


AUSTRALIAN PROTECTED CROPPING STRATEGY 2021–2030

Opportunities for research, development and extension to support the adoption of protected cropping in the Australian horticulture industry


CONTENTS

ACKNOWLEDGEMENTS

The Australian Protected Cropping Strategy 2021-2030 was funded through the project *Australian Protected Cropping RD&E Strategy 2030* (AS19005) by the Hort Frontiers Advanced Production Systems Fund, part of the Hort Frontiers strategic partnership initiative developed by Horticulture Innovation Australia (Hort Innovation), with co-investment from the Department of Agriculture and Fisheries, Queensland (DAF), and contributions from the Australian Government and the Food Innovation Australia Limited (FIAL). FIAL contributed with funds towards the collaborative work with Strategic Journeys.

Published and distributed by: Hort Innovation
Level 7, 141 Walker Street
North Sydney NSW 2060
Telephone: (02) 8295 2300
www.horticulture.com.au

Queensland Government FIAL Food Innovation Australia hort frontiers Strategic partnership initiative ADVANCED PRODUCTION SYSTEMS FUND

FOREWORD

Horticulture production systems using protected cropping (PC) combine a range of technologies and agronomic practices to address climate variability challenges, crop biological constraints and market opportunities in the Australian horticulture industry. The Australian Protected Cropping Strategy 2021-2030 (the Strategy) provides horticulture growers and businesses, Hort Innovation and industry stakeholders with a clear direction and priorities for investment in research, development and extension (RD&E) initiatives to benefit vegetable, berry, nursery and tree-fruit value chains. The Strategy underpins activities not typically funded by Hort Innovation that will enable or contribute to PC adoption.

The Strategy is based on extensive consultation with industry stakeholders, as well as an analysis of global trends in the use of PC within horticulture: 47 groups/organisations and over 100 individuals were engaged as part of its development, including state and territory agricultural departments, industry associations, universities and educational centres, growers, producer and marketer groups, consultants, and input and service suppliers.

While the consultation confirmed several challenges and barriers to future growth that the sector is currently experiencing, there was also consensus about the opportunities to harness PC to drive industry growth in the horticulture sector. The information was used to identify PC RD&E outcomes and strategies, which were road-tested and refined with industry stakeholders throughout the first half of 2021.

The development of an Australian PC strategy for the next 10 years is a foundational input to future investment and will provide the wider Australian PC research network with a strategy and priorities for RD&E investment. Protected Cropping Australia and other key stakeholders including Hort Innovation and investors in RD&E will oversee the implementation of the Strategy.

ACRONYMS & ABBREVIATIONS

AgTech
Agricultural technology

DAF
Department of Agriculture and Fisheries, Queensland

E&A
extension and adoption

EMS
environmental management systems

FIAL
Food Innovation Australia Limited

IPDM
integrated pest and disease management

KPIs
Key performance indicators

M&E
monitoring and evaluation

NCC
National Construction Code

PC
protected cropping

PCA
Protected Cropping Australia

RD&E
research, development, and extension

RDC
Research and Development Corporation

SME
Small and medium enterprises

Strategy
Australian Protected Cropping Strategy 2021-2030

DEFINITIONS






Protected cropping is the production of crops within, under or sheltered by structures to provide modified growing conditions. The aim of PC is to maximise crop production and quality, extend or target supply periods, and provide protection from pests, diseases and adverse weather. Common structures include plant factory rooms, glasshouses, passive ventilated greenhouses, retractable roof structures, poly-tunnels, screen and shade houses, hail netting, row covers and floating crop covers.

For the purposes of the Strategy, the term **'PC systems'** is used to refer to whole-of-enterprise PC solutions. This term encompasses PC structures and related agricultural technologies. It was coined to reflect the fact that PC systems are much more than just the structures that cover the cropping system. PC systems also encompass all of the tools and technologies that are used within the cropping system to optimise plant growth and increase productivity. These tools and technologies are critical elements of the system and need to be refined and/or developed for specific use in covered cropping. In the context of the Strategy, PC systems can be used across a range of horticultural crops, particularly within the vegetable, berry, nursery and tree-fruit industries.

The **PC research, development and extension community** is the combined group of institutions and people that work and interact with each other in the plant production sector to help stakeholders find solutions, navigate pathways to PC adoption and prepare for future opportunities and challenges. The community will have participants from state and territory governments, the Australian Government, universities, funding agencies, industry and industry associations, as well as other domestic and international institutions.

