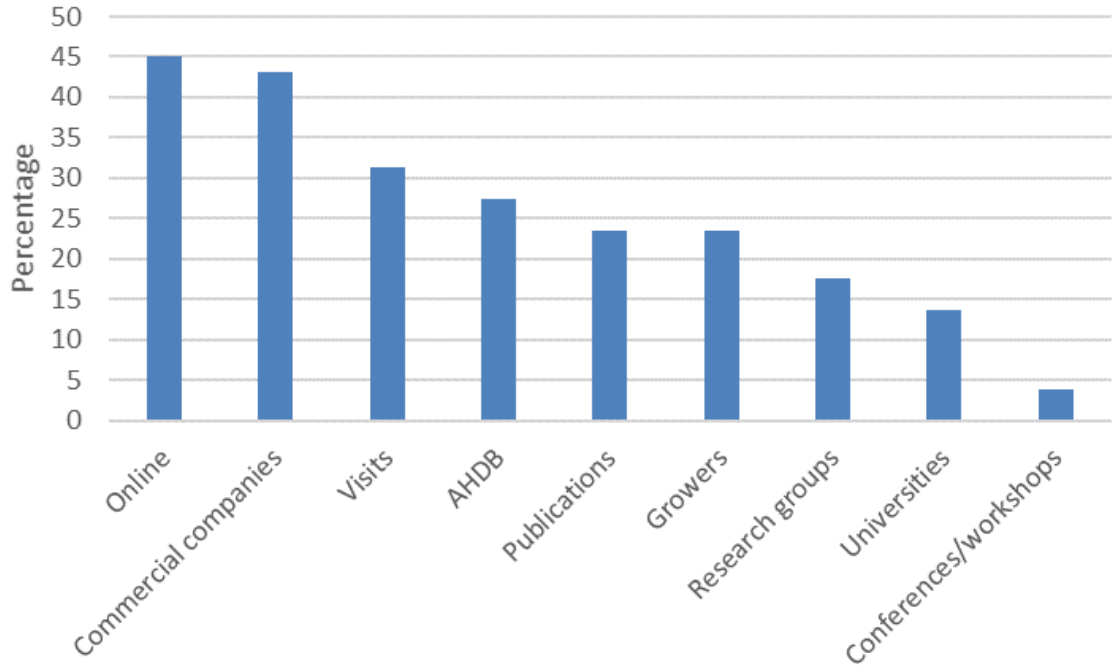

Figure 12. Percentage of growers mentioning each category where they get their information on automation and robotics

The use of AHDB's programme of SmartHort resources was questioned. Fifty-three percent of respondents had made use of the resources, SF and HNS sectors making the most use, FV the least. This figure is likely to be higher on a per business basis as respondents occasionally said I don't, but others might. Data was further examined for those 53% as shown in Figure 13; the Lean package of work was the most popular being used by a third, a quarter of those using SmartHort had attended or watched a conference. The workshops were the next most popular with 22%, of those that had made use, having taken part.

