

# Automation in the Floriculture Sector

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## **2. Acknowledgements**

Funding for this project was provided by the Ontario Ministry of Agriculture, Food and Rural Affairs as part of their Agri-food Prevention and Control Innovation program. The Flowers Canada (Ontario) Inc. (FCO) team is grateful to OMAFRA for facilitating this project. The views expressed in this report are the views of the Recipient and do not necessarily reflect those of the Province.

FCO would also like to thank the many ornamental greenhouse farmers who provided data and information to support the completion of this project. FCO would like to recognize the contribution of some regional health authorities for their valuable insight into the impact that automation could have on COVID-19. Finally, FCO would like to thank the members of the project steering committee, inclusive of numerous farm operators, greenhouse builders, service providers and other specialists. Without the assistance of all these individuals, this project would not have been possible.

### **3. Introduction and Using This Document**

Flowers Canada (Ontario) Inc. is the provincial trade association of Ontario's flower producers. Our members across the province include greenhouse farmers, distributors and importers/exporters all dealing with cut flowers, potted plants, bedding plants, cut greens and propagative material. It is our goal to improve and strengthen the unity of the floriculture sector. We strive to create an environment for ornamental farmers in which they will thrive and contribute as major contributors to the economy and to the quality of life in Ontario.

Automation has long been proposed as an opportunity for the advancement of Ontario's agricultural community, both through improvements to productivity and reductions in labour demand, but for many of Ontario's flower farms, increases in automation have been and remain inaccessible. As the Province reels from the impacts of the COVID-19 pandemic, FCO has been tasked with exploring the potential of mechanization and automation to lower transmissibility risk associated with COVID-19 as well as evaluating opportunities for automation to both increase productivity while reducing labour demand for the floral sector. This study was initiated with a number of broad objectives in mind:

1. Characterize the state of automation in the floriculture sector
2. Determine the opportunity to offset the risk of COVID-19 using automation
3. Characterize the opportunity to increase productivity using automation
4. Explore strategies to encourage automation uptake in the sector

This document represents a review of the results from FCO's technology study regarding automation in the floriculture sector. Great detail is presented within each of the above broad objectives. The study also contains FCO's analysis of these results and their significance to the industry today and the future. ***Please treat this document as confidential and not for distribution.***

## 4. Executive Summary

This report outlines the results of numerous efforts to characterize automation and COVID-19 risk in Ontario's floriculture sector

The four key objectives that FCO sought to address include:

- *Characterize the state of automation in the floriculture sector*
- *Determine the opportunity to offset the risk of COVID-19 using automation*
- *Characterize the opportunity to increase productivity using automation*
- *Explore strategies to encourage automation uptake in the sector*

### *Characterize the state of automation in the floriculture sector:*

FCO found that, generally, most farms had previously engaged in automation advancement, though there exists considerable opportunity and desire for further expansion of automation technologies.

In addition, it was determined that farms are spending between 2.4% and 6% of their annual revenue on automation, equating to between \$20 million and \$49 million annually across the province.

### *Determine the opportunity to offset the risk of COVID-19 using automation:*

Based on farmer responses, automation appears to provide limited opportunity to offset COVID-19 risk on farms. The on-farm tasks that appear to enhance COVID-19 risk include packaging and planting, that happen to be production responsibilities where significant automation presently exists. Survey respondents indicated that 80% of farms have automation infrastructure in place in key COVID-19 risk areas. Sixty percent of farmers believed that their automation systems had some benefit (or co-benefit) to reducing COVID-19 on their property, while 40% felt that their automation systems provided no benefit.

### *Characterize the opportunity to increase productivity using automation:*

Farms have undertaken considerable improvements in terms of labour productivity over the past 12 years. Farms that added more labour clearly saw improvements in productivity, with a strong positive relationship between labour and productivity. Also observed was that farms that invested more on automation saw greater improvements in productivity with a moderate relationship between automation expenditure and productivity. Interestingly, farms that spent more on automation systems did not see reductions in workforce or staffing hours. In fact, farms that spent more on automation generally saw increases in workforce with increasing expenditure in automation.

These results imply that automation may not be an ideal tool for reducing workforce on a farm, but a strong tool for increasing productivity and may be an important factor in overall farm growth.

### *Explore strategies to encourage automation uptake in the sector:*

Survey participants expressed a wide diversity of rationales for automation, with production/efficiency gains, labour reduction, and quality improvement being the three most desirable outcomes. Other motives included worker safety, meeting customer specifications, and allowing for crop changes. Financial barriers were by far the most significant obstacle to automation on farms. The average cost for the next automation purchase of ornamental farms surveyed was \$300,000 per farm, with a median value of \$150,000. Approximately 40% of farms favour investment in greenhouse expansion over investment in automation expansion. The vast majority of farms (100% large farms, 93% medium farms, 86% small farms) would invest in automation should their barriers (financial) be addressed.

### Recommendations:

FCO recommends that incentivization programs for automation uptake avoid focus on specific outcomes such as workforce reduction or mobilizing the workforce beyond activity-based employment. Numerous automation priorities were identified in this study, and the results highlight the need for funding that targets a diverse range of automation outcomes.

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Incentivization programs must provide sufficient capital to cover the extensive cost of automation tools - an average cost of \$300,000 was reported in this study, with median costs being \$150,000. FCO recommends increasing maximum value of incentivization cost-share share programs to a minimum of \$300,000.

## 5. State of Ontario's Floriculture Sector

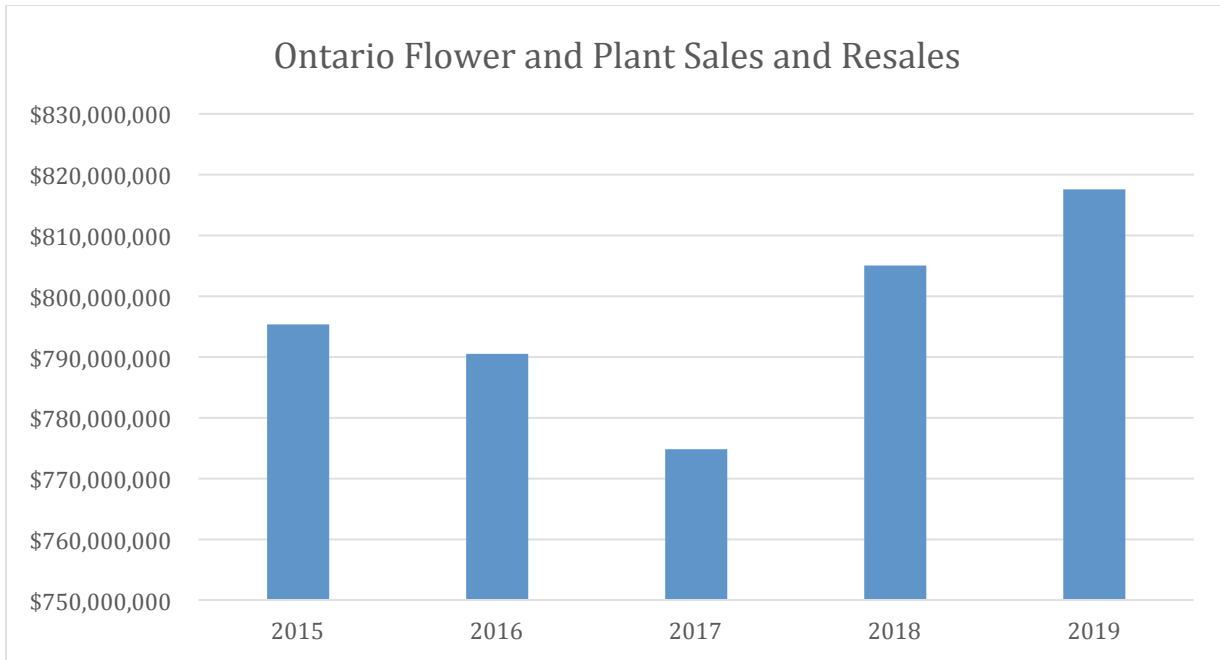


Figure 1. Ontario flower and plant sales and resales between 2015 and 2019 (Source: Statistics Canada, 2019)

Ontario’s floriculture sector is growing. Both the provincial and national farm gate values dipped in 2017 before rebounding and increasing by 5.5%. Ontario accounts for just over half of the national floriculture farm gate.

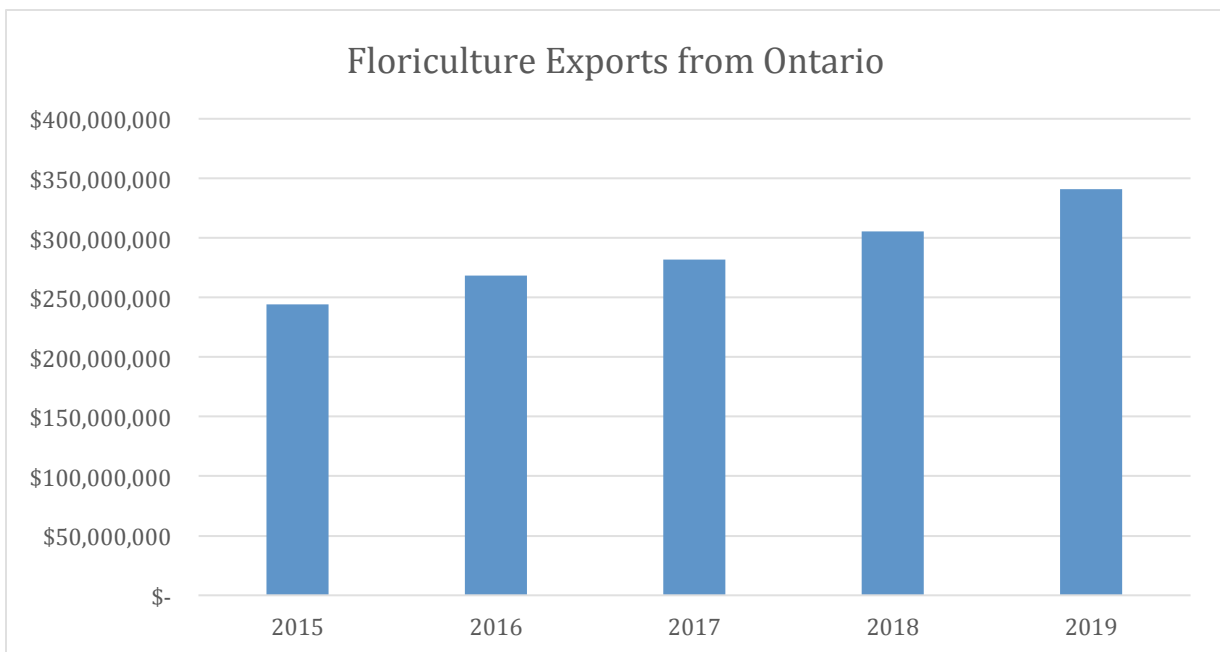


Figure 2. Value of floriculture exports from Ontario between 2015 and 2019 (Source: Statistics Canada, 2019)

Exports appear to be driving the growth of the floriculture sector. In fact, domestic consumption has decreased over the past 5 years and had the industry realized steady increases in export capacity, the sector would have seen a contraction.

*Table 1. Summary of Ontario farm cash receipts in 2019 for agricultural products and crops alone (Source: Statistics Canada, 2019)*

<b>Ontario Farm Cash Receipts 2019</b>	
<b>Agriculture Products</b>	<b>Crops Only</b>
#1 Dairy products	#1 Soybeans
#2 Soybeans	#2 Corn
#3 Corn	#3 Greenhouse Vegetables
#4 Hogs	#4 Field Vegetables
#5 Cattle	#5 Ornamental Horticulture*
#6 Greenhouse Vegetables	#6 Cannabis Seeds, Vegetative Plants and Flowering Tops
#7 Chickens for Meat	#7 Total Fresh Fruit
#8 Field Vegetables	#8 Wheat (Excluding Durum)
#9 Ornamental Horticulture*	#9 Unstemmed Leaf Tobacco
#10 Cannabis Seeds, Vegetative Plants and Flowering Tops	#10 Ginseng Root, Medicinal

\*Ornamental Horticulture includes Floriculture, Nursery & Sod

Ornamental Horticulture, which includes Floriculture, Nursery & Sod, was the ninth largest agricultural product produced in Ontario and the fifth largest agricultural crop in 2019.

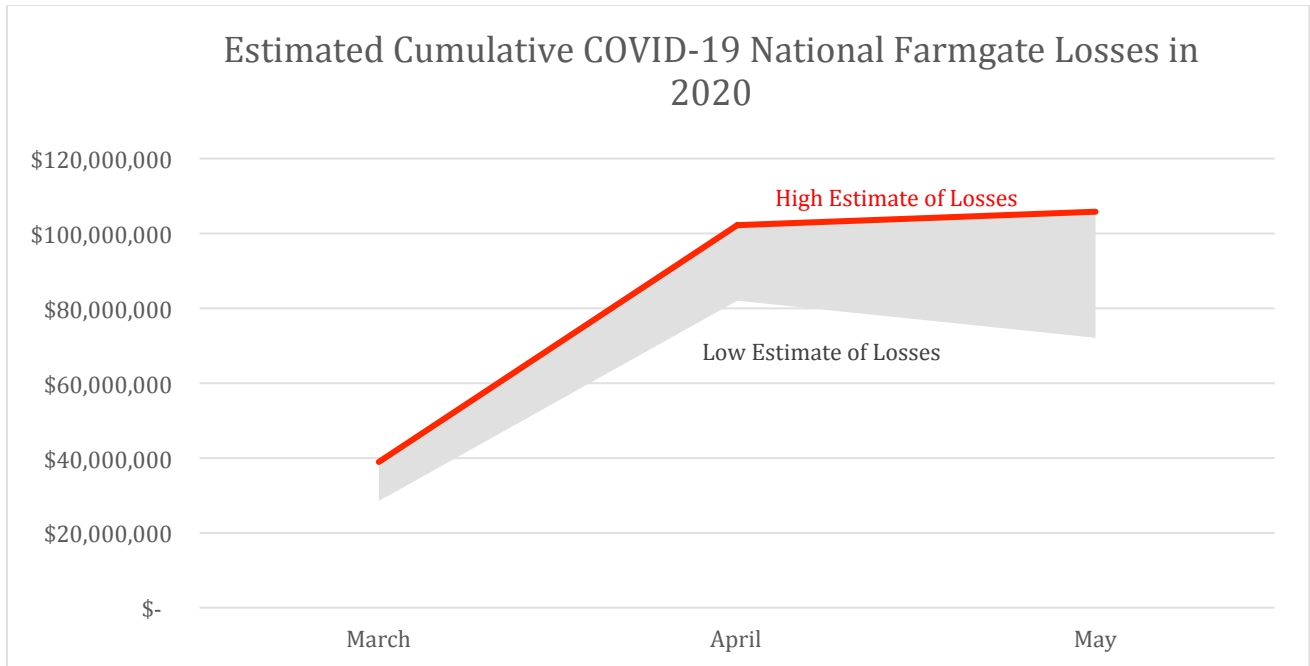


Figure 3. Value of estimated cumulative COVID-19 national farmgate losses in 2020 between March and May. (Source: Grower Survey conducted May/June 2020)

As with many commodities and industries, the COVID-19 pandemic and subsequent public shutdown events damaged the ornamental industries substantially across Canada. Nationally, by May 2020, loss estimates (based on an FCG farmer survey) were estimated at between \$75 and \$105 million. The cause of these significant losses is attributable to the shutdown coming prior to Easter – a major sales event for the ornamental industry. On average, 40-50% of the floriculture farm gate is generated between Easter and the end of the spring planting season. A provincial shutdown was implemented just before Easter resulting in devastating losses to many growers producing crops for this holiday as demonstrated in Figure 3. However, it should be stated that the industry has experienced a resurgence from the extreme losses experienced between March and May 2020 with farm gate and export numbers demonstrating tremendous year-over-year growth.



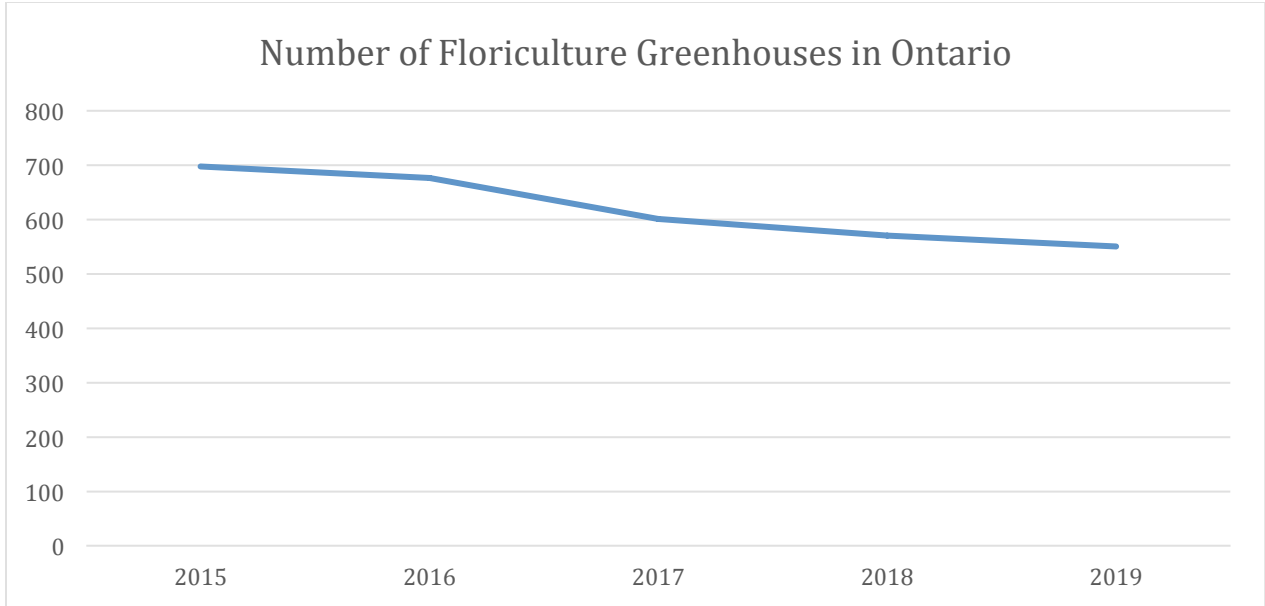


Figure 4. The number of greenhouse floriculture farms in Ontario between 2015 and 2019 (Source: Statistics Canada, 2019)

However, success is not equally distributed across all farms. The actual number of floricultural farms is decreasing (Figure 4). This is not simply a provincial trend, but a national one. Over the past 4 years, across Canada, 31,251 square feet of greenhouse production space is lost every week.

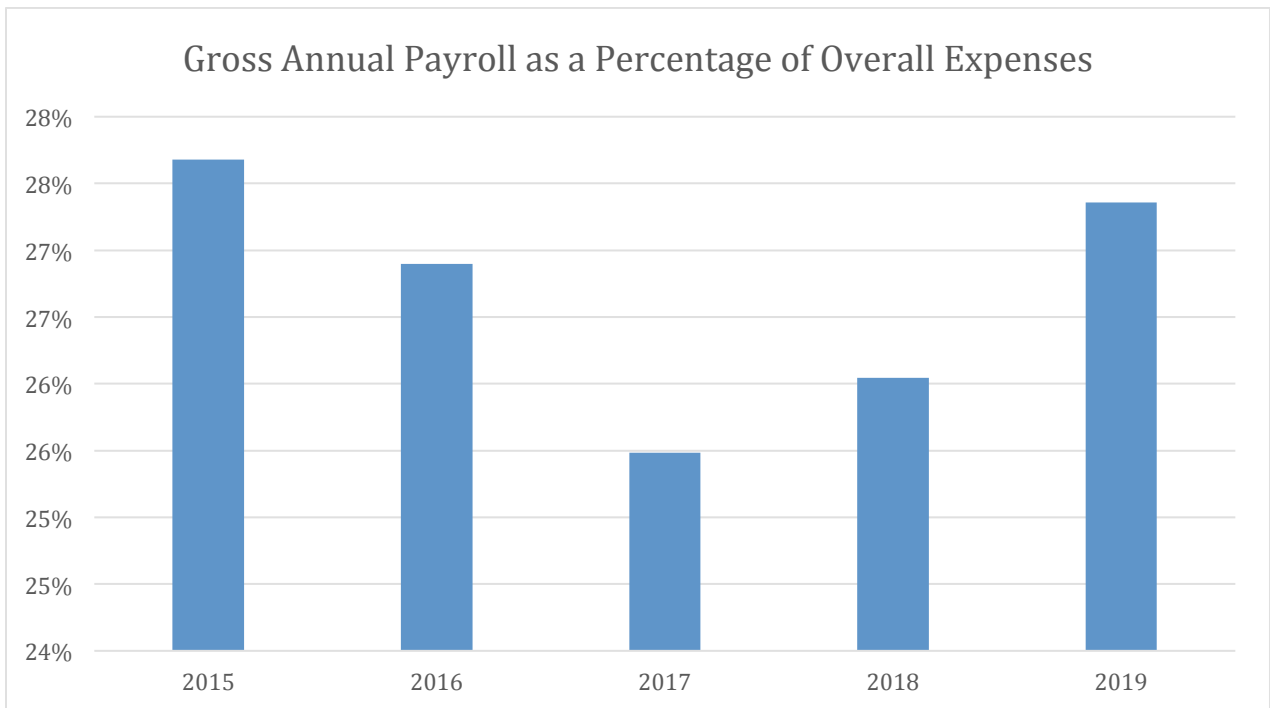


Figure 5. Gross annual payroll as a percentage of overall expenses (Source: Statistics Canada, 2019)

Gross annual payroll is the largest expense, on average, that a floriculture farm will incur in any given year. Labour costs appear to correlate with sales (Figure 1), and this suggests that labour-saving opportunities should be explored to facilitate growth of the sector.

## 6. Study Background and Engagement

This study is composed of data derived from five resources:

1. A preliminary survey distributed by FCO to member farms (Appendix I)
2. A late survey distributed by FCO to key farms with an interest in automation (Appendix II)
3. A literature review on current automation systems for floriculture production (Appendix III)
4. Publicly available data provided by Statistics Canada (CANSIM Database)
5. Private data collected and maintained by FCO through regular operation

While other data was used to supplement the findings within the project study, Surveys 1 and 2 provided the majority of data used in the assessment of automation herein. This report links all data to its original source in the text. All questions and data collection have been aimed to address the following broad objectives of this study:

1. Characterize the state of automation in the floriculture sector
2. Determine the opportunity to offset the risk of COVID-19 using automation
3. Characterize the opportunity to increase productivity using automation
4. Explore strategies to encourage automation uptake in the sector

Survey 1 was available for completion between January 29, 2021 and March 2, 2021 and was delivered as an online survey via SurveyMonkey to member farms. Farms had the opportunity to remain anonymous or avoid answering specific questions while completing the survey. FCO staff reviewed all answers and removed any potential double completions by analyzing IP addresses of respondents.

Survey 2 was initially offered as a phone interview but was adjusted for delivery as an online survey via SurveyMonkey to address significant time constraints on members due to the onset of the production season. Survey 2 was also modified to remove several questions that were deemed difficult (or impossible) to answer by respondents. Similar to Survey 1, farms had the opportunity to remain anonymous or avoid answering specific questions while completing the survey. FCO staff reviewed all responses and removed any potential double completions by analyzing IP addresses of respondents.

