

Final Report

Agri-technology investment opportunity in the mushroom industry

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MU18002

Project:

Agri-technology investment opportunity in the mushroom industry MU18002

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Content

Agri-technology investment opportunity in the mushroom industry	1
Content	3
Summary	4
Keywords	6
Introduction	7
Methodology	8
Outputs	11
Outcomes	15
Monitoring and evaluation	17
Recommendations	19
Refereed scientific publications	19
References	21
Intellectual property, commercialisation and confidentiality	24
Acknowledgements	25
Appendices	26

Summary

MU18002 has scoped and assessed potential technologies in global markets and complementary industry sectors that could be utilised by the Australian mushroom growers to achieve key goals of the industry. The overall outcome has been a select number of prioritised options for the industry to explore further, through a series of recommended next steps. KPMG have completed this project with Horticulture Innovation Australia Limited (Hort Innovation).

The first phase of the project sought to understand the industry's needs and challenges, including the current state of technology use and pain points across specific stages of the supply chain that would benefit from technological advancement. A kick-off workshop with the Mushroom SIAP was followed by a number of targeted grower interviews and site visits, resulting in a list of priority areas that scoped technologies should seek to address – forming the seven 'core criteria' by which each identified option would be graded. These included:

- Has the potential to cut input or production costs.
- Has the potential to value-add/increase quality.
- Has the potential to increase the yield (quantity).
- Limited capital investment required.
- Low-level training skillset required.
- Acceptable time frame for adoption.
- Predicted average ROI within 3-5 years.

During this first phase, a number of parameters for the analysis were also defined. From a longlist of major mushroom producing countries, three geographies were selected for particular focus during the industry consultation sessions. These included China, Japan, and Western Europe as a result of their scale, extensive use of agri-technologies, and best practice reputation respectively. Three core sectors of interest were also agreed as mushrooms, protected horticulture, aerospace. In addition to these 6 key markets/sectors, technologies identified from additional markets including USA, Canada, and Israel, and other industries were considered as a result of their potential to be complementary to the mushroom sector.

In the second phase, research was conducted across the in-scope countries and parallel sectors. Alongside desktop analysis, KPMG utilised its network in the target markets – with offices across Europe and Asia, to connect to specialists and opportunities in those locales. A patent search and analysis of academic journals also formed part of this multi-pronged research period.

The research uncovered a significant number of technology options for the mushroom industry. These were filtered into a longlist that was seen as having potential to address the particular Australian context and key challenges noted by growers in the earlier phases. Thirty one (31) technologies in total formed this longlist and are profiled in the final report. Their key details have been noted in the document, including background to the company, and how the technology operates/functions. Each profile then also maps the technology against the seven core criteria of assessment and the 'technology readiness level'. This has resulted in ten of the options being prioritised as of greatest relevance to the Australian mushroom industry – meeting the greatest number of the core criteria and being seen as having the largest potential to support industry growth in the shorter and longer terms.

Alongside prioritising ten technology options, a series of next steps has been framed for industry. The roadmap to commercialisation offers a series of clear, progressive ways in which the industry should develop an understanding of the options, form individual cost-benefit analysis, conduct farm trials, seek investment, and then support implementation. Particular activities to be conducted and the roles of various stakeholders along the mushroom value chain has also been noted, which includes how Hort Innovation can continue to support technological adoption in the mushroom industry.

Overall, MU18002 has followed a focused methodology and approach to identify technologies from across the world and alternative sectors, and to consider those most relevant to the Australian mushroom industry. The outcome of the project is that with ten prioritised opportunities, the industry will be able to focus efforts to advance through technologies with the potential to address their pain points. There is also a clear suggested pathway in which the Australian mushroom industry can engage with and implement technology to drive growth in the sector.

In addition, the research identified a number of technologies that were considered to be of interest to the Australian mushroom industry, however of lower priority. These technologies were classified as “technology to watch”. Typically these technologies are in the earlier stages of market and technology readiness and/or would require adaption from another sector or industry. Profiles for these technologies have been provided as well as a suggested pathway for next steps such as exploring interest and sources of funding for research collaborations / technology co-development for the Australian mushroom industry.

Keywords

Mushrooms; Technology; Global Markets; Commercialisation; Efficiency; Quality; Agtech; Agritech; Innovation; Internet of Things; Robotics, Automation, AI, Artificial Intelligence

Introduction

MU18002 has sought to identify and assess the opportunities for agri-technologies to be used in the Australian mushroom industry. A need was identified by the industry and Hort Innovation to conduct this research given developments and trends in international mushroom industries. In many major mushroom producing nations, there have been growing levels of research, development and commercialisation of digital technologies. The Australian sector needed to quickly understand these technologies in order to not be left behind, and to leverage global best practice to drive industry growth.

