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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.

Becky Turner

Director

HortSolutions

Signature ..... Date .....

Report authorised by:

[Name]

[Position]

[Organisation]

Signature ..... Date .....

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GROWER SUMMARY

Headlines

- The UK horticultural industry is highly automated with most growing tasks utilising automation where it is available, robotics are not widely used.
- Over 84% of growers surveyed were planning to invest further in automation or robotics and a similar number are actively searching for solutions suitable for their businesses.
- Automated harvesting and application of crop protection controls were the priority topics for research.

Background

Horticulture is an important area of agriculture with an estimated farm-gate value of over £3.1 billion. It also a growing area with the value of vegetable production alone increasing by 20% to £1.5 billion in 2016 with the majority of crops showing a year on year increase. There are opportunities to increase production further by increasing the use of automation and robotics for many stages of production. The drivers for automation can be a reduction in labour, energy or materials with a potential increase in productivity, quality, accuracy and consistency.

Human labour accounts for between 30% and 70% of total variable production costs in horticulture. The National Living Wage is driving labour costs up substantially at a time when margins are under strong downward pressure from retailers. It is therefore important that the UK horticulture industry looks forward to incorporate new technologies, including automation and robotics, to existing practice to reduce labour costs where possible.

The aim of this project is to produce a report of current and potential implementation of automation and robotics across the UK horticultural industry to help inform future AHDB activity. The report is based on data collection from telephone interviews with 50 growers, who were chosen to represent the diversity of horticultural sectors and holdings of different sizes. Data is also presented from an on-line survey which was open to all growers.

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Summary

A representative sample of 50 growers were surveyed on the telephone. A supporting sample of 18 growers volunteered to take an on-line survey. The results showed that the current use of automation in the horticultural industry is high and continually updated. Figure A shows the most recent (10 years) grower investments in automation include; transplanting/planting, weeding and harvest during crop production and in product transport, grading and packing, postharvest. The packhouse has benefitted from the most frequent developments with upgrades in, for example, sorters, graders, auto weighers, heat sealers and flow wrappers.

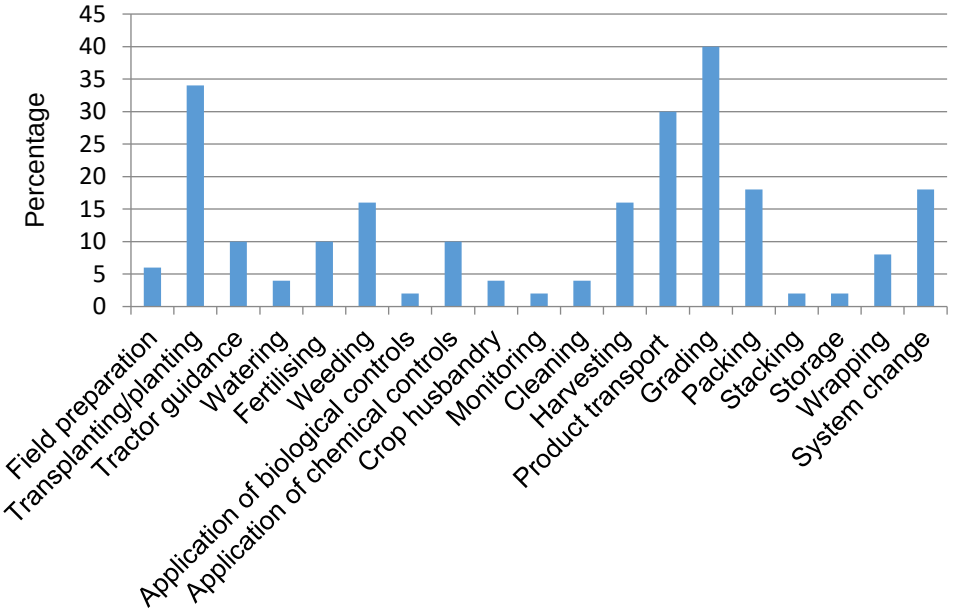

Figure A. Percentage of growers mentioning updates in automation over the past 10 years from the telephone survey

The use of intelligent robotics is not so widespread, 32% of growers had what they described as some element of robotics (which had feedback and sensing) in their system and the areas mentioned are shown in Figure B.

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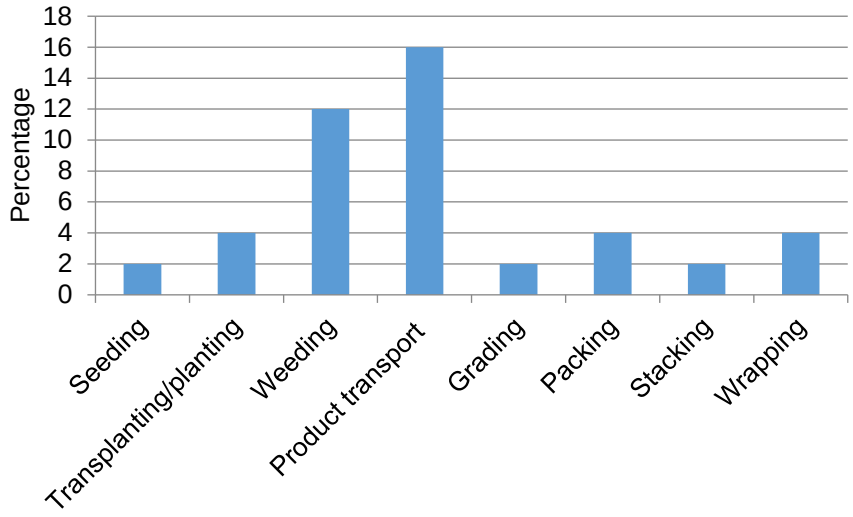

Figure B. Percentage of growers mentioning each category when asked where they had robotics in their system from the telephone survey

The overwhelming majority (82%) felt automation had reduced labour or increased efficiency and more growers (88%) were positive for future developments.

The majority of growers could see the greatest potential for automation and robotics developments in their businesses coming from the harvesting, grading and packing end of the system (Figure C). Over 50% of growers felt their harvesting process could be improved with automation.

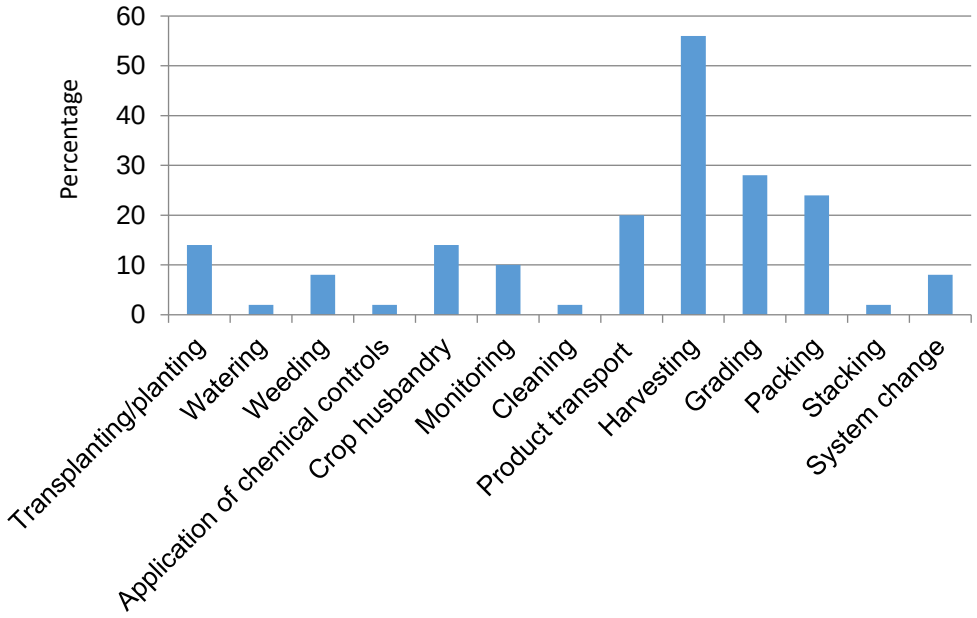

Figure C. Percentage of growers mentioning each category when asked where they could see automation/robotics helping in their system from the telephone survey

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Eighty percent of growers questioned knew of automation that was in development that could be helpful for their system. Many mentioned research projects or commercial companies that were developing technology. Automation discussed included; sensing technology, image analysis, crop monitoring, forecasting systems, de-leafing robots, moving robots, harvesting machinery and learning robots.

Around a third of growers are developing their own in-house automation solutions and the same number are involved in research projects or had applied for grant funding for automation.

Eighty-four percent of growers surveyed on the telephone were planning to invest in automation/robotics. Although not directly questioned whether they would invest, all but one grower on-line specified a timeframe for investment all of which were within five years.

In line with where growers see the greatest potential business benefits, picking or harvesting technologies are what growers would most like to see researched (Figure D) nearly 60% of growers mentioned this topic. Monitoring of crops (12%) and grading (16%) were the other two areas where there was agreement on research needed. On-line, alongside harvesting, the application of chemical controls, biological controls, planting/transplanting and transport systems were important.

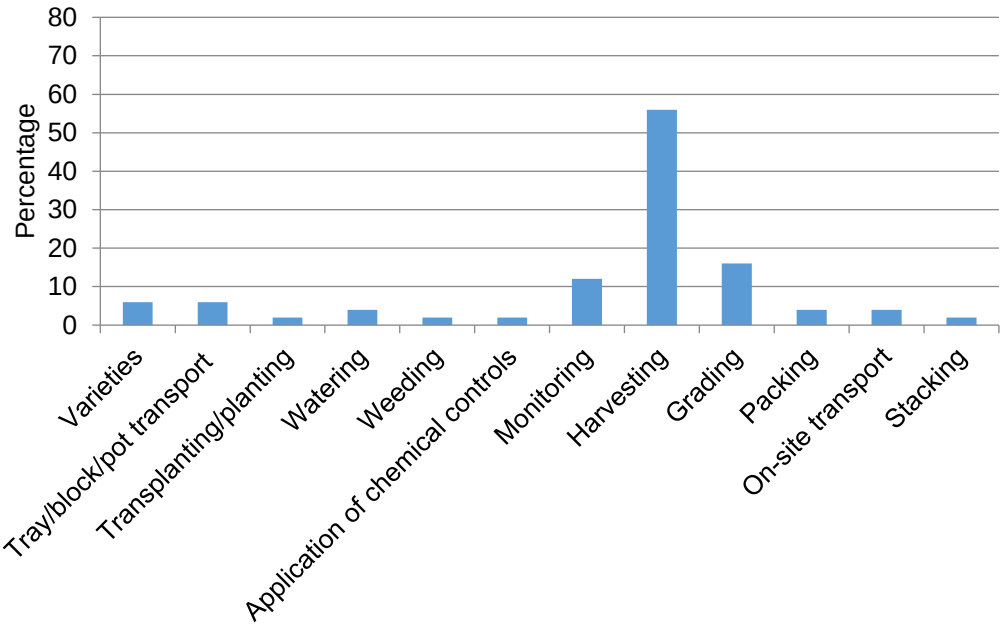

Figure D. Telephone survey responses for what growers would like to see researched

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On-line the question was asked ‘Would you like to see more research into automation/robotics at a Government level?’, to which 94% of growers said yes. On the telephone growers were asked directly if they would like to see AHDB funding automation/robotics research and 66% agreed they would like to see levy money being directed to this topic.