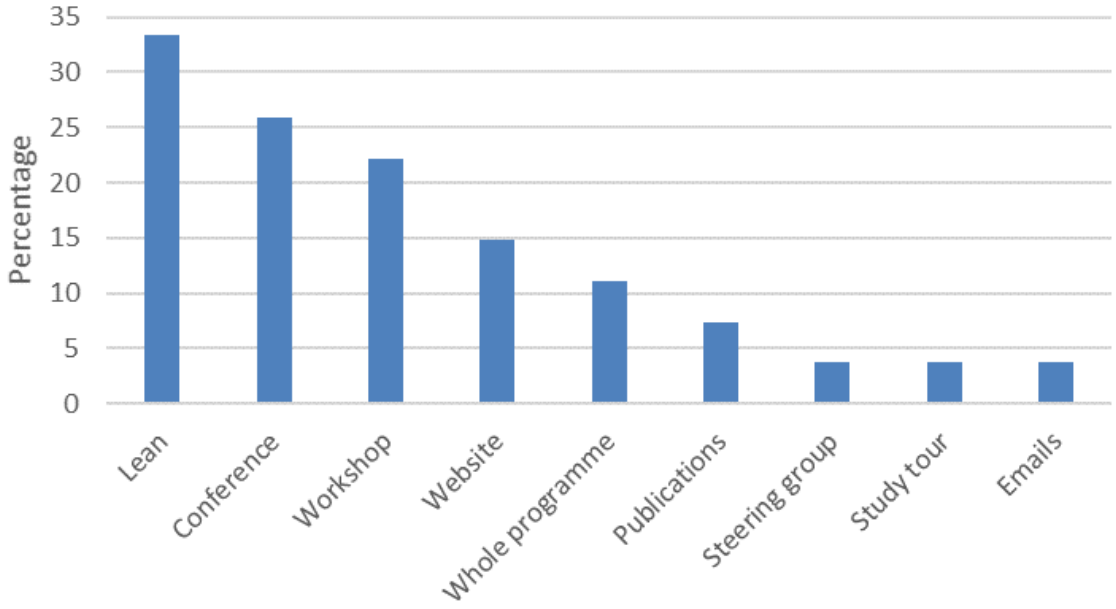

Figure 13. Percentage of growers mentioning each category of the SmartHort programme from those answering 'Yes' to using SmartHort

10) Comparison of 2017 and 2021 automation and robotics survey

It was decided to reconnect with growers who were surveyed about automation and robotics in October 2017. Forty of the fifty businesses previously questioned were reinterviewed in this survey. Thirty-four of the same growers repeated the survey, six were the same business but the actual contact had changed (through staff turnover or someone else being better placed to answer). The previous survey can be found on the AHDB website (AHDB, 2017).

Thirty-five percent had changed what they listed as their three main crops. Half were cropping approximately the same area, around one third had increased the area they were growing on, and 17% had reduced hectarage. Sixty-five percent stated an increased turnover, 20% had decreased.

Eight percent of growers reported using robotics who were not using it in 2017 (SF and POBOF sectors). Thirteen percent of growers who previously mentioned robotics, responded they were not using robotics (mainly FV).

Ten percent of growers who had said they did not think automation would reduce labour for them four years ago had changed their minds and now believed it would (PEM and TF sectors). Three percent reversed their decision as they could not see a viable option for growing vegetables in the future (FV).

When asked about automation available, a quarter of growers who didn't know of anything in development, now did (mainly SF and PEM), conversely 18% who did previously did know, now didn't know of any (these were mainly FV sector). Thirty percent now knew of machinery in development that didn't previously (FV, SF and HNS) and only 5% who said yes previously, now didn't know of anything in development.

Eight percent of growers previously not developing in-house solutions were now working on automation (PEM and HNS), Three percent previously working, were now not (SF). Eight percent now had funding for automation that didn't previously, and fifteen percent that had funding four years ago now didn't.

Eight percent of growers that previously weren't going to invest in automation now replied positively that they would be.

There was a comparison of the same questions asked in 2017 and 2021. There is reduction in the use of robotics reported, 32% to 22%. There is a more positive outlook on whether automation will reduce the need for casual labour, from 88% to 94%. There is a slight reduction in the perceived availability of automation and robotics, from 56% to 49%, but a slight increase in knowledge of what is in development, from 80% to 88%. Around the same percentage were developing in-house solutions, was 30% now 31%. Again, around the same percentage were taking part in research trials was 32% now 39%. A greater proportion, 94%, said they would now invest in automation and robotics compared with 88% four years ago.