Particularly in European nations, the mushroom value chain is increasingly shifting towards automation and applying technology to create efficiencies that benefit growers. These trends were understood by the Australian industry, but there was a lack of specific detail and understanding of which of these agri-technologies being adopted elsewhere may be most beneficial for the specific Australian context. Learning of the spread of opportunities and best practices abroad and then understanding how to apply and scale these back in Australia, was thus seen as a critical next step in the industry's development.

Alongside the opportunities that technology presents, and seeking to benefit from these, addressing the Australian mushroom industry's key challenges was a further factor leading to MU18002 being commissioned. Lowering production costs, increasing yields, and improving product quality were seen as crucial points for the industry to address. Growers and Hort Innovation recognised that technology has a role to play in improving across these metrics, and thus a project scoping technological options that have the potential to enhance each of these factors was formed. Therefore MU18002 was driven by both the opportunities and challenges faced by the Australian mushroom industry.

The significance of the project to the industry is that through improved understanding of existing and developing technologies as well as technologies in parallel sectors, the Australian mushroom industry is better positioned to capture opportunities and address challenges for sustainable, profitable growth, yield improvement, risk management and cost reduction across growing, harvesting and processing.

Methodology

The below methodology was followed to carry out MU18002. A staged approach was used in order to ensure that targeted objectives were met at each phase.

Phase 1: Setting industry priorities for agri-technology solutions

The objective of this phase was to understand the needs and priorities of the industry for the project. This would ensure that the research and assessments conducted in later phases are relevant and to the industry and improve the existing knowledge of growers. Alongside kicking off the project, industry was consulted to shape the assessment criteria and parameters of the next phase's research.

The Phase included:

- Completion of related Hort Innovation project documentation, including the program logic, monitoring and evaluation plan, stakeholder consultation plan, and project risk register.
- A kick off workshop with the mushroom industry SIAP, Hort Innovation and KPMG in attendance. The focus of this session was to confirm the project objectives, timelines and activities, as well as setting scope parameters for the project. These included:
 - Key priority areas along the supply chain – identified areas of interest as determined by the SIAP were input supply, production, post-harvest. Processing and end consumers were classified as out of scope for the research.
 - Markets and categories for assessment – a number of sectors and technology types were identified by SIAP members as of particular interest for investigation – mushrooms, protected horticulture, aerospace/aviation, and other food/industries. In addition, based upon a long list of major mushroom producing markets, China, Japan and Western Europe were selected as core research regions as a result of their scale, and reputation for using agricultural technologies and best practice. These 7 regions/ markets formed the core focus of the Phase 2 research. In addition to this scope, artificial intelligence and digital platform technologies were considered as were relevant technologies from regions outside the core focus.
 - Core criteria for assessment – a discussion was held to determine the criteria upon which each scoped technology would be assessed. This would enable prioritisation of the technologies in the final phase according to how well they may address the needs of the specific Australian industry context. The SIAP indicated a number of key challenge and opportunity areas that are faced across industry, and various ways in which a technology could impact upon these. A list of draft core criteria were then formed, and road-tested during further stakeholder consultations.
- Targeted consultation interviews were then undertaken with individual growers to validate the discussions at the kick off workshop and the drafted core criteria for assessment. These were conducted both in-person during site visits where practical and efficient in terms of managing the project timeframes/budget, and via the phone in other instances. These sessions asked growers to consider the specific needs of their business, and how technology can play a role. Previous and existing attempts to integrate technology were discussed, so that key learnings could be built upon in the remainder of the project and the deliverable outputs.

Phase 2: Agri-technology global hubs solution scanning

The objective of this phase was to identify a long list of potential technology options available to mushroom growers, by scanning the agreed global markets and complementary categories. Analysis of desktop sources, academic journals, patents and industry SME insights were utilised to complete this Phase.

The Phase included:

- Research was undertaken to uncover relevant technologies and businesses across the agreed

market/category parameters. Technologies covered the entire mushroom value chain, and both commercial and research activities.