On the telephone and on-line growers were asked how important this topic was when considered in terms of all the AHDB research needs and asked to score on a scale of 1-5 where 1 would be the lowest and 5 the highest priority. Overall 68% (46 of the 68 growers) surveyed rated automation/robotics as a 4, ‘important’ or a 5, ‘very important’ to their business.

On the telephone growers were asked if AHDB should invest money into knowledge exchange on automation/robotics. Eighty percent felt there should be information shared on the topic. On-line growers were asked if they would like AHDB to provide more information on automation/robotics, 83% said yes.

The telephone survey asked what format growers would like to receive information. Forty percent wanted an event where they could discuss the topic face to face with experts and other growers, listing; working parties, workshops, seminars, demonstrations and conference styles. Nearly a third wanted to receive e-mail updates and 14% wanted to see publications, web content and magazine articles. Study tours were only mentioned by 4% of the sample. On-line growers were given five choices about the format they would like to receive information. Publications were mentioned by the most growers, 55%, followed by web content, 41% and events 32%. Only three growers (14%) ticked for webinars.

On the telephone and on-line growers were asked further about whether they would like to see a dedicated knowledge exchange programme in a similar style to the GrowSave programme for energy efficiency or the GREATsoils work. On the phone opinion was split with 48% saying yes they thought the topic was important enough to put a similar package in place, 52% were against the idea. On-line only 14% were interested in a dedicated package of KE work.

In summary:

- Growers already have highly automated systems and want to continue automating.

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- The importance value placed on automation and robotics has clear links with the escalating problems associated with labour availability and costs.
- The majority of growers surveyed want AHDB to invest in R&D and KE to support industry efforts in adopting automation and robotics.
- Many growers want AHDB to take a facilitating role in:
    - connecting the research chain (funders, academia, commercial companies, growers and retailers).
    - connecting the industry with commercial companies and industries outside of the horticultural sphere that may have technology, knowledge and capabilities to apply to horticultural systems.
- The highest priority for development is harvesting.
- The most popular format for KE is ‘events’.
- Despite the generally buoyant mood of growers towards automation it was stressed that in the short term there was not going to be a robotic revolution and practical measures to help aid the shortfall of workers is a high priority.
- Lack of fit to existing production systems is an important restriction for uptake of existing technologies and an important consideration for the development of future solutions.

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SCIENCE SECTION

Introduction

Horticulture is an important area of agriculture with an estimated farm-gate value of over £3.1 billion (AHDB, 2016). It is also a growing area with the value of vegetable production alone increasing by 20% to £1.5 billion in 2016 with the majority of crops showing a year on year increase (National Statistics, 2017). There are opportunities to increase production further by increasing the use of automation and robotics for many stages of production. The drivers for automation can be a reduction in labour, energy or materials with a potential increase in productivity, quality, accuracy and consistency.

A major driver currently is concern over access and cost of labour which is relied heavily upon in many sectors. The lack of seasonal labour has been widely publicised in the horticultural press. The NFU end-of-season labour survey found that in 2015 nearly a third of growers experienced problems recruiting workers and 69 per cent of growers expect the situation to get worse by 2018 (Gray, 2016). The British Growers Association estimates that the horticulture industry employed 80,000 seasonal workers in 2017 and forecasts that need will increase to 95,000 by 2019 (Pelham, 2017). The NFU reports that the number of seasonal workers coming to work on British farms has dropped by 17%, and the proportion of returnees to farms in the first five months of 2017 dropped from 65% to 33% (NFU, 2017). Brexit may also alter the future availability of seasonal workers.

Human labour accounts for between 30% and 70% of total variable production costs in horticulture (AHDB, 2016). 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). Annual man hours required per hectare of production averages at 16-18 for cereal and oilseed crops contrasting with 280-425 hours per hectare required for outdoor vegetables and fruit and 7,000 to 13,000 for fruit, vegetables and ornamentals grown under protection (SAC Consulting, 2017). The National Living Wage is driving labour costs up substantially at a time when margins are under strong downward pressure from retailers. It is therefore important that the UK horticulture industry looks forward to incorporate new technologies, including automation and robotics, to existing practice to reduce labour costs where possible.

AHDB have commissioned this piece of work to understand the current state of automation and robotics in the industry and to establish the need for research or knowledge exchange in the future.

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Materials and methods

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

1. Telephone survey.
2. On-line survey.

Discussions about the current state of automation and robotics were held with members of AHDB Horticulture staff who represented each sector; Field Vegetables, Soft Fruit, Protected Edibles, Protected Ornamentals, Tree Fruit, Hardy Nursery Stock, Bulbs and Outdoor Flowers and Mushrooms. In collaboration with the staff a standard set of questions for each survey was produced (Appendix 1 and 2).

One hundred growers were contacted to represent the range and size of UK horticultural production and fifty surveys were conducted. Each grower was asked the standard set of questions, responses and any extra comments were recorded and summarised into an Excel spreadsheet.

The opportunity to take part in the on-line survey and register for the telephone survey was emailed to all AHDB Horticulture levy payers who were registered for the monthly news update.

Results

The diversity of British horticultural growing systems produces a complex set of requirements for any research and knowledge exchange topic. Automation and robotics is 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 for each question.

1) The demographic surveyed

Around 100 growers were contacted to participate in the survey and an open invite to be involved was included when the on-line survey was circulated via the August edition of Horticulture News on 30th August 2017. The target 50 telephone surveys were conducted between 28th August and 22nd September 2017. It was possible to nearly exactly replicate the demographic of AHDB Horticulture grower sectors on the telephone survey and the split achieved is shown in Figure 1. Eighteen growers filled in the on-line survey which was live

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between 30th August and 30th September 2017. There was a low response rate of 1% to the on-line survey.

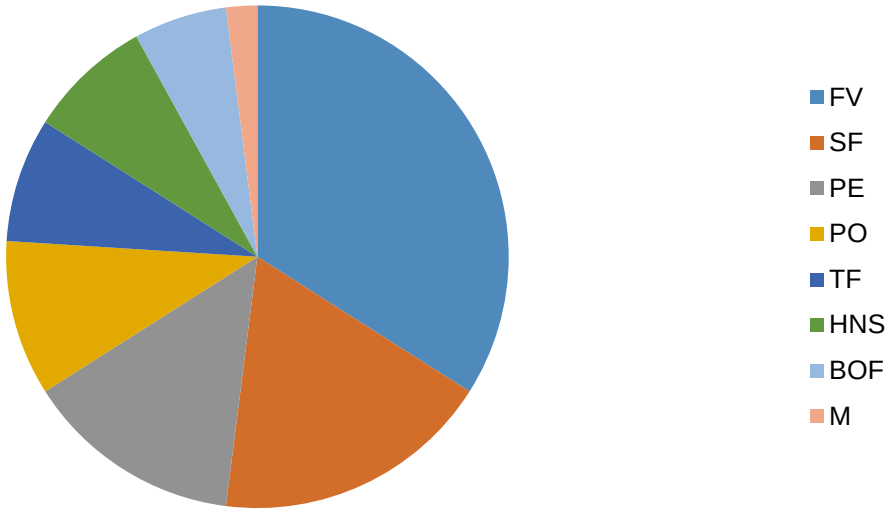

Figure 1. Split of horticultural sectors by number of growers from the telephone survey

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

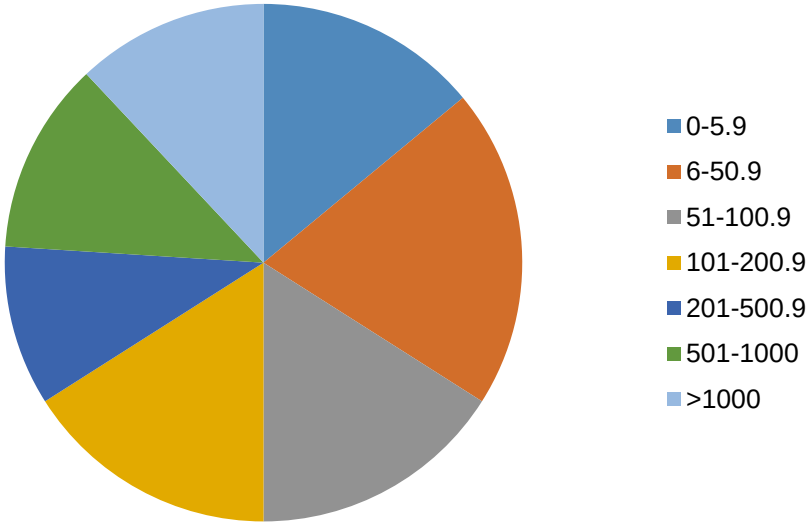

Figure 2. Split of business size (ha) by sector from the telephone survey

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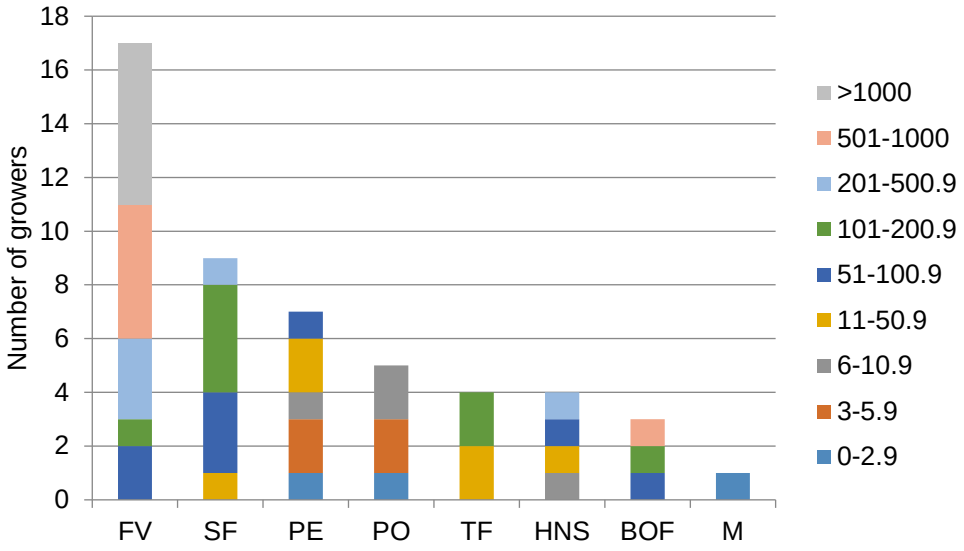