THE STRATEGY ON A PAGE

The purpose is to provide a clear direction and priorities for research, development and extension investment to enhance the profitability of vegetable, berry, nursery and tree-fruit value chains by 2030

VALUE CHAINS

Develop profitable, diversified markets

INVESTMENT PRIORITIES

V.1. Identify profitable value chain opportunities for PC products

V.2. Identify opportunities to grow exports through PC

V.3. Showcase potential for product development and diversification through PC

V.4. Optimise postharvest quality of PC products

PEOPLE

Increase knowledge, capacity, and practice change

INVESTMENT PRIORITIES

P.1. Understand and address barriers to PC adoption

P.2. Examine the extent of PC adoption across Australia

P.3. Build industry capacity and capability to adopt PC systems

P.4. Identify approaches to building a skilled PC workforce

P.5. Investigate options to streamline PC development consents

TECHNOLOGIES

Optimise fit-for-purpose, cost-effective technologies

INVESTMENT PRIORITIES

T.1. Identify and adapt cost-effective technologies

T.2. Develop whole-of-enterprise PC systems and agronomy packages

T.3. Address current issues and limitations in PC systems

T.4. Harness next-generation PC technologies

T.5. Advance technologies and protocols for environmental sustainability of PC systems

T.6. Understand the economics of PC systems

ADOPTION OF NEW KNOWLEDGE AND 'BEST IN CLASS' PC SYSTEMS ACROSS AUSTRALIA'S HORTICULTURE INDUSTRY

2030 OUTCOMES

Australia's horticulture industry has harnessed the potential of PC systems to develop new and existing markets, domestically and internationally

2030 OUTCOMES

Australia's horticulture industry has improved capacity and capability to harness the potential of PC systems across a diversity of crops, regions, climates, business models and markets

2030 OUTCOMES

Australia's horticulture industry has access to cost-effective, fit-for-purpose PC systems to transform productivity, increase profitability and drive industry growth

A vision for a thriving Australian horticulture industry, which is positioned for growth, sustainability, prosperity and international competitiveness

Investment principles of strong collaborative practice, two-way learning, systems thinking and environmental sustainability

OVERVIEW

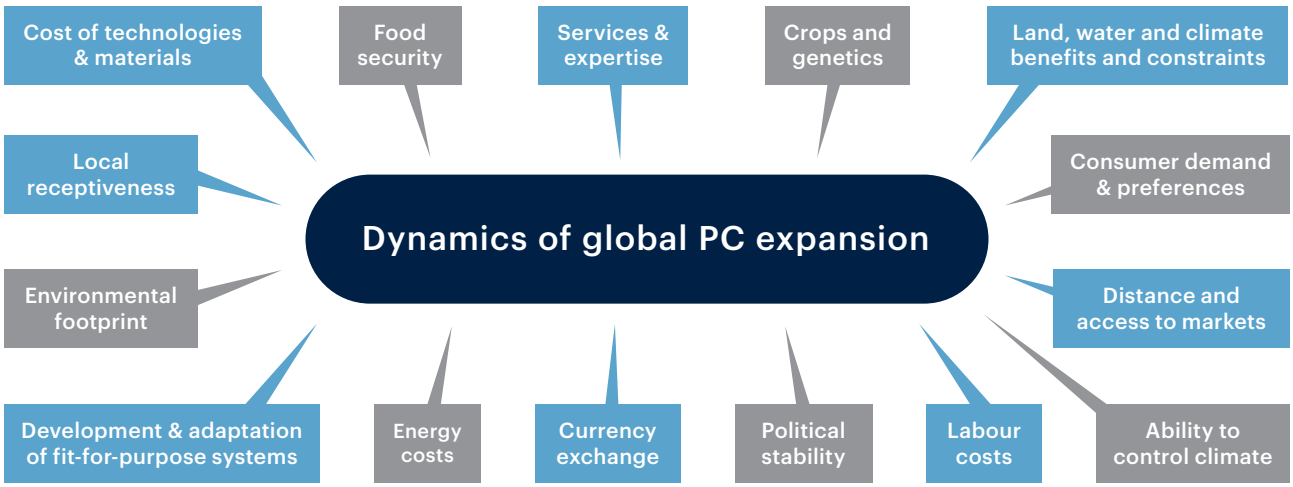
What is happening in protected cropping internationally?

Changes in consumer preferences for horticultural products have been the catalyst for sustained growth in PC development and investment around the world in recent decades. PC is now well-established in many countries and climates. China has the largest PC area in the world, estimated at 3.3+ million ha across all structure designs. Together China, Spain, South Korea, Japan, and Turkey have a combined PC covered area amounting to approximately 96 per cent of world total PC coverage.

The technology packages used around the world are diverse, ranging from simple to advanced systems, in terms of environmental control, automation and mechanisation. Traditionally, technology development has centred in regions with temperate climates (e.g. The Netherlands), desert climates (e.g. Israel), and mild winter climates (e.g. southern Spain). More recently, technology development has expanded into PC systems for subtropical and tropical regions. As farming systems undergo digital transformation, PC systems will continue to evolve and become more productive.