Discussion

Again, four years after the previous survey, growers had been investing in the harvest, grading and packing section of the growing system, as they predicted four years ago they would. Investment had been made in similar packhouse equipment to 2017, and also field harvesting and grading. The other main area of investment has been a system change so growing the existing crops in a different way or changing cropping to other fruits, vegetables or ornamentals. Growing in a different way was mainly seen in the SF sector with growers moving to tabletop production, new crops most frequently mentioned were asparagus and blueberry. If taken with those mentioning expansion this is the most important development. Growers have invested in new systems which are therefore as automated as possible or expanded cropping, which will be with the latest design and technology for those crops, so mainly investing in new systems, alongside retrofitting elements of existing cropping. For example, the predicted long length of time to get field systems as automated as possible

could be circumnavigated by changing cropping to highly automated protected systems for some crops.

Twenty-two percent of growers mentioned having some form of robotics in their system, a decrease on the 32% that mentioned it last time. There were growers who said ‘Yes’ in 2017, who said ‘No’ in 2021, it is likely this is not due to them removing the robotics technologies but that these pieces of equipment have become more mainstream, standard farm machinery, and are not necessarily considered ‘robotics’ anymore; precision guided hoes and in-row weeders attached to the tractor being an example. It may also be that growers have refined their understanding of ‘robotics’ for example growers previously mentioning robotic sprayers in glasshouses in 2017, now interpreting these as automated. The meaning of robotics or robotic technologies was left to the grower’s interpretation unless a definition was requested, which can be found in the glossary, only one grower asked for clarification. Growers are now looking to autonomous vehicles as cutting edge robotic, for example using autonomous modular robots for various tasks, such as UV light treatment for powdery mildew control, weeding or trialling autonomous robotic pickers at harvest. Also, robotic technologies such as hyper spectral imaging for early P&D identification.

Even if the actual figure is a little higher there is not any great change in the use of robotics over the last four years. This shows robotics still currently play a limited role in UK horticulture. This is despite healthy funding for horticultural robotic research and great promise from project proposals. Is this a natural time lag from research to commercialisation or are there gaps on the route to market? Is confidentiality on some work too tight that the trickle-down effect is too long for industry in general? Should there be a more considered funding approach to automation and robotics, for example; should funding be proportionate to crop growing area, current sector value, potential sector value, free market dominated, low hanging fruit, plugging specific research gaps, matched to UK research base expertise, focussed only on sustainable solutions? Should more actors in the research and retail chain be pulled in to help the advancement of automation and robotics for UK Horticulture? Do growers need to make a clearer voice for the technology they would like to see?

Evidence from industry experts in Agri-tech and Agri-robotics (UK Parliament, 2020 & 2020a) to Parliamentary Committees investigating food chain labour supply, make a strong case for further Government support to accelerate automation and robotics uptake in fresh produce. They state ‘without significant intervention from government and industry we estimate that robotics is unlikely to have significant impact on labour productivity in the fresh produce sector until c. 2024/25. However, intervention could significantly accelerate this timeline.’

An interesting conclusion from a Nuffield Australia farming scholar, Fealy, (2019) states "Significant investment has been made through universities and research institutions all over the world to reduce horticultural dependence on manual labour, with almost no commercialisation. The most significant deployment of robotic/automation technology has occurred through development partnerships between growers and private companies".

Around half of growers said there was no automation or robotics available for their growing system. Of the half who believed equipment or technologies were available a third of these said the equipment was too expensive. Although the cost of labour was the biggest driver (54%) for using automation or robotics, the cost to benefit balance had not yet tipped in favour of investing for some. Capital investment in automation, from individual pieces of equipment to system change, is not cheap and growers will always need to determine the business case for their spending. There are competing challenges for funds on the narrow margins operated. This has not gone unnoticed in the market place with companies taking advantage of the move from 'capex' to 'opex' based business models that we are now very familiar with in services such as IT. There are companies promoting robots for automated grading, sorting and packing of fruit and vegetables, where growers only pay a small start-up fee and the remainder in a pay-as-you-use model (Hortidaily, 2019). Grower's trialling harvesting bots for strawberries are doing so with a service contract, with a price cost per weight of strawberries picked, this takes away the burden of the high upfront costs. Although it was commented that the cost of robotics is decreasing, as supply is increasing, an example being a robotic arm, these are expected to further decrease in cost with sales and increase in flexibility with more research. The actual economics of robotics information is even more difficult to find than robotic research, a review by Lowenberg-DeBoer (2019) showed only 18 studies since 1990 had estimated profitability or cost-effectiveness of crop robotics.