Figure 3. Split of business size (ha) per sector from the telephone survey

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

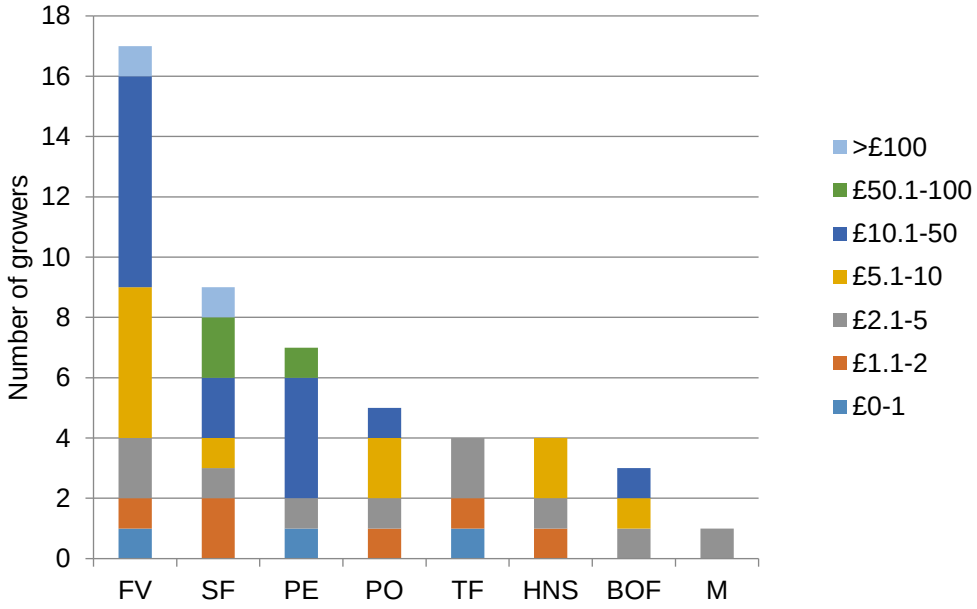

Figure 4. Split of business turnover (£ million) per sector from the telephone survey

The split of growers responding to the on-line survey is shown in Figure 5 and the breakdown of business size is shown in Figure 6. The responses do not represent the demographic of levy payers. There were no responses from protected edibles or bulbs and outdoor flower growers and only one representative for each sector of soft fruit, tree fruit

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and mushrooms. The majority of responses were from field vegetables (7), protected ornamentals (5) and hardy nursery stock (3).

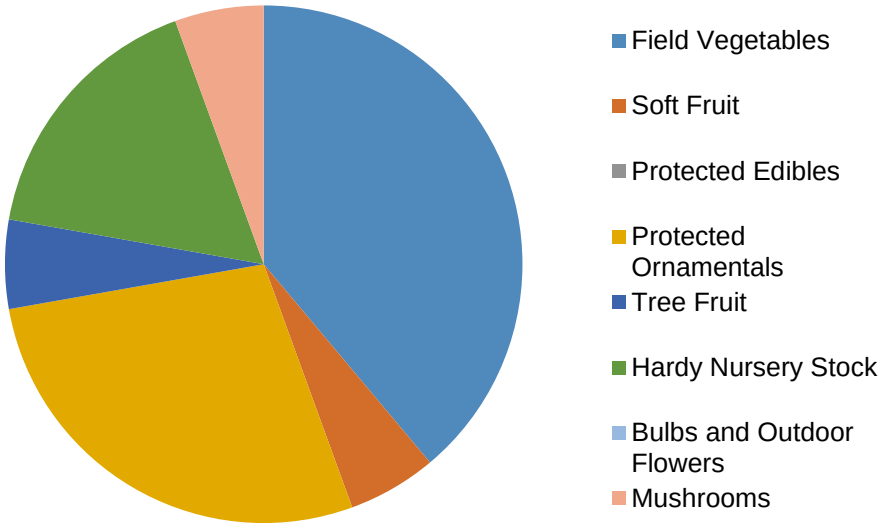

Figure 5. Split of horticultural sectors from the on-line survey

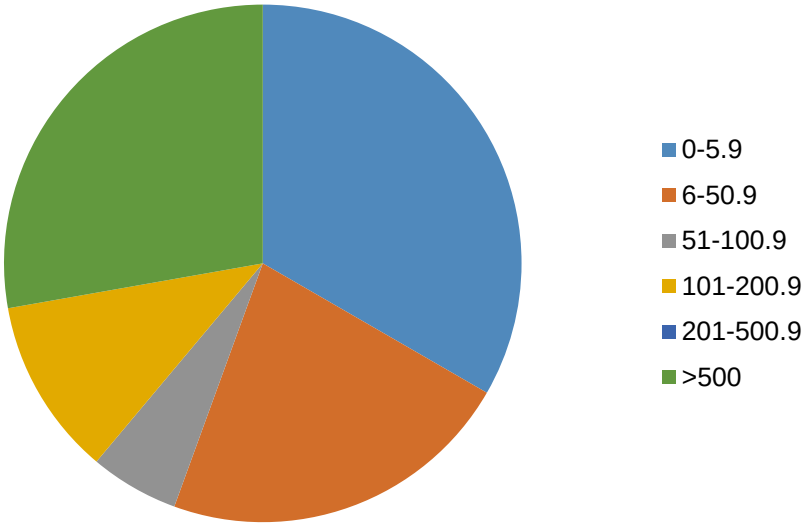

Figure 6. Split of business size (ha) from the on-line survey

When considering the results it must be taken into account that the telephone survey was a larger and more representative sample size, 50 growers as compared with 18 growers responding on-line.

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2) Growers perceptions of their business

The large majority of growers surveyed on the phone (94%) described their businesses as innovative or early adopters. This was similarly high on-line at 89%.

3) Automation usage

The telephone survey asked growers to list any improvements in automation/robotics over the last 10 years. Figure 7 shows the percentage of growers mentioning each category of change.

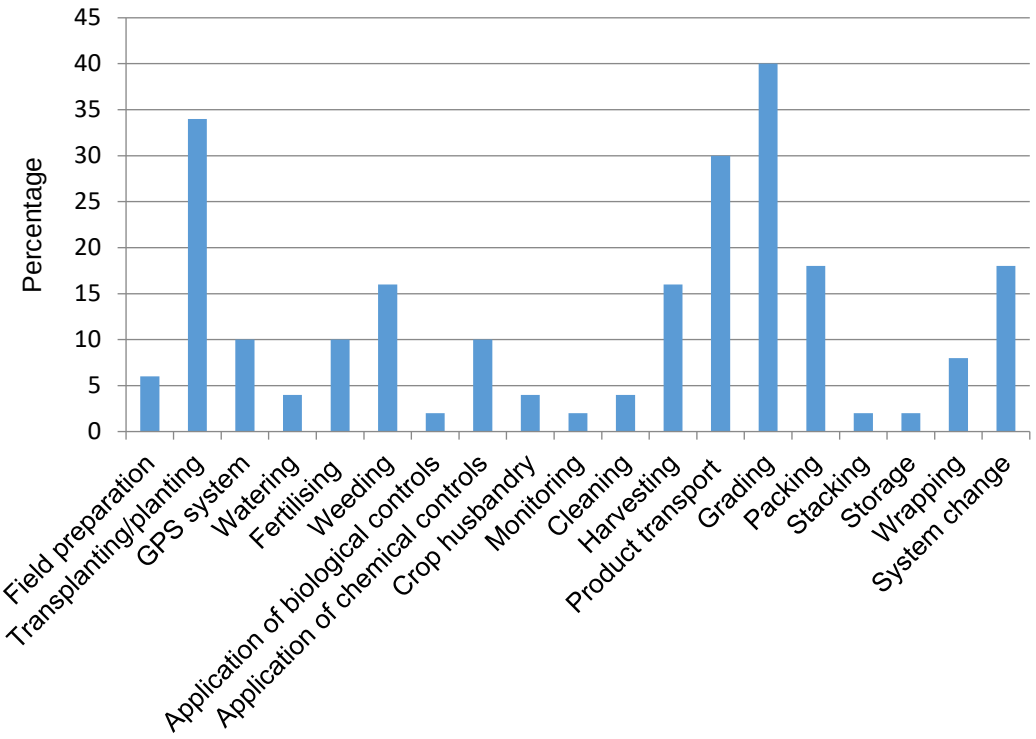

Figure 7. Percentage of growers mentioning updates in automation over the past 10 years from the telephone survey

The most frequently mentioned upgrades were; transplanting/planting, product transport and grading. Weeding, harvesting and packing were also frequently mentioned.

Transplanters/planters/potting machines had increased in speed and reduced labour requirements. Transport systems/conveyor belts had been installed to handle pots, trays or final product boxes. The packhouse had seen the greatest automation/robotic investment with mentions of multihead weighers, automatic checkers and weighers, automatic cutting

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lines, optical and softness graders, bunching machines, heat sealing, box filling machines, flow wrapping and dispatch machinery. The Garford Robocrop in-row weeder was the most frequently mentioned weeding upgrade.

Although not strictly an automation change most soft fruit growers had a complete system change from soil to substrate. This enables a much more efficient harvesting by hand.

Many growers mentioned there were continuous and incremental upgrades to most machinery.

On-line growers were asked what was currently automated in their systems from a fixed list with the option to type in an 'other' box. The category options were; seeding, field preparation, compost treatment, spawning, casing, tray/block/pot transport, grafting, transplanting/planting, watering, fertilising, application of biological controls, application of chemical controls, crop husbandry, monitoring, harvesting, grading, packing, on-site transport, stacking, storage, wrapping and product transport. The only categories that were not chosen by survey respondents were; grafting, crop husbandry and storage.

4) Robotic usage

Thirty-two percent of growers had what they described as some element of robotics in their system and the areas mentioned are shown in Figure 8.