Crops grown under PC are mainly from the horticulture sector and a few of them drive most of the new investments. Nevertheless, the diversity of crops grown with PC is increasing. PC candidates include high value vegetables, berries, nursery plants, flowers, herbs and fruit trees. Although technology currently exists to grow horticultural crops anywhere/anytime, there are certain key factors that are shaping the dynamics of PC expansion throughout the world (Figure 1).

FIGURE 1. Worldwide factors shaping the dynamics of PC expansion



Global megatrends

There are five key megatrends shaping the global environment for agriculture[1]:

1. Growth juggernaut – three billion empowered consumers: rapid growth in emerging economies, particularly in Asia, will lift incomes, expectations, and economic capacity and demand for higher volumes and quality of food and fibre, including more diverse diets and more protein

2. Fractal politics – beware the dance of giants: deep shifts in economic, military and cultural power will continue to reshape the world

3. More from less – the permanent race for advantage: Maintaining profitable and competitive food and fibre enterprises will require ongoing innovation and change

4. Cascading planetary risks – coming, ready or not: accelerating changes in Earth systems at all scales are creating multiple risks, challenges and some opportunities

5. Disruptive technologies – opportunities for the brave: Exponential advances in digital technology, automation, genetics and synthetics will disrupt and change how food and fibre products are made, marketed and delivered

6. Positioning for the future – will the lucky country surf or sink? Australia is indeed lucky 'lifestyle superpower' with competitive industries, vibrant communities, unique landscapes and environmental assets. But unearned advantage risks complacency, and each generation needs to create the luck – and advantages – it will pass on to the next generation.

All five megatrends are directly relevant to PC in horticulture. PC systems are potentially **'disruptive technologies'** that have the ability to transform horticultural production, both in terms of helping to mitigate **'cascading planetary risks'** as well as driving gains in productivity to enable **'more from less'**. PC also enables consistent supply of high-quality products to meet the health, sustainability, provenance and ethics preferences of the expanded and empowered middle-class consumers arising from the **'growth juggernaut'**. In addition, uptake of PC systems will provide Australia's Horticulture industry with the flexibility to adapt to the changes in the global trading environment arising from **'fractal politics'**.

However, the question posed by the megatrends authors, "Will the lucky country surf or sink?", also applies directly to adoption of PC systems by the Australian horticulture industry. The industry benefits from Australia's vibrant communities, world-class RD&E capacity, unique landscapes and environmental assets. However, at present, adoption of PC within the industry is very low by world standards. The question for the future is "Can Australia's horticulture industry make the most of the opportunities presented by PC to **position for the future**"?

[1] Adapted from: Hatfield-Dodds, S, Hajkowicz, S, and Eady S. 2021. Stocktake of megatrends shaping Australian agriculture: 2021 update, Australian Bureau of Agricultural and Resources Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/w3be-an37

What is happening in Australia?

Australia's uptake of PC has been limited in comparison to other countries. In 2017 Australia ranked 28th worldwide, with a total area of 1,310 ha under glasshouses, greenhouses, and tunnels. Industry experts estimate that the current area under production is approximately 2,100 ha, with the recent addition of poly-tunnels for berries (400+ ha), low-cost greenhouses for cucumbers and capsicums, high-tech glasshouses (200 ha), high-tech polyethylene-covered greenhouses (50 ha) for tomatoes and cucumbers, and retractable roof structures (40 ha) for nursery, vegetables and fruit trees. In addition, there is a very significant area under screen/shade structures, across a range of crops.

The lag in PC adoption within Australia can be attributed to a lack of strong drivers for change. Australia has a diverse geography with good natural resources for outdoor production. However, the horticulture industry is currently at a point of change. Climate variability will continue to impact crops each year, limiting the assurance of supply to markets. The economic recovery from crop failures is increasingly difficult for outdoor producers. Over the past 20 years, consumer expectations for year-round availability of fresh produce has increased and retailers are focusing more on producers who can meet these specifications.

There is no other tool like PC to de-risk horticultural production. This has driven growth of PC in recent years, leading to sizable investments in tomato and berry infrastructure.

Newer investments have focused on cucumbers, eggplants, capsicums, leafy vegetables and herbs. Most of these crops are grown in substrates or hydroponics. Fruit trees (tropical and temperate) and grapes are also being tested with PC in new orchards, using hail or shade screens combined with high density systems, dwarfing rootstocks and trellising to de-risk production and reduce harvesting labour. The high value nursery industry (i.e. seedlings, plants, and flowers) has been using PC for many years and is now also focusing on technology innovations. The adoption of advanced vertical farming with closed systems is still very limited in Australia but there are small commercial operations in urban areas.

