Hort Innovation

Final Report

Facilitating the development of the Australian strawberry industry

Project leader:

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Delivery partner:

RM Consulting Group Pty Ltd

Project code:

BS15002

Project:

Facilitating the development of the Australian strawberry industry BS15002

Disclaimer:

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Content

Summary

Strawberry Innovation has been a national program running from 2016 to 2019, aimed at improving the communication and adoption of research outcomes and new practices across the Australian strawberry industry. The Strawberry Innovation program comprised of three projects, namely BS15002 (national coordination), BS15003 (sub-tropical regional delivery partner) and BS15004 (temperate regional delivery partner). Delivery of the program across the three project contracts (BS15002, BS15003 and BS15004) involved the regional delivery partners providing a service focused role for direct engagement with growers and industry stakeholders, with RMCG providing a 'back-of-house' coordination role, supporting the workplan implementation and engagement with industry researchers. The three projects worked together to:

- Improve awareness and knowledge of: innovation and technology, breeding outcomes and safety and sustainability requirements within the strawberry industry
- Increase adoption of strawberry research and changes to on-farm decision-making and practices
- Increase opportunities for information exchange, networking and learning between growers and other industry members.

Key areas of focus for the program (as based on the industry needs analysis) has included the extension and communication of research and development (R&D) relating to breeding, environmental management, production management, markets, business and people management.

Specific activities provided by RMCG through the strawberry industry development program included:

- **Industry coordination** – these activities provided a framework for improving coordination and cohesiveness within the Australian strawberry industry.
- **Knowledge transfer** – these included specific activities and events to address particular needs and/or issues within the industry.
- **Communications** – these activities were focused on informing industry on events, issues and the latest research and development.

The outputs and outcomes of these activities are discussed in further detail in the report however a summary of the key communication outputs delivered by the program are shown in Figure 1.

Strawberry Innovation

Communication Outputs

Simply Red magazine

12 Editions

Mail out distribution to **562** recipients

Punnet e-Newsletter

36 Issues

Email distribution to **389** subscribers

Strawberry Innovation website

11,600 unique visitors

14,600 visits

30,800 page views.

299 news article posts to website

@StrawberryInnov Twitter Handle

88 Tweets

297 Followers

21 Fact Sheets

5 Case Studies

4 Webinars

3 Posters

12 varietal information summary cards

Strawberry Industry Good Practice Guide

Strawberry Industry Pest Identification App

Figure 1: Communication outputs

Learnings from the Strawberry Innovation program have highlighted that for industry development to occur successfully in the Australian strawberry industry:

1. All strawberry producing states need to be formally engaged within the program (especially WA)
2. National and state-based industry associations need to be 'on-side'
3. R&D funded through state-based levies should be leveraged and included within the program
4. Access to better industry data (such as runner numbers) would assist in industry planning and program delivery
5. An increased level of industry relevant research (on topics beyond breeding) would benefit industry
6. Contractual arrangements for service delivery should be altered to assist performance management.

Keywords

Strawberry, extension, communications, industry development, awareness, knowledge, adoption.

Introduction

Purpose of project

This project provided industry development services to the Australian strawberry industry between 2016-2019.

The objective of the project was to enhance the adoption of innovation and technology in the Australian strawberry industry through brokering research and development information and facilitating capacity building in the Australian strawberry industry. This was supported by:

- Providing national co-ordination and leadership for the successful development and delivery of innovation information products to the strawberry industry
- Building industry partnerships and networks
- Addressing market failure in strawberry industry regions and groups
- Delivering regionally specific activities.

The project was branded as *Strawberry Innovation* to assist with building a national profile, independent of industry agri-politics, and provide connection for growers and other industry stakeholders with productivity and industry funded R&D.

Case for Investment

During development of the former strawberry industry strategic plan (2012-2017) it was noted that industry adoption was a critical issue, characterised by concerns about effective communication. Emerging and remaining issues identified relating to research and development included:

- The need for a national IDO to optimise the benefits of industry communication
- Two-way communication was poor with little opportunity to encourage feedback from growers
- National and state levy projects were not always communicated effectively
- Relevant new information needed to be captured
- Final reports should be produced in a form that encouraged clarity
- Project milestones should be noted on the website.

The strategic plan and identification of research and development needs provided strong justification for a nationally focused development program that would inform the design and delivery of the development program for the strawberry industry based on the information needs and preferences of growers.

Linkages to industry strategic plans

The project supported the communication and development of the core strategies of the Strawberry Strategic Investment Plan – 2017-2021. In particular, the project had direct alignment to Strategic Outcome 3: Greater skills, capacity and knowledge in the industry.

Methodology

Project Plan

A detailed Project Plan was developed for the project at inception. This document contained the:

- Program Logic and MERI (monitoring, evaluation, reporting and improvement) framework
- Risk management plan
- Stakeholder engagement plan
- Communications plan
- Program design.

The original Program Plan is provided in Appendix 1.