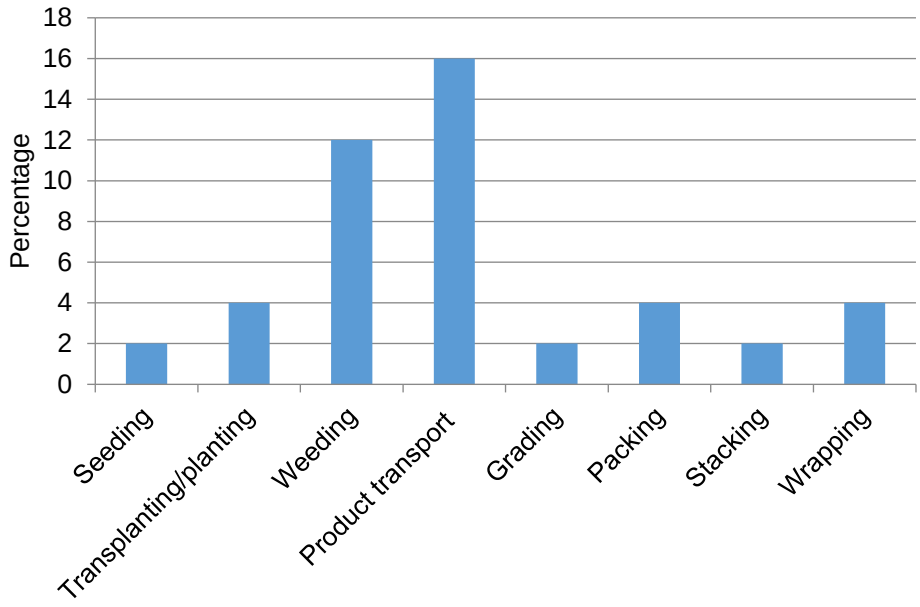

Figure 8. Percentage of growers mentioning each category when asked where they had robotics in their system from the telephone survey

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The main area mentioned was in transport of trays, blocks, pots, benches or final product. In field crops robotic weeders were the most common use. The field vegetables sector reported the highest use of robotics, primarily weeding machinery, at 53%, followed by the protected ornamentals sector 43%, mainly utilising robotics for moving product in some form.

5) Grower perception of past labour levels

Growers were asked on the telephone if the changes they had put in place in terms of automation and robotics had reduced their labour requirements over the past 10 years. Eighty-two percent thought they had. Several commented that their actual labour figures may not have reduced but their productivity had increased and this increase in efficiency was included as a reduction in labour per unit of product output.

6) Grower perception of future labour needs

Eighty-eight percent of growers thought that changes they would make to their system in the next 10 years would reduce their labour needs. Eight percent of growers could not see anything on the horizon in that timeframe that would make a difference and 4% of growers mentioned they were already completely automated and couldn't see any further reductions. On a smaller scale where there was currently only one person in charge of a crop it was commented that completely automated or robotic tractors would be the only way to reduce the labour bill.

7) Grower perception of current needs

When asked where they could see automation and robotics helping growers in their businesses the majority of responses fell in the harvesting, grading and packing end of the system (Figure 9).

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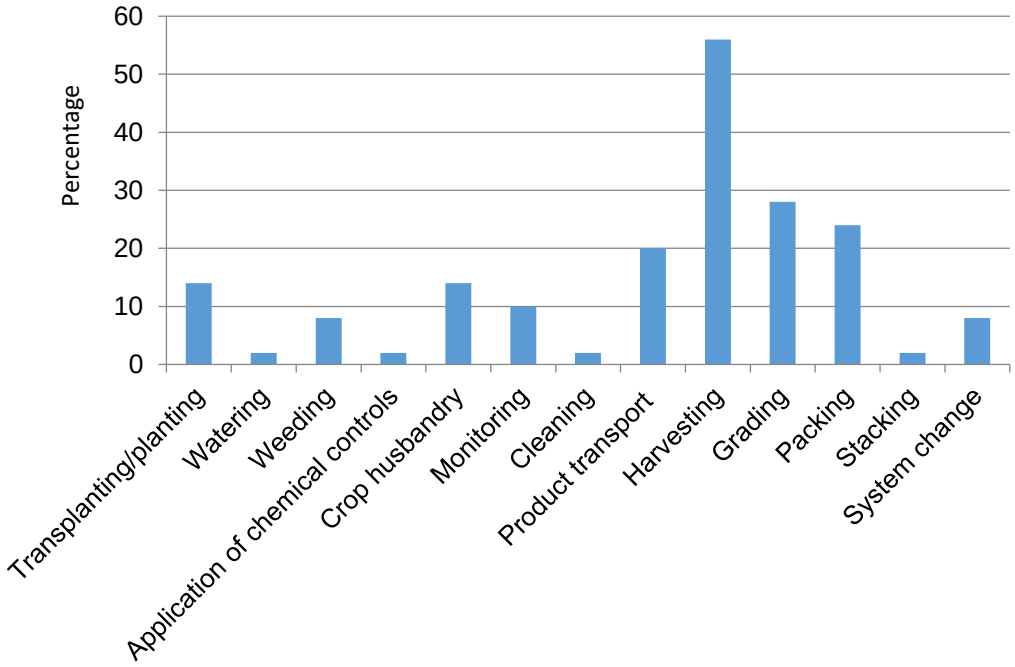

Figure 9. Percentage of growers mentioning each category when asked where they could see automation/robotics helping in their system from the telephone survey

Most growers (56%) many of whom had the biggest labour requirement at harvest wanted to see automated picking or harvesting for their crops. Many felt the packhouse was the area where the easiest wins would come with automation as it is more controllable than the growing environment. Several (8%) mentioned thinking about completely changing the growing system to fit automation.

8) Commercial availability of automation/robotics

When asked if the automation required for their system was available 44% of growers said no. The remaining 56% described why they did not have the technology in place or couldn't see where it could help, summarised in Figure 10. This was mainly because the technology known about did not fit into their system currently, for example if harvesting whole head lettuce requires several passes a harvesting machine that takes out the whole bed in one cut is not useful for the UK market. There was a lack of confidence in off the shelf automation/robotics, the machinery was not quite right for a very diverse growing environment that in many cases has to be flexible to meet market demand. Many said what they had seen of commercial systems was just 'too slow' compared with human labour which effectively came to the same conclusion as the 18% that specified 'too expensive'.

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Three growers felt they were already completely up to date and couldn't see anything else helping at present.

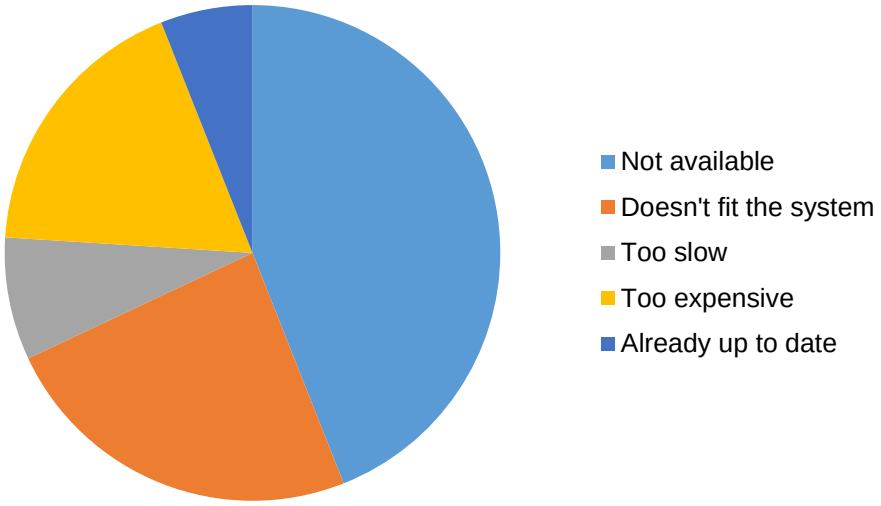

Figure 10. Split of reasons for not having automation/robotics in place from the telephone survey

9) Future availability of automation/robotics

Eighty percent of growers questioned knew of automation that was in development that could be helpful for their system. Many mentioned research projects or commercial companies that were developing technology. Automation discussed included; sensing technology, image analysis, crop monitoring, forecasting systems, de-leafing robots, moving robots, harvesting machinery and learning robots.

10) Grower innovation in automation/robotics

When questioned on the telephone 30% of growers said they had in the past or were currently developing their own in-house solutions with automation/robotics. The figure was 33% for the sample that filled in the survey on-line. Bulbs and outdoor flower growers were the most innovative in-house with 67% engineering their own solutions.

11) Grower support from funding or research

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Thirty-two percent of growers surveyed on the telephone and 33% of growers surveyed on-line had been involved in research projects or applied for funding on the topic. Several mentioned INNOVATE projects and Agri-Tech grants. Six percent were independently funding researchers and 4% mentioned they were involved in AHDB automation/robotic work (Appendix 3 lists the current AHDB automation/robotics projects).

12) Grower investment plans

Eighty-four percent of growers surveyed on the telephone were planning to invest in automation/robotics. Although not directly questioned whether they would invest, all but one grower on-line specified a timeframe for investment. All of the hardy nursery stock growers surveyed confirmed that they would invest in future, the most optimistic sector.

When questioned on timeframe for investment, responses from telephone survey growers are shown in Figure 11. Responses from growers on-line are summarised in Figure 12, where there were only the categories stated from which to choose. Growers on the phone tended to be vaguer on timeframes with 35% stating continuous investment as needed. The business case (viability) and availability of automation were also specified to inform investment decisions. On-line all of growers who answered the question thought they would be investing in automation/robotics within five years. On the phone 8% would envisage spending within a year, 24% within five years and 2% within 10 years. Ten percent thought it would be longer than the 10 year timeframe. Where growers mentioned what they were looking at it was mainly harvesting or packhouse equipment.