Both surveys asked growers to self-identify their overall greenhouse farm size (<150,000 sqft, 150,000-649,999 sqft, and >650,000 sqft) (Figure 6, 7). Size designations of farms were established to divide the entirety of production space in FCO's membership into thirds. Large, medium and small growers each independently represent approximately one third of all production area in FCO's membership. This division in size was used to validate that survey responses were relevant to the applicable farm sizes within FCO's membership

Survey 1 received a total of 62 responses out of 185 FCO members (Figure 6). Survey 2 received a total of 30 responses out of the FCO membership (Figure 7).

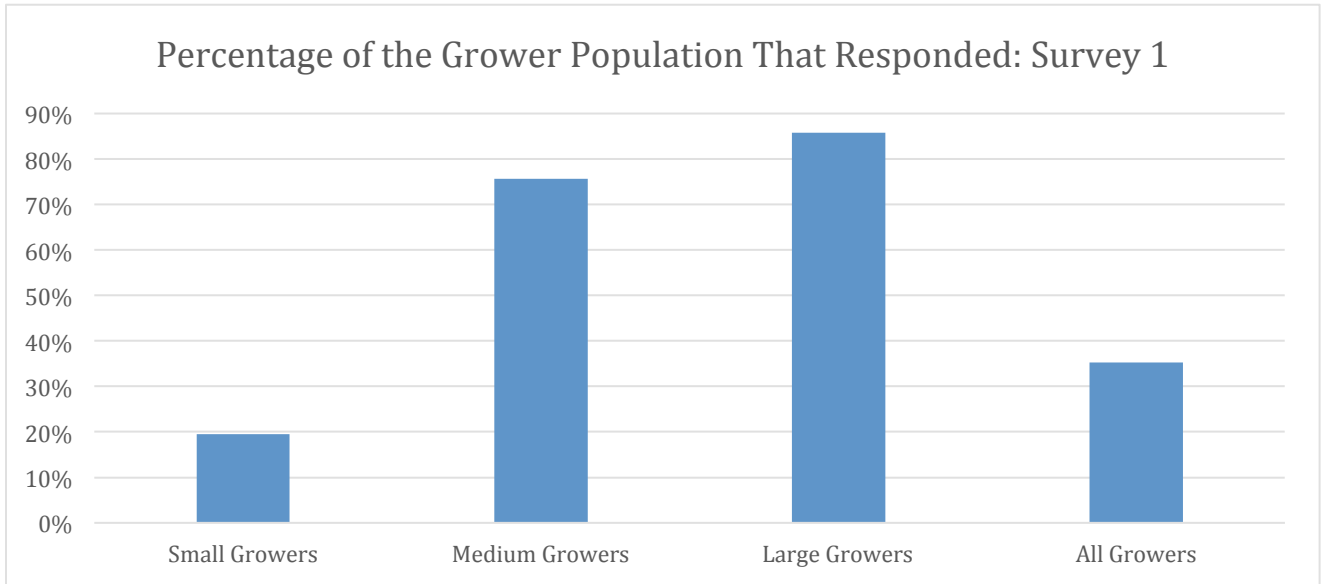


Figure 6. Percentage of the grower population that provided responses to survey 1 (Source: FCO Survey 1, 2021)

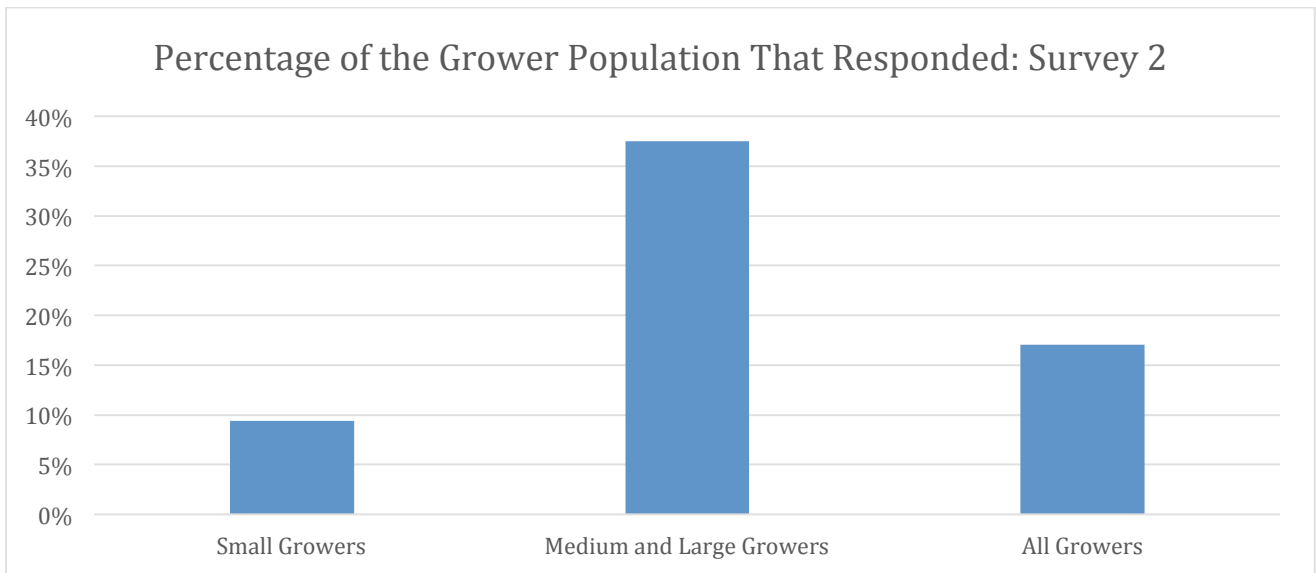


Figure 7. Percentage of the grower population that provided responses to survey 2 (Source: FCO Survey 2, 2021)

A larger proportion of growers responded to the first survey over the second survey. The discrepancy in survey responses is likely attributable to:

- Survey 2 being requested during one of the busiest production periods of the year
- Survey 2 took more than double the amount of time to complete
- Survey 2 asked for more in depth and potentially more sensitive information
- Survey 2 encouraged farms to self-identify

Both surveys saw a larger proportion of FCO's large and medium producer members respond, though FCO has a larger number of small grower members overall than medium and large growers combined. As

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a result of the reduced completion rate in Survey 2, medium and large farms needed to be grouped together for analysis to protect the identity of large farms. This was not necessary in Survey 1 due to strong completion rates by all farm size categories. The response rate was consistent with FCO's past member engagement experience and suggests that responses received in Survey 1 may be reflective of greater than two-thirds of FCO members' production area. Regardless of completion rates, both surveys yielded useful data.

Many questions throughout both surveys received answers with varying degrees of completeness. This report attempts to highlight any data or graphs that were derived from such answers or caveat the FCO team's confidence in the responses received.

## 7. Characterizing Floriculture Automation

### 7.1. Current State of Automation

Please note: respondents were asked to rate their perceived level of automation based on a subjective scale. Due to personal interpretation and the customized nature of automation, growers may consider their automation level differently than that of their peers. Farms were asked to rate their automation in several business lines from 0% to 100%, 0% meaning nothing was automated, where 100% meant everything that could be automated has been automated.

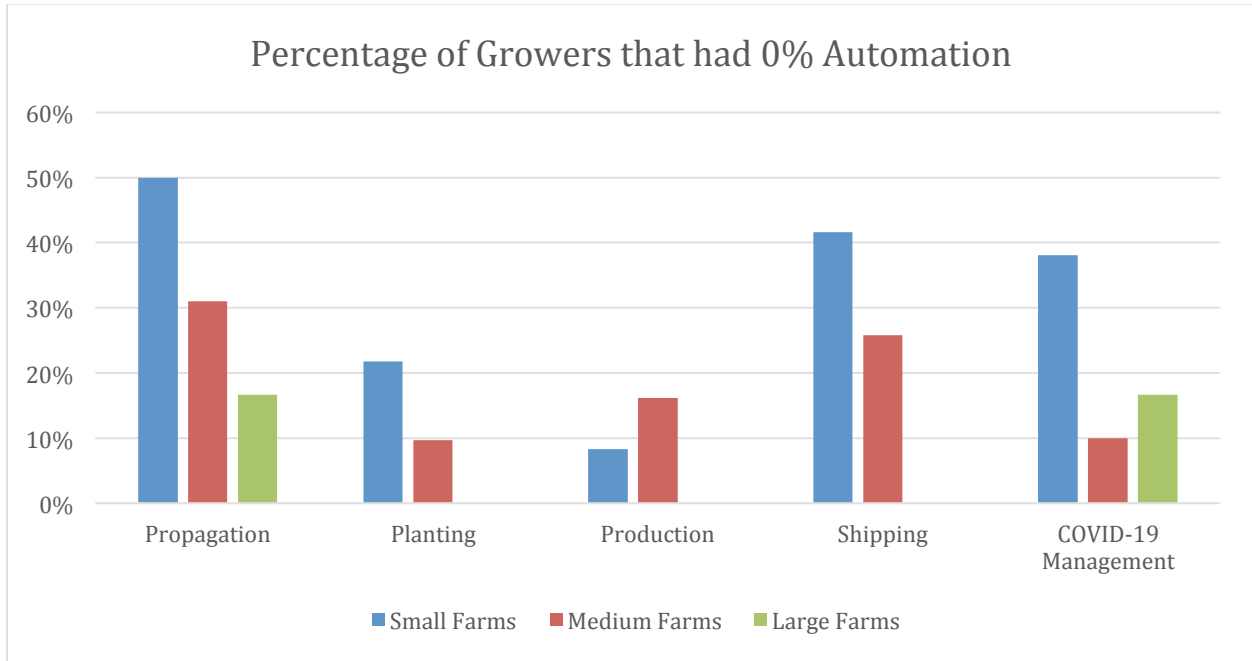


Figure 8. Percentage of growers, of various sizes, that had no automation for major production activities/tasks (Source: FCO Survey 1, 2021)

Figure 8 displays the proportion of different sized growers that responded to the survey question with “0% Automation” within each activity category. The largest group who responded in this manner were small farms distributed over most activity categories. A larger sample size may result in an even larger population of small members using no automation compared to the medium and large growers. Propagation automation appeared to differ notably between farm sizes. It appears that all but the largest farms are outsourcing this activity (i.e., larger farms automating, and smaller and medium size farms contracting this work out so automation is irrelevant).

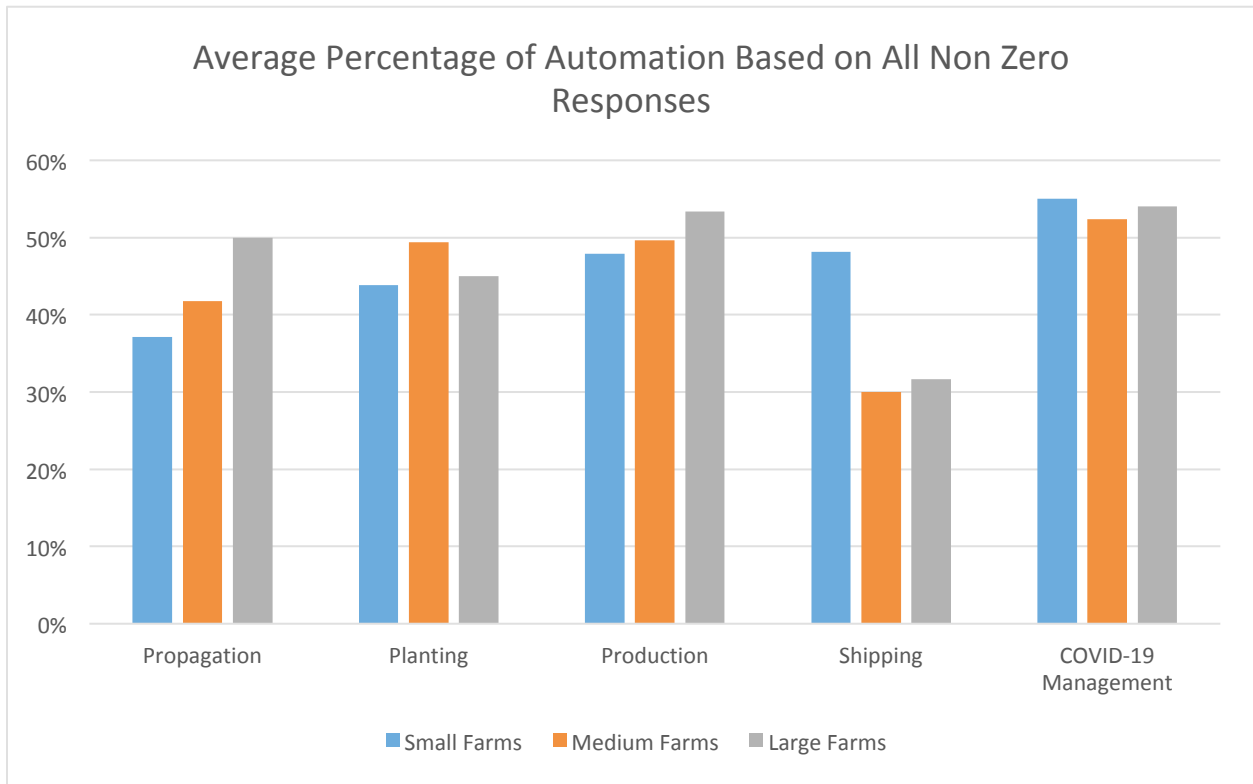


Figure 9. The average percentage of automation of small, medium and large farms based on responses above 0% (Source: FCO Survey 1, 2021)

Responses on automation progress presented (Figure 9) are shown for farms reporting greater than 0% automation. The average perceived automation level appears to be comparable regardless of farm producer size. This appears especially true for medium and large farms, which are close in all categories, though the reasoning for this similarity warrants further investigation.

Shipping automation processes had the most room for growth. It would be interesting to investigate what shipping technologies various sized farms are using, and where opportunities may exist.

For the high level of COVID-19 management automation, it is difficult to characterize what responding farms are considering as automation. We provided examples such as screening, sanitation and ventilation technologies. It may be that there are too few automation devices available (e.g., facial scanners, cameras, disinfectant dispensers) that are specific to health so that it is not difficult to achieve high levels of automation with a relatively small investment. For example, if you add automated disinfectant dispensers, are you 50% towards automating everything you can in terms of COVID-19? This report will explore COVID-specific technology (Section 8) in more detail and demonstrate that while farms have not specifically invested in technology for COVID risk mitigation, some co-benefit was achieved through automation for other purposes.

Figures 10, 11 and 12 explore in more detail the perceived automation level between small, medium and large farm sizes.

### Small Farm - level of automation

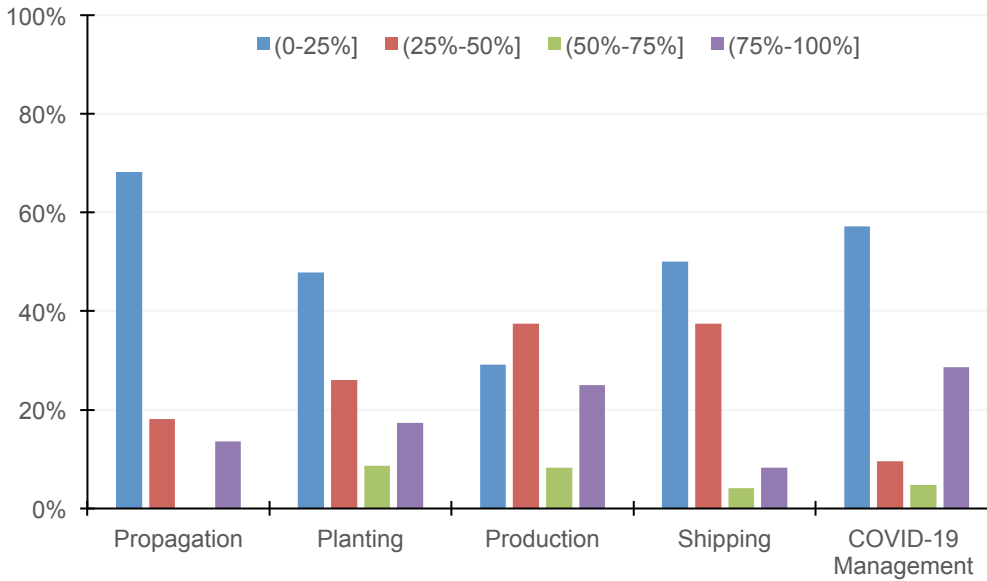


Figure 10. The level of automation on small farms based on common farm tasks (Source: FCO Survey 1, 2021)

For all categories other than production (33%) and shipping (48%), half or more responding small farms reported between 0% and 25% automation. This broadly suggests that many small farms may not have yet undertaken significant automation efforts.

### Medium Farm - level of automation

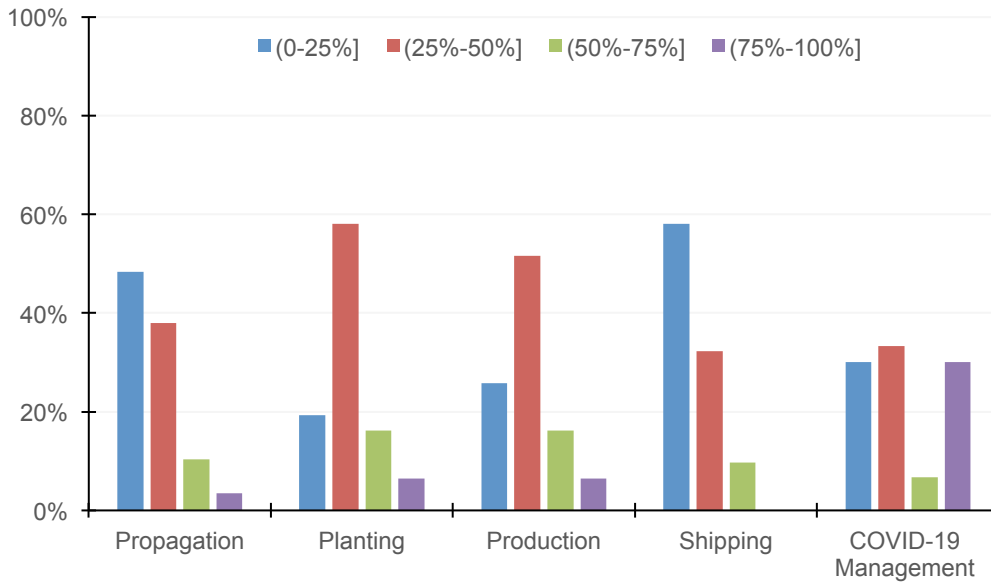


Figure 11. The level of automation on medium farms based on common farm tasks (Source: FCO Survey 1, 2021)

Medium sized greenhouse ornamental farmers provided a wide array of responses on perceived automation levels. Fewer farms indicated that the degree of planting and production automation was between 0% and 25% implying that the majority of businesses had invested in these key automation areas, though the vast majority of producers still reported 50% or less automation in all business lines.

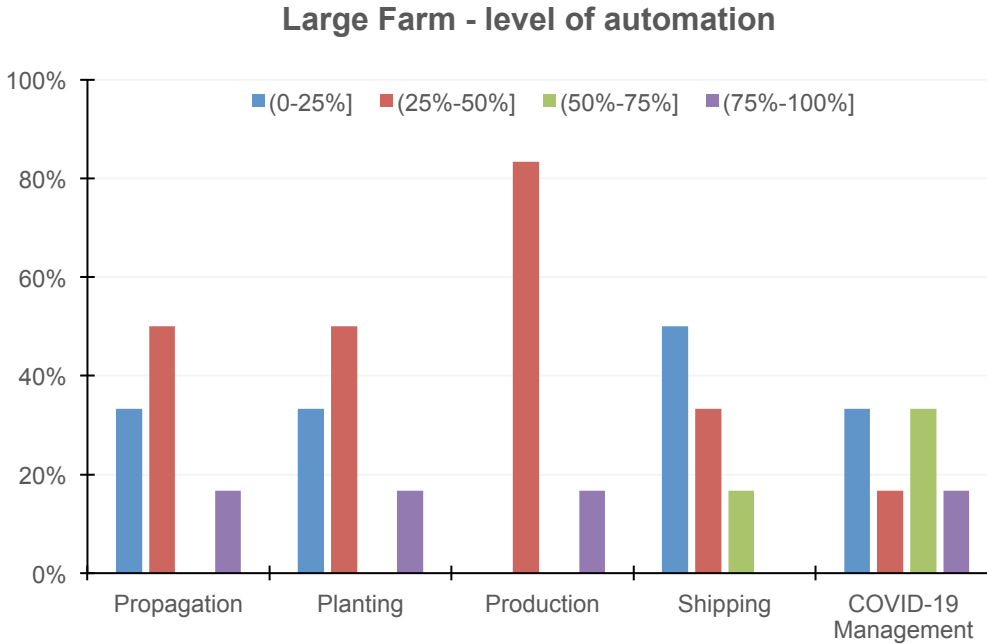


Figure 12. The level of automation on large farms based on common farm tasks (Source: FCO Survey 1, 2021)

Large farms appear to have made investments into most automation categories, with all farms reporting possession of production automation systems. While all large farms invested in production automation systems, only 17% reach the 75%-100% automation levels. This result may imply significant demand for production automation systems. Demand for each automation system will be explored in more detail later in this report.

Figures 13, 14 and 15 compare the perceived automation levels for each production type.



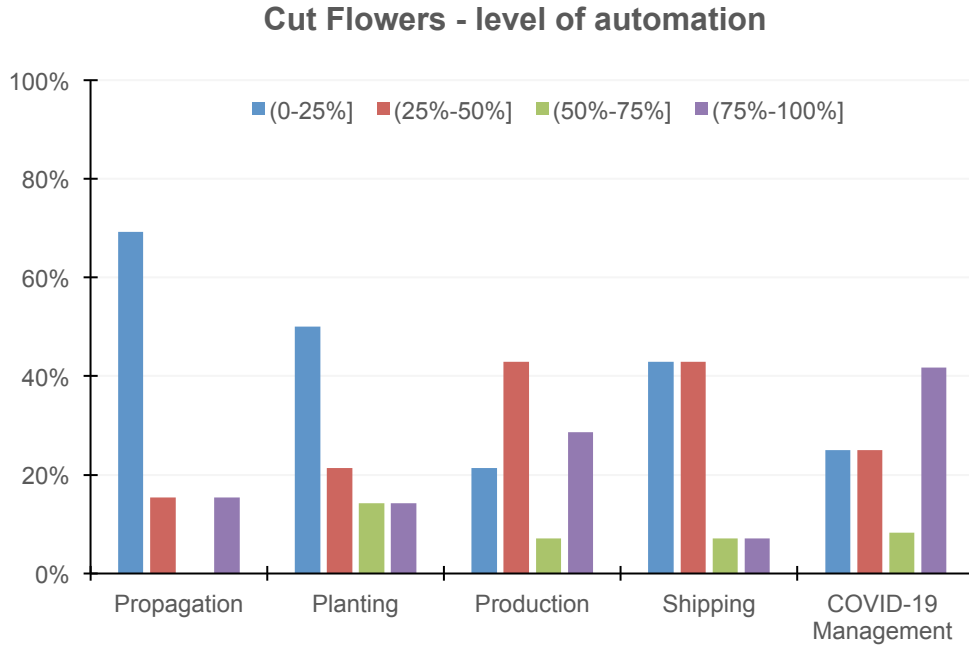


Figure 13. The level of automation in cut flower production based on common farm tasks (Source: FCO Survey 1, 2021)

A low level of automation is generally observed for propagation and planting activities among cut flower growers, with higher automation (>25%) observed in production and shipping. It is unclear if this perceived relationship is related to cut flower producers having less automation in these key areas, or due to farms being generally smaller than some potted plant or spring plant producers. Over 35% of cut flower producers responding in Survey 1 were small farms, with 16 and 17% of cut flower producers for the medium and large farms, respectively.