Program logic

A program logic was developed to provide the high-level framework for the Project Plan and govern the subsequent MERI framework. This included considering the hierarchy and connection between:

- Vision: aligned to Australian Strawberry Industry Strategic Investment Plan
- Long-term outcomes (3-10 years): what the project will contribute to after completion
- Project outcomes (1-3 years): within the sphere of influence and measurement of the project timeframe, these include:
    i. Improved awareness and knowledge of: innovation and technology, breeding outcomes and safety and sustainability requirements within the strawberry industry
    ii. Increased adoption of strawberry research and changes to on-farm decision-making and practices
    iii. Increased opportunities for information exchange, networking and learning between growers and other industry members
- Activities: that will be undertaken annually
- Foundational activities: that will underpin and inform the implementation of annual activities.

The Monitoring and Evaluation Plan is included in the project plan in Appendix 1, with the program logic presented in Figure 2.

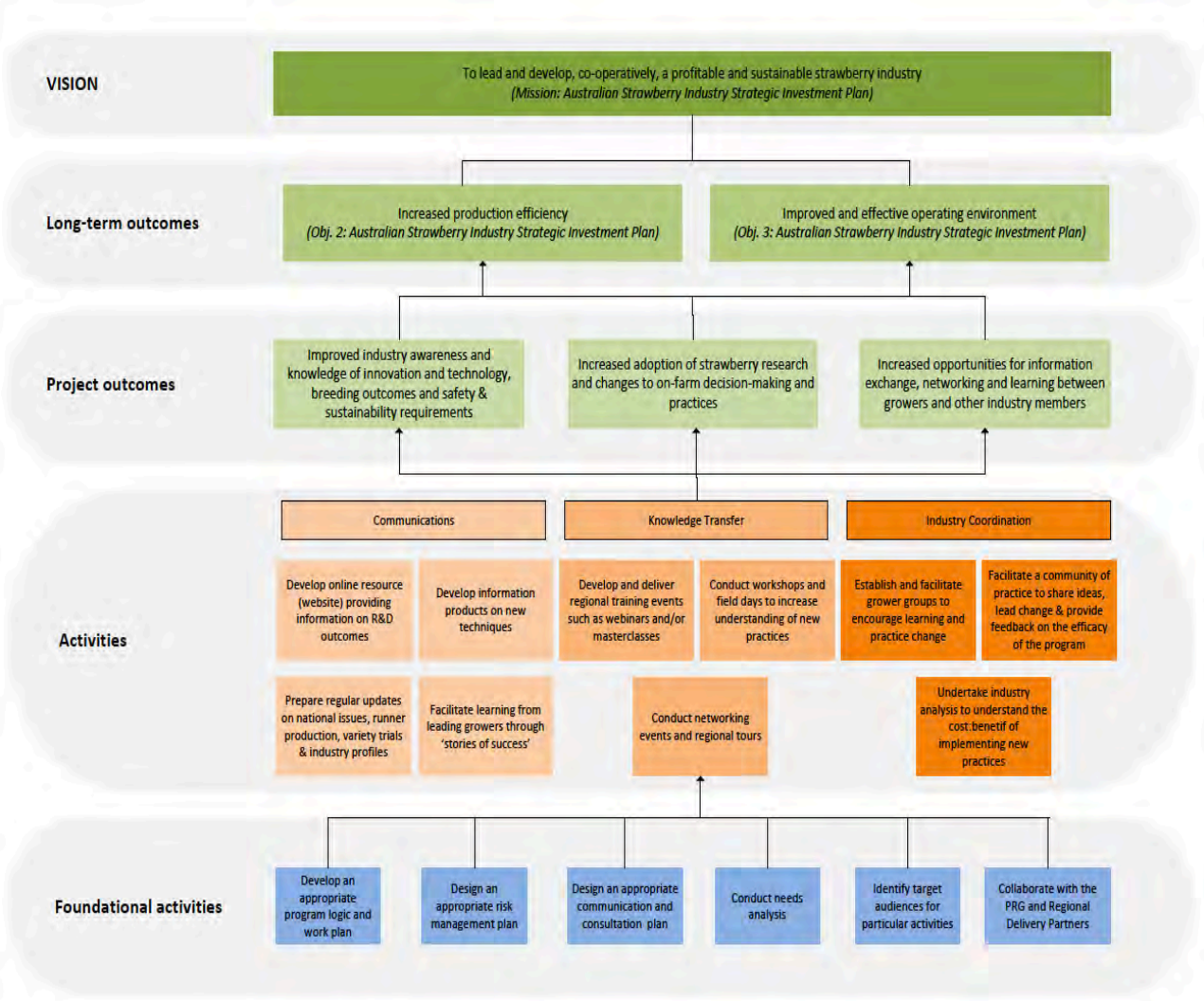

Figure 2: Program logic for the Facilitating the development of the Australian strawberry industry project 2016-2019

Risk management plan

A number of risks were identified that required management for project outcomes to be achieved. The risks identified range across technical, biophysical, extension, partnerships and internal.