- Multiple sources were used for this desktop-based assessment, including:
 - Online public sources – KPMG searched across reliable and current data sources, including industry associations in foreign markets, global research institutions, and other organisations.
 - Patent databases – a high-level scan of patents relating to mushroom growing was completed, which included both global patents and locally-specific patents in the assessed countries.
 - Academic journals – recent research publications were reviewed (within the past 3 years), to understand latest academic developments relating to mushroom industries and complementary technologies.
 - KPMG’s global network – agriculture and technology specialists from across KPMG’s international network were interviewed to direct the project team to relevant resources and options. Direct insights from several venture capital investors and Wageningen University & Research were also gathered to direct the research focus.
- The Phase culminated in a long list of thirty one (31) technologies across the selected markets/categories that may be relevant for mushroom growing. Each of these options was profiled as to their stage of commercialisation, business owners, and how the technology operates, as seen on each technology slide in the main report pack. These details allowed an assessment in Phase 3 according to the relevance that each long list option holds for the Australian mushroom industry context and core criteria set in phase 1.

Phase 3: Assessment of agri-technologies for mushrooms within the Australian industry context

The objective of this phase was to analyse and prioritise each of the identified technology options according to whether they meet the core criteria for the Australian mushroom industry and thus would be likely to be suitable for the specific context in Australia. Though many of the technologies may be suitable in their respective markets/sectors, not all would address the key challenges and opportunities raised by the Australian industry. Therefore, each option was graded and prioritised accordingly – leading to a short list of high potential technologies, and a series of next steps for adopting them.

The Phase included:

- Criteria assessment – The project team cross-referenced between the agreed core criteria and the technology profiles of phase 2 findings, and graded each technology as to whether they are likely to fulfil each criteria metric given their details. Rational was provided for each decision on the profiles, with the options then scored between 0 and 7.
- Prioritisation – Based upon the assessment with the core criteria, technologies were prioritised according to the number of criteria that they met and therefore their likely relevance to the Australian mushrooms industry. Ten technologies out of the 31 identified in phase 2 were flagged as recommended for further assessment and progression by the industry. These each met four or more of the criteria and therefore are likely to be highly relevant in meeting the needs and challenges of the Australian industry that were identified in Phase 1. These 10 options were highlighted in a section of the report.
- Roadmap to commercialisation – A series of next steps were identified, for how industry can progress now that a number of technologies have been identified and prioritised. KPMG’s innovation and agri-technology SMEs were engaged during this stage for specific insights relating to how other industries have previously scoped, trialed, invested in and then adopted technologies to improve their operations. The strategic, operational and financial factors related to this were all considered, alongside the idea that each grower will have slightly nuanced perspectives and needs.

- Final reporting – A final report has been produced, which lays out the information from each of the above phases. The report summarises the methodology utilised on the project, the prioritised and additional researched technology options, and the next steps commercialisation roadmap. The report has been socialized with Hort Innovation and certain industry members for feedback prior to being finalised for release.

Outputs

The major deliverable for project MU18002 was an agri-technology scan of opportunities for the Australian mushroom industry in the agreed seven markets and complementary sectors. The high-level structure of the report, with a description of the section and examples of slide outputs, is as follows:

- **Executive summary**

The executive summary offers a quick-stop overview of the below sections and the critical takeaways for a reader. Starting with the project background and an overview of the selected international markets and complementary sectors, the section also summarises the project’s methodology, how the technologies were ranked and prioritised, and the next steps for the industry to commercialise and adopt the priority opportunities.

- **Introduction**

The introductory section goes into greater detail as to the project’s background, methodology, and key industry drivers that shaped the research. It explains the five-step approach that was followed to conduct the work, including understanding the industry’s needs, forming assessment criteria, completing the desktop scan, engaging with stakeholders, and analysing the technology’s alignment to the criteria. It charts key learnings from the multiple consultations and interviews with growers, which shaped the project and the types of technologies that were researched. Overall, the section aims to provide the reader with sufficient context to understand how and why the following sections were conducted. Example slides can be seen below.

A targeted scan of leading markets and complementary sectors for relevant agri-technology for the mushroom growers

Project background

The global mushroom industry is experiencing a period of increased innovation. Along the value chain, growing, harvesting, packing and processes are being disrupted by emerging agri-technologies which have the potential to optimise grower outcomes.

Australia’s mushroom sector has the opportunity to further innovate to address some of the current challenges met by growers to lower costs (e.g. labour efficiency, waste, energy), increase yields (e.g. substrate quality, growth monitoring, selective harvesting and climate and airflow technology) and improve product qualities through fit-for-purpose technology solutions.

Vision for Australian mushroom industry

Enabling a more profitable and sustainable Australian mushroom industry by providing insights into the current global landscape of agri-technology solutions being used in mushroom growing, or with the potential to be applied to mushroom growing.