### Potted Flowers - level of automation

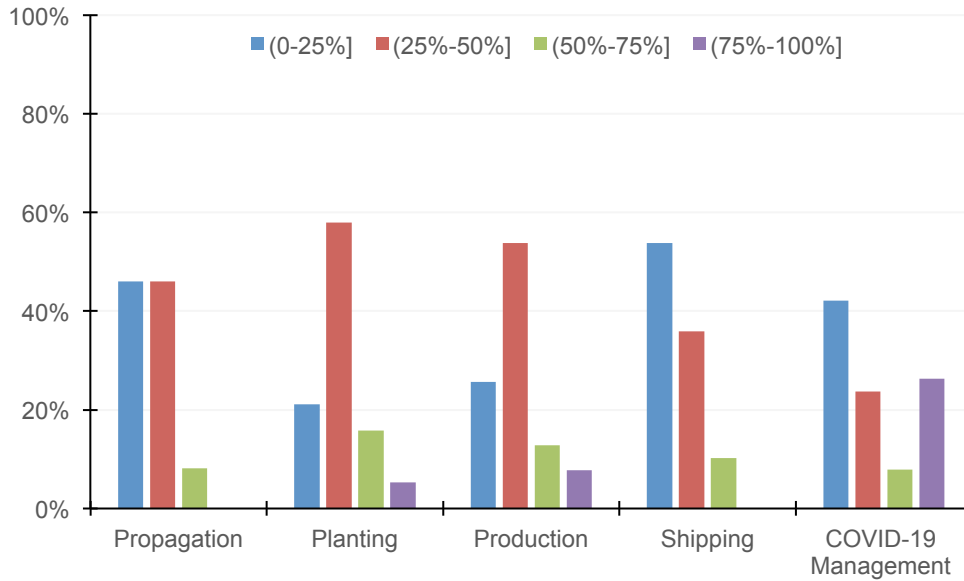


Figure 14. The level of automation in potted flower production based on common farm tasks (Source: FCO Survey 1, 2021)

Most potted plant farms have less than 50% automation among all activities, indicating potential opportunities for automation improvement. More than half of respondents reported very low levels of automation for shipping related tasks.

### Seasonal Flowers - level of automation

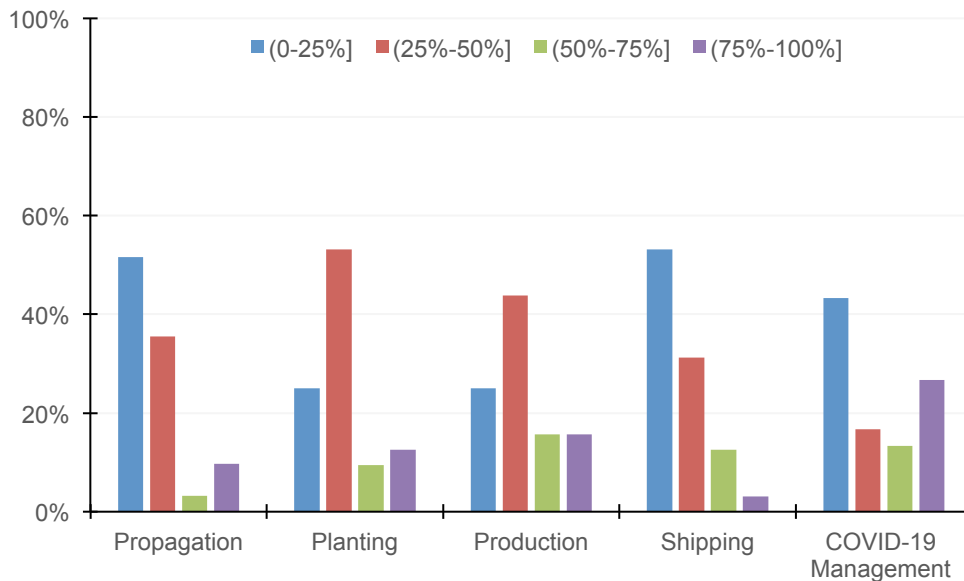


Figure 15. The level of automation in seasonal flower production based on common farm tasks (Source: FCO Survey 1, 2021)

Figure 15 demonstrates that more than half of the farms automate less than 50% or even less than 25% for each production task. More than 50% of farms reported below 25% automation in both propagation and shipping.

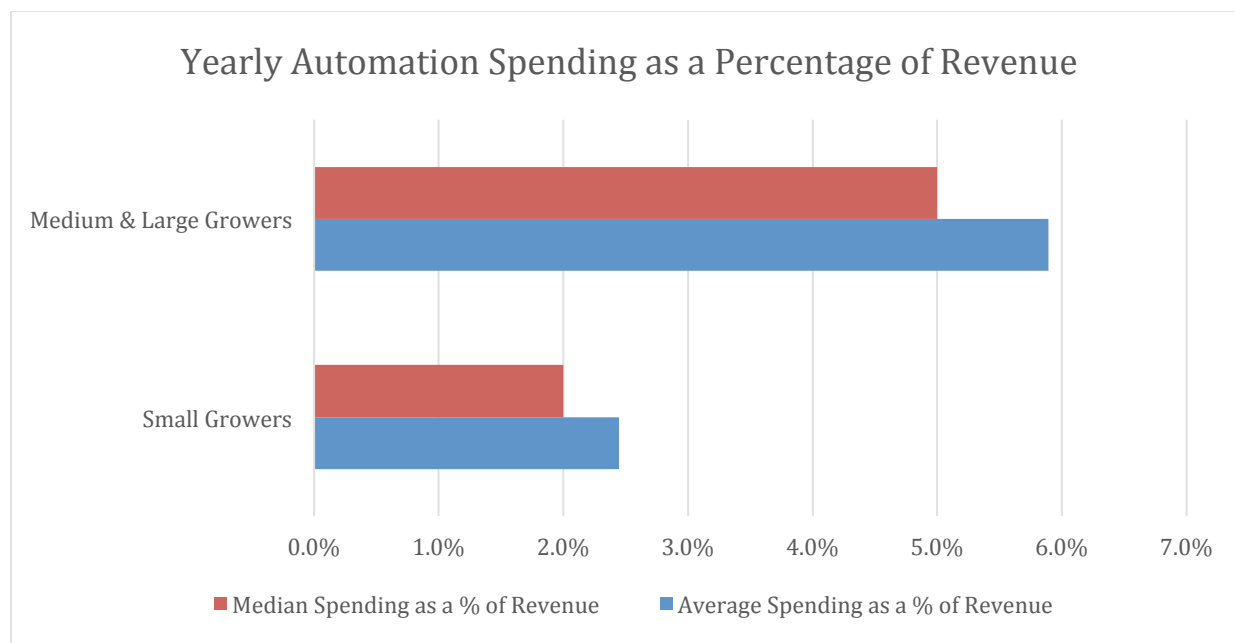


Figure 16. Percentage of annual automation spending between small and medium/large growers (Source: FCO Survey 2, 2021)

Expenditure on automation is closely guarded among flower growers, and many producers expressed concern with providing specific values. Survey 2 requested that farms estimate their expenditure on automation as a percentage of their annual revenue as a way to reduce the sensitivity of data collected while still benchmarking the degree to which farms are focusing on automation in their business. It is not currently possible to conclusively identify the total amount invested in automation by the floriculture sector on an annual basis. While actual expenditure on automation can vary significantly from one farm to another, considering the average expenditures (between 2.5% and 6% of revenue) shown in Figure 16, in coordination with annual revenue of Ontario's sector suggests an annual automation expenditure of between \$20 and \$49 million. This estimate could be inaccurate considering that the number of respondents to Survey 2 is not large enough to assign a high level of confidence to these figures.

## 7.2. Automation Equipment on Farms Now

Survey 1 included several open-ended questions on automation equipment installed on farms - these questions are often challenging to interpret, and the resulting data should be considered with caution compared to questions with binary responses. However, these questions are effective in gathering responses that can be useful in navigating further assessment. Responses from these open-ended sections were carefully considered while designing Survey 2.

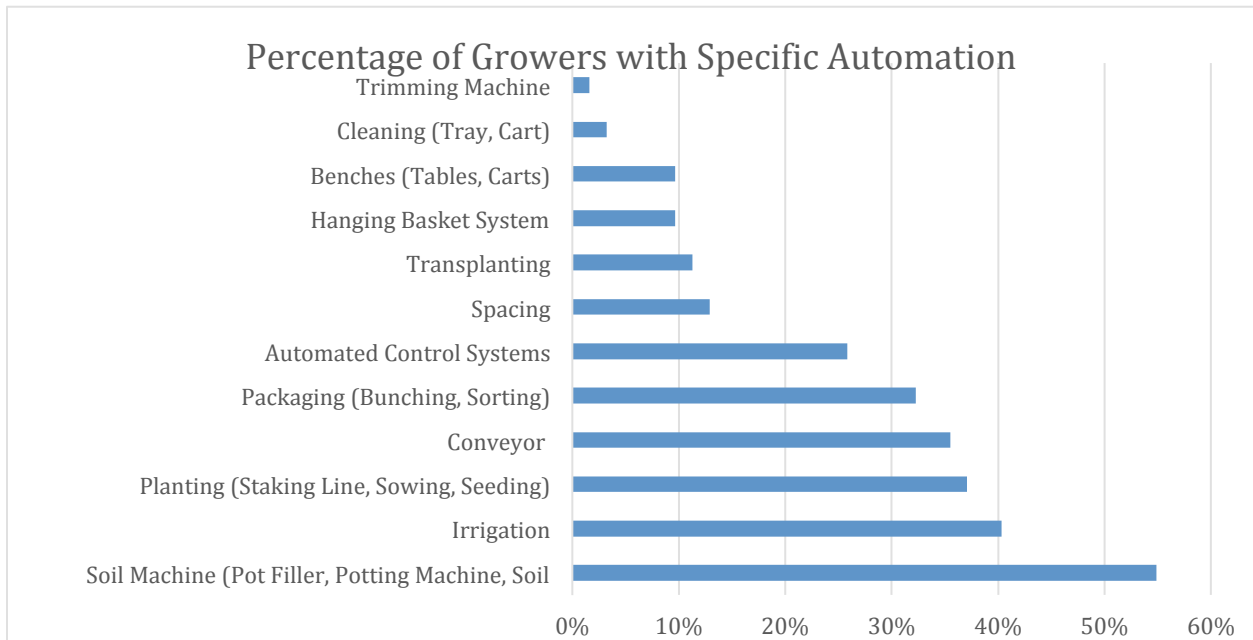


Figure 17. Percentage of farms housing common automation equipment (Source: FCO Survey 1, 2021)

Figure 17 illustrates the proportion of survey respondents that reported having automation equipment commonly found on floriculture farms. The results presented in Figure 17 should be considered carefully: the broad categories of systems listed were prepared by FCO based on open ended responses from farms and aggregated into groupings for data review. For example, irrigation equipment is highly variable by and within crops depending on the producer, and further complicated by customization. For clarity, the survey included some examples of equipment under some of the activities. Planting equipment was the most commonly present automation system for respondents, though the reasoning behind this priority (i.e. technology available, cost of systems, labour offset potential, ROI for systems etc.) is currently unclear.

While some technologies seem to be common or uncommon across the sector, splitting responses by farm size (Figures 18, 19, 20) shows that some technologies are in greater use for different farm sizes than others.

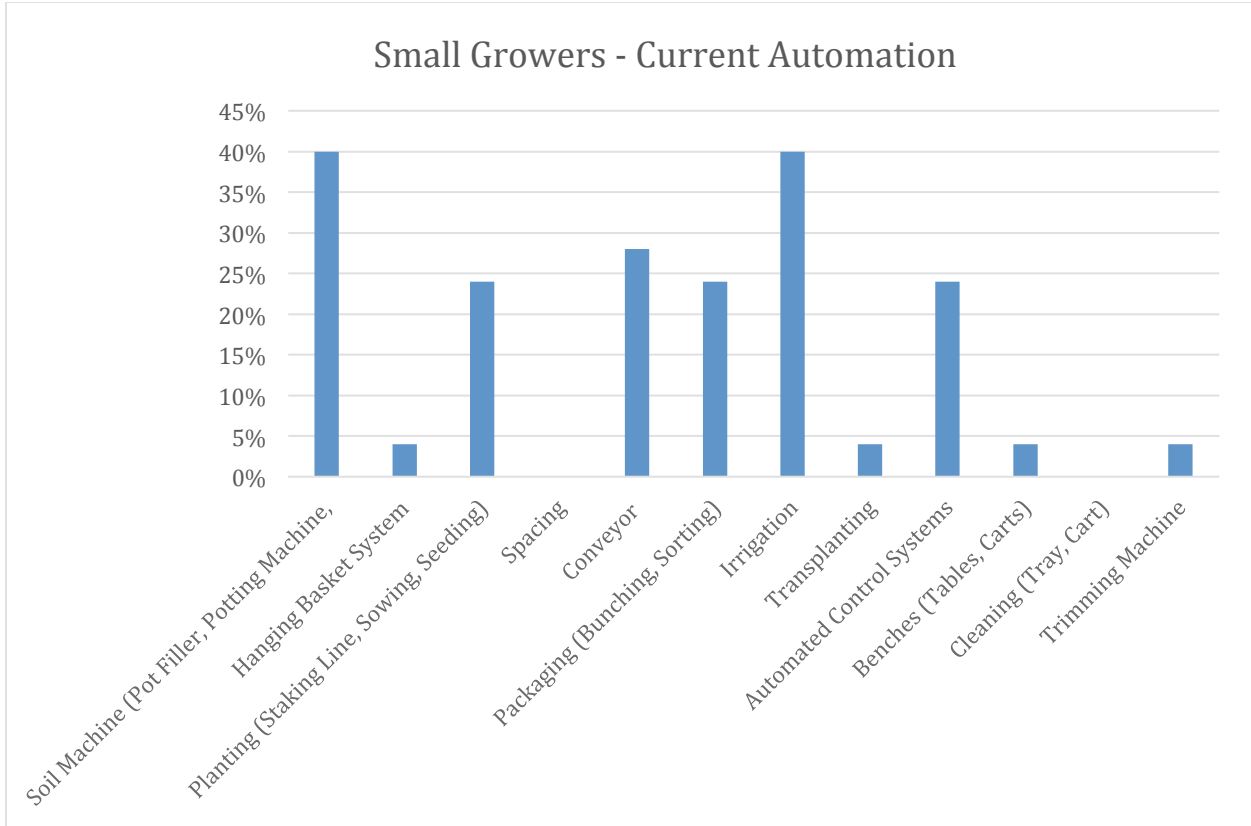


Figure 18. Percentage of small growers that currently house common automation equipment (Source: FCO Survey 1, 2021)

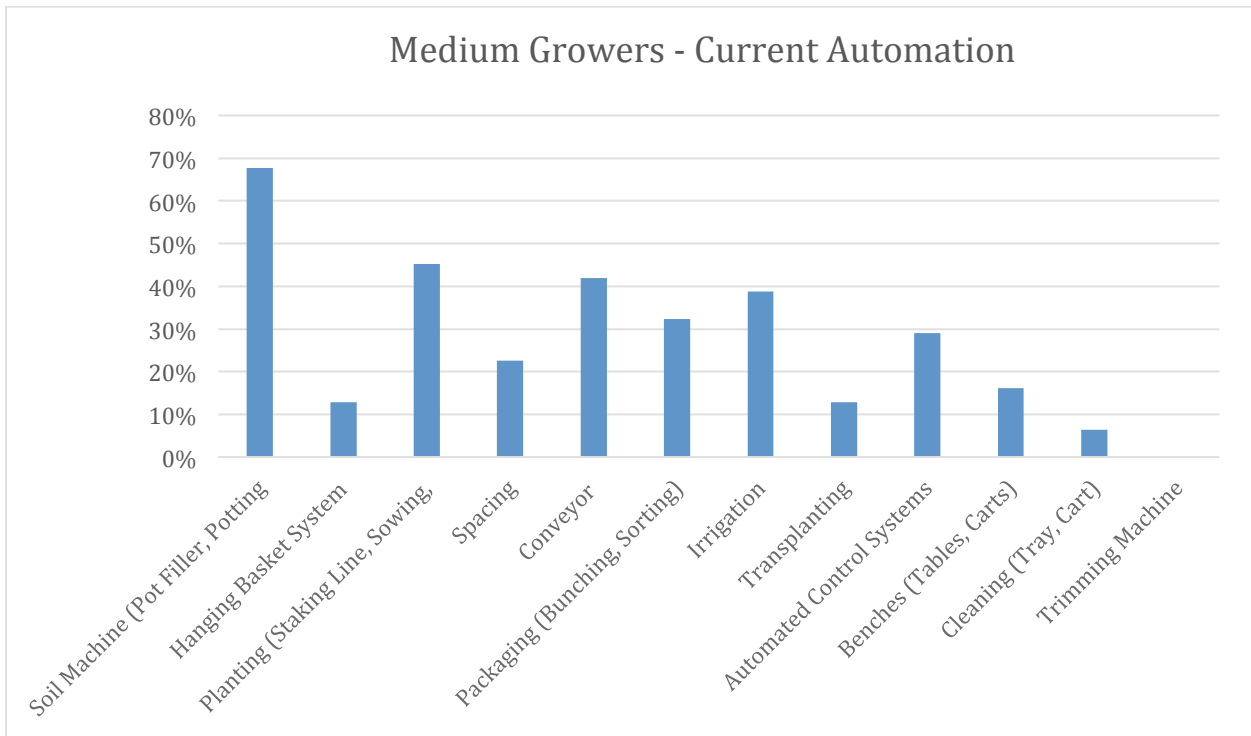


Figure 19. Percentage of medium growers that currently house common automation equipment (Source: FCO Survey 1, 2021)

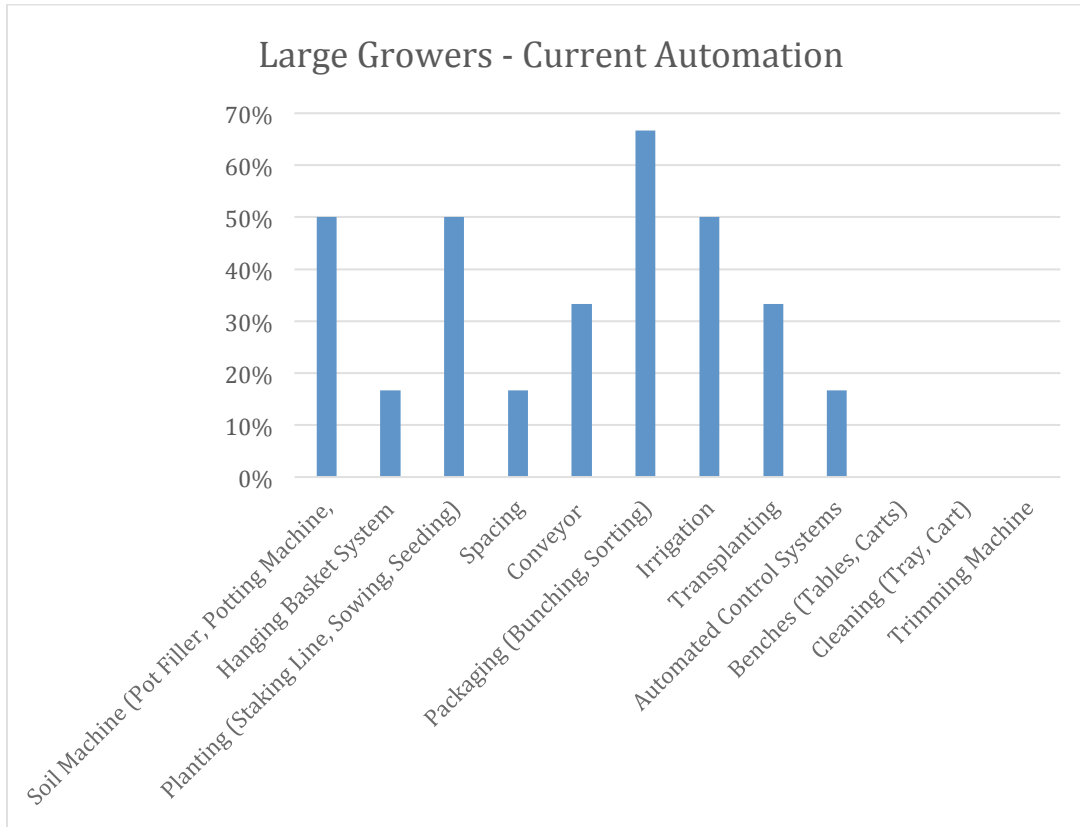


Figure 20. Percentage of medium growers that currently housed common automation equipment (Source: FCO Survey 1, 2021)

All farm sizes demonstrated considerable utilization of soil/potting machines and related equipment. Larger farms were more likely to possess packaging systems (70% of large farms, compared to 26% and 27% of small and medium farms respectively). Small farms were less likely to possess planting equipment (21% of small farms possessed these, contrasted against 46% and 50% of medium and large farms respectively).

### 7.3. Automation Systems Available

Literature review on automation and available technologies for floriculture sector was conducted from a few different sources: FCO associate members, Canadian Greenhouse Conference trade exhibitors, Agriculture and Horticulture Development Board (AHDB), Greenhouse Canada, HortiDaily, MMJDaily, FloralDaily, GPN Greenhouse Product News, and others.

There are totally 40 manufacturers or suppliers found within the project timeline, which can offer total of 400 different automation products to the floriculture sector. These products can either help to offset labour requirement, to increase productivity, to improve product quality, or to improve worker safety. None of them so far is designed specifically for COVID-19 migration, however, by using some of those automation, less people are required working in an area and workers are able to do their job at a distance, which is a co-benefit of reducing COVID-19 exposure. Within the 40 companies, 19 of them are from Northern America (either locally or from US), 16 from Netherlands, and the rest are from the other countries. Besides that, there are about 14 companies that can provide automated greenhouse for

environmental control, irrigation, etc. There are also 3 companies that can provide devices that can be used for body temperature measurement, which is helpful for site entry assessment.

Within the total 43 companies, there are only 11 companies that provide detailed information to us, including the product cost/budget, time for installation, number of labour can be offset, return on investment (ROI), etc. The following Table 2 shows the price range, ROI, and increased productivity of each technology type based on the limited data that we have.

*Table 2. Comparison between technology types on price, return on investment, and increased productivity (Source: Equipment Database)*

Technology Type	# of companies	# of products	Price range	Return on investment (ROI)	Increased productivity
Propagation (e.g. taking cuttings, sowing seed, sticking)	12	47	7k-150k	1-3 yrs	50% - 90%
Planting (e.g. potting, transplanting)	18	114	10k-200k	1-3 yrs	40% - 90%
Production (e.g. spraying, irrigation, applying/scouting biocontrols, trimming/pinching)	30	155	1k-200k	1-3 yrs	40% - 90%
Shipping (e.g. picking/harvesting, packaging, boxing)	17	79	10k-350k	1-5 yrs	40% - 70%
COVID-19 Management (e.g. screening, site entry assessment, ventilation enhancement)	4	17	1k-12k		

Note: the data for Price range, ROI, and Increased productivity is only based on the available data from 11 companies.