Operating environment

The Australian horticulture industry is an open, complex system comprised of a myriad of interconnected factors and forces that shape the nature of the industry landscape. Some parts of the system are highly stable and predictable, while others are constantly evolving, creating opportunities and/or uncertainty. A number of forces influence the balance of stability and instability, as shown in Figure 2. The Strategy is a response to these forces.

Increased uptake of PC systems, as shown in the Figure 2, will strengthen industry resilience to external factors such as biosecurity events, global pandemics, climate variability, extreme weather events and changing weather.

This will position the industry to continue to prosper and grow in the face of adversity and ensure future food security for all Australians.

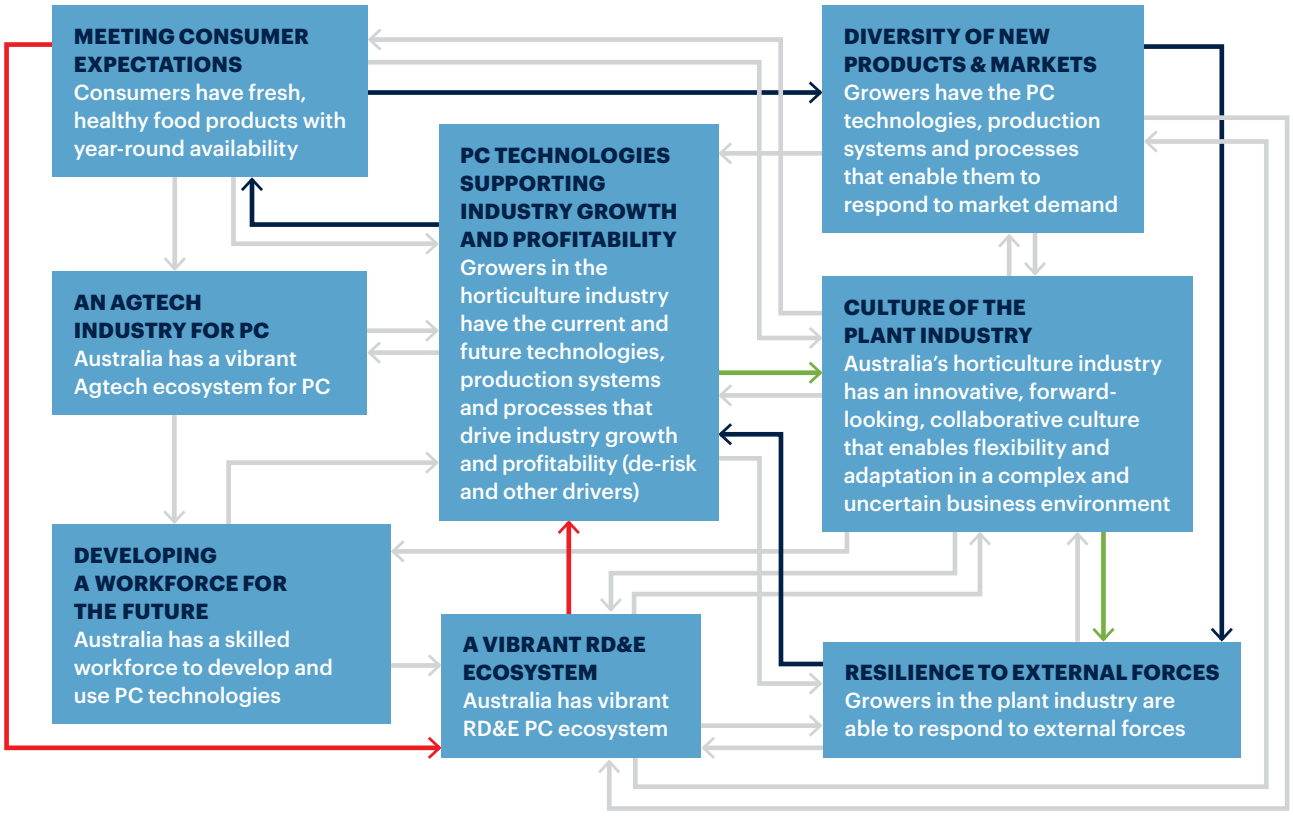
PC systems also offer the potential to transform productivity, leading to increased yields, improved quality and greater consistency. These gains will position industry to deliver products that meet or surpass consumer expectations and support diversification of products and markets.

However, the potential for transformation through PC will only be realised if increased productivity is balanced with market growth. To remain viable into the future, it will be essential for Australia's horticulture industry to grow domestic and export markets in parallel with increases in PC adoption. Without market development and expansion, the potential for enhanced profitability and industry growth through PC will not be realised.

Realising the full potential of PC will also require a vibrant PC community that develops, adapts and fosters uptake of Australian and overseas innovations, along with an innovative, forward-looking and collaborative industry culture, which enables flexibility and adaptation in a complex and uncertain business environment. It will also require a skilled workforce for the future, which has the capacity and capability to develop and use 'best in class' PC systems suited to Australian conditions.