These included:

- Partnerships not developed with advisors and key influences
- Unable to identify good practices and tools to address industry needs
- Unable to identify and involve key experts in strawberry production and identified needs
- Growers and advisors not willing and/or able to participate
- Loss of key personnel
- Limited stakeholder 'buy-in'
- Project management risks (budget, time, quality, scope).

The likelihood and consequence of these risks were analysed using a recognised risk matrix. While some risks were rated as Very High when uncontrolled, all risks had a residual treated risk level of below medium.

Stakeholder consultation plan

The key stakeholder groups for this project included:

- **Fruit producers:** including corporate, mid-large and small/agri-tourism growers
- **Runner growers:** including those growers certified with the Australian Strawberry Runner Certification Authority and Victorian Strawberry Industry Certification Authority
- **Advisors and extension providers:** including commercial resellers and agronomists, private agri-chemical companies, specialist advisors, financial and business management providers
- **Industry associations:** including Strawberries Australia and state industry associations
- **Researchers:** including consulting firms, State and Federal Government agencies and Australian and international universities
- **Supply chain participants:** including input providers (e.g. fertiliser suppliers), packers, contract service providers (planting, harvesting, labour, cool stores and transport, wholesalers and markets, retailers)
- **Project Reference Group**: including representation of the project team, Hort Innovation and grower and industry stakeholder representatives from the key strawberry producing states.

These stakeholder groups were considered and analysed further in the Project Plan to determine the most appropriate engagement methods in terms of type, delivery, timing and location. This governed the design of the knowledge transfer and event outputs in particular.

Communication plan

Communication was central to the project to work towards improved awareness, knowledge, adoption and information exchange between growers and other industry stakeholders. A communication plan was developed which outlined:

- **Target audiences and outcomes:** included the main stakeholder groups outlined in the engagement plan. A desired outcome from communicating with each group was analysed against the International Association of Public Participation (IAP2) framework
- **Mode, tools and purpose:** project communication involved a mix of face-to-face delivery across the regional areas, as well as online, and both soft and hard copy resources. The different tools and purpose within each of these modes was analysed at the start of the project
- **Options analysis:** as the strawberry industry had a number of established state-based and national communication channels, an options analysis was considered to ensure the use of these existing channels through the project to avoid duplication and ensure the information shared through the project was communicated in a fit-for-purpose way.

Needs analysis

A needs analysis was undertaken with Australian strawberry growers and industry stakeholders at the commencement of the project to identify core industry development themes of interest to growers. The analysis identified several areas that were supported throughout the project and aligned to the industry Strategic Investment Plan, including:

- Varieties
- New growing systems
- Soil health / diseases
- Supply Chain Management
- Marketing
- Exports
- Business Management.

These issues remained relatively consistent over the three-year delivery period, and as such the project team continued to deliver activities and communication to address these needs, structured around the thematic focus areas of:

- Production
- Breeding
- Environment
- Markets
- Business
- People.

Program Delivery

The project was delivered in partnership with the Queensland Strawberry Growers Association (BS15003) and the Victorian Strawberry Industry Development Committee (BS15004). The implementation framework for the project is outlined in Figure 3.