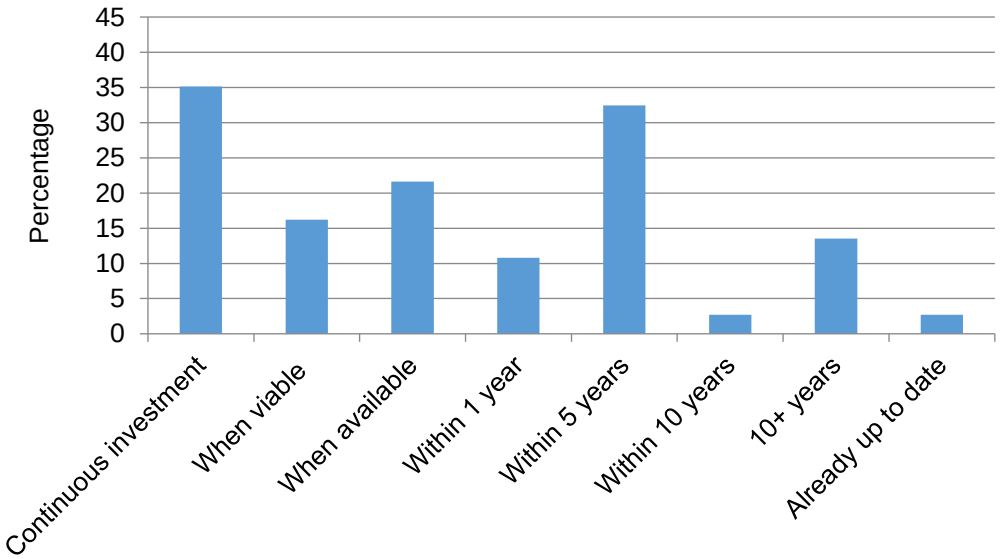

Figure 11. Percentage of telephone survey grower responses to timeframe for investment in automation/robotics

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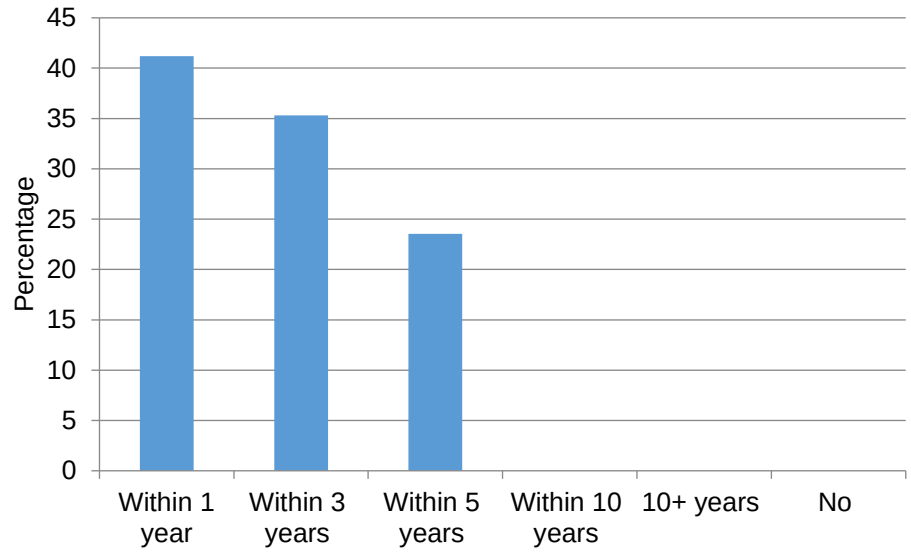

Figure 12. Percentage of on-line survey grower responses to timeframe for investment in automation/robotics

Where category choices were given on-line growers were more forthcoming with amount of money they would be spending. Of the 17 growers that responded 6% suggested they would spend 0-1% of turnover, 65% predicted 2-5% of business turnover, 24% spending 6-10% and one business suggested more than 21% of turnover would be invested.

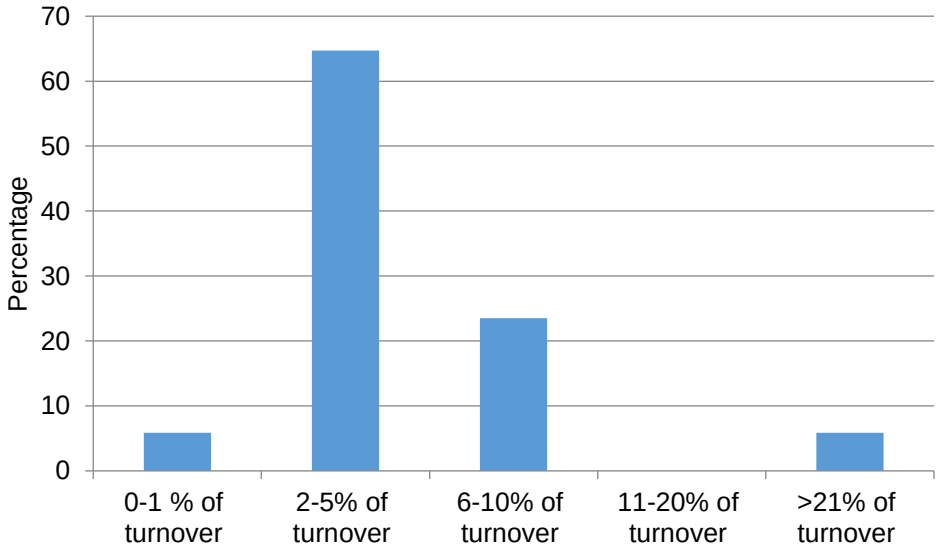

Figure 13. Percentage of on-line survey grower responses to the amount of money to be invested in automation/robotics

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13) Sources of information

Growers were asked where they got their information from on automation/robotics. Figure 14 details the responses of growers answering the telephone survey, Figure 15 shows the response of growers who had multiple categories to choose from in the on-line survey.

On the telephone AHDB was the most mentioned source of information, with 42% of growers citing them. Other growers, service providers, press and trade shows were the next most frequently mentioned categories.

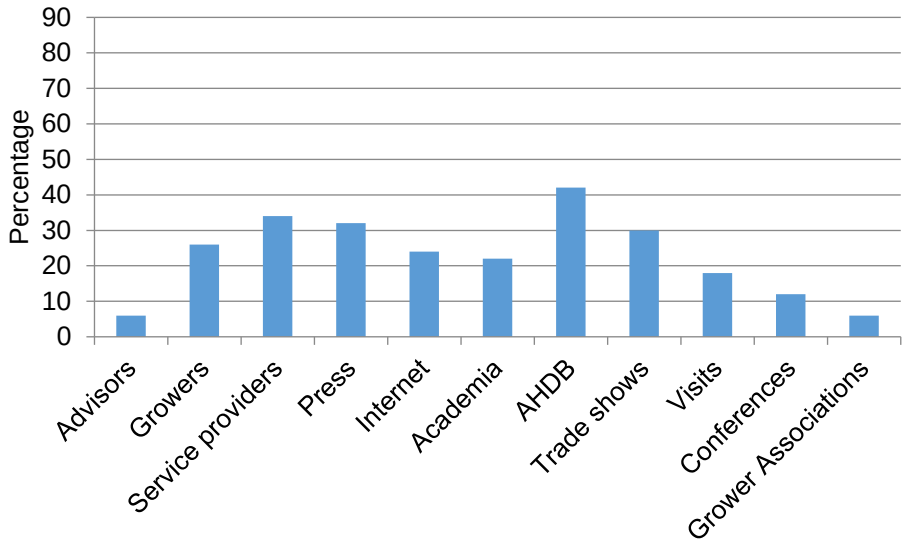

Figure 14. Telephone survey responses for sources of information on automation/robotics

On-line with fixed category choices the most frequently cited source of information was the Internet (88%), followed by growers and overseas tradeshows (both 69%).

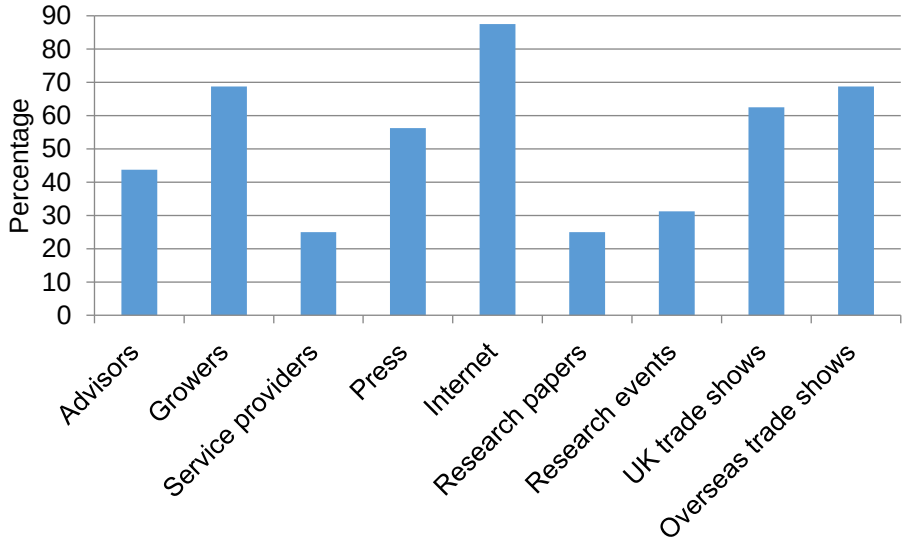

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Figure 15. On-line survey responses for sources of information on automation/robotics

Several growers noted actual sources of information and these were recorded and can be found in Appendix 4. This is not intended to be a comprehensive resource but purely a list of noted sources as described during the fifty interviews, many of the sources offer newsletters or email feeds which may be of interest to other growers.

14) Research and Development requirements

When questioned on the telephone as to what growers would most like to see researched, picking or harvesting technologies was a clear leader (Figure 16), nearly 60% of growers mentioned this topic. To a considerably lesser extent monitoring of crops (12%) and grading (16%) were the other two areas where there was agreement on research needed.

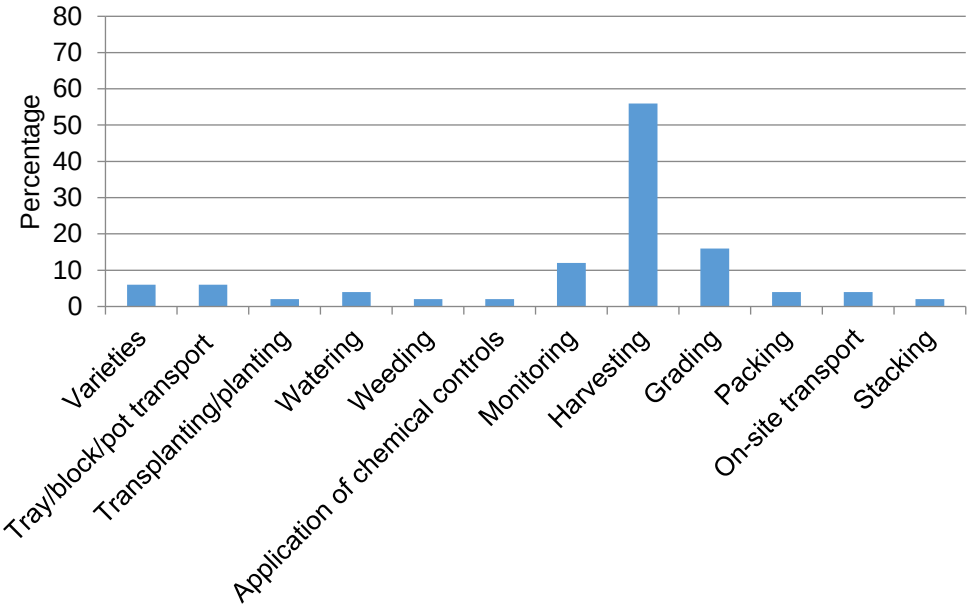

Figure 16. Telephone survey responses for what growers would like to see researched

On-line growers where asked where they would like to see developments and given category boxes to tick. Again harvesting was the priority area with 71% of those taking part checking this box. Fifty-seven percent of on-line grower respondents would like to see developments in the application of chemical controls. There was interest in all categories provided apart from spawning for mushrooms and grafting.