A project designed to scan leading agri-technology markets and relevant sectors across key priority areas along the supply chain

The defined scope of this research was established with the mushroom strategic investment advisory panel (SIAP) on 31st July 2019. The project had a core focus on upstream stages of the supply chain (inputs, production and logistics), three international markets (China, Japan and Western Europe), across three core sectors (mushrooms, protected horticulture, aviation/aerospace). Beyond these core markets/sectors, technologies identified from additional markets and industries were considered for relevance.

1 Key priority areas along the supply chain

Input Supply	Production	Post-harvest	Processing	End Consumers
<ul style="list-style-type: none"> Chemicals and supplies Input volumes required Composting process 	<ul style="list-style-type: none"> Airflow Temperature and humidity Labour Harvesting Disposing of waste Training & Service 	<ul style="list-style-type: none"> Handling (food safety) Packaging and labelling Traceability/provenance 	<ul style="list-style-type: none"> Value-added processing Alternate end product (i.e. mushroom leather) 	<ul style="list-style-type: none"> Marketing

2 International markets considered in scan

In scope markets considered

China Japan Western Europe

Additional markets considered

3 Sectors considered in scan

Mushrooms Protected Horticulture Aerospace/Aviation

Other Food or Industry

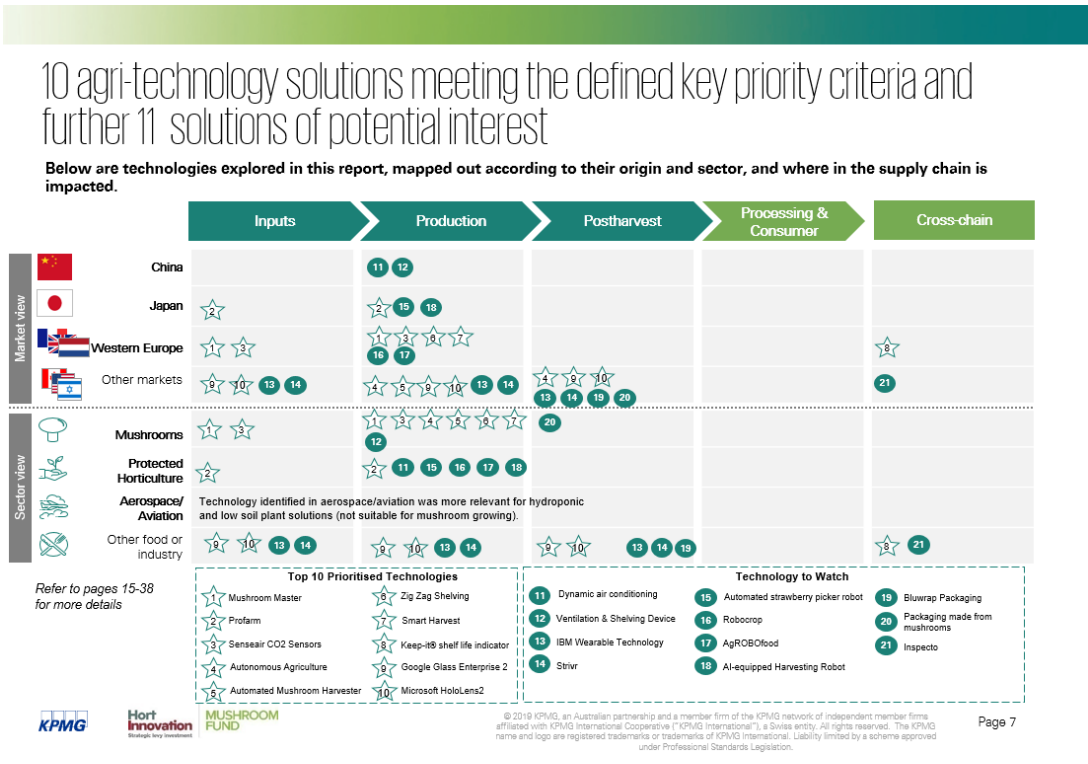
In addition technologies identified from other food or industry including artificial intelligence and digital platform technologies were considered.

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Page 5

● **Prioritised technologies**

This section contains profiles of the ten technologies that most aligned to the core criteria, and are thus viewed as high potential opportunities for the Australian mushroom industry. Each profile includes details as to the company and stage of the technology, high level overview of how the technology works, and maps the attributes against the seven core criteria for assessment. An example slide can be seen below.