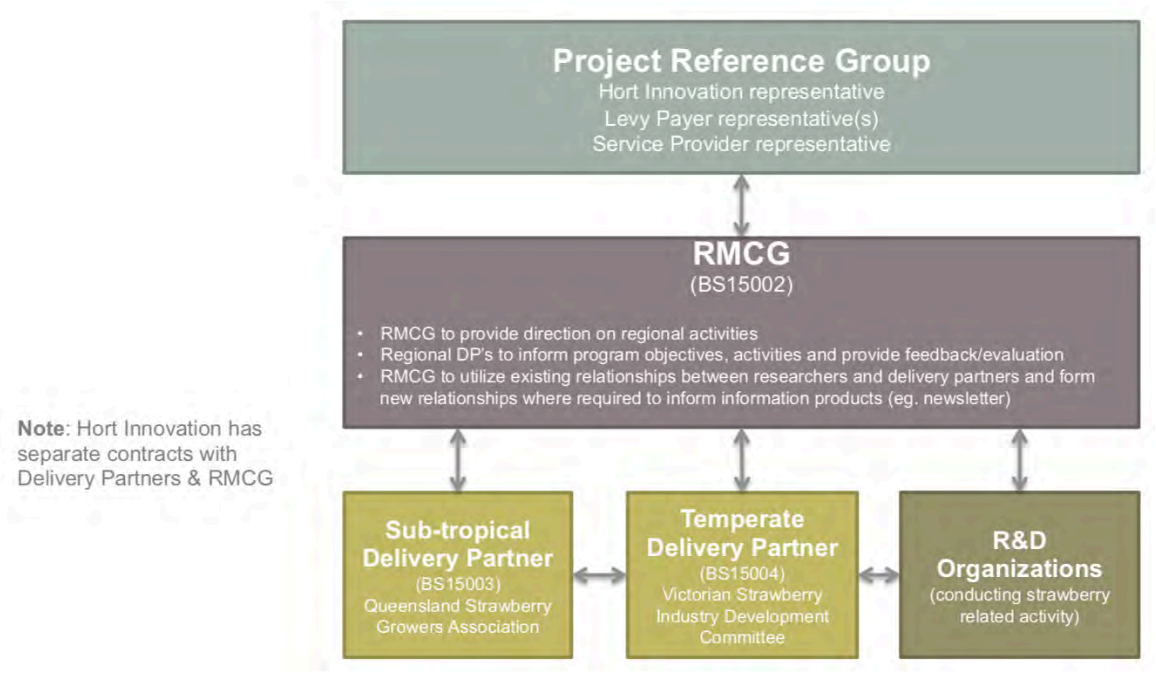

Figure 3: Project implementation framework

Annual work plans were developed to guide the operation and delivery of the Strawberry Innovation project. These were based on the program logic (as shown in 2), the needs analysis conducted at the start of the program and input from the regional delivery partners.

The project team, including RMCG and the Temperate and Sub-Tropical Industry Development Officers, met monthly via skype to update the evolving project workplan and review the effectiveness and appropriateness of the projected activities. During these collaborative meetings, the project activities were adjusted and redefined to ensure the needs of growers and the industry continued to be met. A formalized review of the workplan was conducted annually.

Delivery of the program across the three project contracts (BS15002, BS15003 and BS15004) involved the regional delivery partners providing a service focused role for direct engagement with growers and industry stakeholders, with RMCG providing a 'back-of house' coordination role, supporting the workplan implementation and engagement with industry researchers.

Specific activities provided by RMCG through the strawberry industry development program included:

- **Industry coordination –** these activities provided a framework for improving coordination and cohesiveness within the Australian strawberry industry.
- **Knowledge transfer** – these included specific activities and events to address particular needs and/or issues within the industry.
- **Communications** – these activities were focused on informing industry on events, issues and the latest research and development.

Evidence of progress and completion of these plans were included in 6-monthy milestone reporting to Hort Innovation. The annual work plans for Year 1, 2 and 3 are provided in Appendix 2. Note a revision to the format of the annual workplan was made after Year 1 following the release of the Strawberry SIP.

Program Reference Group

A program reference group was formed as the principal group responsible for providing guidance and information on project direction, plans, outputs and activities. The Group brought together key people with expertise and experience in the strawberry industry. The PRG met 6-monthly over the course of the project.

The scope of the PRG was to provide input into planning and implementation of the project. This included:

- Strategic direction for the projects
- Ensuring that the projects meet the needs of the strawberry industry; this includes growers, runner growers, advisors and extension providers and other stakeholders
- Making sure that sound science is used
- Ensuring the projects stay focused on required outcomes throughout their life.

Outputs

The key outputs produced over the life of the Strawberry Innovation program relate to:

- Improved **coordination** of industry relevant activities and increased collaboration.
- Increased **transfer of knowledge** relating to industry relevant R&D
- Improved **communication** of industry relevant R&D.

These outputs were produced through a collaborative approach with the regional delivery providers and included the development of a joint workplan to support the industry coordination of the program and knowledge transfer events delivered by the regional service providers. Resources were also developed to inform knowledge transfer activities and communicated through platforms such as a quarterly hard copy newsletter, e-newsletters and website. These outputs are discussed in further detail below.

Program and industry coordination

These activities provided a framework for improving coordination and cohesiveness within the Australian strawberry industry. Further details on the industry partnerships and networks developed will be provided in the final reports for BS15003 and BS15004. Outputs from BS15002 include:

- Monthly project meetings with regional delivery partners to discuss issues, opportunities and activities. These were documented with monthly meeting minutes, action plans and updates to the annual work plan.
- Attendance at industry relevant events such as BerryQuest in 2018 (including funding of attendance by WA IDO), CSIRO Food Waste workshops and soil management field days.
- Liaison with QDAF researchers and pest management specialists across Australia (Pest and Disease Community of Practice)
- Attendance (or requests to attend) state industry association meetings and events.

Significant effort was expended to improve the level and quality of industry data available for industry planning purposes. In particular there was a strong desire to secure better information on the type and number of runners planted for each strawberry production period. It was not possible to secure this data despite many attempts by the regional delivery partners due to claims of confidentiality by the runner growers and the competitive nature of this sector. There is also a significant number of growers producing for Driscolls who do not make this type of information public.

A number of networking events and regional tours were delivered by the temperate and tropical regional delivery partners (which will be detailed in their final reports). Effort was made by the regional delivery partners to establish young grower groups however these were not sustained over the life of the project.