The detailed information about the company names, the products list, the price (only 11 companies providing the price), their contact information, etc., can be found in the Appendix III – Equipment Database. Appendix IV is a visual matrix that can help the growers to get the whole picture of the equipment database and help them to find the automation that they are interested in. All automation and technologies are also categorized into 5 groups: propagation (e.g. taking cuttings, sowing seed, sticking), planting (e.g. potting, transplanting), production (e.g. spraying, irrigation, applying/scouting biocontrols, trimming/pinching), shipping (e.g. picking/harvesting, packaging, boxing), and COVID-19 (e.g. screening, site entry assessment, ventilation enhancement), which are the same as Survey 1.

## 8. COVID-19 and Automation

### 8.1 Survey 1 Results - Automation to address COVID-19 risks

This section summarizes results from several open-ended questions in Survey 1, and again results must be cautiously interpreted. Regardless, the responses provide insight into farm perception of COVID-19 management and the opportunities presented by automation to reduce the risk of spread and infection.

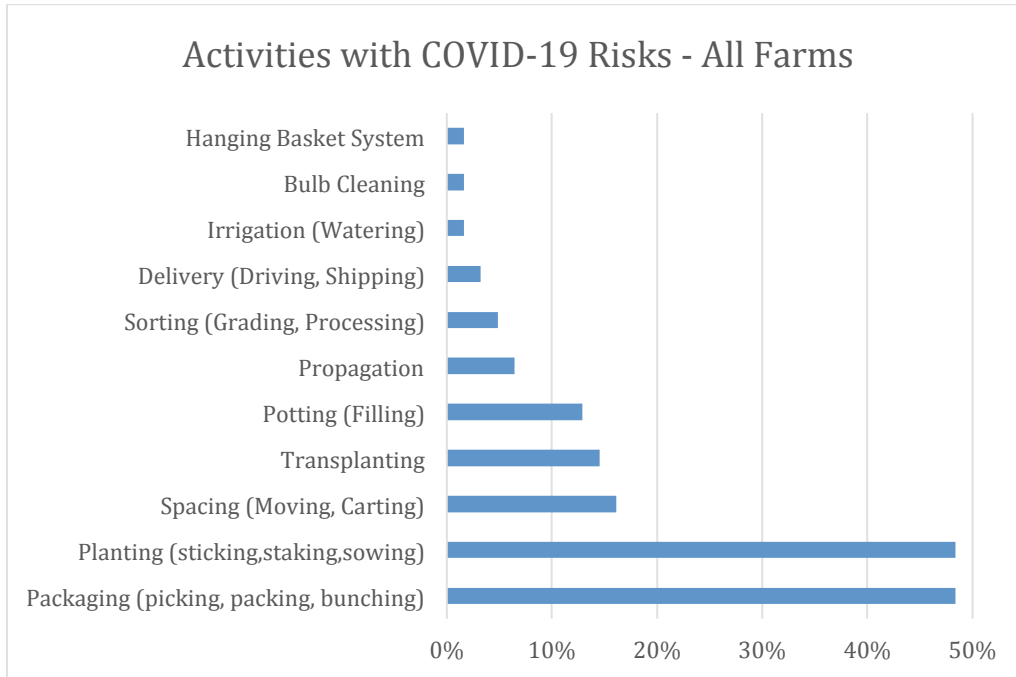


Figure 21. Percentage of farms that identified ornamental farm production tasks that they felt represented a high risk of COVID-19 spread or infection (Source: FCO Survey 1, 2021)

As evident Figure 21, two areas stand out as providing the most risk of COVID-19 exposure: planting and packaging activities. In a previous iteration of this graph, we included a category that was “None, if we are careful/modify activities”, as was reported by 7% of respondents. Farms that are able to fully segregate staff and accomplish viral exposure avoidance have a considerable advantage, but realistically, few farms can manage production without some level of worker interaction. Comparing responses between farm sizes indicated minimal differences in perceived risk for small, medium and large sized farms (Figures 22, 23, 24).



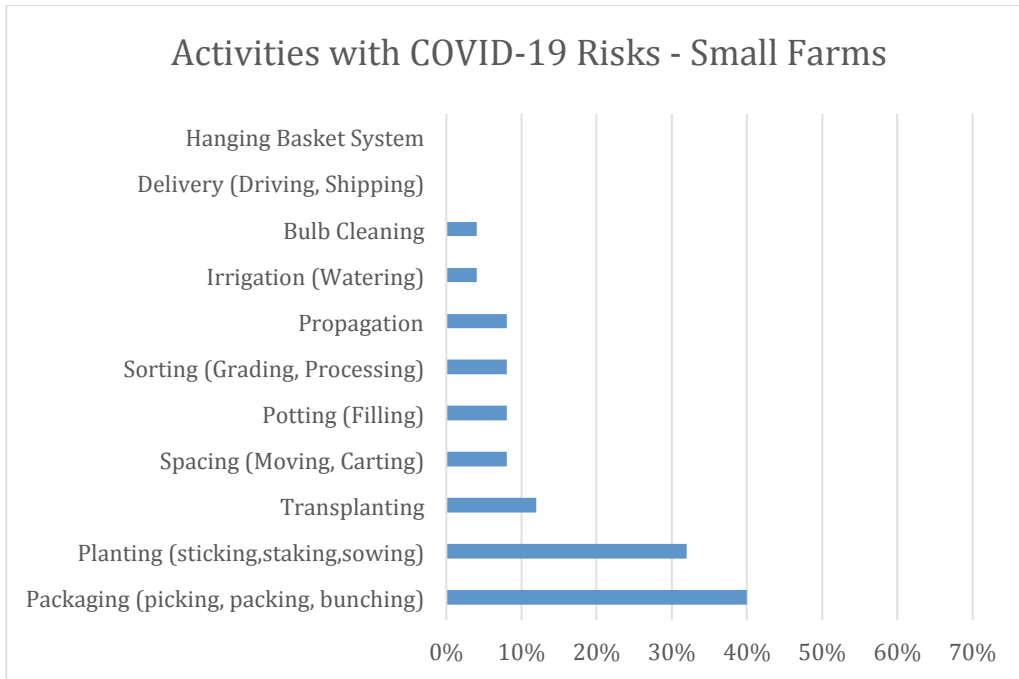


Figure 22. Percentage of respondents from small farms that perceive the risk of COVID-19 infection or spread for specific tasks (Source: FCO Survey 1, 2021)

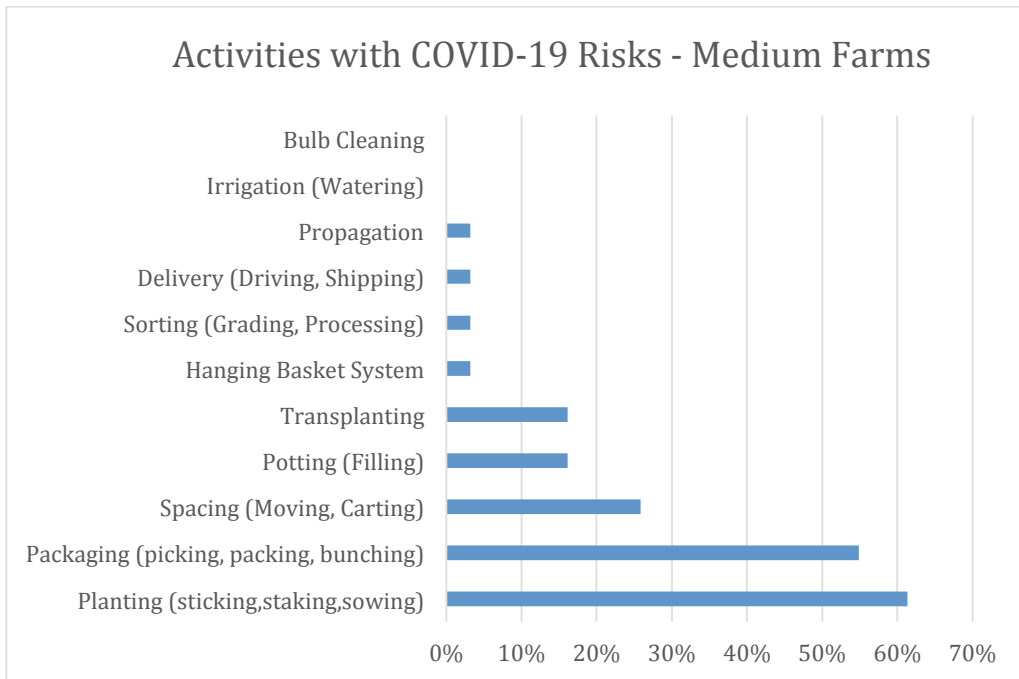


Figure 23. Percentage of respondents from medium farms that perceive the risk of COVID-19 infection or spread for specific tasks (Source: FCO Survey 1, 2021)

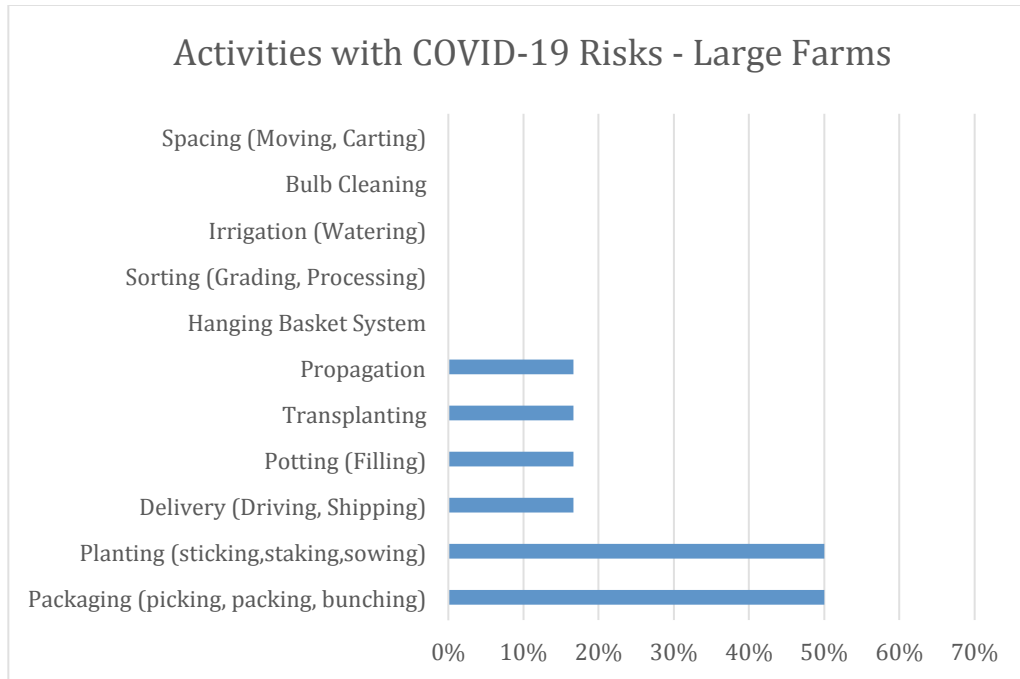


Figure 24. Percentage of respondents from large farms that perceive the risk of COVID-19 infection or spread for specific tasks (Source: FCO Survey 1, 2021)

All farm sizes listed planting and packaging as the first and second largest problem areas for COVID-19 spread, but only medium sized farms listed spacing as an issue. All farm sizes reported some concern with potting, transplanting and propagation, though at a lower frequency than planting and packaging.

It is possible that that automation may increase COVID-19 exposure risk in some scenarios. For example, potting machines are often acquired to increase potting efficiency and productivity, but the design of many potting systems is to have a crew of several labourers working closely together. Alternatively, automation in some instances may help reduce COVID-19 risk by reducing the total number of individuals needed for an activity. Ideally, automation improves productivity while minimizing increased proximity risk in the context of the COVID-19.

In terms of level of automation adopted that would have the co-benefit of reducing the risk of COVID-19 exposure, there was a wide range provided by farmers (Figure 27). Survey 1 provided ranges in ten percent increments for level of adoption, however, the perception of the level of automation by various respondents complicated the analysis. Looking at the total responses, most farms indicated some level of automation that would lessen the impacts of COVID-19.

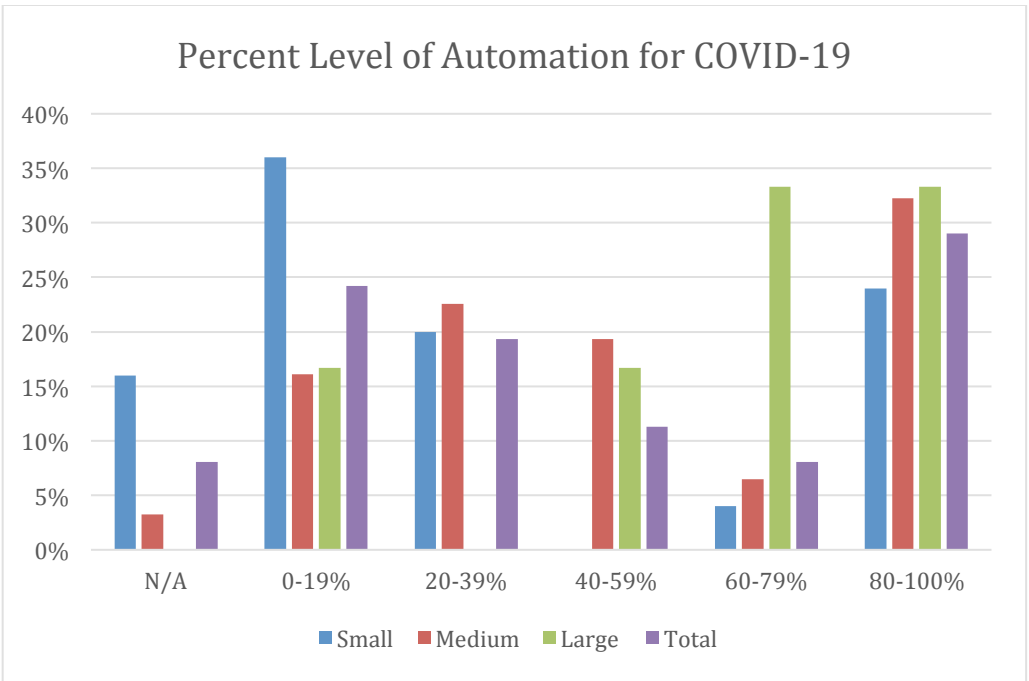


Figure 25. Percentage of growers by farm size that have automation equipment for COVID-19 (Source: Survey 1, 2021)

Small farms appeared to have the least automation that would assist with risk exposure, with medium and large farms consistently reporting more automation that would have the co-benefit of mitigating COVID-19 risks.

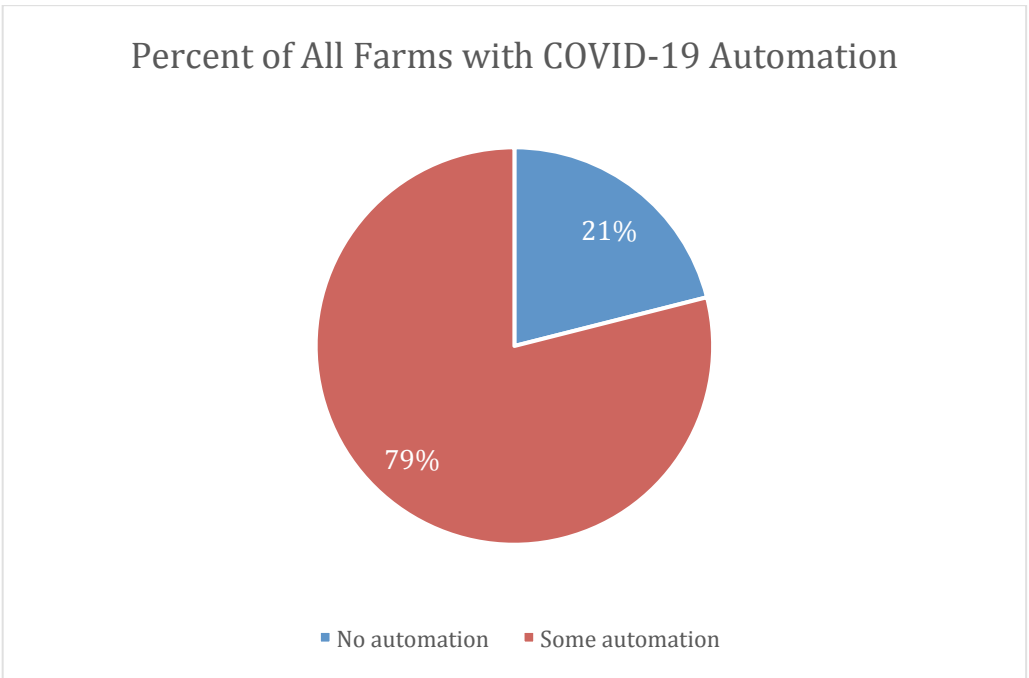


Figure 26. Percentage of growers that have at least some automation equipment specifically to address COVID-19 risks (Source: Survey 1, 2021)

Overall, almost 80% of respondents indicated they had at least some level of automation that would have the side benefit of addressing risks for COVID-19 exposure. Of the growers that mentioned COVID-19

risk areas, 80% (range of 69-100% by activity) of them also indicated that they had automation specific to those tasks (Figure 27).

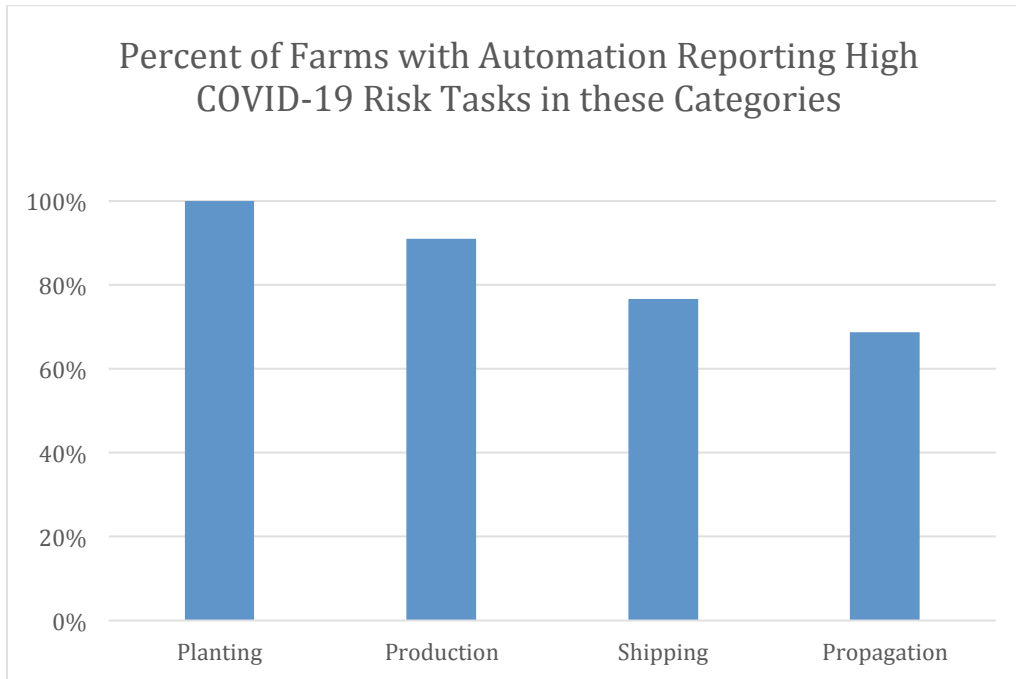


Figure 27. Percentage of growers that reported automation equipment for activities identified as higher risk for COVID-19 transmission (Source: Survey 1, 2021)

The number of farms purchasing automation equipment primarily to address COVID-19 risks paints quite a different picture than farms that have purchased automation equipment for other reasons (Figure 28 compared to Figure 17).

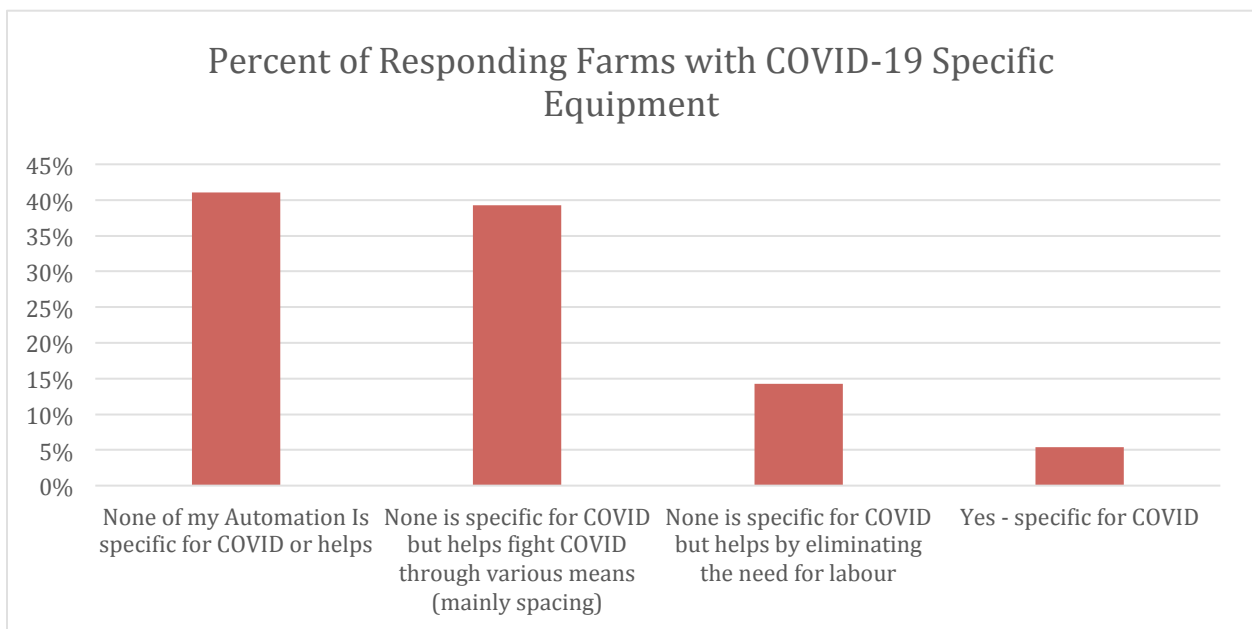


Figure 28. Degree of COVID-19 infection control technology on farms (Source: FCO Survey 1, 2021)

Very little automation has been installed to directly address COVID-19 on farms (5% of responses), and 40% of respondents did not believe that their automation systems were reducing COVID-19 risk for their workers. Farms likely achieve enhanced COVID-19 protection by eliminating staff or spacing workers using existing automation equipment already installed (totals over 50% of respondents). Additionally, there may be little motivation to invest anything but nominal amounts in COVID-19 automation as a return to common production practices may occur following vaccination rollout.