Agri-technology assessment Top 10

TRL 9 – Actual system “flight proven” through successful mission operations

Mushroom Master

Drip-irrigation solution to enable precise irrigation as needed

Background

- Key investors/stakeholders: Netafim, Galilee Research Institute, Champignon Farm at Moshav Zarit.
- Established in 1965, Netafim’s drip irrigation products are considered easy to install and use.
- Mushroom Master irrigation solution was released to market in 2016 with testing carried out on 3 commercial mushroom farms with different growing techniques (one layer system and standard shelf system). Netafim claims that yields have the ability to increase by 4%-10%, casing soil usage can be reduced by up to 30%, energy and water costs are reduced by 20%, and A-quality mushroom harvest is possible from the third flush.

What is the technology?

- Commonly, mushrooms are irrigated by a moving sprinkler system. Sprinkler usage is limited and cannot be used during mycelium development. Mushroom Master applies drip irrigation pipes through the casings enabling consistent and optimal moisture to the growing substrates. This can be controlled through a computer or smart phone.
- With this low-flow and uniform irrigation method, the casing soil and compost are at optimal moisture levels throughout the growing cycle. Demonstrated benefit of increased stiffness and weight per unit. As you need to harvest less mushrooms to achieve the same weight, there are opportunities for labour cost savings per kg.
- The hydraulic infrastructure is a one time installation with the dripper lines rolled and fitted into casings and diverted aside when emptying the casing soils. It is recommended that dripper lines are replaced three times a year.

PDF with more information [here](#)
 Video available [here](#) and [here](#)

Relevance for Australian mushroom growers

Irrigation solution enables improved yield and quality, and input cost savings (water, energy, labour).

- Reduction in costs for energy and water as well as reduction in casing material.
- Improvement in mushroom quality (especially during the third harvest).
- The solution has demonstrated improved yields of +4%.
- Cost is dependent on size of mushroom farm (for example number of rooms, frames and shelves etc.). The cost of the dripper installation equipment is approximately A\$150,000 and cost for irrigation solution for a room with 12 shelves and 6 beds is A\$12,000.
- Training requirements are low.
- Already in use at 3 commercial mushroom farms internationally.
- ROI will need to be determined for specific mushroom sites.

Assessment of the technology based on the core criteria

Core criteria	# criteria met
1. Has the potential to cut input or production costs	Yes
2. Has the potential to value add/increase quality of the product	Yes
3. Has the potential to increase the yield (quantity)	Yes
4. Limited capital investment required	Yes
5. Low-level training skillset required	Yes
6. Acceptable time frame for adoption	Yes
7. Predicted average ROI within 3-5 years	?

Sources: 1) Netafim, Mushroom, Accessible [here](#), Accessed September 2019 2) Revaho, Mushroom Master, Accessible [here](#), Accessed September 2019 3) Communication with the company

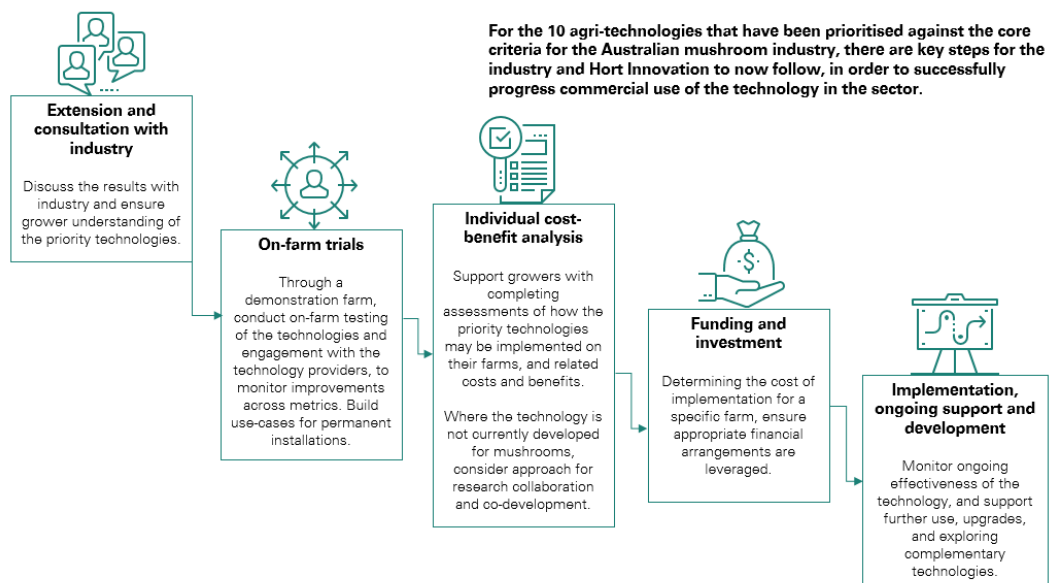
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• **Next Steps for driving technology adoption**

This section lays out a roadmap to commercialisation for Hort Innovation and the mushroom industry to follow in order to use the report’s findings to progress and ultimately adopt high potential technologies. Providing a simple five-step process, the section also gives practical suggestions as to immediate activities that can be conducted in order to drive industry engagement with the report’s outcomes, including trials, case studies, technology roadshows, and international technology exchanges. The roles of specific stakeholders in the value chain in enacting this process is also suggested. Example slides can be seen below.