FIGURE 2. High-level overview of the PC ecosystem within Australia's horticulture industry

Arrows indicate relationships and feedback loops identified in the dynamics influencing PC adoption within Australia's horticulture industry.



THE STRATEGY

PURPOSE

The purpose is to provide a clear direction and priorities for research, development, and extension investment to enhance the profitability of vegetable, berry, nursery and tree-fruit value chains by 2030

VISION

A high performing protected cropping ecosystem underpinning a thriving, profitable Australian horticulture industry, which is positioned for growth, sustainability, prosperity and international competitiveness by 2030

PRINCIPLES

- Ensure industry members are involved in decision making and project/program delivery, including SMEs as well as larger operators
- Encourage national collaboration and cooperation
- Leverage/tap into overseas innovations, where appropriate
- Leverage/tap into completed projects and/or relevant cross-sector initiatives, where relevant
- Utilise 'best practice' extension and adoption approaches, such as co-innovation and peer to peer learning
- Invest in a balanced portfolio, including 'whole-of-industry' research (long term impact) and regional/crop-specific development and extension (short to medium term impact)
- Consider longer projects with more flexibility to change/adapt to meet industry needs ('agile' approaches)

PRIORITIES*

OUTCOME: VALUE CHAINS

DEVELOP PROFITABLE, DIVERSIFIED VALUE CHAINS

Australia's horticulture industry has harnessed the potential of PC systems to develop new and existing value chains, domestically and internationally

STRATEGIES	POSSIBLE DELIVERABLES
V.1. Identify profitable value chain opportunities for PC products	■ Report on characteristics of PC-grown products (consistency in quality and extended supply) and how these intersect with domestic and international value chain needs ■ Factsheets and information resources on existing and future market opportunities for PC-grown products ■ Targeted communications, across a wide range of formats including social media and extension events, to raise industry and stakeholder awareness of market development opportunities for PC products ■ Training events to build industry capability and capacity to develop profitable markets for PC-grown products
V.2. Identify opportunities to grow exports through PC	■ Information on opportunities to use PC to grow markets, which could include: □ Establishing 'pest-free areas of production' or an equivalent approach to secure market access □ Developing PC approaches to expand production windows ■ Extension materials and events to build industry awareness and capacity to adopt findings
V.3. Showcase potential for product development and diversification through PC	■ Case study reports and other information resources on use of PC to grow markets, diversify products and/or reduce risks ■ Targeted communications, across a wide range of formats including social media and extension events, to raise industry awareness of opportunities ■ Extension events to build industry capability to develop markets, diversify products and manage risk through PC
V.4. Optimise postharvest quality of PC products	■ Report on produce quality changes along the supply chain and factors that influence postharvest quality and consumer acceptance ■ Report on approaches that can be used to maximise produce quality and shelf life in PC systems, which could include: □ Agronomy techniques □ Harvesting approaches □ Packaging options □ Transport and storage protocols □ Quality monitoring systems ■ Economic case studies and benefit cost analyses

** The priorities and principles closely align with the Food Innovation Australia Ltd Roadmap for Doubling Australian Food and Agribusiness by 2030*

OUTCOME: PEOPLE

INCREASED KNOWLEDGE, CAPACITY, AND PRACTICE CHANGE

Australia's horticulture industry has improved capacity and capability to harness the potential of PC systems across a diversity of crops, regions, climates, business models and markets

STRATEGIES	POSSIBLE DELIVERABLES
P.1. Understand and address barriers to PC adoption	■ Report on barriers to adoption and implications for PC uptake by Australia's horticulture industry ■ Prioritised list of 'safe to fail' projects that would assist to address barriers to PC adoption ■ Research reports on ways to increase adoption of PC systems ■ Communication and training events to transfer knowledge and insights to industry stakeholders and the PC community
P.2. Examine the extent of PC adoption across Australia, across the diversity of crops, regions, business models and markets	■ Interactive, web-based national map of PC systems, which is updated on a regular basis (annual or biennial) ■ Data on the value of PC production across Australian regions ■ Annual/biennial reports on changes in the geographical footprint and value of PC production
P.3. Build industry capacity and capability to adopt PC systems, across a range of crops, regions, climates, business models and markets	■ Prioritised list of 'best practice' capability and capacity building activities, including practice change initiatives ■ Report on options to improve industry access to PC information and knowledge resources ■ Regionally-relevant PC extension and adoption events and initiatives ■ Case study reports and communication materials ■ Demonstrations and on-farm trials of 'best in class' PC systems, across a range of Australian crops and regions ■ PC learning events, including study tours, conferences and workshops
P.4. Identify approaches to building a skilled PC workforce	■ Information on industry learning preferences and list of PC education and training needs (short, medium and long term) ■ List of priority education and training and workforce development initiatives and potential funding sources ■ A diverse suite of targeted, industry-relevant education & training and workforce development initiatives to build skills and capabilities in: □ Business – to de-risk investments and support business growth □ Agronomy – to boost performance □ Contemporary PC technologies – to increase business efficiencies □ Interpretation of 'big data' – to improve decision making ■ Diploma, micro credential, and MSc and PhD degree programs with PC focus
P.5. Investigate options to streamline PC development consents	■ Report on current approval processes and options for streamlining development consents, including promising overseas models ■ Tools and resources to support decision-making, such as information about PC systems aimed at Legislators/Government/municipalities ■ Training initiatives targeted at development decision-makers ■ Implementation of a nationally recognised protected cropping standard within the National Construction Code (NCC)