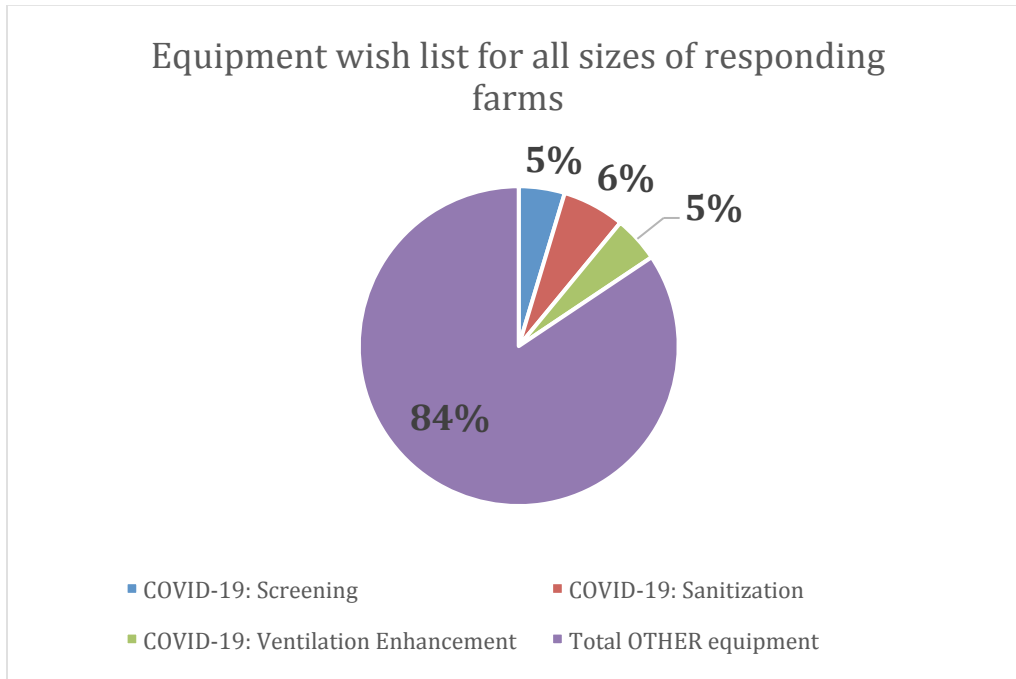


Figure 29. COVID-19 automation investments planned by all farms compared to all other investments (Source: FCO Survey 1, 2021)

Farms are planning on investing in automation for primarily farm-related activities (Section 10, Figures 41-43), but there is some interest in investments related specifically to COVID-19 mitigation, about 15%. If automation systems have the co-benefit of spacing or reducing worker interaction, it is likely these types of systems will appeal to FCO members.

In addition to the belief that investing in COVID-19 automation may be redundant if the vaccination rollout is successful in mitigating the risks of exposure on farm, there are other barriers to investing in COVID-19 automation.

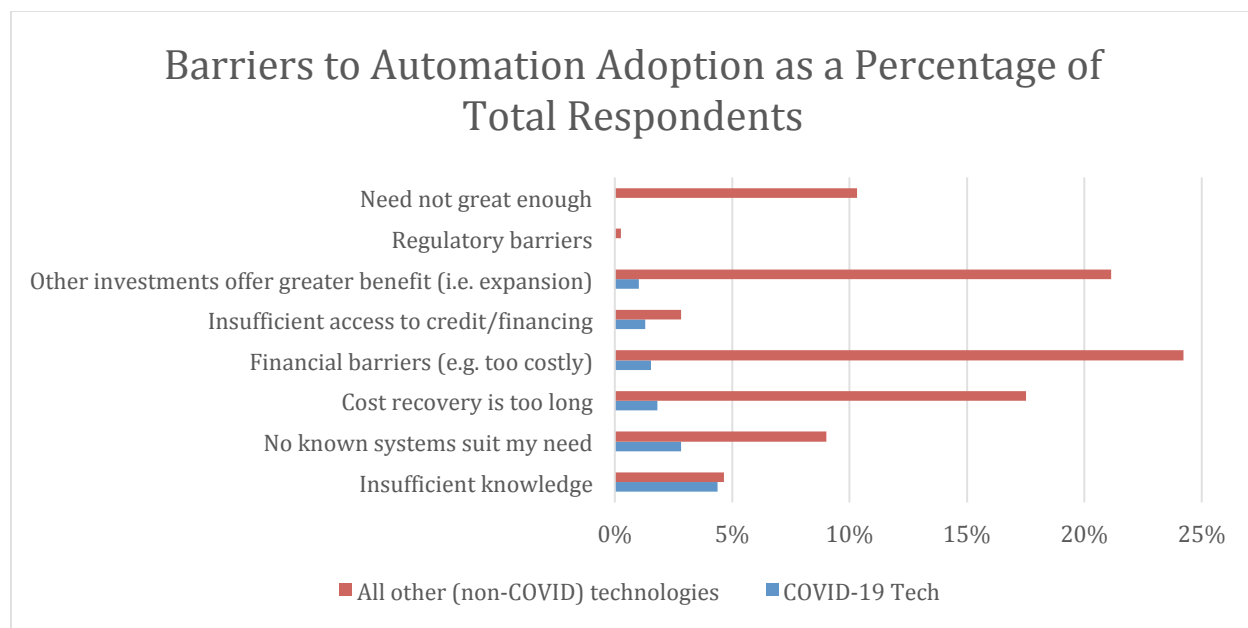


Figure 30. COVID-19 automation investments planned by all farms compared to all other investments (Source: FCO Survey 1, 2021)

Based on the responses from Survey 1, it is clear that knowledge and availability of COVID-19 specific automation is very limited. Interestingly, no farms responded that there was insufficient need for addressing COVID-19 through automation. Pandemics are not a common occurrence, and thus, technologies to prevent disease spread have not been developed or incorporated into production machinery.

#### Summary of Survey 1 COVID-19 and Automation Findings:

- High risk activities for all farms include propagation, planting and packaging
- These high-risk activities are often the most automated
- Automation can have some co-benefits for mitigating the risks of COVID-19
- Automation may have the impact of bringing workers closer together physically
- The availability of specific automation to decrease COVID-19 exposure risk is limited
- Farms are more likely to consider automation for other purposes (productivity, etc.)
- Farms are considering COVID-19 risks when purchasing equipment in the future

## 8.2 Discussions with other organizations and Health & Safety representatives

The risks for COVID-19 transmission are more likely to be mitigated through addressing congregate settings such as entrances/exits, lunchrooms, washrooms, farm vehicles, locker rooms, propagation and potting areas, and on-farm housing. Management of these spaces through automation may be considered, for example: sanitizing mists at regular intervals in washrooms and lunchrooms, decreased capacity limits for common areas, installation of facial scanners to replace punch clocks, and improving ventilation of indoor workspaces by installing air exchangers. However, education and administrative controls (physical barriers, signage (posted and floor markings), active screening) may be equally effective. When implementing administrative controls, compliance must be encouraged and enforced by management.

## 9. Mapping Farm Productivity and Labour

### 9.1. Current State of Labour

There are several labour and productivity measurements available through Statistics Canada for the state of labour in the sector.

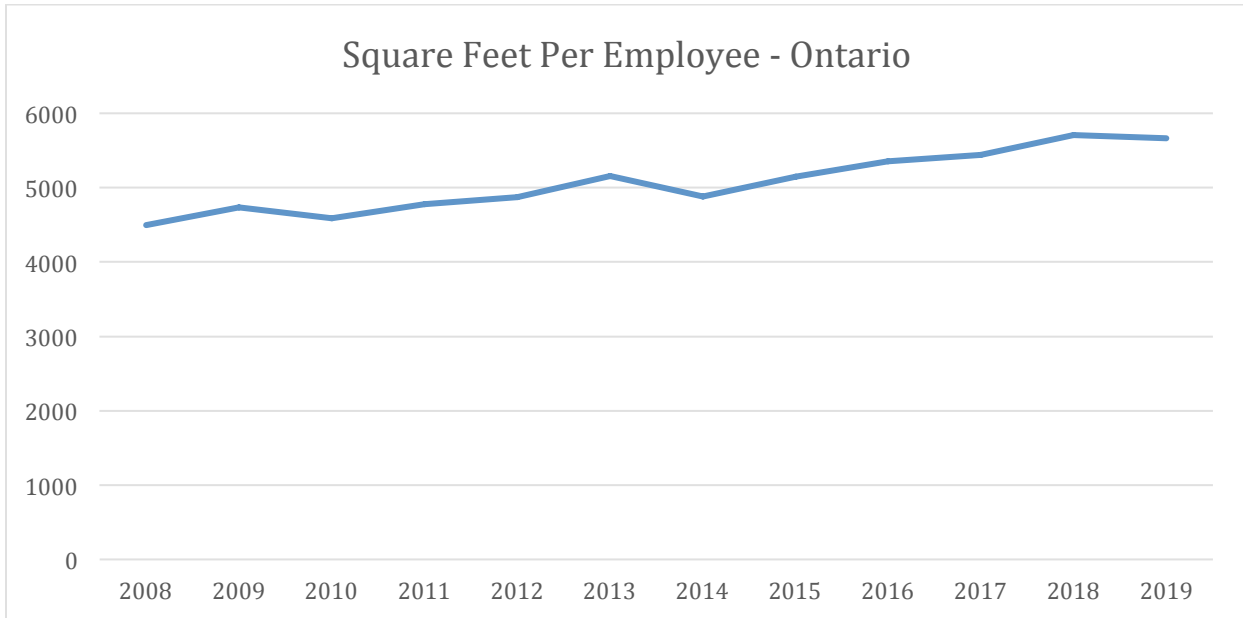


Figure 31. Average number of square feet per employee in Ontario (Source: Statistic Canada, 2019)

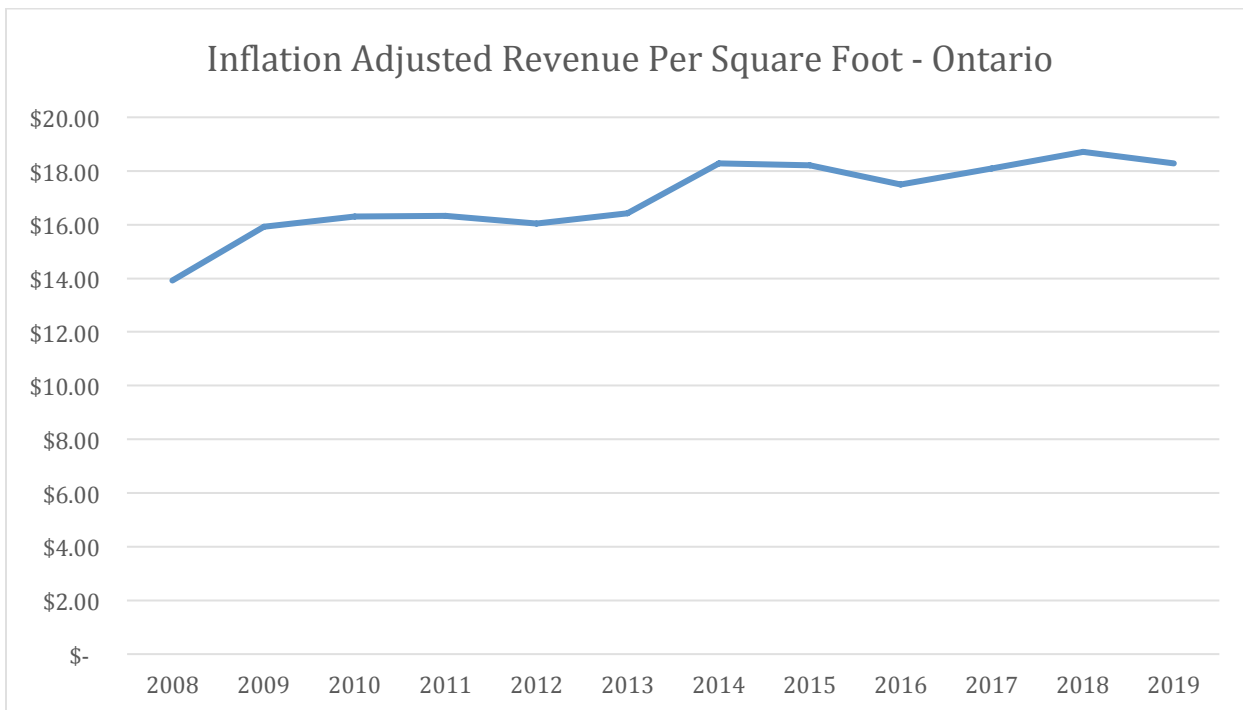


Figure 32. Estimated revenue per square foot in Ontario with inflation adjustments (Source: Statistic Canada, 2019)

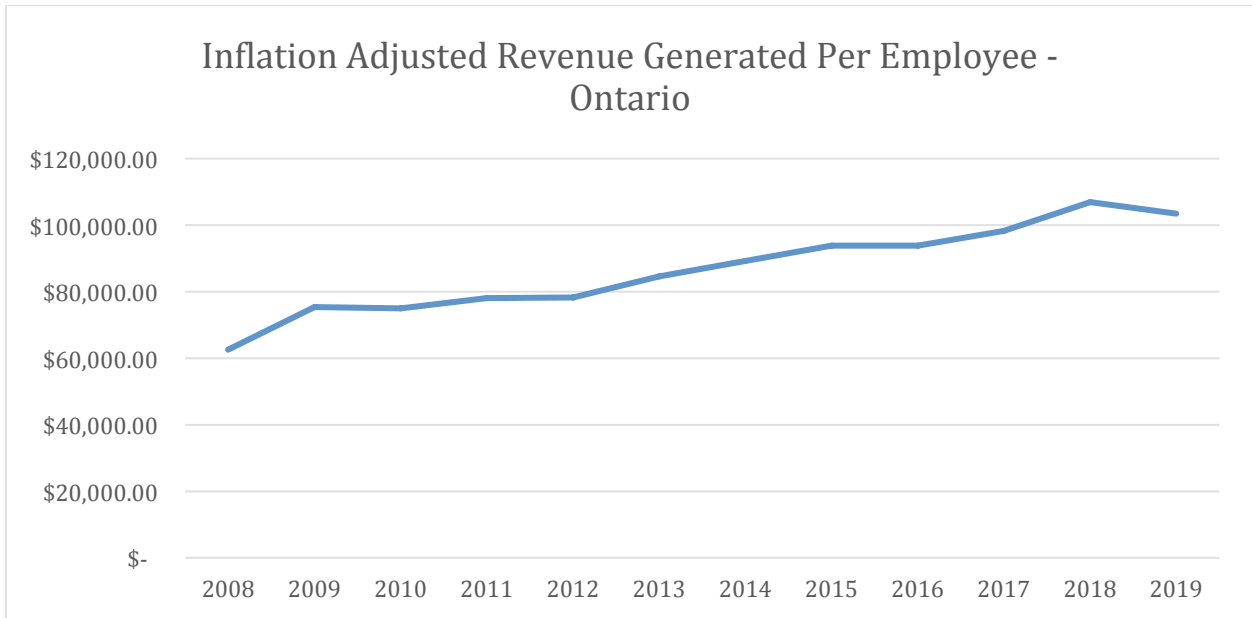


Figure 33. Estimated revenue generated per employee in Ontario with inflation adjustments (Source: Statistic Canada, 2019)

Figures 31, 32 and 33 highlight a trend of increasing productivity in the sector:

- Figure 31 shows that the amount of square feet one employee can farm has increased by 26 % since 2008.
- Figure 32 shows that inflation adjusted revenue per square foot has increased by 31% since 2008.
- Figure 33 shows that inflation adjusted revenue per employee has increased by 65% since 2008.

There are many potentially interconnected explanations for these increases including; growers transferring to either more profitable crops or crops that are easier to farm, exchange rate gains, price increases outside of inflation, etc. However, this data, when taken in conjunction with the findings of our surveys, demonstrates that advances in technology and automation play a key role in the growth of the sector.



## 9.2. Impact of Labour on Productivity

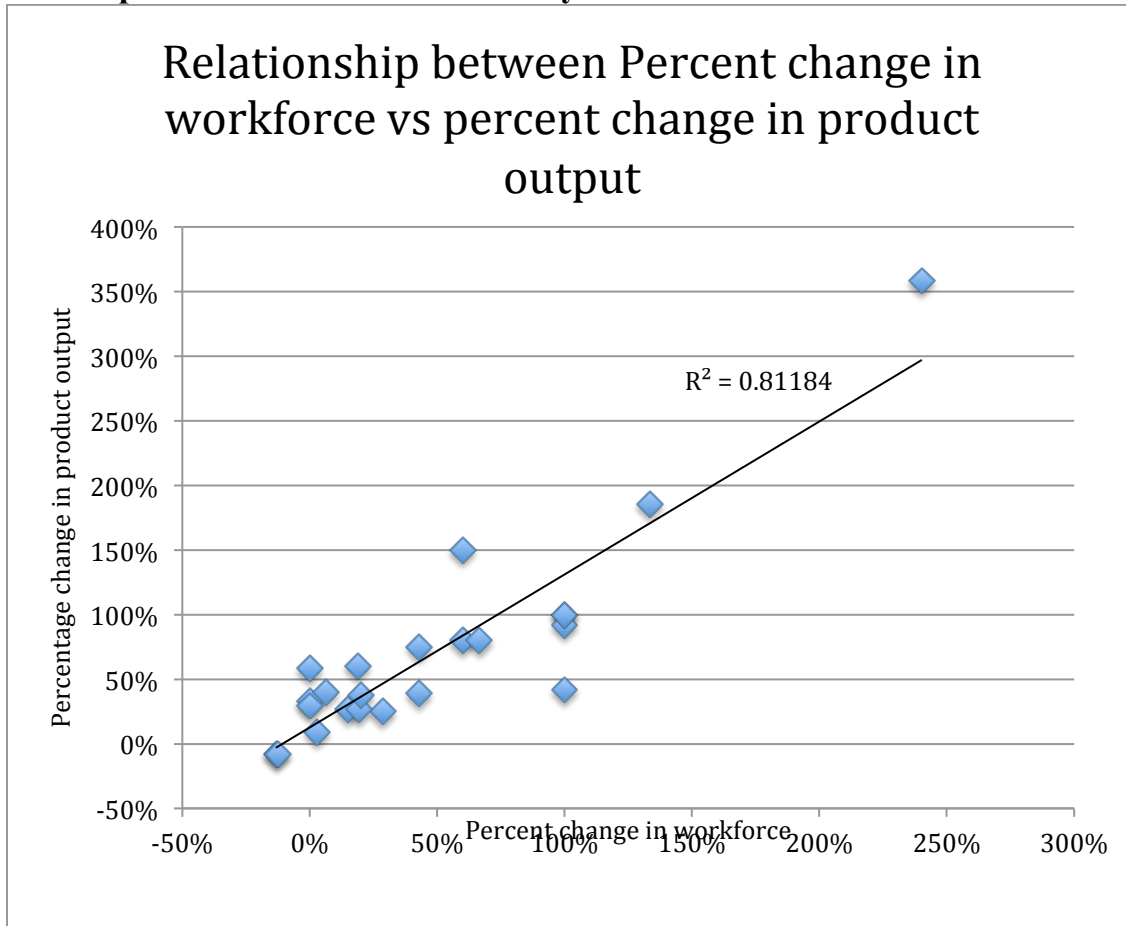


Figure 27. Relationship between the percentage of change in a workforce against the percentage of change in product output (Source: Survey 2, 2021)

Survey 2 requested that farms disclose the change in their workforce (by number of people and number of hours), and percent change in productivity by number of plants produced (pots/cuts/plants etc.). Figure 34 compares changes in productivity with changes in workforce size by percent change, and demonstrates the existence of a strong relationship between the number of workers added to a farm and the number of plant units produced by the farm: farms that proportionately add more workers produce proportionately more product. Splitting responses between small and medium/large growers illustrates some variability in this relationship.

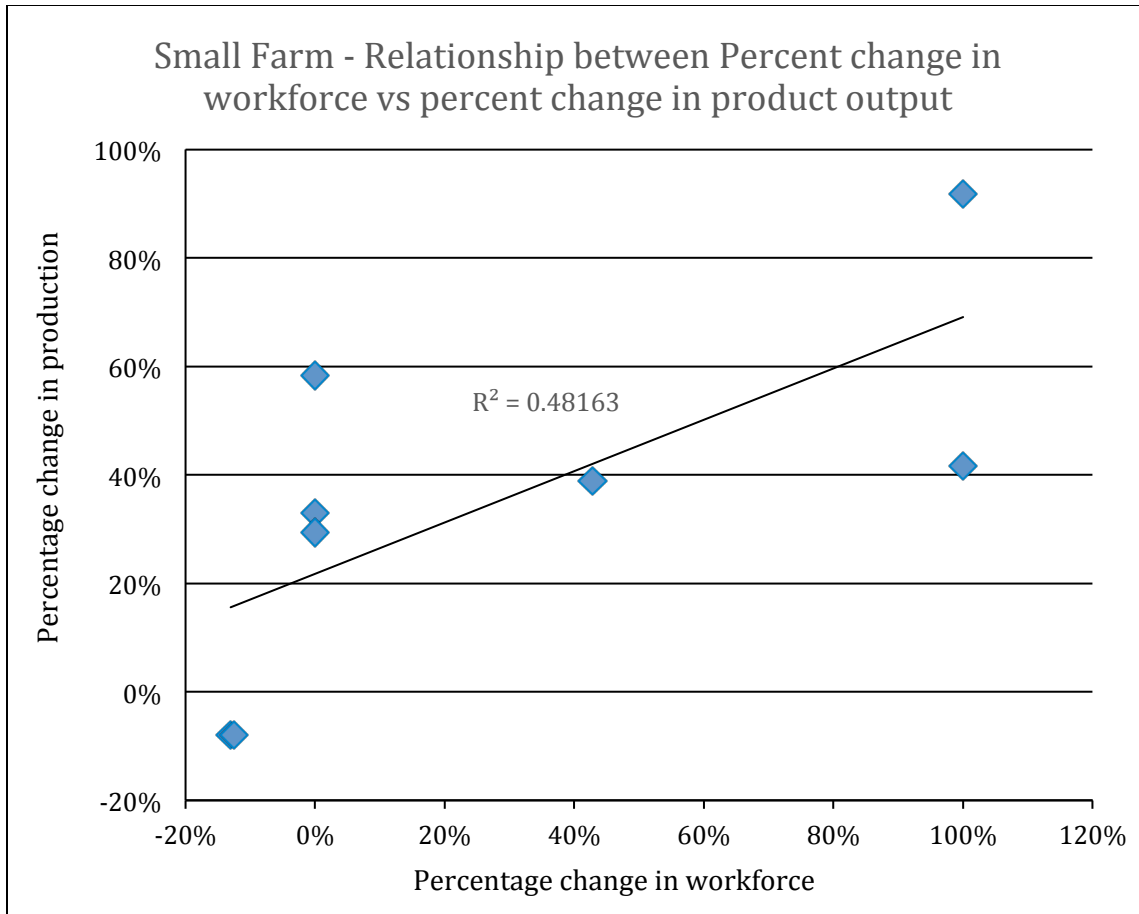


Figure 28. Relationship between the percentage of change in a work force against the percentage of change in product output on small farms (Source: Survey 2, 2021)

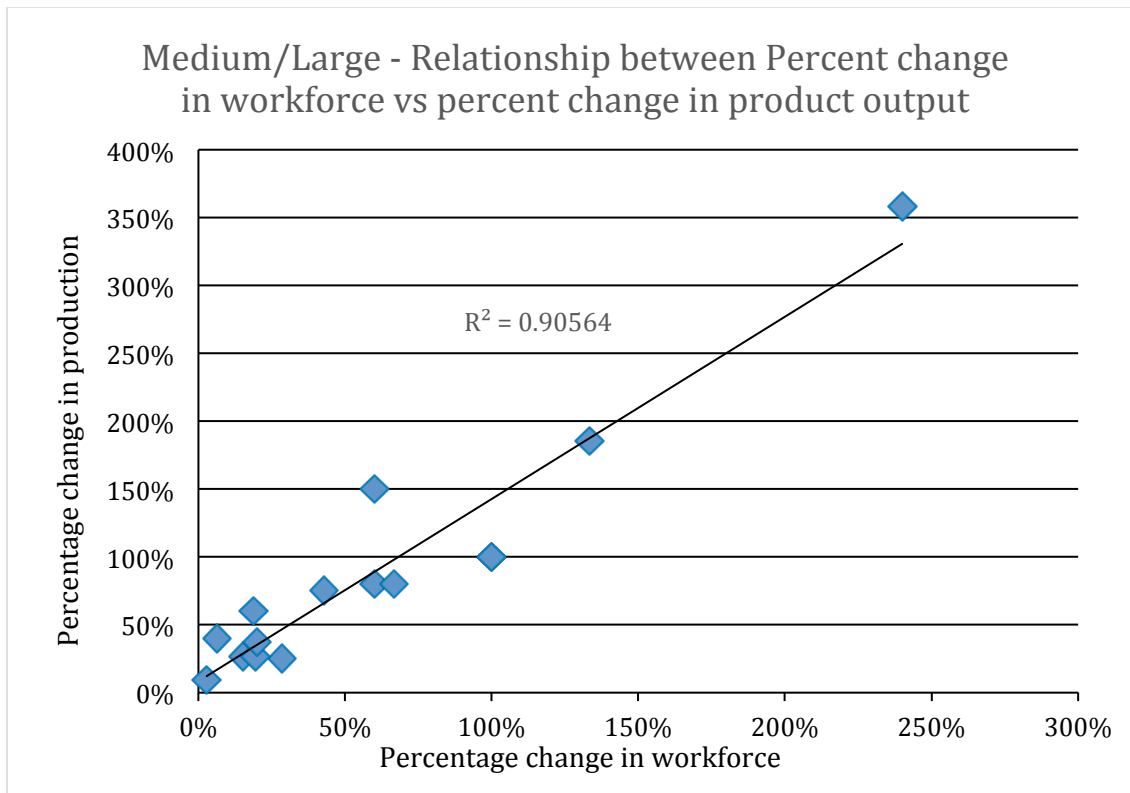


Figure 36. Relationship between the percentage of change in a work force against the percentage of change in product output on medium/large farms (Source: Survey 2, 2021)

As shown by Figure 35 and 36, medium/large growers have stronger relationships between productivity and labour than do small farms. As demonstrated previously, small farms are more likely to have no automation in any given section of the farm and are, on average, less automated than medium and large farms. While the difference in this relationship between farm size is pronounced, it may be caused by the small sample size of small farm respondents or may imply that automation plays a key role in improving productivity.