The below roadmap is suggested to progress the priority technologies



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Specific activities to develop technology adoption in the Australian mushrooms industry can be immediately progressed

Across these next steps, specific activities should be undertaken by Hort Innovation and industry. These will have the combined effect of ensuring appropriate extension of the outcomes of this study, supporting practical and successful implementation of the priority technologies, and ensuring ongoing engagement in industry with the theme of technology-driven development.



Funding/project for trials

Hort Innovation and industry may consider funding trials of the technologies at a demonstration shed, to pilot the technology and develop use-cases of the benefits gained from use.

This will develop a basis for further use across other growers in Australia, and promote expertise in using the specific technology.



Technology open days for industry

The technology may be taken to the main growing regions for practical demonstrations or virtual reality insights with explanations from technical providers.

This would encourage ongoing engagement with the technology in-person, and regional spread.



International technology tours

To effectively connect the Australian industry to the technologies from abroad, and to develop networks that will enable future technologies to be more easily transferred, international exchanges or delegations can be sponsored.

Growers and industry could visit sites in other markets where technologies are being developed and have been successfully implemented for both mushrooms and parallel industries.



Case study development

Showcasing examples of where the technology has been successfully implemented in the Australian context is a method of demonstrating to other growers how it may be relevant for their farm.

Working with these businesses who are early adopters of the technology, may extend knowledge of the benefits and technology options to other growers.



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- **Appendices**

There are a number of appendices to the document. The most substantial contains the remaining technology profiles, of those classified as outside of the top ten priorities. The details thus remain in the report, for growers to follow up if particularly interested in one of the alternative options. A further appendix provides detail as to the consultations conducted during the project.

Outcomes

The key outcome for MU18002 listed in the Monitoring and Evaluation plan program logic was that:

‘The mushroom industry is able to better understand the current global landscape of agri-technology solutions being used in mushroom growing, with a focus on those that may be most advantageous for Australian growers to adopt or develop.’

With the two contributing intermediate outcomes identified as:

- 1) *‘Grower engagement and awareness in current and relevant agri-technology solutions to assist with mushroom growing.’*
- 2) *‘Growers awareness of better practice innovation developments in international markets.’*

We consider that these outcomes have been achieved.

The project was led using a stepped and collaborative approach to firstly incorporate grower perspectives and needs, and to ensure that the outputs meet the industry priorities as defined during the SIAP kick-off and industry consultations. Technologies have been assessed in line with the agreed set of core criteria and recommendations with clearly defined next steps for the industry to consider

The market scan was supported by a comprehensive desktop research, including patent searching, academic journals, global databases and insights from international networks.

From over 150 technologies identified, 31 were selected for detailed assessment based on 7 core criteria and 10 were prioritised as having the greatest relevance to the mushroom growers of Australia.

The top 10 agri-technology solutions scored 5 to 7 on the core criteria list. Solutions are currently in use for mushroom growers globally or could be transferable from other food sectors, have the potential to address identified challenges for Australian mushroom growers, and initial cost estimations are identified as reasonable with an ROI forecasted to be highly likely between 3 to 5 years.

The 10 technologies that were prioritised for further scoping and progression by the industry, met 5+ core criteria, are interested in Australian opportunities and have a TRL (technology readiness level) of 6+. These included:

- 1 Mushroom Master by Netafim – Applies drip irrigation through pipes laid within the casings enabling consistent and optimal moisture to the growing substrates.
- 2 Profarm - monitoring sensors are installed across the soil, power/electricity, lighting, temperature, irrigation and other input systems. Data is collected with real-time tracking and insights of growing conditions provided to the grower.
- 3 Senseair CO² sensors - Measures CO² levels with sensors and complementary systems enable tailoring of levels for optimal mushroom growing conditions.
- 4 Autonomous agriculture – System that integrates sensors, cameras, data collection, artificial intelligence and robotics to provide analysis on size, colour, disease/defects, and automate precise picking, sorting and packing.
- 5 Automated mushroom harvester - Automated harvesting system applying decision support, computer vision and suction picking. Vineland Research and Innovation Centre is pursuing commercialisation pathways for the technology.
- 6 Van den top Zig Zag shelving and harvesting machine - Zig Zag shelving that creates space for easier manual picking and access for mechanical harvesting. Van Den Top also has also harvesting machines that can be integrated with the shelving.
- 7 Smart Harvest - a smart visualisation system that guides manual harvesting through projecting

colours onto the mushroom bed providing picking recommendations. Mobile tray systems are required for the visualisation tool.