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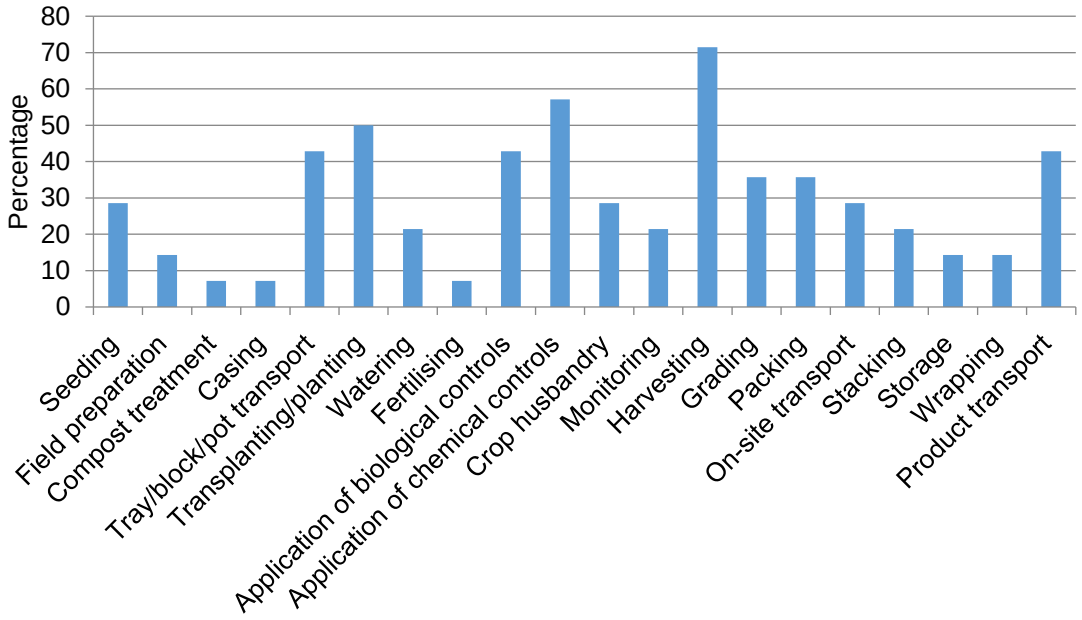

Figure 17. On-line survey responses for where growers would like to see developments in automation/robotics

15) Research providers

On the telephone growers were asked who they would like to see funding research (Figure 18). Of those that answered 38% wanted to see AHDB funding going into this topic, 34% mentioned the Government and 30% the commercial sector. Fourteen percent thought individual growers should be doing their own research.

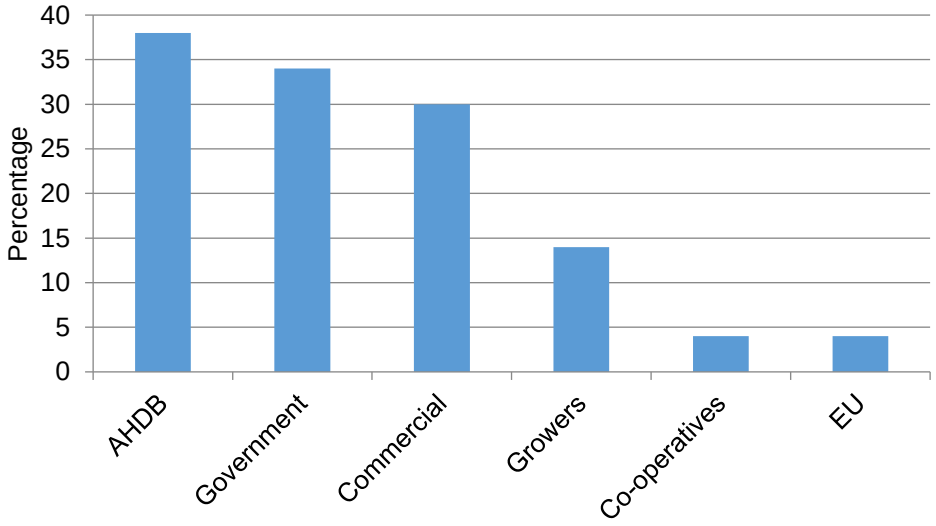

Figure 18. Telephone survey responses to who should fund research

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On-line the question was asked 'Would you like to see more research into automation/robotics at a Government level?', to which 94% of growers said yes.

16) The role of AHDB

On the telephone growers were asked directly if they would like to see AHDB funding automation/robotics work and 66% agreed they would like to see levy money being directed to this topic. One hundred percent of hardy nursery stock and bulbs and outdoor flowers wanted to see investment, whereas only 14% of protected edibles growers, 25% of tree fruit and 29% of protected ornamentals felt levy should be invested. There were caveats to investment for some growers which included; deciding when more information was available (mentioned by a Panel member), only on the right project, with more control of direction, in a steering capacity and for projects where everyone would benefit.

On-line growers were given four prescribed options as to how AHDB could best support the future automation/robotics aspirations of their business (Figure 19). Eighty-one percent wanted to see case study updates, 69% study tours, 44% would like to see investment in pre commercial research. Three growers or 19% of the sample wanted to leave investment to the commercial arena.

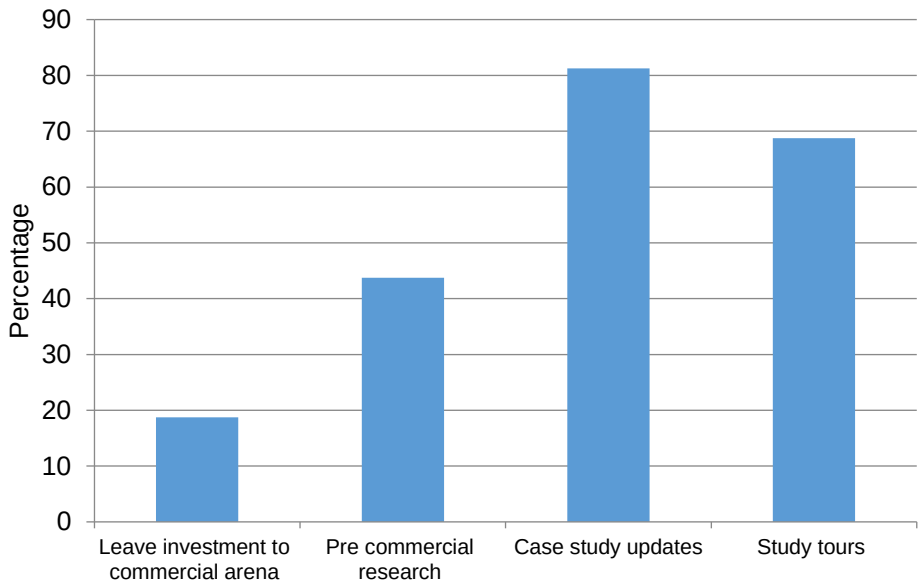

Figure 19. On-line responses as to how AHDB could best support the future automation/robotic aspirations of the business

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17) The importance of automation/robotics

On the telephone and on-line growers were asked how important this topic was when considered in terms of all the AHDB research needs and asked to score on a scale of 1-5 where 1 would be the lowest priority and 5 the highest. On the phone 34% of growers rated the topic as a 5 priority to their business with 32% rating the importance as a 4 (Figure 20).

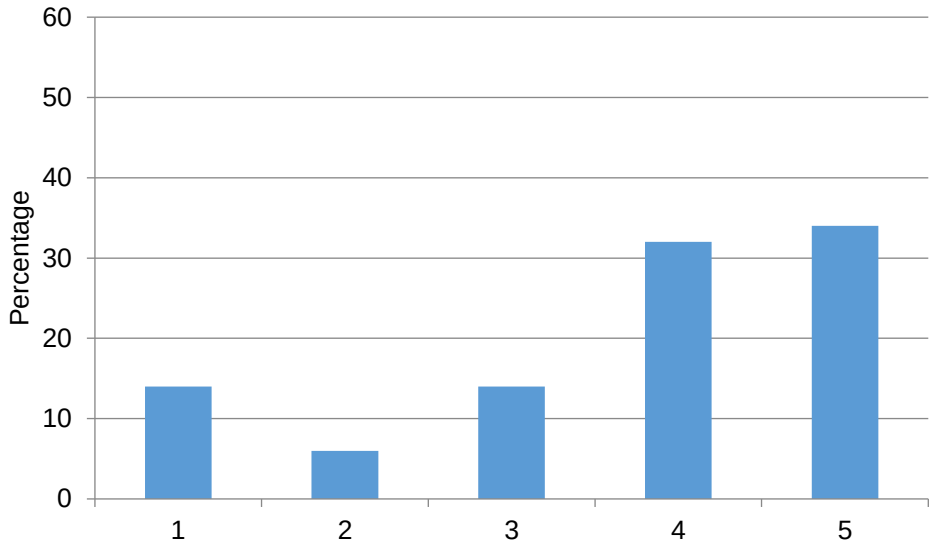

Figure 20. Telephone survey responses to the importance of automation/robotics as a topic

On-line all the growers responded and 50% rated the topic as a priority 5, with 22% rating it as a 4 and a 3 (Figure 21).