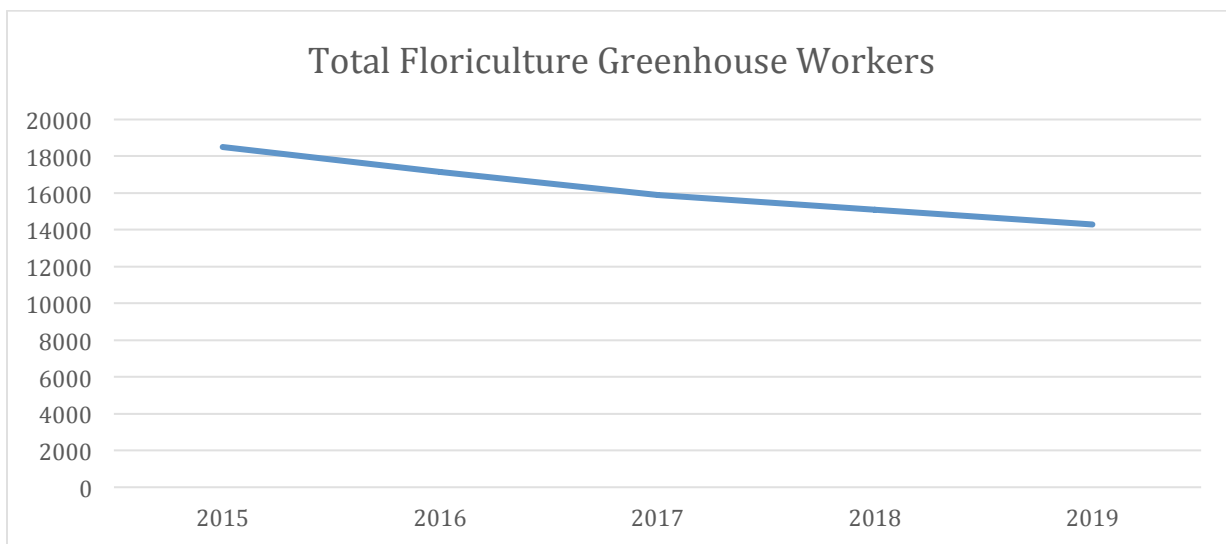


Figure 29. Total greenhouse floriculture workers in Canada (Source: Statistics Canada, 2019)

Additionally, the total number of greenhouse workers has decreased since 2015 (Figure 37); however, output has increased. As previously stated, there are numerous potential reasons for the observed increase in productivity, though automation and technology are undoubtedly part of the cause. Furthermore, had productivity per employee not improved since 2008, the sector would have theoretically needed 29,605 workers in 2019 to match the revenue achieved; nearly 10,000 more workers than were employed by the sector in 2019 (19,651).

### 9.3. Impact of Automation on Productivity

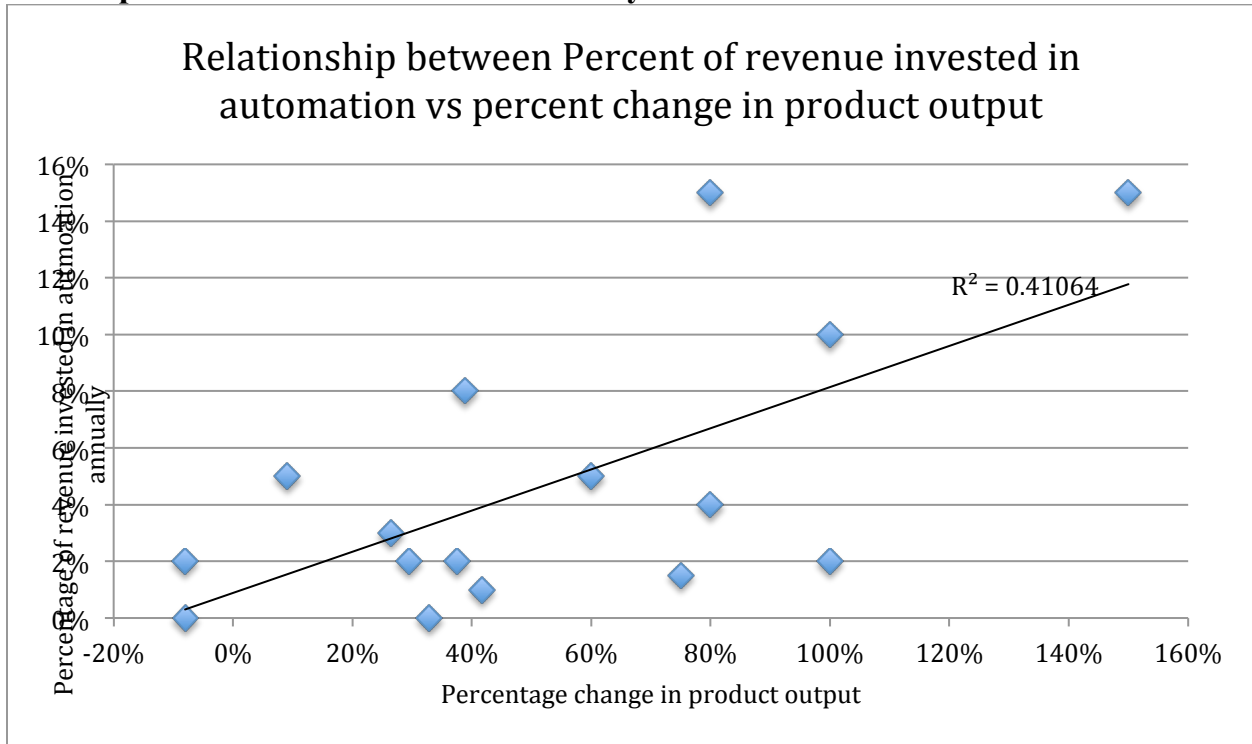


Figure 30. Relationship between the percentage of revenue invested in automation on a farm against the percentage change in product output (Source: Survey 2, 2021)

Figure 38 displays the relationship between investment in automation (by percent of revenue spent on automation annually) and the change in product output (by percent increase in plant output). While the relationship is not as strong as the relationship between output and labour, a significant relationship exists ( $R^2 = 0.4106$ ). Farms that spent higher proportions of their revenue on automation tended to have greater increases in product output.

### 9.4. Impact of Automation on Labour

Broad sector statistics have shown that the worker population on flower farms is in steady decline (Figure 37), yet productivity has increased and automation has been shown to improve productivity. Assuming that automation expansion is the primary cause of workforce population reduction is reasonable, exploring relationships between automation investment and workforce population changes suggests a different story.

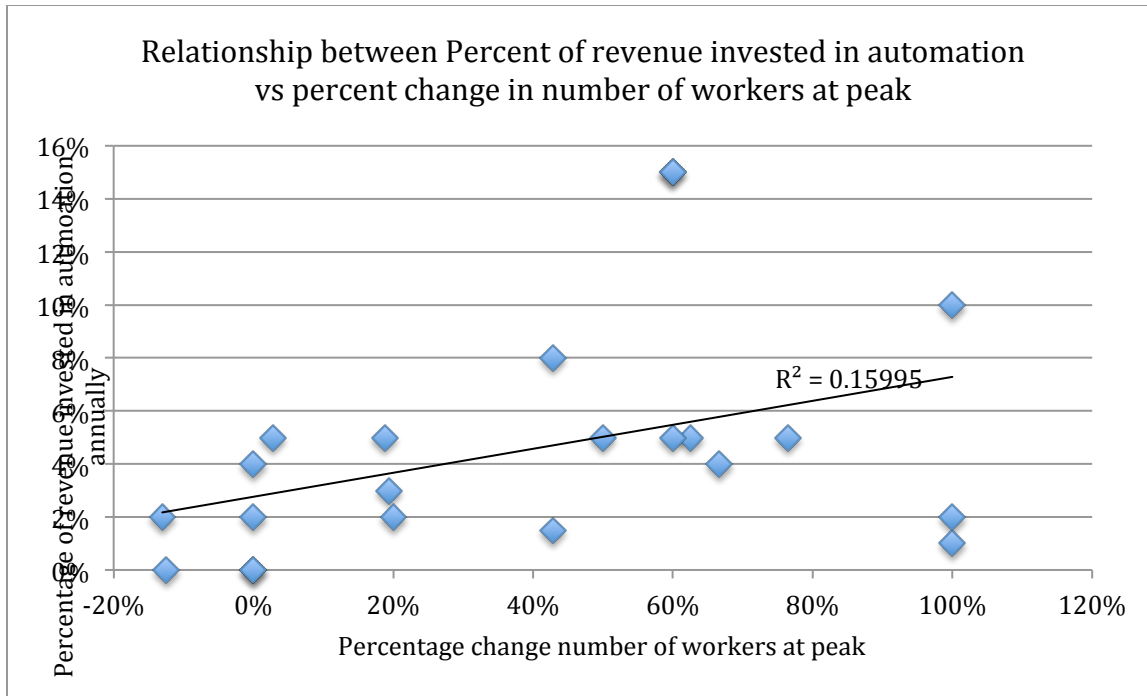


Figure 39. Relationship between percent of revenue invested in automation against the percentage change in the number of workers at Peak production (Source: Survey 2, 2021)

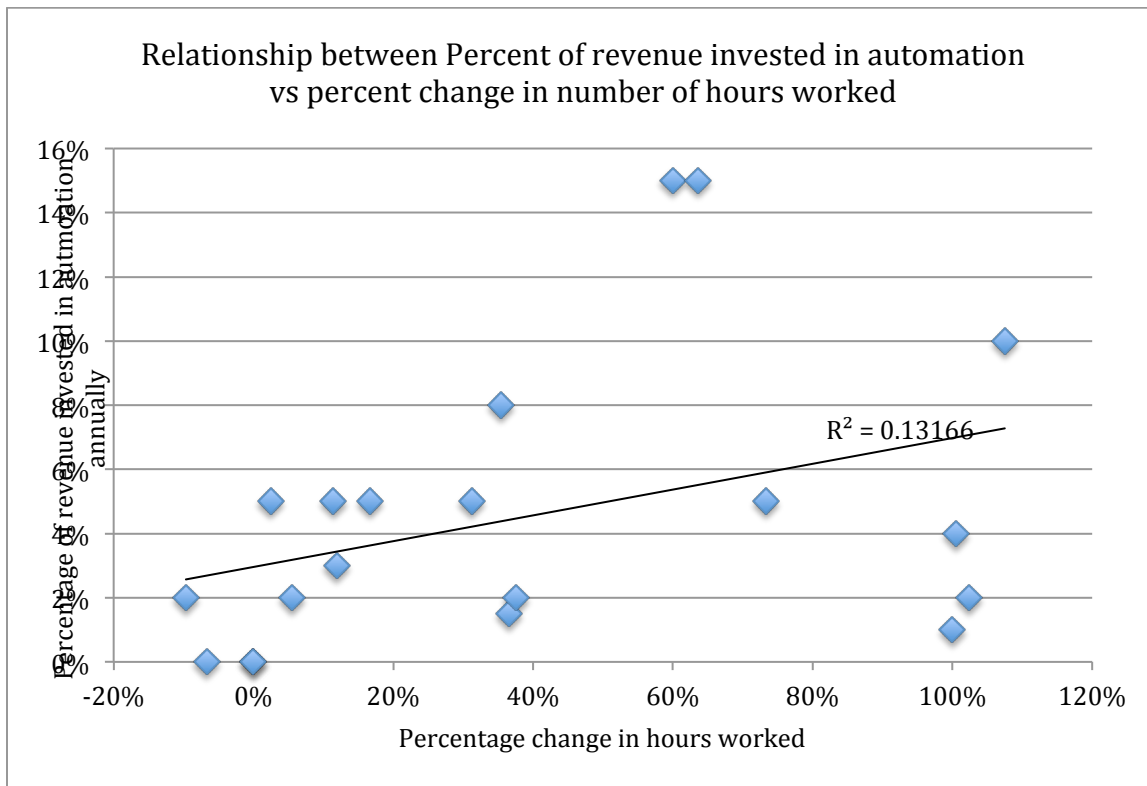


Figure 40. Relationship between the percent of revenue invested in automation against the percentage change in the number of hours worked (Source: Survey 2, 2021)

Figures 39 and 40 explore the relationship between the percent of revenue invested by farms and the proportionate changes in their workforce. Counterintuitively, automation expenditures showed weak or no relationship to workforce changes. Farms that spent more on automation saw no change in their workforce, or possibly small increases in their workforce.

These findings imply that expanding automation investment has not created the primary benefit of reducing a workforce population by the farms that completed Survey 2. However, increasing automation expenditure did indeed improve productivity for respondents, as did increasing workforce. Automation likely holds greater potential for expansion of productivity than workforce reduction.

One possible explanation for these results may be the nature of automation within the floriculture sector. Floricultural automation, in general, results in augmenting a worker's productivity. Automation rarely replaces or eliminates a worker's job. Therefore, when farms add automation, they typically need to keep labour levels at pre-automation levels, if not increase them, to maximize any output gains from automation. Farms adding automation may see labour improvements, but rather than releasing workers, those workers may be shifted to other roles to further improve output or address other farm priorities (e.g., improved quality). Considering that increasing labour is very strongly related to increasing productivity, transitioning workers to new roles, rather than reducing the workforce after automating a labour-intensive task, holds great opportunity to both maintain worker opportunity in the sector and increase product output.

## 10. Opportunities in Automation

The following sections will explore which tasks farms are attempting to automate, the rationale for automating, and the anticipated next investments in automation.

### 10.1. Farm Automation Priorities

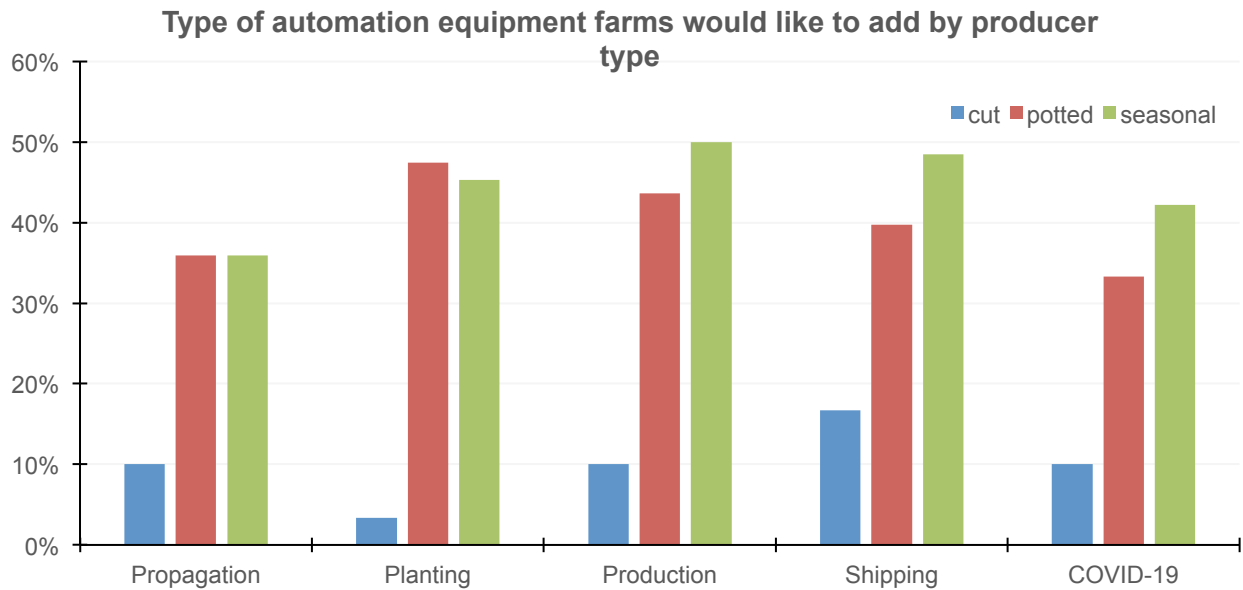


Figure 41. Types of automation equipment that various segments of the ornamental industry would like to add to their farm (Source: Survey 1, 2021)

Potted and seasonal farms are looking broadly at all types of automation, but for cut flower growers, shipping is their first priority, compared to the other farm tasks. Please note: cut flower producers reported a low desire to add propagation and planting automation systems, and a low level of automation progress among those farm tasks (see Figure 12). This may imply that these automation systems are less important to cut flower producers.

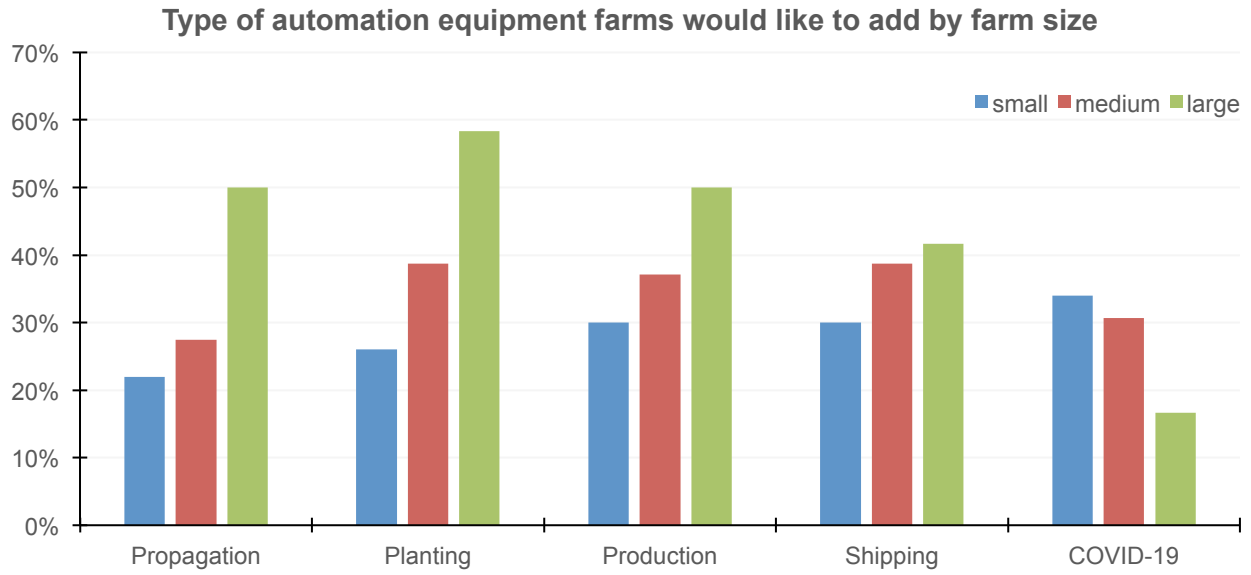


Figure 42. Type of automation equipment farms would like to add based on farm size (Source: Survey 1, 2021)

Large farms are frequently seeking planting/potting machines, and then are eager to automate propagation and production systems. However, as indicated within the survey results, large farms are presently at higher levels of automation than their small and medium counterparts. It is possible that the return on investment (ROI) is shorter, or the financial barriers are different for larger farms. There is no particular difference between small and medium farms as to which types of automation equipment they would like to add in their farms. Compared to large facilities, small and medium farms are less automated.