- 8 Keep-it® shelf life indicator - A real time shelf life indicator showing the actual degradation of packaged fresh food products based on time and temperature. The indicator constantly monitors temperature over time and so provides insight on cold chain storage and logistics as well as a more accurate expiry date for consumers.
- 9 Google Glass Enterprise 2 - Wearable smart glasses enable faster, smarter and safer businesses with improved quality of outputs. With customised application, there is the potential to reduce cost of manual labour through real time access to instructions, visualisation tools for grading and harvest readiness, and access to checklists.
- 10 Microsoft HoloLens2 – Mixed reality headset that provides hands-on workers with virtual reality applications for collaboration, real time access to work processes, 3D visualisation, and training.

The report has been socialised with Hort Innovation and certain industry members for feedback prior to being finalised for release.

Monitoring and evaluation

We consider MU18002 to have been a success – having received good engagement and feedback from key stakeholders. The outcomes noted in the previous section can be evaluated by tracking against the five key evaluation questions listed in the project’s Monitoring and Evaluation plan.

- *To what extent has the project achieved its expected outcomes?*

MU18002 has met the expected outcomes listed in the Monitoring and Evaluation plan. Please see the above ‘outcomes’ section for relevant details as to how the project has met the intended outcomes.

- *How relevant was the project to the needs of intended beneficiaries?*

Early interest from growers in the technology short list has indicated that industry participants have benefited from introductions to new technologies.

- *How well have intended beneficiaries been engaged in the project?*

Grower consultations and interviews were built into each stage of MU18002, involving the intended beneficiaries at each step of research and reporting. An article was also published in the Australian Mushrooms Journal Edition 3 2019 profiling the project and offering an open invitation to all industry participants interested to be involved in the project. In total 11 stakeholders were consulted during the process, which included in the initial kick-off workshop with the industry SIAP, and through individual site visits or phone interviews.

Intended beneficiaries played a significant role in shaping the project, in terms of how technologies were assessed, and which markets and sectors were scanned. Industry led the focus for the research by collaboratively setting the three international markets and three sector categories where analysis was to focus – ensuring that the following work built upon existing knowledge and addressed gaps in understanding relating to these specific markets and sectors. Furthermore, the industry was consulted as to the core criteria that were used to assess each technology. Developing a list of priorities for each technology option, this meant that the ten recommended technologies are those that best address the industry’s cited needs and challenges. Industry thus actively shaped how the assessments were approached, and what technologies were assessed.

- *To what extent were engagement processes appropriate to the target audience/s of the project?*

Growers who participated in the interviews and site visits got the opportunity to focus the research and engage with the consultants, and through the article “Opportunities in AgTech” in the Australian Mushrooms Journal Edition 3 2019 all sector participants were made aware of the project and opportunity to get involved.

- *What efforts did the project make to improve efficiency?*

A number of conscious decisions were made that allowed the project to run more efficiently and effectively. These were focused on project approach and operational/logistics factors.

Firstly, the delivery team was selected in order to improve execution of the project. Team members with specific previous experience in the horticulture sector and/or with agri-technologies were resourced, which enabled prior knowledge to be appropriately leveraged and built upon. The team were informed on key resources in which to scan for technologies, best practice for engaging with horticultural stakeholders, and could leverage existing networks.

Furthermore, the team was selected with appropriate geographic spread for the Australian mushroom industry. With the majority of production located in Victoria and New South Wales, team members were predominantly from these offices. This led to efficiencies relating to

reduced travel costs, and the ability to meet face-to-face with a greater proportion of stakeholders. Intended beneficiaries were able to be engaged with more efficiently. Adding to this, though a number of site visits were conducted, the cost of each trip was kept to minimum and those deemed too expensive or time consuming were completed as phone interviews.

KPMG's global agribusiness and agrifood tech network was leveraged to access in-market insights and contacts within key international markets to benefit the Australian Mushroom Industry.

Secondly, the project itself was designed to have future efficiencies in the mushroom industry for how technology options are assessed. The development of the core criteria that were used to judge opportunities in MU18002 can be carried forward to future assessments, allowing for a consistent approach that has been pre-verified by key Australian mushroom industry stakeholders. It is hoped that in future agri-technology scans and projects, these projects can be streamlined as there is a ready-made framework for industry to use.