Josefsson (2019) reported on 'Adoption of Automation in the Horticulture Industry: A Case Study at a Robotics Company in the U.S. and Canada' also found that cost not only is the single biggest factor restricting investment, but also the only factor being brought up in every type of business questioned (glasshouse, nursery and mixed holdings), as in this survey. Could there be greater commitment to support growers to make investment? There was a repeated comment about lack of contract commitment from customers, which was preventing spending, particularly on the scale needed for some automation. The inability of customers to guarantee market or develop sustainable partnerships is an important factor in hampering investment in automation and robotics.

Other methods to allow growers the 'system change' type level of automation have been seen, as they make use of commercial finance brokers to match their investment need to the

appropriate lender. Sixty-three percent in this survey said they would have to look externally for finance options for automation investment.

With the exception of a grower who did not believe he would continue in horticulture and two growers who felt they were fully automated, everyone (94%) said they were going to invest in automation or robotics. Seventy-seven percent said they would invest within 10 years, with a great range of spend, as compared with turnover; most would have to borrow money for investment. The question as to how to speed up investment was dominated (41%) by there actually being a product or technology available in the marketplace. Growers are looking to de-risk labour supply issues and need available, affordable options. The complexity and diversity of horticulture (fruit, vegetables, ornamentals), yet specialist growing systems within it (aeroponics to perennial field crops), with relatively small market opportunity, alongside economic considerations are all delaying automation and robotic solutions for growers.

The ability to automate is critically dependent on the crop and the growing system, it is not technically feasible to automate all tasks. Achieving crop uniformity in growth, architecture, ripeness and therefore yield can improve automation options, and speed up adoption. Twenty-two percent of growers mentioned the need for R&D to speed automation, this included one grower suggesting the need to use gene editing. This involves cutting and splicing sections of DNA, within a single genome, to accelerate the improvement of crops without intensive breeding programmes. The practice is effectively banned in Europe, but following Brexit the UK government held a consultation on its use in the UK which closed in March 2021 (Defra, 2021c).

Again, four years on, the priority for automation investment was at harvest, this dominated responses with 59% mentioning this area, very similar to 56% in 2017. Also similar to a survey by Korir, *et al*., (2021) that found 61% of grower respondents thought harvesting had the most potential for automation. The secondary priority was packing of produce, where it is easier to envisage automation or robotic solutions, in a less variable environment to the field. In the growing end of the system, crop husbandry was mentioned by 16% of respondents as somewhere they intend to upgrade. The majority of robotic research funding, for example UKRI Innovate programme (Innovate, 2021), does appear to be dominated by harvesting and crop husbandry tasks. Many researchers have used the Covid-19 recovery innovation fund to further robotic work, for example to address the shortage of labour, due to Covid movement restrictions.

Thirty-one percent of growers were doing their own in-house research and 39% were involved in some form of research project. Again, this is very similar to four years ago. With over half of growers not finding machinery available, or it not fitting their system, it is not surprising to

find they are seeking their own solutions. It was clear that where growers had formed bonds and associations with companies or researchers, these connections remained strongly in place over time, and would be revisited for further partnerships or advice. Over 40% of growers got information on automation directly from commercial companies, 45% online and 14% from Universities. Several growers were involved in research groups, as for example part of a producer organisation.

Seventy-eight percent of growers said 'Yes' they would get involved in research projects on automation with a further 12% saying maybe, a very positive response which shows demand is there, and many growers not currently involved in research, would like the opportunity to engage with academics, or the commercial sector, that can work on their specific problems. Several mentioned having tried but failed to get funding, others mentioned that funding was just not accessible for smaller businesses. Funding programmes tend to be geared towards fewer, larger, projects which offer easier administration for funders. There was a grower demand for smaller, more easily available pots of money, that did not require vast amounts of paperwork to access, that may only yield relatively minor funds, but these could be extremely valuable for smaller scale growers. It is known that large businesses may struggle with funding paperwork and rely on academic partners to guide them through the system. If this is a common problem it may be hampering grower and commercial company partnerships, if their expertise is not grant funding applications either. Several who had attempted to apply for funding but not been successful were put off going through the process again.