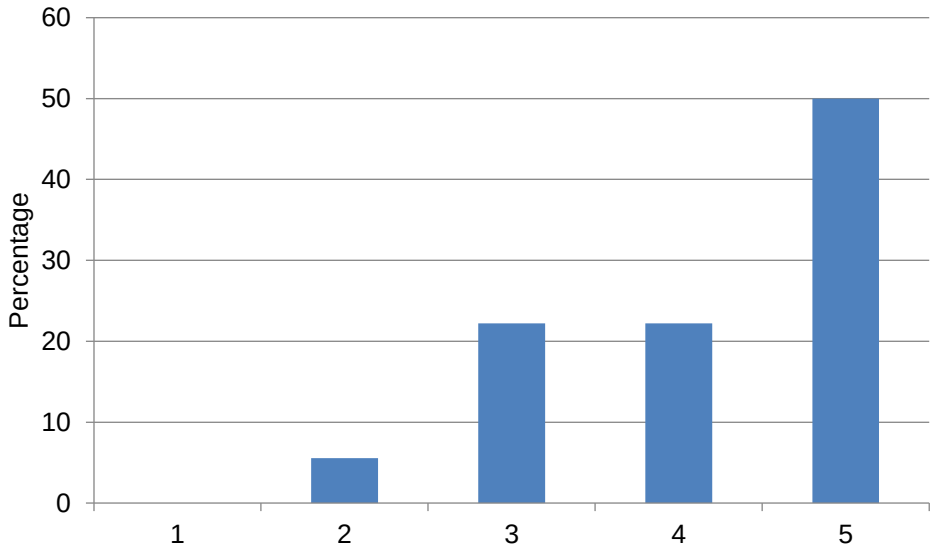

Figure 21. On-line survey responses to the importance of automation/robotics as a topic

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18) The role of AHDB in knowledge exchange (KE)

On the telephone growers were asked if AHDB should invest money into knowledge exchange on automation/robotics. Eighty percent felt there should be information shared on the topic. Tree fruit was the least sure with 50% of growers surveyed wanting to see information. On-line growers were asked if they would like AHDB to provide more information on automation/robotics, 83% said yes.

19) The format and scale of information

On-line growers were asked if they had actively searched for information on automation/robotics and 83% had. The telephone survey asked an open question of 'What format growers would like to receive information?'. Figure 22 shows the grower responses. Forty percent wanted an event where they could discuss the topic face to face with experts and other growers, listing working parties, workshops, seminars, demonstrations and conference styles. Nearly a third wanted to receive e-mail updates and 14% wanted to see publications, web content and magazine articles. Study tours were only mentioned by 4% of growers on the phone.

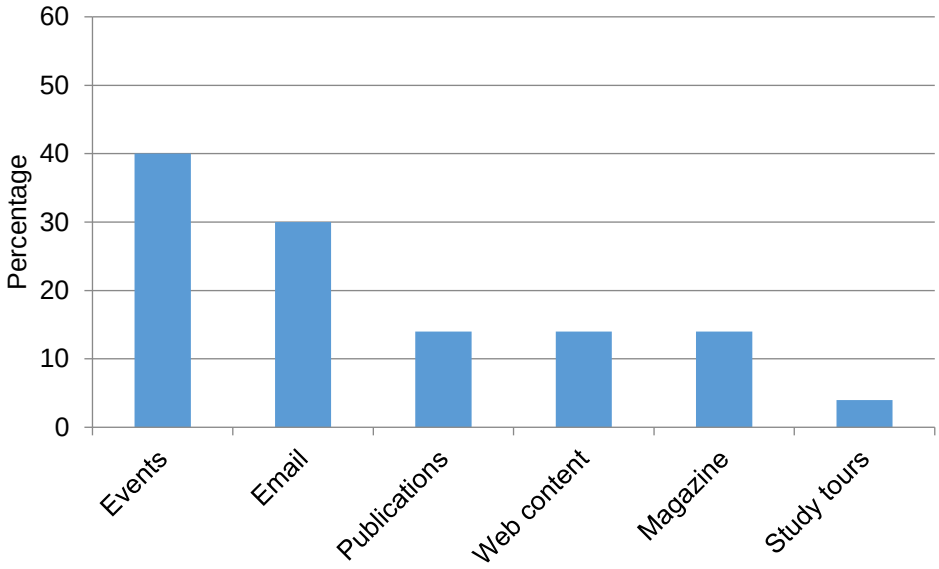

Figure 22. Telephone survey responses for what format growers would like to receive information on automation/robotics

On-line growers were given five choices about the format they would like to receive information (Figure 23). Publications were mentioned by the most growers, 55%, followed

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by web content, 41% and events, 32%. Only three growers (14%) mentioned webinars and a dedicated KE package of work on the topic.

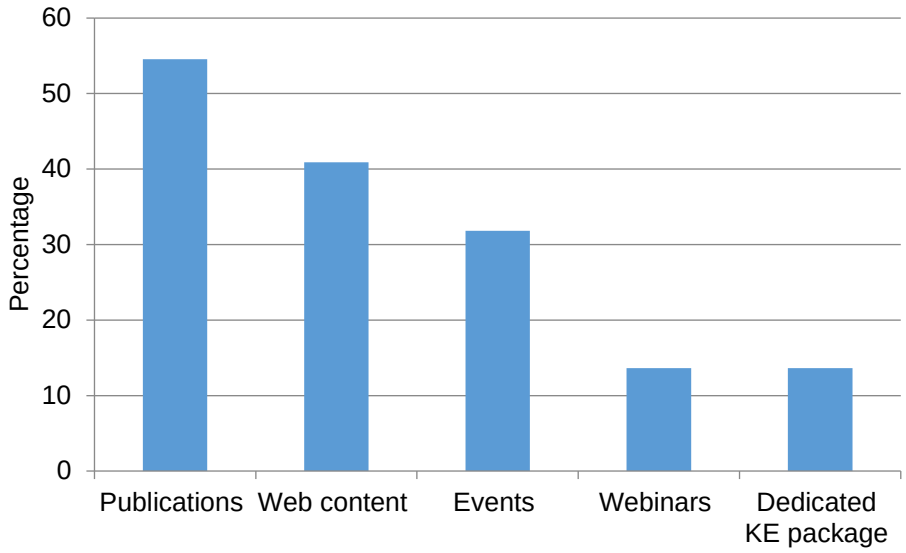

Figure 23. On-line survey responses for what format growers would like to receive information on automation/robotics

On the telephone growers were asked further about whether they would like to see a dedicated knowledge exchange programme in a similar style to the GrowSave programme for energy efficiency or the GREATsoils work. Opinion was split with 48% saying yes they thought the topic was important enough to put a similar package in place, 52% were against the idea. Those not wanting to see larger KE investment stated they didn't feel there was enough information out there to warrant the spend, that the topic was very broad and diverse across the sectors, that individual growers should be doing their own research in this area and that they didn't feel there was enough levy money to spend it in this way. In sectors only 14% of protected ornamentals thought it would be a good idea, with protected edibles, tree fruit and hardy nursery stock relatively low interest between 25-30%. Growers who wanted to see more KE work felt the importance of the topic to most horticultural businesses warranted the spending. One grower noted that without self publicising what was happening there would be little opportunity to attract further investment for horticulture.

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Discussion

The growers surveyed were clearly an innovative group as they had self-diagnosed. From the on-line survey it was clear that most parts of their horticultural systems had some form of automation. From the telephone survey some sectors had great advancements, in others there had been continued development and only two growers felt there had been no changes at all in the previous 10 years. Robotics was not commonplace but noted in 16 separate businesses.

The overwhelming majority felt automation had reduced labour or increased efficiency and even more growers were positive for future developments. Several commented that they had to be positive because if they could not reduce their labour requirements they did not feel they would be in business.

Many growers spoke about the issues around labour and these varied from business to business. Some were struggling to find enough people; some were not happy with the quality of workers and some were losing workers in the season, feeling they had an amount they wanted to earn and when this was achieved they left, or that they were just not prepared to do the work on offer. It was commented that in the supply to processors sector, crop specifications were tightening so that the processors had to use less labour once the product was at their end of the chain.

It was noted that the rates of pay were being pushed up to ensure securing, retaining and quality of staff. Businesses were aware others were paying higher rates/bonuses. One grower said they had raised basic pay £1.50 per hour and were using bonuses, another grower whose system suited a piece rate payment was working on hourly rates and bonuses to secure staff.

Of the three main issues; availability, quality and retention, quality was most often cited as the major problem of the season and this lack of quality had meant a need for more labour. Looking forwards concern over availability was the main priority. Despite the generally buoyant mood of growers towards automation it was stressed that in the short term there was not going to be a robotic revolution and practical measures to help aid the shortfall of workers was their priority. The current increased automation/robotic rhetoric from academia, government and press worried growers who from previous experience knew the time to get products to market would be years away from practical commercial use. The labour shortage issues really were an immediate priority that would not be solved in the short term by automation and robotics. Growers certainly saw the topic to be of major importance in

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the medium to long term and hence their interest for research, development and knowledge as soon as possible.

All growers could list areas where they could see automation helping in their system apart from two growers who felt they were making use of all the technology currently on the market. There was a good knowledge of what was available commercially and what was in development. A quarter of growers did not have available automation in place because it did not ‘fit’ their system. This was a general comment throughout the surveys that off the shelf was rarely something that worked for horticulture. There was always some adaption of technology, requiring money, time and trialling, to be done to fit the specific business. The diversity in the industry has led to very individual systems which make automation more complex in the growing and in some packhouse environments. A retrofit may be difficult to achieve and automation/robotic systems can be more useful if starting from scratch but modification of existing scenarios is often complex.

The range of markets does not help growers to install automated systems. Those doing their own packing and retailing to several multiples have to accommodate the different requirements of those companies. So weight of product, packaging size, type and orientation, crate size, type and packing height etc can all vary and then have to be changed between sometimes on a daily basis. This means there has to be flexibility in the packhouse so investment in specific task automation is not possible for every option. There are also frequent changes in customer requirements making investment even less likely. One grower mentioned investing in a machine that packed an exact number of punnets into a tray only to have the customer change their guidelines on stacking making the equipment useless. For growers in the ornamental sector, operating flexible cropping systems responding to market changes, it is not viable to invest in specific kit despite there possibly being an automation solution available. Even in large scale single cropping systems there is reluctance to fully automate at the packhouse stage as market requirements change. Investment in automation has also been hampered by the lack of market certainty. It was commented that sales contracts were too short term to give growers confidence to invest in long payback equipment.

Instead of looking to automate their current system a few growers mentioned changing cropping to a less labour intensive option. Several growers mentioned thinking about a

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complete system change instead of trying to fit automation to complex growing systems, simplifying the growing systems to fit the automation was discussed. On a less dramatic scale growers spoke of the importance of breeding to make crops easier to mechanise, for example, higher crown head broccoli varieties for ease of harvest or thicker skinned fruits to prevent bruising. Despite the reservations 84% of growers on the phone said they were planning to invest in automation/robotics and 94% of growers on-line specified a timeframe for investment.