Knowledge transfer

Specific activities and events to address particular needs and/or issues within the industry were developed and delivered by the Strawberry Innovation program. Further details on the regionally specific activities and events delivered by the regional delivery partners will be provided in the final reports for BS15003 and BS15004. Resources developed by RMCG to support knowledge transfer included:

Good Practice Guide

Available best management practice guidelines for the Australian strawberry industry were outdated and didn't reflect current production practices within the industry. Subsequently, on request from the strawberry industry for an updated management guide, the Australian Strawberry Good Practice Guide was developed.

Five chapters and associated fact sheets and case studies were produced to:

- Provide clear guidelines and practical advice on sustainable and profitable production of strawberries in Australia
- Demonstrate that Australian strawberries are produced in a an environmentally sustainable manner.

The chapters were released as they were produced, and a final complete version of the Good Practice Guide was printed as a hard copy resource and distributed via post to 560 recipients across the strawberry industry. An electronic version of the Good Practice Guide is available on the project website at http://strawberryinnovation.com/good-practice-guide/ and has received 662 page views.

Figure 4: Good Practice Guide

A summary of the content and structure of the Good Practice Guide is provided as follows, with a copy of the Guide provided in appendix 5.

7. Land and soil management
   Related fact sheets and case studies:
   - Managing you soil: Taking soil tests
   - Keeping soil in its place: Improving soil cover and managing drainage
   - Managing your soil: Crop rotation and soil amendments
   - Grower profile: John Hasan: Wandin, Victoria
8. Water management
   Related fact sheets and case studies:
   - Irrigation water quality for strawberries
   - Using recycled water for strawberry production
   - Grower profile: Paul Mancarella – Silvan, Victoria

9. Pest management

   Related fact sheets and case studies:

   - Managing foliar and fruit diseases in strawberries
   - Managing chewing and biting pests in strawberries
   - Managing soilborne diseases in strawberries
   - Managing sucking pests in strawberries

10. Nutrient management
11. Postharvest handling

    Related fact sheets and case studies:

    - Postharvest diseases and disorders of strawberries

Fact sheets

Fact sheets were developed to prioritise and package the latest available research and development for growers and advisors. Topics were selected by the project team, based on the priority thematic areas identified within the workplan or as priorities emerged. Core topic areas included pest and disease management, soil health and transitioning to protected cropping. These fact sheets were used to support the Good Practice Guide, published in the Simply Red magazine and are also available on the strawberry innovation website at www.strawberryinnovation.com.au

Figure 5: Fact sheet

Fact sheets produced through the project are listed as follows, with a copy of all fact sheets provided in appendix 3.

1. Transitioning to protected cropping: What are the costs and benefits?
2. How can I control pests? Options for controlling sucking pests in strawberries
3. How can I control pests? Options for controlling fruit and foliar diseases in strawberries
4. How can I control pests? Options for controlling chewing and biting pests in strawberries
5. Organic strawberries: A small slice of Australia's billion-dollar organics industry
6. Managing soilborne diseases in strawberries
7. Managing foliar and fruit diseases in strawberries
8. Managing chewing and biting pests in strawberries
9. Managing sucking pests in strawberries
10. Silicon for strawberry plant health
11. Irrigation water quality for strawberries
12. Using recycled water for strawberry production
13. Minor use permits
14. Managing your soil: Taking soil tests
15. Keeping soil in its place: Improving soil cover and managing drainage
16. Managing your soil: Crop rotation and soil amendments
17. Growing strawberries in Western Australia
18. Developing Asian markets for Australian strawberries
19. Postharvest diseases and disorders of strawberries
20. New technology in strawberry production
21. Export Supply Chain – Queensland strawberries to Hong Kong

Case studies

Case studies were developed to showcase changes in practices from leading growers and demonstrate relatable success stories in practice change. Topics and case study growers were selected by the project team, based on the priority thematic areas identified within the workplan or as priorities emerged. Case studies produced through the project were used to support the Good Practice Guide, published in the Simply Red magazine and also available on the strawberry innovation website at www.strawberryinnovation.com.au.

Grower profile

John Hasan: Wandin, Victoria

STRAWBERRY INNOVATION

John Hasan is a second generation strawberry grower, whose family has been growing strawberries and other produce in Wandin since the 1930s. John is also the Chairman of the Victorian Strawberry Industry Development Committee (VSIDC), and involved in many other aspects of the industry. He and his wife Annette have grown strawberries on their farm for 26 years.

While not large growers, John and Annette grow a high quality product that finds its way to independent retail outlets and farmers markets, where their fruit commands premium prices. John attributes a lot of this success to his focus on the health and biology of his soil.

JOHN ASKS

'If you haven't got good soil, how can you grow good fruit?'

Over the years, John has worked with agronomists and industry to find new ways to improve soil health. John rests his soil, with a break of a year or more between crops, rotating with a green manure crop, such as Italian ryegrass. The benefits of this practice include returning organic material back to the soil, replacing the nutrients removed by the strawberry crop, and helping to break the life cycle of disease-causing organisms in the soil.