It was noted that the research projects growers mentioned they were involved with, tended to be closer to market than research mentioned four years ago. Several mentioned commercial trials with developed, rather than developing technology.

Some of the questions in the survey may have touched on commercially sensitive areas, and requested information businesses were not able to share, therefore there may be greater innovation, research and potential activity in this area than documented.

A few growers questioned what will happen to the UK research base if funding is not available from AHDB, will this lead to researcher, and researcher organisation, focus moving to other topics? Will the UK lose its horticultural research capability? There are wider questions to answer on what will happen without the role of AHDB as a part of the research and development pipeline. How will that facilitating link, between growers, research, commercial companies and funders be forged? Is there a greater role for Grower or Trade Associations, or more direct links between key stakeholders? Over a quarter of growers named AHDB independently as an information provider on automation and robotics to the open question.

When asked specifically, over half had used the SmartHort programme for a range of activities. Without AHDB will there be greater delay to the advancement of automation and robotics?

There was a greater focus on sustainability from growers in this survey than 2017, futureproofing their systems in the move to net-zero carbon was mentioned by several. This was noted in comments about upgrading heat systems to use heat pumps, upgrading lighting systems with LEDs, changing growing media away from peat, changing diesel tractors to electric buggies, and making packaging 100% recyclable. As growers move towards the net-zero challenge greater automation innovation in this area is another need. Area expansion of the main cropping season, feeding to the domestic market, would automatically reduce the environmental footprint of fruit, vegetable and ornamental crops. Retailers can be seen competing to reach net-zero carbon first in their marketing and promotion campaigns, this will need UK grower partnership commitment to deliver on their promises. Growers need contract confidence to fund innovative automation and robotic solutions to make this happen.

The focus of the survey was on automation and robotics/robotic technologies but labour issues were often discussed in responses. Most grower systems are not currently suitable to be completely automatic, human seasonal labour will always be needed for some sectors of horticulture. Several growers mentioned the need to support their labour or 'automate labour', so making sure everything surrounding the individual was as mechanised as possible, to help them improve speed and quality of work. This could also be through the use of cobots, collaborative robots that share space with humans, or augmentative technologies that can interact with the human body. This additionality/augmentation to improve worker performance is an important step in the whole automation process, rather than just direct replacement driven thinking.

The balance of labour needs over the season was also discussed, it was important to have things for the workforce to do over the entire season. In light of the fact there will always be some seasonal labour required, the need to improve the speed and skills of the workforce was mentioned as still being a research and knowledge exchange need. The flexibility a human labour force could offer was also mentioned, one example cited was a 30% yield increase on a particular day due to hot weather, it was felt a human team could be more responsive than a robotic team to these types of demands.

The 'Pick for Britain' campaign to recruit UK workers in 2020 had not been as successful as hoped, several mentioned, despite great efforts, it was difficult to acquire or retain British staff, and their speed and work quality was not up to usual seasonal worker standards. Defra has announced the campaign will not continue for the 2021 season (FarmingUK Team, 2021).

The seasonal workers pilot scheme though, has been extended to 30,000 workers for 2021 (Defra, 2021b), but ornamental growers were keen to stress they were not eligible to access this labour, one describing non-edible crop growers as the ‘forgotten people’. The press has reported growers calling for an adaption of the scheme or they believe millions of blooms will go unharvested (Evans, 2021).