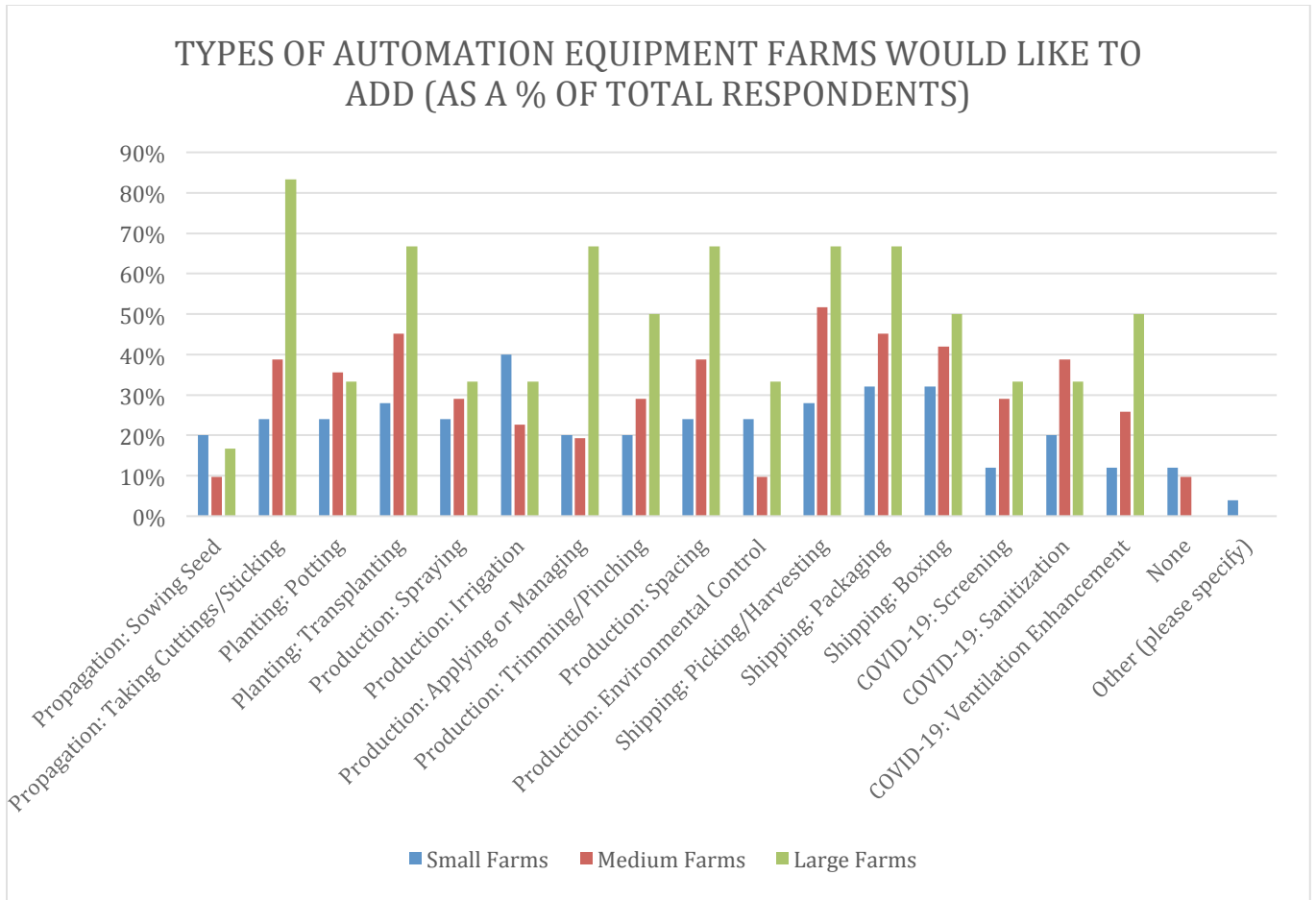


Figure 43. Specific types of automation equipment farms of varying sizes would like to add as a percentage of total respondents (Source: Survey 1, 2021)

Figure 43 illustrates the number of respondents within each farm size that responded with a ‘yes’ in each of the more specific automation task categories provided. As shown in Figures 42 and 43, larger farms have notable interest in automation improvements across nearly all activities at the farm. Of note, large farms did not have a consistent desire to automate within the more general automation task categories (i.e., propagation, production, etc.). While most specific categories were in demand for automation by large farms, less demand was seen for automation in sowing seeds, potting, spraying, irrigation, and environmental control. It is possible that larger farms may have already invested in these particular farm activities, while smaller farms have yet to invest in these systems.

This information supports the argument that floriculture producers know what automation they want, and where on the farm it is needed. It’s not from lack of knowledge that they are not automating, as evidenced in the barriers to automation figures below (Figures 48-51).

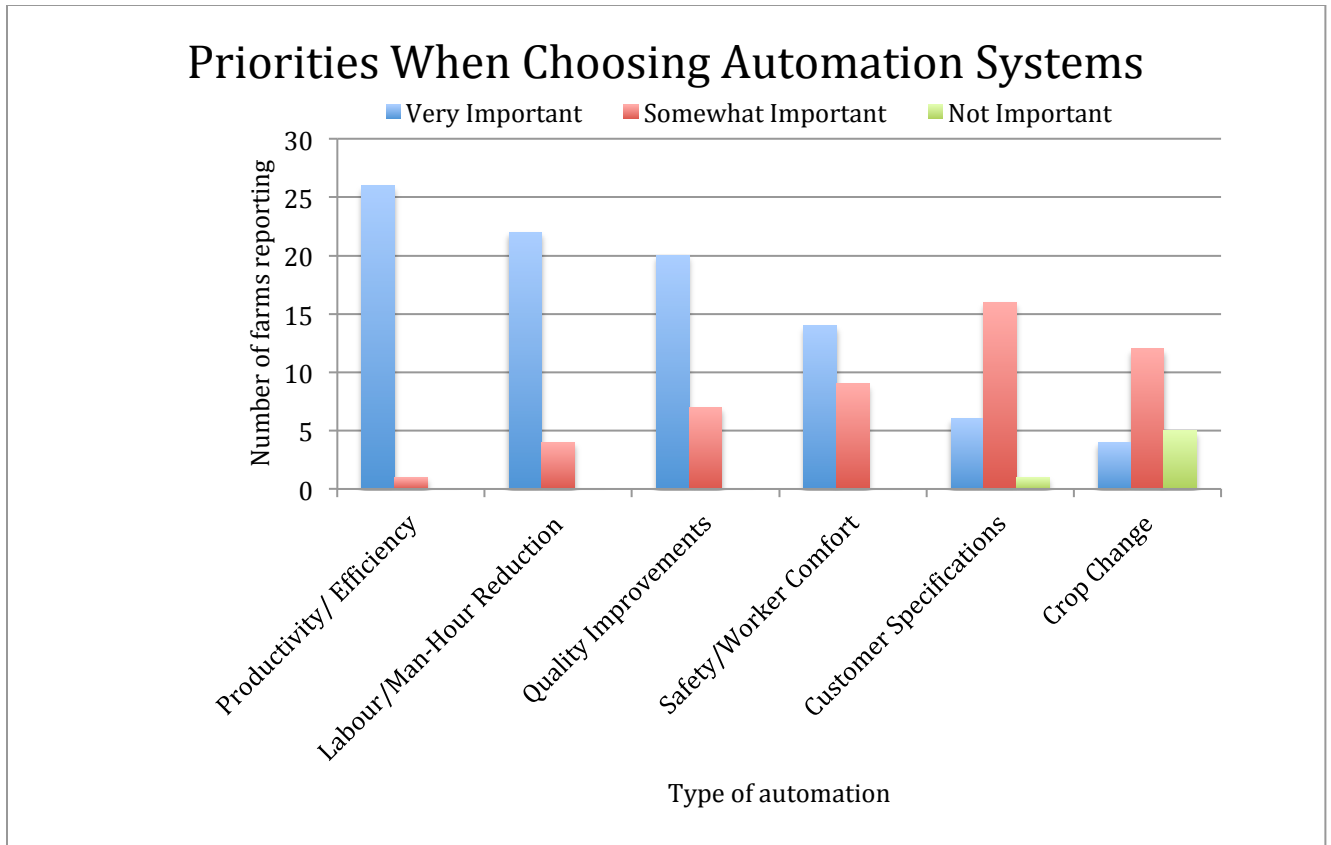


Figure 31. Automation system priorities based on the number of reporting farms (Source: Survey 2, 2021)

Improving productivity and decreasing workforce demands have long been presented as good reasons to invest in automation, though in truth the intent behind automation is less uniform. Figure 44 above indicates that there are competing considerations that can vary drastically depending on an individual automation system and operational needs. Notable reasons for automation may include production/efficiency, labour/workforce reduction, product quality improvements, worker safety, customer specifications, and even crop changes. Regardless of the variability in why farms automate, the top three priorities for the average piece of automation are:

1. Production/Efficiency Improvements
2. Labour/Work Hour Reduction
3. Quality Improvements

Please note; these results were based on subjective answers - farms identified which automation objectives were very important, somewhat important, or not important. Each of the priorities presented above were identified as "very important" by at least one farm.

Beyond the relative automation priorities and desires listed by farms, the anticipated outcomes of farms' next automation purchase provide further insight into the opportunities farms are seeking for their business. Survey 2 requested that farms disclose the next automation purchase, including the anticipated impacts on:

1. Number of employees on the farm
2. Number of staff-hours worked on the farm
3. Changes in plant output (i.e., increases in production)

Comparing the anticipated outcomes from future purchases demonstrated that farms anticipated a decrease in their workforce by 8.5%, decrease staff-hours by 10.2%, but an increase in productivity by 47%. This generally implies that the next systems to be added to farms will hold greater potential for increases in productivity rather than workforce reduction.

## 10.2. Projecting Future Farm Automation Investment

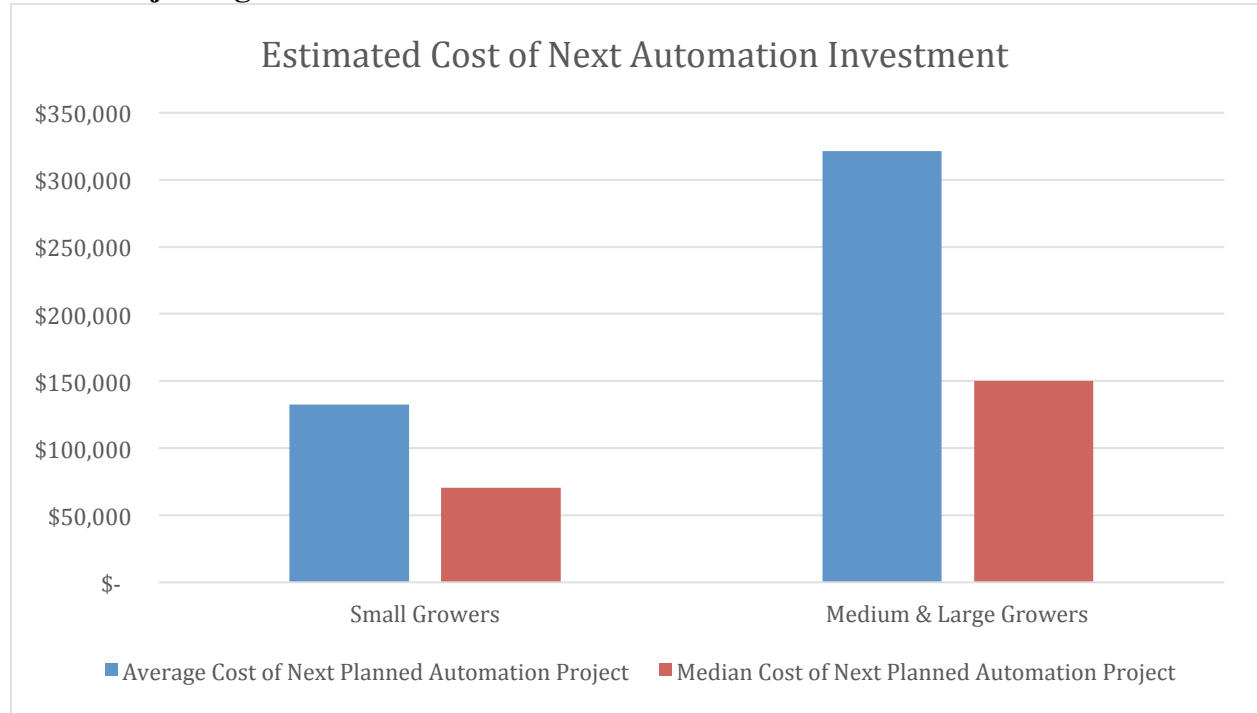


Figure 32. The estimated cost of upland automation investment for responding flower farmers (Source: Survey 2, 2021)

Figure 45 displays the estimated cost of respondents next planned automation investment. The cost for medium and large growers was considerably higher than that of small growers. Across all respondents, the average cost of the next investment was \$1.73 per square foot of production area. Extrapolating the anticipated next expenditure in automation to the entire sector would imply an approximate automation investment of \$32 million, which is well within the range estimated in Figure 16 (section 7.1) of between \$20 and \$49 million. Again, this estimate must be carefully considered carefully bearing in mind the low sample size of Survey 2.

Further exploring the cost and outcomes from the stated next automation investment by farms suggests that on average a farm will spend \$88,900 to reduce their workforce by one worker, or \$77.40 to reduce their staff-hours by one hour.

It is important to also recognize that expenditure on automation is not entirely linked to the purchase of new equipment. Increased automation comes with both maintenance and upgrade costs as product in demand continues to change. Farms investing in automation must also consider costs of equipment upkeep and regular upgrades for increased capacity.

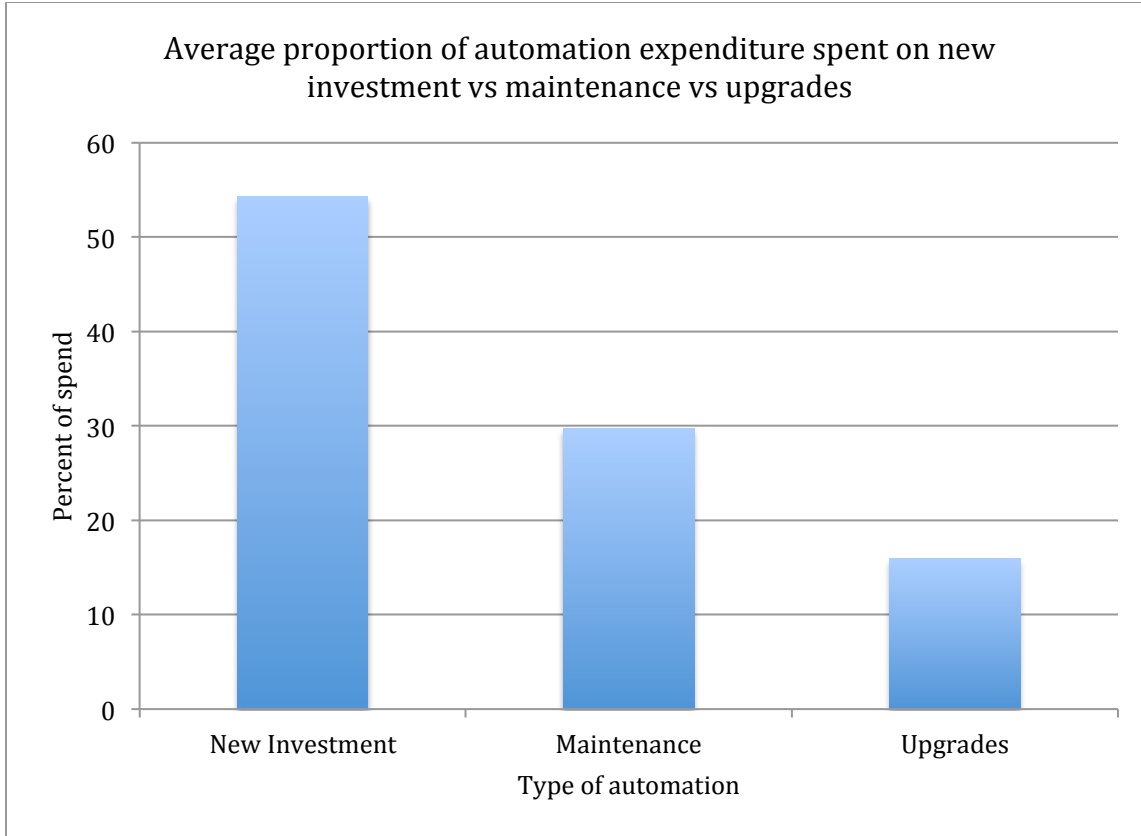


Figure 33. The average proportion of automation expenditures on new investments versus maintenance versus upgrades (Source: Survey 2, 2021)

New purchases account for, on average, over 54% of a farm's automation expenditure, while 30% of expenditure is assigned to maintenance with over 15% to upgrades.

Despite the opportunity for automation investment, many farms continue to seek other investments to help further improve their business.

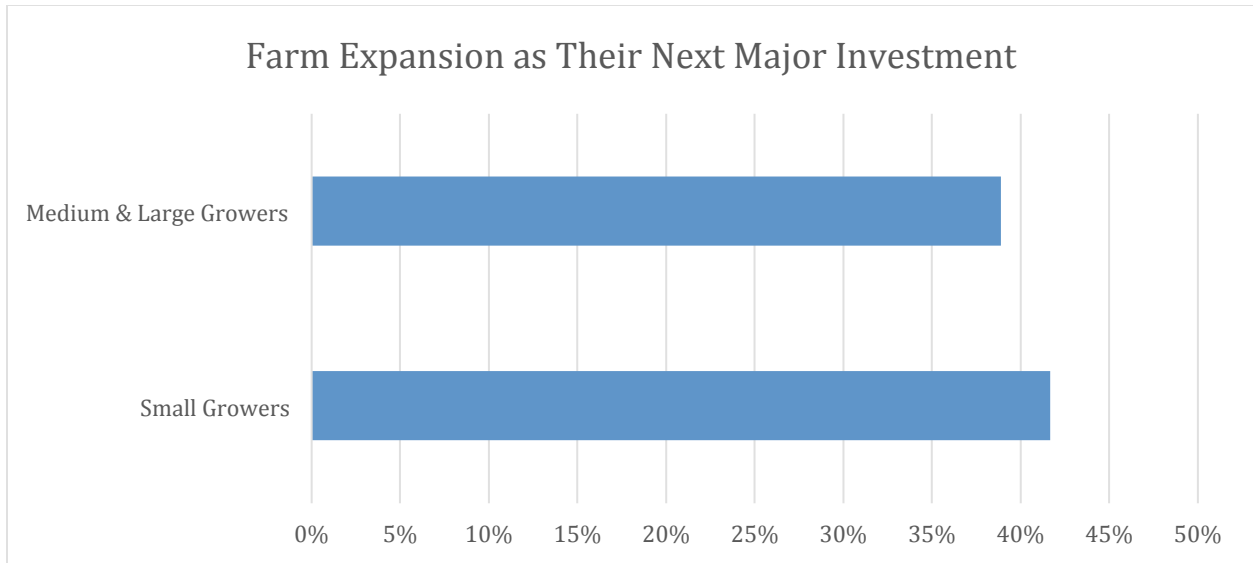


Figure 34. The percentage of respondents who indicated that a farm expansion was to be their next major investment (Source: Survey 2, 2021)

For many growers, expanding their growing area is a priority. Approximately 40% of respondents to Survey 2 expressed their prioritization of farm expansion over automation expansion (Figure 47). While there are many explanations for this, two major contributing factors could be that farm expansions come with considerably less risk and farm expansions have historically offered a higher return on investment.

### 10.3. Barriers to Automation

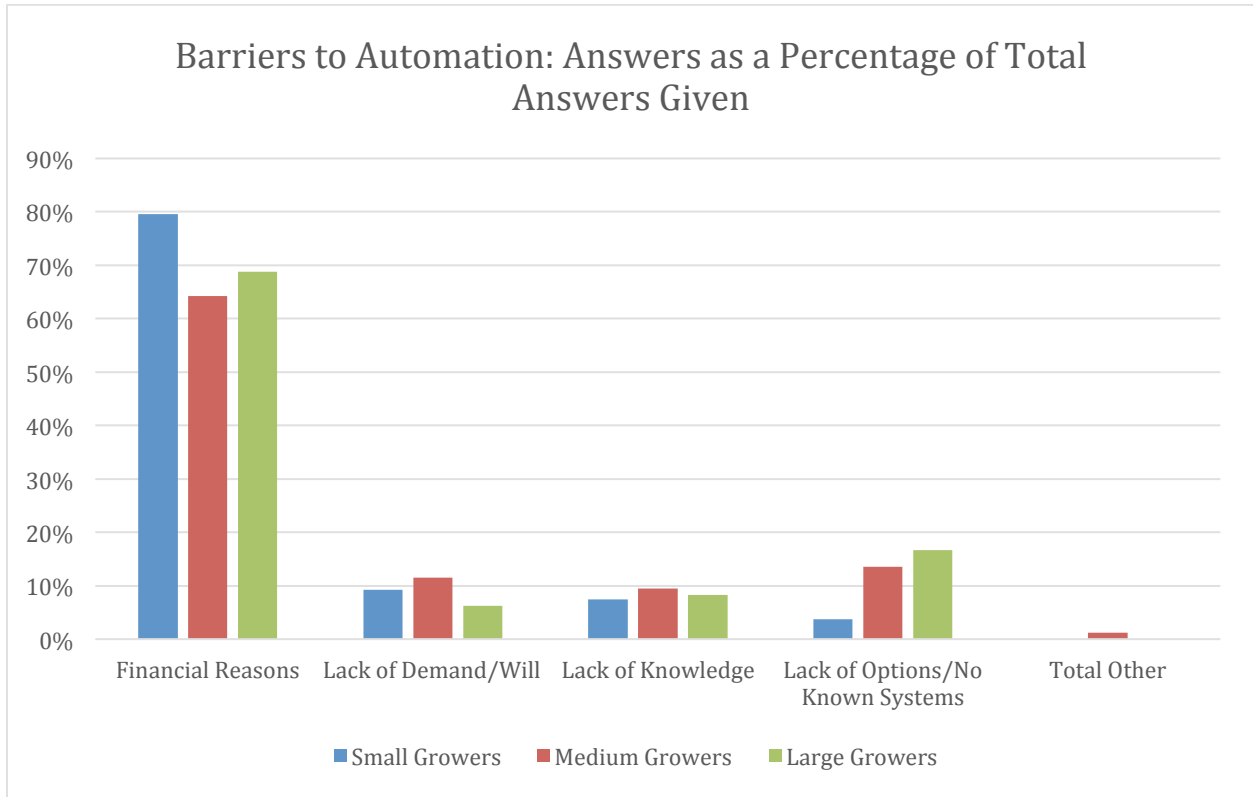


Figure 35. Barriers to automation on farms of various sizes (Source: Survey 1, 2021)

Less than 10% of the responses indicated that they didn't have enough knowledge in order to expand their automation systems. For large growers, 20% of barriers to automation were linked to no system existing that suited their needs.

Financial barriers were by far the most reported barriers to expansion of automation on Ontario's flower farms. Financial barriers may include access to credit, willingness to take on debt, or cost of equipment compared to relative return. Determining accurate ROI's for these technologies within the context of this study has not been feasible due to custom pricing and general supplier hesitancy to share costing information.

Financial barriers to automation were consistent for small, medium and large producers, regardless of the automation category they were investigating. The next three figures explore barriers to automation for each producer size within each automation category.