OUTCOME: TECHNOLOGIES

FIT-FOR-PURPOSE, COST-EFFECTIVE PC TECHNOLOGIES AND SYSTEMS

Australia's horticulture industry has access to cost-effective, fit-for-purpose PC technologies and systems to transform productivity, increase profitability and drive industry growth

STRATEGIES	POSSIBLE DELIVERABLES
T.1. Identify and adapt cost-effective technologies suitable for use within Australian PC systems (market-ready or close to market)	■ Information on current and emerging cost-effective PC technologies suitable for use in Australian conditions ■ Case studies including benefit cost analyses on use of new technologies within Australian PC systems ■ Demonstration of research findings to build PC capability of industry stakeholders (across Australia)
T.2. Develop whole-of-enterprise PC systems and agronomy packages to suit Australian circumstances (across a range of crops, climates, regions, biosecurity issues, business models and markets)	■ Cost-effective, whole-of-enterprise PC systems suitable for use in Australian conditions ■ Case study reports including benefit cost analyses on use of whole-of-enterprise PC systems ■ Communication materials and guidelines for crop agronomy practices and environment management in whole-of-enterprise PC systems ■ Demonstrations of research findings to build PC capability of industry (across Australia)
T.3. Address current issues and limitations in PC systems, such as labour and energy efficiency	■ Communication materials and guidelines on how to address current issues and limitations Australian PC systems, which could include information on: □ Genetics and other inputs suitable for use in PC systems □ Opportunities to increase labour efficiency in PC systems □ Ways to increase energy efficiency within PC systems □ How to maintain the health of soil and soilless media ■ Case study reports on approaches to address issues and current limitations in PC systems ■ Demonstrations of research findings to build PC capability and capacity of industry (across Australia)
T.4. Harness next-generation PC technologies, with a focus on robotics, automation and use of 'big data'	■ Guidelines and information on next-generation technologies suitable for use in Australian conditions, which could include: □ Robotics, automation, and visual technologies to optimise crop management and performance □ Software systems that utilise 'big data' to enhance decision making □ Systems that predict crop growth/yields and automate operations □ Technologies to reduce energy use in closed/semi-closed systems ■ Case study reports on next-generation technologies for PC systems ■ Demonstrations of next-generation technologies for use in PC systems ■ Prototypes and commercialised PC technologies with potential to enhance decision making, increase labour efficiency, improve energy efficiency and/or increase profitability

T.5. Advance technologies and protocols for environmental sustainability of PC systems	■ Information on ways to reduce the environmental footprint of PC systems, which could include:
	  □ Guidelines for recycling water, fertilisers, netting, polyethylene films and other plastic inputs
	  □ Biodegradable inputs
	  □ Integrated pest and disease management (IPDM) systems
	  □ Revised environmental management system (EMS) guidelines
	■ Case study reports on ways to reduce the environmental footprint of PC systems
	■ Extension materials and events to communicate research findings to industry
	■ Demonstrations of research findings to industry and the broader community

T.6. Understand the economics of PC systems	■ Economic case study reports and benefit cost analyses, covering a range of possible PC systems (crops, climates, regions, business models and markets) ■ Business plan and feasibility plan templates, and related information resources ■ Benchmarking resources that compare the economics of Australian PC systems with international best practice and identify opportunities for improvement ■ Guidelines for structure designs and management practices to mitigate damage to PC systems from extreme weather events

Monitoring and evaluating the Strategy

Delivering on the Strategy is dependent on implementation through funding of RD&E projects and other support activities that enable and contribute to PC adoption. The research and support activities may be funded by Hort Innovation as well as by other investors such as government, private horticulture growers, industry organisations and value chain businesses. There are external factors contributing to the achievement of key performance indicators (KPIs). Appropriate KPIs for individual projects will need to be defined as part of each project development.