It is also critically important when thinking about advances in automation and robotics to think about skills and training requirements of the workforce to be able to use, and get the best performance from these new technologies. Planning is also required on how to staff new roles that will be created in future. In 2019 AHDB and others commissioned a skills survey (AHDB, 2019 & 2020), which analysed responses from over 550 edible and over 1,100 ornamental horticulture businesses across the UK, providing insight into the specific skills and labour challenges affecting the sectors. Businesses predict that automation and innovation will alter job roles and skills requirements. For instance, a growing need for robotics and automation specialists is envisaged and businesses expect that upskilling will be required to operate upgraded existing technology. New roles for operatives, technicians, mechanics, engineers, data management and general IT roles are predicted to be needed. Manager and supervisor roles will also need upskilling to adapt to new technologies.

Aside from a marketplace product or technology being available, there were some requests noted from growers about what they felt was missing in order to help the whole industry become more automated:

- Clear and costed UK horticultural R&D strategy
- R&D community innovation for horticulture
- Support to move products/technology from research to commercial stage
- Multifunctional automation equipment
- Contract commitment from retailers
- Grower partnership commitment from retailers
- Grower partnerships with commercial companies
- Easily accessible funding information
- Easily accessible funding
- Accessible grants specifically for smaller businesses
- A UK re-design and expansion of PO type funding

- Enhanced R&D tax credit system
- Alternative ELMS support for the protected sector
- SWP support for the ornamental sector
- Automation specific advisers
- Training and upskilling the workforce
- Impartial sources of automation information
- Advertising space for automation/robotic companies
- Demonstration of machinery or technology

Conclusions

This survey was commissioned to establish if AHDB, through its SmartHort programme, was meeting the needs of the horticultural community on the topic of automation and robotics. With 53% of growers saying they actively use SmartHort it can be concluded the work is valuable to UK horticulture. More broadly the survey collected higher level market intelligence on the current state of automation and robotics, and shows:

- The need to get cost-effective automotive/robotic solutions to the marketplace is the main priority to advance automation
- Growers are continually automating and looking for automation and robotic solutions
- Investment in the last four years has been focussed on grading, packing and new growing systems
- Growers are highly confident automation and robotics will reduce casual labour in future
- There is a clear desire to invest in automation and robotics from growers
- The main drivers for automation and robotic investment were labour costs and availability
- The biggest barrier to investment is the lack of equipment or technologies
- Where there is automation and robotics available, the biggest barrier to investment is cost

- Growers are very keen to be involved in research projects to find automation and robotic solutions
- The clear priority for automation and robotic needs is harvesting

The findings of this survey suggest activity needed by AHDB is to:

- Provide information for researchers and commercial companies on grower automation and robotic needs
- Provide information on grant funding
- Support lobby groups working with policy makers on financial support
- Provide reliable, up to date information on automation and robotic R&D and marketplace products and technologies
- Demonstrate R&D and marketplace technology

SmartHort has delivered some of these needs, but would have to be resourced going forwards to continue, and expand the programme, to address all requests. If not funded, another barrier to automation uptake will be created.

Knowledge and Technology Transfer

Presentation to AHDB and Defra - 26th May 2021.

Glossary

Automation - the technology by which a process or procedure is performed without human assistance.

Robotics - automation of robots that includes programming and an ability to interact with their environment on their own without a control source, and can determine reactions to objects and problems encountered using their pre-existing programming.

Acknowledgements

The author and AHDB would like to thank all the growers that took the time to answer the survey questions. Thanks, are also extended, to the thousands of seasonal workers that sustain the UK horticultural industry.