**Barriers to Automation: answers as a percentage of total answers given - small farm**

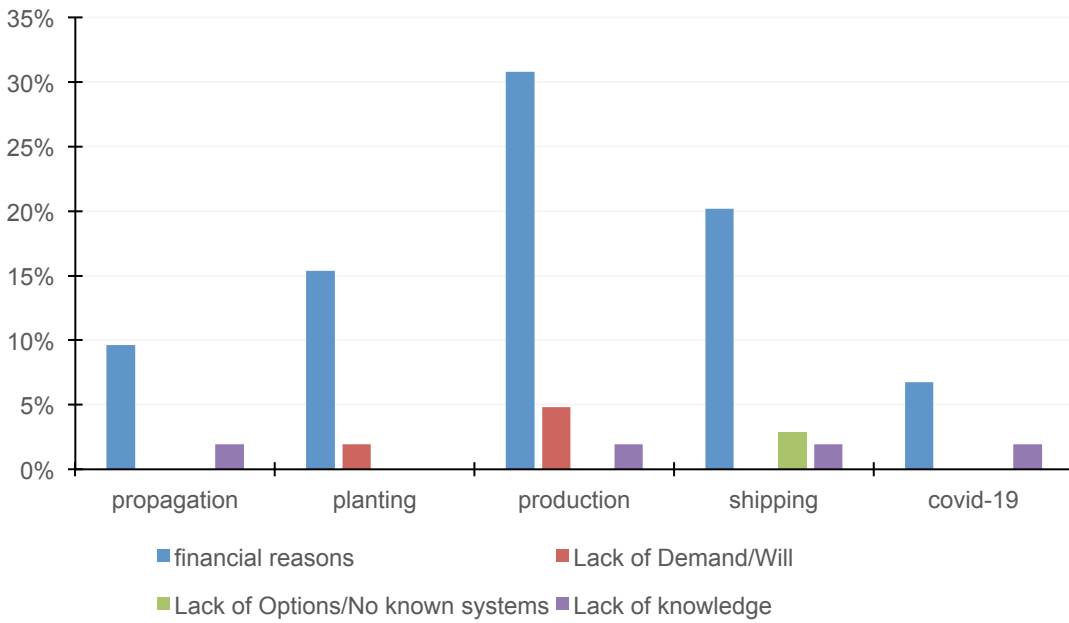


Figure 36. Perceived barriers to automation of specific tasks provided by small farms (Source: Survey 1, 2021)

**Barriers to Automation: answers as a percentage of total answers given - medium farm**

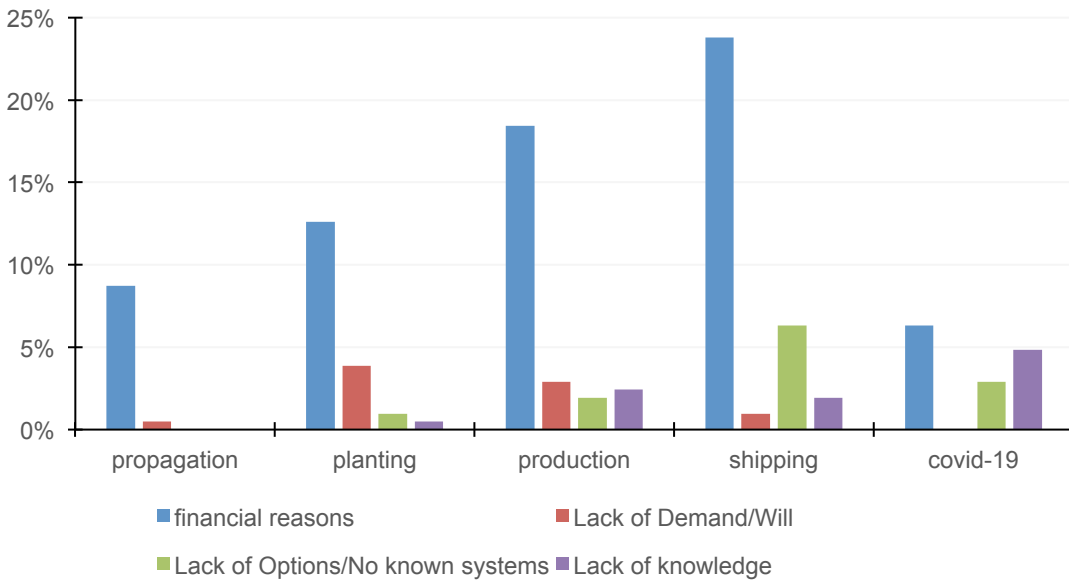


Figure 37. Perceived barriers to automation of specific tasks provided by medium farms (Source: Survey 1, 2021)

### Barriers to Automation: answers as a percentage of total answers given - large farm

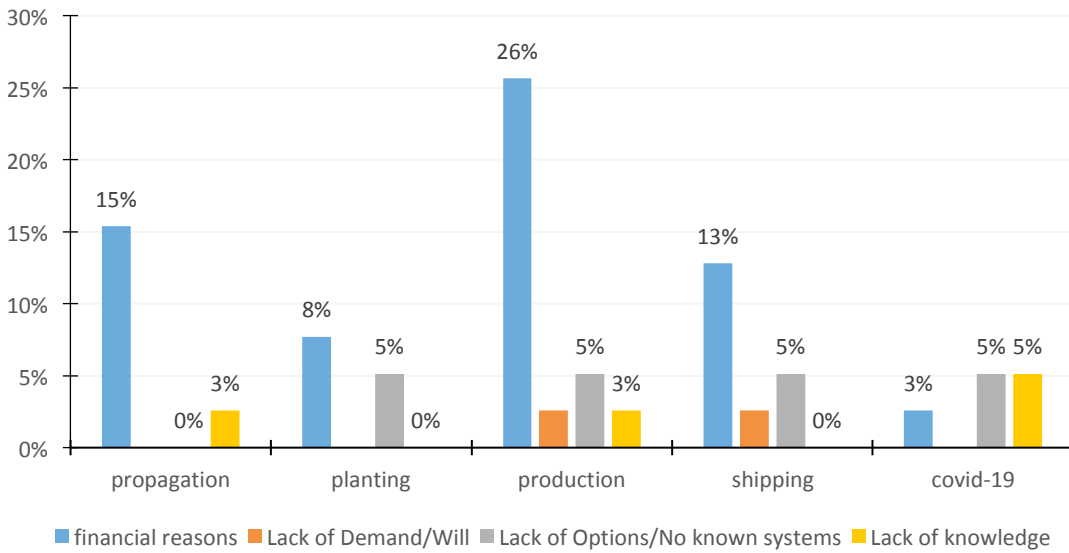


Figure 51. Perceived barriers to automation of specific tasks provided by large farms (Source: Survey 1, 2021)

Financial barriers were paramount for small, medium, and large producers for all farm tasks other than for COVID-19, though the barrier was especially pronounced for "production" automation equipment. Financial barriers do not appear to be key in the decision to adopt COVID-19 automation equipment.



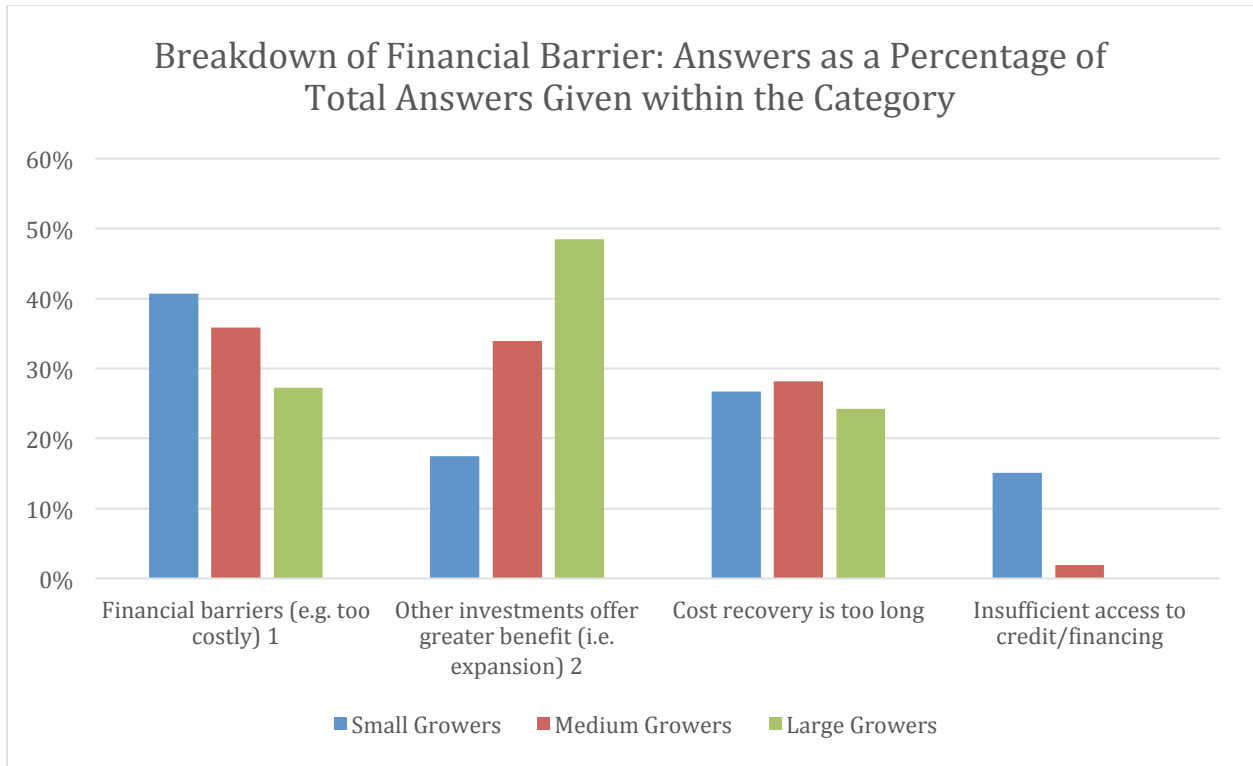


Figure 52. Summary of financial barriers provided by various farm sizes (Source: Survey 1, 2021)

Break down of financial reasons further indicates that access to credit/financing is not a major barrier for medium and large farms, while all farms are concerned with the cost of adopting new technologies. These barriers may include the equipment being too costly, or the cost recovery period being too long - both of which can be solved through cost share programs or investment in the agricultural sector while the potential of increased demand should lower the price of equipment in the longer term. New technologies may need time on the market before the required capital investment decreases. The “Other investments” response is challenging to interpret because a farm may be willing to invest in some technologies that have a greater perceived value than others to the business. Not all of these decisions are based on full cost analyses.

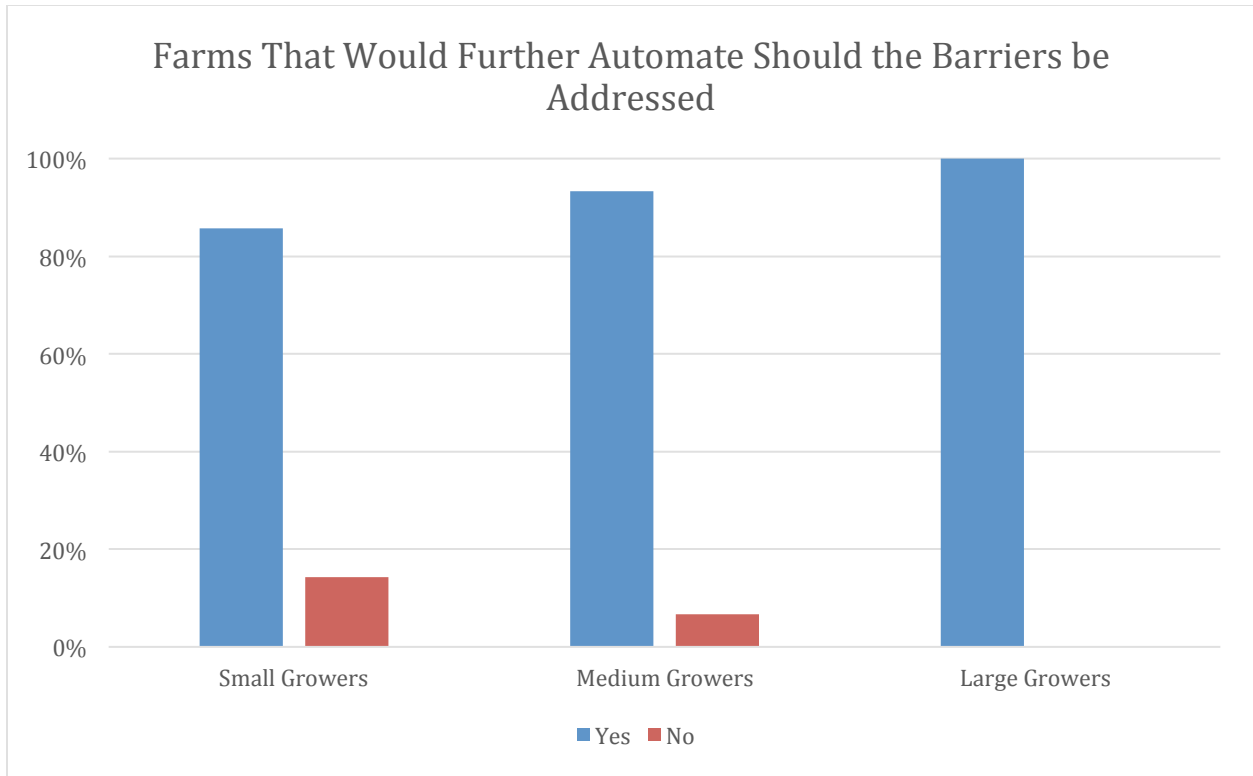


Figure 53. Degree of motivation to automate based on farm size (Source: Survey 1, 2021)

Finally, if the barriers were addressed most growers would advance automation on their farm.

## **11. Conclusions and Summary**

This study explored a wide array of factors influencing the status of automation in Ontario's flower growers, with a broad aim to:

1. Characterize the state of automation in the floriculture sector
2. Determine the opportunity to offset the risk of COVID-19 using automation
3. Characterize the opportunity to increase productivity using automation
4. Explore strategies to encourage automation uptake in the sector

Each of these priorities are explored individually below.

### **11.1. Observations the State of Automation**

The vast majority of farms have begun automation or are automated to a high degree, though smaller growers have less on-site automation than their larger counterparts. Similarly, cut flower growers appear to be less automated than potted or seasonal plant producers. Regardless, all producer sizes and product types showed eagerness to further invest in automation indicating that the floral sector can indeed expand its automation systems. Despite the opportunity for more expenditure, farms are investing between 2.5% and 6% of annual revenue into new automation systems every year, which equates to between \$20 million and \$49 million annually.

Within the sector, some types of automation systems appear to be more common than others. Soil and potting machines were the most common automation system on farms, followed by irrigation systems. Packing systems appeared to be much more present on large farms than on medium and small farms.

### **11.2. Determining the Opportunity to Offset the Risk of COVID-19 Using Automation**

The activities of highest risk of spreading COVID-19 (across all farm sizes) were considered to be packaging and planting; activities that are presently highly automated within the farm community. In addition, 80% of respondents reported having automation systems present in use for tasks that could provide heightened COVID-19 mitigation. In validating whether or not farms believed that their current automation systems specific to production activities (i.e., propagation, planting, production and shipping) could reduce COVID-19 risk, 40% of respondents did not believe their automation would reduce risk. Sixty percent of respondents believed that their systems would reduce risk through either co-benefit of reducing labour, enabling distancing on the farm, or through having systems specifically designed to reduce COVID-19 risk. Within this group, only 5% reported having systems to specifically address COVID-19.

In short, automation systems are available for key COVID-19 risk areas, though few systems are available to directly and specifically offset COVID-19 risk, and most of the COVID-19 protection comes from the co-benefit of enabling distancing or reducing workforce numbers. Technologies that specifically target reducing COVID-19 exposure risk are limited (e.g., screening, sanitation, ventilation), however, there is a desire by farms to adopt these technologies if they become available, as 16% of all responses indicated a willingness to invest in COVID-19 automation.

### **11.3. Characterize the Opportunity to Increase Productivity Using Automation**

Improving productivity through increasing output, reducing workforce, or both, has long been thought to be key justifications for automation investment. Historically, the floriculture sector has seen considerable improvements in labour productivity despite fewer workers being required to increase revenue and production area. The worker population in the sector has continued to decline, though output and revenue have both increased.

This study showed clear relationships between labour, automation investment, and productivity. Farms which added more labour saw greater increases in production output, indicating that adding labour is a clear and predictable path to increasing production output. Similarly, farms that invested more in automation saw greater increases in production output, but with a somewhat weaker relationship than adding labour.

Considering that automation was shown to increase productivity, it was postulated that increases in automation would also enable farms to reduce their workforce per unit of production. Conversely, no detectable relationship was found between increasing automation investment and labour force present on a farm. The minor relationship present indicated that, if anything, farms that spent more on automation were more likely to increase their workforce than reduce it.

These results imply that automation can indeed improve productivity on a farm, but farms that automate may be more likely to move workers out of automated tasks and into other roles to further expand productivity, as adding labour to a task very clearly improves production output. Further, the hypothesis that increasing automation on flower farms may reduce COVID-19 risk by reducing worker populations does not appear to be a realistic assumption in practice.

#### **11.4. Explore Strategies to Encourage Automation Uptake in the Sector**

Understanding the motivation of farms to automate, their automation priorities, and barriers to automation were considered to be critical to encouraging farmer uptake of automation systems.

This study indicated that potted and seasonal flower producers showed far greater interest than cut flower producers in expanding automation systems across all available systems. Similarly, larger farms had the greatest interest in expanding automation in nearly all categories, followed by medium and small farms.

Farms indicated that their top priorities in automation included targeting production and efficiency improvements, followed by reduction in labour or worker hours, and then by quality of product improvements. Many farms indicated that numerous automation priorities were relevant including worker safety, customer specifications, and crop change capacity. Productivity and labour were the most important automation targets, but not the only automation targets.

Farms expressed interest in numerous automation systems for their next automation purchase, but the anticipated outcomes from these purchases helped to identify further benefits of automation. Across all systems anticipated for purchase, respondents were anticipating a decrease in workforce by over 8%, a decrease in staff-hours by just over 10%, but an increase in productivity by 47%. This outcome, when considered with the previously identified relationships between automation, productivity, and labour, further indicates that farms are finding the greatest automation benefit in improving production output and not in workforce reduction.

The cost of automation for floriculture can be significant. On average, medium and large farms anticipated that their next purchase would cost over \$300,000, and new investments in automation often come with increasing maintenance and upgrade costs. Farms reported that their annual automation expenditure included approximately 55% dedicated to new equipment, 30% for maintenance and 15% for upgrades. The cost of automation must also be weighed against other investment opportunities for farms: approximately 40% of farms indicated that they would prioritize greenhouse expansion over automation.

Farms very clearly demonstrated that financial issues were the largest barrier to automation expansion, and nearly all other obstacles were inconsequential by comparison. Only 10% of respondents indicated a

lack of knowledge as being a barrier for automation; while 80% of small farms, 64% of medium farms and 69% of large farms indicated that financial impediments were an issue. Within financial barriers, nearly 50% of large farms reported that other investments held greater benefit, while for small and medium farms the financial barrier was largely the cost was too great. The vast majority of respondents (100% large farms, 93% medium farms, 86% small farms) indicated that they would expand their automation if these barriers were offset in a meaningful manner.

Crop diversity of floral production from within Ontario flower farms presents a considerable financial barrier for automation – in that if a farm is growing dozens of plant species staggered throughout the year any one investment may only automate a small proportion of a farm's production for a limited window. As a result, single farms may be burdened with purchasing numerous ever-specialized pieces of equipment to enable further productivity expansion.

Regardless of these challenges, farms may be encouraged to expand their automation level should the financial barriers be offset. Considering that the average cost of automation expansion immediately desired was over \$300,000 per farm (with a median value of \$150,000), current incentivization programs may not be sufficiently lucrative to encourage automation uptake. Further, with investments in automation put on hold in favour of investments to protect workers through 2020 and 2021, there will be a pent-up demand for investments in the near term. Should financial programs be established to encourage automation in the floriculture sector, the eligible expenses must reflect the actual costs of automation. With appropriate incentivization in place, it is reasonable to assume farms would seek to invest in technologies that improve their productivity as a primary benefit. Potted plant and seasonal plant producers may be more likely to seek automation advancements than cut flower producers, with large farms expressing the greatest interest.

These investments would not likely result in reductions in workforce size on a farm, ensuring that new investments do not result in lost jobs for labourers. Rather, workers are more likely to be moved to other roles within the business, potentially enabling further protective social distancing and benefiting workers who desire to learn and work in more diverse roles. This overall focus on increased productivity that is not at the expense of workers is a strong driver for our economy as FCO members continue to invest in growth.

## **11.5. Final Statements and Recommendations**

This study has demonstrated that flower farms have invested considerably in automation and have significant opportunity for further automation expansion. Despite these opportunities, many of the technologies show limited opportunity to offset COVID-19 risk. Productivity remains the greatest opportunity for automation in the sector, and worker populations have not been reduced by automation advancement in the past. The greatest opportunity for encouraging further automation in Ontario's flower farms is to seek strategies or incentivization programs to offset financial barriers.

FCO recommends that incentivization programs for automation uptake avoid focus on specific outcomes such as workforce reduction or moving workers outside of specific farm roles. Numerous automation priorities were identified in this study, and the results highlight the need for funding that targets a diverse range of automation outcomes. Incentivization programs must provide sufficient capital to cover the extensive cost of automation tools - an average cost of \$300,000 was reported in this study, with median costs being \$150,000. FCO recommends increasing maximum value of incentivization cost-share share programs to at least \$300,000.

## **12. Appendices**

### **12.1. Appendix I - Survey 1**

Available on Request

### **12.2. Appendix II - Survey 2**

Available on Request

### **12.3. Appendix III - Equipment Database**

In the database, there are 4 tabs, Visual Matrix 1 (the “X” is also linked to the detailed information of the company to “Company product list”), Company directory (with the company number, name, and contact/website), Company product list (with all automation and technologies, as well as product for COVID-19 screening, site entry assessment), and Greenhouse control system (with companies that can provide environmental control, etc). This database is available on request.

## 12.4. Appendix IV - Visual Matrix

Visual Matrix: Company Name vs Technology Type

Company Name	Propagation (e.g. taking cuttings, sowing seed, sticking)	Planting (e.g. potting, transplanting)	Production (e.g. spraying, irrigation, applying/scouting biocontrols, trimming/pinching)	Shipping (e.g. picking/harvesting, packaging, boxing)	COVID-19 Management (e.g. screening, site entry assessment, ventilation enhancement)
A.M.A. Hydroponics	X				
AgriNomix	X	X	X	X	
Beijing Sangreen International Agricultural Tech	X	X	X		
Bellpark Horticulture	X	X	X	X	X
Bercomex Flower Processing Solutions		X		X	
Blackmore Company	X	X	X		
Bold Robotics		X	X	X	
Bosman Van Zaal			X	X	
Bouldin & Lawson	X	X	X		
Codema			X		
Da Ros	X	X	X	X	
Ellepot		X			
ErfGoed			X		
Eurotec B.V			X		
Flier Systems	X		X	X	
Global Horticultural Inc.				X	
Hamill Agricultural Processing Solutions Inc.			X	X	
Harvest Automation			X		
HAVAtec				X	
Helper Robotech Co.	X	X			
HETO Agrotechnics		X	X	X	
HT Verboom Transport System			X		
ISO Group		X		X	
Jamafa Machinery B.V.			X	X	
Javo U.S.A. Inc.		X	X		
Jiangsu Grow-Green Agriculture Co. Ltd.	X	X			
Logiqs			X		
Machinerie S.B. Inc		X	X		
Martin Stolze	X		X	X	
Metazet FormFlex			X		
Niagara Seeder	X				
PB tec Canada Ltd			X		
Premier Tech Systems and Automation			X		
Rapid-Veyor			X		
RISHA			X		
Southpoint Automation			X	X	
TAVA Systems		X	X		
TTA		X	X	X	
WPS - We Prove Solutions			X	X	
Zwart Systems			X		
Northern Dock Systems Inc.					X
Kontrol Energy Corp.					X
Tequipment					X

Note: X in red means the approximate cost is known.

2021-03-29