The project approach was also deliberately phased, with key stage-gates or objectives set for each of the three major phases. This was designed to ensure that the project was process driven and robust in how it approached the industry's requirements. As a result of clear timelines being laid out in the project plan, given at a granular level, this ensured that the project ran more efficiently and was delivered on time, to budget, and effectively. Providing the team with set goals for each phase ensured that MU18002 was completed in a logical manner.

Recommendations

There were two sets of recommendations arising from project MU18002 – relating to specific technology opportunities, and next steps for commercialisation and adoption.

For the ten (10) agri-technologies that have been prioritised against the core criteria for the Australian mushroom industry, the five recommended key steps for the industry and Hort Innovation to now follow, in order to successfully progress commercial use of the technology in the sector, are:

- 1. Extension and consultation with industry** - Discuss the results with industry and ensure grower understanding of the priority technologies.
- 2. On-farm trials** - Through a demonstration farm, conduct on-farm testing of the technologies and engagement with the technology providers, to monitor improvements across metrics. Build use-cases for permanent installations.
- 3. Individual cost-benefit analyses** - Support growers with completing assessments of how the priority technologies may be implemented on their farms, and related costs and benefits. Where the technology is not currently developed for mushrooms, consider approach for research collaboration and co-development.
- 4. Funding and investment** - Determining the cost of implementation for a specific farm, ensure appropriate financial arrangements are leveraged.
- 5. Implementation, ongoing support and development** - Monitor ongoing effectiveness of the technology, and support further use, upgrades, and exploring complementary technologies.

Complementing these five steps, there are specific activities that Hort Innovation and the Australian mushrooms industry can engage in to build upon the report's findings in the short term. Four activities in particular include:

- 1. Funding/project for trials** - Hort Innovation and industry may consider funding trials of the technologies at a demonstration farm, to pilot the technology and develop use-cases of the benefits gained from use. This will develop a basis for further use across other growers in Australia, and promote expertise in using the specific technology.
- 2. Technology open days for industry** - The technology may be taken to the main growing regions for practical demonstrations and explanations from technical providers. This would encourage ongoing engagement with the technology in-person, and regional spread.
- 3. International technology tours** - To effectively connect the Australian industry to the technologies from abroad, and to develop networks that will enable future technologies to be more easily transferred, international exchanges or delegations can be sponsored. Growers and industry could visit sites in other markets where technologies are being developed and have been successfully implemented for both mushrooms and parallel industries.
- 4. Case study development** - Showcasing examples of where the technology has been successfully implemented in the Australian context is a method of demonstrating to other growers how it may be relevant for their farm. Working with these businesses who are early adopters of the technology, may extend knowledge of the benefits and technology options to other growers.

Refereed scientific publications

There are no refereed scientific publications published during the reporting period that can be attributed or partly-attributed to the project.

References

The below international contacts have contributed to the market scan for relevant technologies:

- Dr Johan Baars, Researcher Mushrooms, Wageningen University & Research, the Netherlands
- Professor Oded Shoseyov, Food and Agtech Fund JVP & The Hebrew University of Jerusalem
Head of Plant Biology, Israel
- Nitza Kardish, CEO, Trendlines VC Israel
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- Emma Wheeler, AgriFood specialist, KPMG New Zealand
- Idit Blank, Head of Agrifood Tech, KPMG Israel
- Thomas Beelaerts, Innovation and AgriFood, KPMG Netherlands

In addition to direct connection to the profiled companies, the following publications and sources of information were referred in the final report:

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Intellectual property, commercialisation and confidentiality

No project IP, project outputs, commercialisation or confidentiality issues to report.

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Project Input	Name	Organisation
Workshop	Michael Worthington	Chair, Mushroom Strategic Investment Advisory Panel
Workshop / Phone Interview	Steven Willemse	SJW Mushrooms
Workshop / Site consult	Tim Adlington	Parwan Valley Mushrooms
Site consult	Phil Higgins	Parwan Valley Mushrooms
Site consult	Munya Nyanhanda	Parwan Valley Mushrooms
Workshop	Kevin Tolson	White Prince Mushrooms & Elf
Workshop / Site consult	David Tolson	White Prince Mushrooms & Elf
Workshop	Mick Surridge	Scato Plus
Workshop	Elisa Siliato	Costa Group
Site consult	Jose Cambon	Costa Group (Adelaide Mushrooms)
Workshop / Phone interview	Geoff Martin	Dr. Mush

Appendices

Final report - MU18002 – Agri-technology in the mushrooms industry (pdf)