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Appendices

On-line and telephone survey questions

1) Are you a UK grower?
   Yes, No (please specify occupation in box)
2) What is your main business sector?
   PE, FV, BOF, M, SF, HNS, TF, PO
3) What are your three main crops?
   Tick box options of main crops or box to write
4) What size is your business?
   0-2 ha, 2-5 ha, 6-10 ha, 11-20 ha, 21-50 ha, 51-100 ha, 101-200 ha, 201-500 ha, 501-1000 ha, 1000+ ha
5) What is your business turnover?
   £0-100k, £101-1m, £1.1-2m, £2.1-5m, £5.1-10m, £10.1 - 50m, 50.1-100m, 100+m
6) Where do you sell your products?
   Processor, service sector, wholesaler, retailer, direct to end customer ('Other' option to write in box)
7) What has been automated in last 3 years? Please tick all that apply
   Tick box options: Seeding, Field preparation, GPS System, Compost treatment, Spawning, Casing, Production transport, Sticking/Grafting, Transplanting/planting, Watering, Fertilising, Weeding, Energy, Lighting, Application of biological controls, Application of chemical controls, Crop husbandry, Monitoring, Harvesting, Grading, Packing, Packhouse transport, Product stacking, Storage, Wrapping, Product transport, System change ('Other' option to write in box)
8) Are you using robotic technologies?
   Yes, No
9) If you are using robotics, what areas are they being used? Please tick all that apply
   Tick box options: Seeding, Field preparation, GPS System, Compost treatment, Spawning, Casing, Production transport, Sticking/Grafting, Transplanting/planting, Watering, Fertilising, Weeding, Energy, Lighting, Application of biological controls, Application of chemical controls, Crop husbandry, Monitoring, Harvesting, Grading, Packing, Packhouse transport, Product stacking, Storage, Wrapping, Product transport, System change ('Other' option to write in box)
10) Do you think automation/robotics will reduce casual labour requirement in your business in future?
    Yes, No ('Comments' option to explain in box)
11) Is there automation/robotics available to improve your system?
    Yes, No ('Comments' option to explain in box)
12) Are you aware of automation/robotics in development that could improve your system?
    Yes, No
13) What are the main reasons you aren't you using automation/robotics already?
    Not available yet, too expensive, too slow, doesn't fit the system, no retailer contract commitment, COVID/Brexit uncertainties (please tick all that apply, option to write in box)
14) What are your drivers for wanting to use automation/robotics?
    Reduce labour needs, improve efficiency, reduce environmental impact (please tick all that apply, option to write in box)
15) Are you currently developing in-house automation/robotics solutions?
    Yes, No
16) Are you involved in automation/robotics research projects?
    Yes, No
17) If so, have you applied for any external funding or been involved in any funded projects in the last 3 years?

Yes, No

18) Would you like to be involved in a team working on automation/robotic solutions?
Yes, No
19) What are your priorities for automation investment? Please tick all that apply
Tick box options: Seeding, Field preparation, GPS System, Compost treatment, Spawning, Casing, Production transport, Sticking/Grafting, Transplanting/planting, Watering, Fertilising, Weeding, Energy, Lighting, Application of biological controls, Application of chemical controls, Crop husbandry, Monitoring, Harvesting, Grading, Packing, Packhouse transport, Product stacking, Storage, Wrapping, Product transport, System change ('Other' option to write in box)
20) Are you planning on investing in automation/robotics?
No, In the next year, 2-3 years, 4-5 years, 6-10 years, >10 years?
21) If so, what percentage of turnover do you envisage spending?
0-1%, 1-4%, 5-10%, 10-20%, 20%+
22) Where will you get funding for investment?
Internal investment, banks, venture capitalists, PO, government funding ('Other' option to write in box)
23) Have your investment plans been affected by Covid or Brexit? (please tick all that apply)
24) What do you need to accelerate the uptake of automation? (free text option)
25) Are you concerned about the public perception of autonomous automation?
Yes, No
26) Where is your go to place for information on automation/robotics?
Advisors, Growers, Contractors/service providers, Press, Internet press, Internet searches, Research papers, Research events, AHDB, Grower associations, UK trade shows, Overseas trade shows, UK visits, Overseas visits
27) Have you used the AHDB SmartHort resources?
Yes, No
28) If so which resources?
Website, attended the conference, watched the conference, attended workshops/courses, attended a study tour, part of SmartHort Centre programme, part of WMG project, emails, watched YouTube, listened to podcasts, watched webinars, read publications etc ('Other' option to write in box) etc
29) Any other comments on automation, robotics and SmartHort? (option to write in box)