An innovative approach that John has taken to increasing his soil health is to use regular applications of soil additives that contain beneficial microorganisms (bacteria and fungi). Fumigation of the soil destroys disease-causing microorganisms, but it can also kill the beneficial fungi and bacteria, that play important roles in forming good soil. The application of beneficial microorganisms improve soil structure, and hence water-holding capacity, improve drainage and air movement in the soil, and break down organic material in the soil to release nutrients and produce humus.

In addition, beneficial microorganisms in the soil can protect the plant's root system against disease-causing organisms in the soil, much in the way that beneficial insects used in an IPM program work.

Even in the first year of using biological soil additives, John saw a difference in the health of his plants, and by the second year he saw a "massive" improvement in plant health and fruit yield. The plants also suffered less from stress in the hot weather last summer.

John and Annette

JOHN BELIEVES THAT

In the same way transitioning to using IPM to control insect pests in the crop is not immediate, using beneficial microorganisms is not an instant fix, as it takes time return the soil to health.

Some patience is needed, but John has seen major improvements in plant health and fruit production with subsequent seasons.

As well as working to increase the biological health of his soil, John also has regular leaf analyses done to help determine

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Hort Innovation Strategic levy investment

STRAWBERRY FUND

RMCG

Figure 6: Case study

A copy of all case studies is provided in appendix 4 and include:

1. Grower profile: Vanessa and Brenton Sherry: Harvest the Fleurieu
2. Grower profile: Sunny Ridge Strawberry Farm
3. Grower profile: Simon Dornauf: Hillwood Berries
4. Grower profile: Paul Mancarella – Silvan, Victoria
5. Grower profile: John Hasan: Wandin, Victoria.

Webinars

Webinars were delivered to build knowledge and capacity of growers and industry stakeholders on specific topics or issues. The webinar format provided an interactive environment for the audience to engage with a range of expert speakers (both national and international) and hear practical insights and shared lessons from growers who have embraced the practice change. Webinar topics were selected by the project team, based on the priority thematic areas identified within the workplan or as priorities emerged.

Figure 7: Webinar

Recordings of the webinars are available on the project website and RM Consulting Group You Tube channel and include:

1. Fruit fly management in strawberries (https://www.youtube.com/watch?v=iwy0WEnECy0)
2. Transitioning from soils to substrates in strawberry production (https://www.youtube.com/watch?v=rdT5SXUhRuI)
3. Spotted Wing Drosophila preparedness (https://www.youtube.com/watch?v=EGUe_F2JQ00)
4. Accessing export markets – opportunities and shared lessons for strawberries (https://www.youtube.com/watch?v=gun_bKs0U3E)

Applications

Several requests from growers were received via the regional delivery partners for an App to support integrated pest management decisions on farm. A partnership was established with the Queensland University of Technology (QUT) and an App was produced. RMCG engaged the lead developer from QUT to finalise the production and release of the app. The app was released at the conclusion of the project and is available from https://apps.apple.com/us/app/strawberry-infections/id1471363342?ign-mpt=uo%3D2. The App will be publicized through the strawberry innovation website and other communication avenues such as the Hort Innovation newsletter.

Posters

Several posters were produced through the project to support simple and visual communication on specific topics. Poster topics were selected by the project team, based on the priority thematic areas identified within the workplan or as priorities emerged. Posters produced through the project are listed as follows, with a copy of all posters provided in appendix 6.

1. Queensland Fruit Fly Identification
2. How 'clean' are our strawberries?
3. Want to identify major strawberry pests and beneficials?

Postcards

Communication of key commercial strawberry varieties produced through the Australian Strawberry Breeding Program were requested through the project. The intended audience of the varietal characteristics was for growers and domestic and international markets. Varietal information cards were produced as presented in appendix 7, for the following varieties:

1. Red Rhapsody – Export
2. Red Rhapsody
3. QHI Sugarbaby
4. Sunglow ASBP
5. Venus ASBP
6. Parisienne Kiss
7. Sundrench
8. Meadowsong
9. Suncoast Delight
10. DPI Rubygem
11. Scarlet Rose ASBP
12. Ausiegem.

Communications

These activities were focused on informing industry on events, issues and the latest research and development. A comprehensive list of the communication outputs delivered by the project between March 2016 and June 2019 is presented as follows. All outputs produced through the project are available on the Strawberry Innovation website at www.strawberryinnovation.com.

Simply Red

At the commencement of the project, an options analysis was undertaken to determine which communication tools should be pursued through the program, based on the criteria of:

- Recognition of existing state-based and national communication channels;
- A desire to use these existing channels where possible to avoid duplication; and
- Ensure industry information is communicated in a fit-for-purpose manner.