Around a third of growers were developing their own in-house automation solutions and the same number were involved in research projects or had applied for grant funding for automation. There were a range of methods employed; staff designing and fabricating machinery, working with engineering companies to make bespoke items for their systems, working with commercial companies on novel growing systems or automation/robotic solutions, working with Universities or AHDB on research projects, employing research scientists at grower businesses or academic institutions, innovation, Agri-Tech and INNOVATE grants, Knowledge Transfer Partnerships. Some had developed ties with research groups or individual researchers both in the UK and overseas. A smaller business mentioned the need for help with the larger government funded schemes. They felt only businesses with a large enough workforce could tackle the paperwork required to achieve any funding. They had many innovative ideas and would have liked support to understand how to tackle the form filling and help them through the grant application process.

Although automation and robotics is a cross cutting theme the diversity in horticulture means that its application in different sectors and even crops is very different and hence growers have very different opinions on what AHDBs role should be with regard to research and knowledge exchange.

Some growers felt strongly that AHDB should not invest in this topic as it was up to individual businesses and there was just not enough levy money to make a worthwhile impact. It was felt to be such a specific topic that it did not suit the collective funding approach and it was better left to growers and commercial companies to address. They felt that other priorities were more critical; many mentioned if crop protection chemistry was not available there would be no crop to harvest so they would always prioritise AHDB spending on crop protection before automation. It was mentioned that the horticultural industry itself may not have enough to invest in developing technologies but must wait for other more

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economically viable sectors to develop the technology which could then be adapted and adopted into horticulture.

The majority though did want to see investment, many because they felt the topic was so important (over both surveys two thirds of growers rated this topic as 'important or very important' the two highest priority categories) and because they could see no alternative source of funding. One commented that R&D should be the main focus as KE would always trickle down eventually. There were some sector specific differences which may best be addressed by discussing requirements with grower associations or at sector panel level.

There were also many wider ideas on what AHDBs role should be on the topic:

- AHDB should have a pivotal role in making links between the key players in the field, i.e. the researchers, the research bodies, the innovative start up's and the commercial companies.
- AHDB should have a connecting role completing the circuit between academia and growers.
- AHDB should have a high level interest in linking key stakeholders and drawing together information on what is out there that could have any potential for horticulture.
- AHDB should identify other manufacturing areas where innovation may be transferred to the sector.
- AHDB should provide the link between what the growers want and what the researchers do. Research needs to be really well integrated between the pure science, the applied science and the growing business.
- AHDB should help growers apply for research funding.
- AHDB should have greater interaction with the Agri-Tech boards to avoid duplication of effort.
- AHDB should review the literature to see where the next advancements may come from.
- AHDB should form a steering group of growers like GrowSave has, directing research or KE work.
- AHDB should be involved at the early stages of research proposals which need to be grounded to ensure the outputs are of practical benefit to growers.

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- AHDB should seed fund projects which have the potential to be picked up in larger pieces of work.
- AHDB Horticulture should work with other sectors of AHDB as labour is a cross sector issue.
- AHDB should involve retailers in their R&D conferences.
- AHDB should engage discussions with the multiples. There were ideas about how the retail sector could improve the situation for UK growers:
    - widening market specifications and grades.
    - unifying packaging.
    - reducing frequency of deliveries.
    - lengthening contracts.

When asked on-line if growers would like to see Government funding there was a resounding 94% positive response. Growers would like to see Government support and some of those that are currently in the EU Producer Organisation system would like to see the UK Government take up a similar model as they feel match funding could be critical to aid development of new technologies for horticultural businesses.

The Government via Defra has recently (October 2017) announced a new support scheme to improve farm productivity by investing in new technology. It is inviting grant applications as part of the Country Productivity Scheme. Growers must be able to match fund applications with at least £50,000 of their own investment which may be difficult for some smaller growers and funding will be granted up to 40% of total project costs.

Eighty percent of growers wanted AHDB to invest in KE activities. Opinions were spread on the best format to receive information. Comments on what was wanted included:

- Another SmartAg event aimed at growers
- An annual conference or seminar
- A working party with an expert facilitator
- A couple of articles in the magazine
- Factsheets that can be handed to staff without computer access

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- Sign up and get monthly update email
- Road shows around the country like ‘Keep it Clean’
- Video clips
- Website articles

There was almost a 50:50 split on whether automation/robotics required a larger package of KE in similar vein to GrowSave or GREATsoils. Those against the idea cited that the topic is not focussed enough to have a whole KE package, there are many different systems and it would not be as effective as other specific (energy efficiency or soils) KE packages have been. There was a feeling that not enough information is out there on the topic, it is not a mature enough area in horticulture for information to be useful and not in grower ready format. It was also mentioned that growers should find their own information for their own systems.

On the other hand the main comment for the need for investment was driven by the importance growers placed on the topic. The more growers were aware of the current AHDB KE packages the greater the tendency to be supportive of work in this area. One grower commented that horticulture had to be self-publicising with promoting automation to show there was a desire for investment in the sector.

Conclusions

- Growers already have highly automated systems and want to continue automating.
- The importance value placed on automation and robotics has clear links with the escalating problems associated with labour availability and costs.
- The majority of growers surveyed want AHDB to invest in R&D and KE to support industry efforts in adopting automation and robotics.
- Many growers want AHDB to take a facilitating role in:
    - connecting the research chain (funders, academia, commercial companies, growers and retailers)
    - connecting the industry with commercial companies and industries outside of the horticultural sphere that may have technology, knowledge and capabilities to apply to horticultural systems.

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- The highest priority for development is harvesting.
- The most popular format for KE is ‘events’.

Knowledge and Technology Transfer

- Article in the AHDB Horticulture Grower magazine
- Presentation to AHDB staff

Acknowledgements

We would like to thank all the growers that kindly took part in the telephone and on-line surveys.

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.

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Appendices

Appendix 1. Telephone survey

1) Characterise the holding; system, size, turnover, crops, market?
2) Would you describe the business as innovative and an early adopter?
3) What has been automated in the past 10 years?
4) Are you using robotics?
5) If so in what capacity?
6) Do you think automation/robotics has reduced the casual labour requirement in your business in the last 10 years?
7) Do you think automation/robotics will reduce the casual labour requirement in your business in the future 10 years?
8) Where could you see automation/robotics helping?
9) Why haven't you got automation/robotics there now?
10) Is there automation/robotics available to improve your system currently available?
11) Is there automation/robotics in development that you know of?
12) Have you in the past or are you developing your own in-house automation/robotics?
13) Have you applied for any funding/involved in any projects to help your development?
14) Are you planning to invest in automation/robotics?
15) If so what approx. what value and timeframe for investment?
16) Where do you get information on automation/robotics?
17) What would you like to see researched in automation and robotics?
18) Who would you like to see funding automation/robotics research?
19) Do you think AHDB should invest in automation/robotics research?
20) On a scale of 1-5, where 5 is highest priority, what level of priority is this for you?
21) Do you think AHDB should invest in automation/robotics KE?
22) If so what is the best way to present the information for your business?
23) Would you like to see a larger package of KE information on automation/robotics like the GrowSave/GREATsoils type initiative?

Appendix 2. Internet survey

1) Are you a UK grower? Yes, No
2) If no please describe your occupation (option to write in box)
3) Please tick your business sector: Protected Edibles, Field Vegetables, Bulbs and Outdoor Flowers, Mushrooms, Soft Fruit, Hardy Nursery Stock, Tree Fruit, Protected Ornamentals (option to write in box)
4) Please list your three main crops (option to write in box)
5) What is your business size: 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+ ha
6) What tasks in your system are currently automated (replace human labour with mechanical operations) or robotic (an automated task which includes feedback and sensing)?: Seeding, Field preparation, Compost treatment, Spawning, Casing, Tray/block/pot, transport, Grafting, Transplanting/planting, Watering, Fertilising, Application of biological controls, Application of chemical controls, Crop husbandry, Monitoring, Harvesting, Grading, Packing, On-site transport, Stacking, Storage, Wrapping, Product transport (option to write in box)
7) Would you describe your business as innovative? Yes, No
8) Are you planning on investing in automation or robotics in the next: 1 year, 2-3 years, 4-5 years, 6-10 years, >10 years, No?
9) If so, how much do you envisage spending?: 0-1%, 1-4%, 5-10%, 10-20%, 21%+ turnover

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10) Are you currently developing in-house automation/robotics solutions? Yes, No
11) Are you involved in automation/robotics research projects? Yes, No
12) Would you like to see more research into horticultural automation/robotics at a Government level? Yes, No
13) How can AHDB best support the future automation/robotics aspirations of your business?: Leave investment to commercial arena, Pre commercial research, Case study updates of new developments, Study tours focussing on new technologies (option to write in box)
14) In the context of all AHDB Horticulture research needs, how important is this topic to you?: Not important, a little important, quite important, important, very important
15) Where would you like to see developments in either automation/robotics?: Seeding, Field preparation, Compost treatment, Spawning, Casing, Tray/block/pot, transport, Grafting, Transplanting/planting, Watering, Fertilising, Application of biological controls, Application of chemical controls, Crop husbandry, Monitoring, Harvesting, Grading, Packing, On-site transport, Stacking, Storage, Wrapping, Product transport (option to write in box)
16) What is the most important piece of new technology you would like to see? (option to write in box)
17) Have you actively searched for information on automation/robotics? Yes, No
18) Where do you get information on automation/robotics?: Advisors, growers, service providers, Press, Internet, Research papers, Research events, UK trade shows, Overseas trade shows, (option to write in box)
19) Would you like AHDB Horticulture to provide more information on automation/robotics? Yes, No
20) If so in what format?: Events, web content, webinars, publications, dedicated KE package (option to write in box)
21) Any other comments on the topic (option to write in box)
22) If you are happy to be contacted on this topic please add your e-mail address (option to write in box)

Appendix 3. Current AHDB automation and robotics projects

CP 107c - Soils Programme: Precision farming technologies to drive sustainable intensification in horticulture cropping systems.

CP 134 - “eyeSpot” – leaf specific herbicide applicator for weed control in field vegetables.

CP 153a - Development and demonstration of an automated, selective broccoli harvester.

CP 170 - Bioinspired vision systems for automated harvesting.

CP 172 - Robotic touch, sense, and learning of delicate vegetables (PhD Studentship).

HNS/PO 194 - GROWBOT: A Grower-Reprogrammable Robot for Ornamental Plant Production Tasks (PhD Studentship).

Appendix 4. List of noted sources of information as commented by the telephone survey growers

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Agri-Epi

BPOA

Bristol Robotics Laboratory

CHAP

Fresh Plaza

Future Farming

Harper Adams University

Hortidaily

PGRO

SmartAg conference

University of Cambridge

University of Lincoln

Wageningen University and Research

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