OUTCOME: VALUE CHAINS

DEVELOP PROFITABLE, DIVERSIFIED VALUE CHAINS

Australia's horticulture industry has harnessed the potential of PC systems to develop new and existing value chains, domestically and internationally

STRATEGIES	POSSIBLE KPIs (DATA SOURCES OR METHODS)
V.1. Identify profitable value chain opportunities for PC products	■ New and diversified PC-grown products developed to target lucrative domestic and international market opportunities (extension and adoption (E&A) surveys) ■ Growth in domestic and export markets for PC-grown products (market surveys and trade figures)
V.2. Identify opportunities to grow exports through PC	■ Increase in industry awareness of opportunities to grow markets and exports through PC (E&A surveys) ■ Industry confidence to implement approaches to grow markets and exports through PC (E&A surveys) ■ Industry adoption of approaches to grow markets and exports through PC (E&A surveys) ■ Growth in domestic and export markets for PC-grown products (market surveys and trade figures)
V.3. Showcase potential for product development and diversification through PC	■ Industry participation in case study demonstrations and related extension events (E&A surveys) ■ Industry confidence to implement PC approaches to develop markets, diversify products and manage risk (E&A surveys) ■ Industry adoption of approaches to develop markets, diversify products and manage risk through PC (E&A surveys) ■ Growth in domestic and export markets for PC-grown products (market surveys and trade figures)
V.4. Optimise postharvest quality of PC products	■ Industry participation in relevant extension events (E&A surveys) ■ Industry confidence to implement approaches to maximise product quality and shelf life along the supply chain (E&A surveys) ■ Adoption of approaches to maximise product quality and shelf life along the supply chain (E&A surveys) ■ Increased value chain satisfaction with PC-grown products (market research)

OUTCOME: PEOPLE

INCREASED KNOWLEDGE, CAPACITY, AND PRACTICE CHANGE

Australia's horticulture industry has improved capacity and capability to harness the potential of PC systems across a diversity of crops, regions, climates, business models and markets

STRATEGIES	POSSIBLE KPIs (DATA SOURCES OR METHODS)
P.1. Understand and address barriers to PC adoption	■ Attendance of communication and training events by members of the PC community (E&A surveys) ■ PC community awareness of best practice extension approaches and methods to increase adoption of research findings (targeted survey) ■ RD&E community incorporation of extension/adoption findings into project proposals (scan of project proposals) ■ Benefits and impact from PC investments (longitudinal analysis of benefit cost analysis results) ■ Effectiveness of PC RD&E ecosystem (industry stakeholder survey)
P.2. Examine the extent of PC adoption across Australia, across the diversity of crops, regions, business models and markets	■ Number of users and queries of the mapping tool/s (website statistics) ■ Industry and stakeholder awareness of changes in PC adoption over time (industry and stakeholder surveys) ■ Industry and stakeholder usage of adoption statistics to monitor and evaluate the effectiveness of PC RD&E and education and training initiatives (industry and stakeholder surveys) ■ Improved benefits from PC RD&E investments (benefit cost analyses and impact assessments)
P.3. Build industry capacity and capability to adopt PC systems, across a range of crops, regions, climates, business models and markets	■ Industry participation at capability and capacity building events (E&A attendance records) ■ Industry awareness of 'best in class' PC systems relevant to their circumstances (crops, region, climate, biosecurity issues, business model and markets) (E&A surveys) ■ Industry adoption of 'best in class' PC systems, relevant to their circumstances, as a result of regionally-relevant extension and adoption initiatives (E&A surveys) ■ Growth in use of PC systems within Australia's horticulture industry (regular benchmarking studies)
P.4. Identify approaches to building a skilled PC workforce	■ Number of targeted, industry-relevant PC education and training and workforce development initiatives on offer (environmental scan) ■ Number of industry stakeholders and students enrolling and completing PC-focused training and study programs (survey of education and training providers) ■ Workplace relevance of PC education and training and workforce development initiatives offered by education providers (industry survey) ■ Industry confidence to adopt and manage PC systems as a result of participation in education and training initiatives (surveys)
P.5. Investigate options to streamline PC development consents	■ Attendance at training initiatives by development decision makers (training surveys) ■ Understanding of PC systems and implications for development applications (training surveys) ■ Improved planning decision-making processes as a result of increased understanding of PC systems (surveys) ■ Geographic spread of PC infrastructure across Australia (regular benchmarking studies)

OUTCOME: TECHNOLOGIES

FIT-FOR-PURPOSE, COST-EFFECTIVE PC TECHNOLOGIES AND SYSTEMS

Australia's horticulture industry has access to cost-effective, fit-for-purpose PC technologies and systems to transform productivity, increase profitability and drive industry growth