Consultation was also undertaken with active industry associations to confirm industry expectations of the national communications. From this assessment, three existing hard copy publications were identified, including:

- Strawberries Australia - Wild About Strawberries – last active issue April 2009
- Victorian Strawberry Industry Development Committee – Vic Strawberries – last active issue Spring 2013
- Queensland Strawberry Growers Association (QSGA) – Simply Red – active quarterly publication distributed to all Queensland growers and bulk distribution points to Victoria and Western Australia.

Due to the active nature, consistent publication and broad distribution, Simply Red was identified as the preferred existing publication to continue. Agreement was reached with QSGA in April 2016 for the re-branding and national distribution of Simply Red, on the provision of a continued income source for the association through advertising revenue. This agreement was reached on the basis that the income source from advertising covered the desktop publishing, printing and distribution costs associated with postage of the magazine to all Australian strawberry growers. No project funds from either BS15002, BS15003 or BS15004 was paid to QSGA for Simply Red.

The quarterly publication and hard copy distribution of Simply Red to 562 recipients across the national strawberry industry provided a platform to provide information on specific topics and/or project updates to the industry. A list of the issues and core features produced through the project is outlined as follows.

Issue	Features
#42 – June 2016	• Strawberry Innovation: A new approach to industry development • National Strawberry Breeding Program Update • Sustainable control of powdery mildew and leaf blotch by using different fungicides for runner and fruit production • South Korean Strawberry Imports update • Pinata Farms launches substrate strawberries
#43 – September 2016	• Campaign launched to source local workforce • Simply Redder? – significant opportunities to boost strawberry health credentials • The future beyond methyl bromide – perspectives from the US • International Strawberry Symposium brings together world leaders in research, technology and innovation • More key horticulture industry investment panels kick off • Best farmers, monitor their crops • *Phytoplamsa* and *rickettsiz* infections in Australian strawberry industry
#44 – December 2016	• Identifying Strawberry genotypes with resistance to charcoal rot • New chairman for Strawberries Australia • The economics of strawberry traits • Challenge set to find solution to plastic waste in the strawberry industry • Lessons from the field: John Hassan, Wandin Victoria • Bayer Biologics range: Serenade Prime • Indonesian strawberry exports
#45 – March 2017	• Industry-wide fungicide coordination for control of powdery mildew and leaf blotch • Tissue culture in the national strawberry varietal improvement program • Victorian horticultural exports to be boosted from new x-ray technology • International Strawberry Symposium – from a Plant Pathology Perspective • Control of fruit size in strawberry plants – implications for the productivity of strawberry fields in Qld • Native vegetation insectaries create a buzz in horticulture • Industry push to raise employment standards • Addressing methamphetamine in the workplace
#46 – July 2017	• National strawberry breeding program update • Plant development and temperature influence on fruit size in Queensland strawberry crops • Benefits of the Yarra Valley Pest Free Place of Production, Bobby Cincotta – Wombat Berries, Wandin North • QSGA awarded commercial licence of sub-tropical varieties • Biosecurity – it's your responsibility too • HARPS hits the right note for growers and retailers • The Australian Brand • Towards market recognition for fair farm employers • Transitions to substrate production
#47 – September 2017	• The importance of virus indexing of strawberry plants for breeding • Seasonal variations in plant nitrogen in strawberries in Queensland • New import conditions for strawberries from Korea • Organic strawberries: a small slice of Australia's billion-dollar organics industry • How the Horticulture Code helps you? • EDN Fumigas – a promising new soil fumigant for strawberry fruit industry • Grower profile – Vanessa and Brenton Sherry, Harvest the Fleurieu
#48 – December 2017	• Developing improved practices for managing charcoal rot in strawberry • The Heritage, the Nostalgia and the Future: Breeding better berries for all • Sunny Ridge Farm – transitioning from soil to substrate • Highlights from the international research conference on methyl bromide alternatives and emissions reductions • The relationship between productivity and leaf growth in strawberries in Queensland • High folate strawberry – tasty and healthy? • Keeping soil in its place – Mancarella Strawberries • Owner Reimbursement Costs – why is this important for the industry?
#49 – March 2018	• BerryQuest International 2018 • Developing Asian Markets for Australian Strawberries