STRATEGIES	POSSIBLE KPIs (DATA SOURCES OR METHODS)
T.1. Identify and adapt cost-effective technologies suitable for use within Australian PC systems (market-ready or close to market)	■ Number of new technologies tested/adapted for use within Australian conditions (scan of RD&E reports) ■ Number of case studies completed (scan of case study reports) ■ Number of demonstrations of new technologies to Australia's Horticulture industry (scan of RD&E reports) ■ Number of industry stakeholders participating in demonstrations and other extension events (scan of RD&E reports) ■ Adoption of new PC technologies by industry (E&A surveys) ■ Evidence of factors contributing to productivity including increased yields, reduced input costs, improved returns (case study reports)
T.2. Develop whole-of-enterprise PC systems and agronomy packages to suit Australian circumstances (across a range of crops, climates, regions, biosecurity issues, business models and markets)	■ Number of new whole-of-enterprise PC systems developed for use within Australian conditions (scan of research reports) ■ Number of whole-of-enterprise case studies completed (scan of case study reports) ■ Number of demonstrations of integrated PC systems to Australia's Horticulture industry (scan of RD&E reports) ■ Number of industry stakeholders participating in demonstrations and other extension events (scan of RD&E reports) ■ Industry awareness of new systems developed/adapted for use in Australian conditions and capability to select the most appropriate system for their needs (E&A surveys) ■ Industry adoption of whole-of-enterprise PC systems (E&A surveys) ■ Evidence of factors contributing to productivity including increased yields, reduced input costs, improved returns (case study reports)
T.3. Address current issues and limitations in PC systems, such as labour and energy efficiency	■ Number of solutions developed to troubleshoot and/or address current issues and limitations Australian PC systems (scan of RD&E reports), which could include: □ New genetics for use in PC systems □ Opportunities to increase labour efficiency □ Ways to increase energy efficiency □ Approaches to maintaining the health of soils and soilless media ■ Number of relevant case studies completed (scan of case study reports) ■ Number of demonstrations of approaches to troubleshoot issues or limitations in Australian PC systems (scan of RD&E reports) ■ Number of industry stakeholders participating in demonstrations and other extension events (scan of RD&E reports) ■ Industry confidence to apply/use approaches to troubleshoot issues in PC systems (E&A surveys) ■ Industry adoption of approaches to troubleshoot PC systems (E&A surveys) ■ Evidence of factors contributing to productivity including increased yields, reduced input costs, improved returns (case study reports)

T.4. Harness next-generation PC technologies, with a focus on robotics, automation, and use of 'big data'	■ Number of demonstrations of next-generation technologies (scan of RD&E reports) ■ Number of prototypes and commercialised products delivered (scan of RD&E reports, market scan) ■ Number of case studies completed (scan of case study reports) ■ Industry awareness of next-generation PC technologies and potential benefits (E&A surveys) ■ Industry confidence to select/apply/use fit-for-purpose next-generation PC technologies (E&A surveys) ■ Industry adoption of next-generation technologies (E&A surveys) ■ Evidence of factors contributing to productivity including increased yields, reduced input costs, improved returns (case study reports)
T.5. Advance technologies and protocols for environmental sustainability of PC systems	■ Number of solutions developed to reduce the environmental footprint of PC systems (scan of RD&E reports), which could include: □ Guidelines for recycling of water, fertilisers, and plastic components □ Biodegradable inputs □ IPDM systems □ Revised EMS guidelines ■ Number of relevant case studies completed (scan of case study reports) ■ Number of demonstrations of approaches to reduce the environmental footprint of Australian PC systems (scan of RD&E reports) ■ Number of industry stakeholders participating in demonstrations and other extension events (scan of RD&E reports) ■ Industry adoption of environmentally-sustainable PC practices and systems (E&A surveys) ■ Increased community acceptance of PC-grown products (consumer surveys) ■ Reduction in environment footprint of case study PC systems (case study reports)
T.6. Understand the economics of PC systems	■ Number of economic case studies, cost benefit analyses, benchmarking reports, and damage mitigation approaches published (scan of RD&E reports) ■ Number of industry stakeholders participating in communication and extension events (scan of RD&E reports) ■ Industry and stakeholder (banks, investors, councils, etc.) awareness of the economics of PC production (E&A surveys) ■ Industry awareness of international benchmarks and opportunities for business improvement (E&A surveys) ■ Industry and stakeholder confidence to make investment decisions in relation to PC (E&A surveys) ■ Improved financial performance and investment returns from PC investments (E&A surveys) ■ Improved access to PC investment capital (E&A surveys) ■ Reduced economic losses from extreme weather events (E&A surveys)

Image credits: Elio Jovicich, Heidi Wittl, Nicky Mann, Bede Miller, Graeme Smith, Greg Owens, Neil Lantzke, Greg Murdoch, Western Sydney University. Some images were sourced from Shutterstock.




Published and distributed by: Hort Innovation

Level 7, 141 Walker Street
North Sydney NSW 2060
Telephone: (02) 8295 2300
www.horticulture.com.au