	• Growing from 'Labour Pains'; Simon Dornauf – Hillwood Berries • Biosecurity – Queensland Fruit Fly Update • Do Growers Need Robots? • Berry Breeding for Propagation and Speed • The Art of the Freeze Dried Strawberry • Taste 'N See- 2017 Horticulture Farmer of the Year • Is HARPS required for my business? • Protected Cropping – Shared Lessons from BerryQuest • The Importance of Leaf Area Expansion for the Productivity of Strawberries in a Warming Climate
#50 – July 2018	• The fungus causing charcoal rot can survive between crops in infected crowns • Totally impermeable films increase fumigant concentrations in soil • Is transitioning to protected cropping a good idea? • An extract from seaweeds (Seasol) increases root growth and yield of strawberry plants • Sweet strawberries growing Asian exports • Awards, Agreements and Arrangements • Plug production of sub-tropical node varieties for Western Australia • Plug Plants and other developments in High Tech strawberry production: WA strawberry growers workshop • SIT Plus update
#51 – September 2018	• New varieties for all Australian strawberry growers • Breeding varieties for all Australian strawberry growers into the future • Berry exports strategy 2028 • Being ready for spotted wing drosophila – New project to tackle preparedness • Research shows diverse trends for strawberry consumption in Jakarta, Indonesia • The productivity of strawberry fields in a warming climate • Improving integrated pest management through biodiversity • The evolution of sub-tropical runner production in Queensland • National fruit fly symposium helps set direction • Sub-tropical node varieties and new plug plant sub-licence appointed in WA
#52 – January 2019	• The role of media and social media in the strawberry tampering crisis • New practices for improving control of Charcoal Rot • A strawberry legacy – the end of an era for Mark Herrington • Improving our preparedness for Spotted Wing Drosophila • Deep-pigmented strawberries – a potential niche market for the strawberry industry? • Total Nitrogen is better than Nitrate Nitrogen for assessing the nutrient status of strawberries • Transitioning to HARPS • Using property zoning to implement biosecurity on-farm • Strawberries Australia update
#53 – April 2019	• Australian grown strawberries on show in Germany • National masterclasses to improve biosecurity for the better management of soil-borne diseases of strawberry: Western Australia Report • Evaluation of Bioflora® for charcoal rot control in Victoria • Improving our preparedness for spotted wing drosophila: Understanding the enemy to better arm industry • Coir waste management for hydroponics in berries • Reducing the impact of a warming climate on the productivity of strawberries • Horticulture farmer of the year win for Queensland strawberry producer • Yarra Valley strawberry grower wins national biosecurity award • Taking a deep dive into temperate fruit surveillance • Labour hire licencing laws update • CSIRO food innovation centre

#54 – June 2019	• Investigation into an emerging plant affliction – Reddening of strawberry leaves • Temperate breeding program update • Retaining infected crop debris leads to charcoal rot disease in the following strawberry cop • Seeing "red" in Hong Kong • Will strawberry yields under a warming climate be related to increasing or decreasing leaf area? • The use of Totally Impermeable Films (TIFs) with soil fumigants is cost-effective treatment for management of charcoal rot • Finding sustainable packing pathway for Australian Strawberries • Fruit waste management for Queensland fruit fly • Managing young workers • Agri-tourism inspiration farm trail Queensland • What's new at the biosecurity centre of excellence?

The Punnet e-news

A monthly e-newsletter, the Punnet, was produced by the project to provide regular updates on industry news, resources and events to national and state-based contact databases. Content for the Punnet, which was distributed consistently at 4pm AEST on the third Wednesday of the month was sourced from the project team and distributed to 389 subscribers. A list of the issues produced and key features is outlined as follows.

Issue	Features
Issue 1 – July 2016	• Latest developments on Charcoal Rot • New robotic picking wheel design patented • South Africa Study Tour • Temperate Strawberry Industry Development Officer appointed • Coles Nurture Fund (CNF) • Resources: New tissue nutrient reference levels for Victorian day-neutral strawberries cv. "Albion"
Issue 2 – August 2016	• Shedding light on Strawberry Little Leaf Disease in Victoria • Cold-stored runners to extend season for strawberry growers • California Agriculture journal - special edition on methyl bromide • Rural Women's Award • Resources: Industry Biosecurity Plan
Issue 3 – September 2016	• Substrate production trials at Piñata Farms • Cracking the genetic history • Export markets • Aerial attack on two-spotted mites • Resources: Strawberry Production Gross Margins
Issue 4 – October 2016	• Robot Harvesting • Mechanical Planter • Greenhouse Production • Aussie Consumers want 'Australian made' • Resources: Australian Horticulture Statistics Handbook: Fruit
Issue 5 – November 2016	• Addressing agricultural plastic waste • Annual Victorian industry Ladies Dinner • Looking to technology for soil health management • Resources: Strawberry App IPMinfo
Issue 6 – December 2016	• Your thoughts on non-soil substrate production? • Applications closing soon for Masterclass in Horticultural Business • Latest Hortlink available online • Private sector extension in Australian agriculture survey • Resources: Rediscovering cover crops (webinar recording)
Issue 7 – January 2017	• Call for feedback on Strawberry Strategic Investment Plan • Changes to the 'Backpacker Tax' • Invitation to unique agritourism trial! • Resources: Consumer insight research out of Driscoll's - eating berries makes you happy! • Resources: Greenhouse Growers Toolbox App

Issue 8 – February 2017	• Women's Wellness Weekend • Strawberry planting density: 200,000 plants per hectare • Women's Leadership Development Scholarships open • Resources: Strawberry diagnostics videos
Issue 9 – March 2017	• Next steps for the Strawberry Strategic Investment Plan (SIP) • Berries and leafy veg top heart health foods • See your levy in action! • Resources: Queensland Runner Report • Resources: Grower experiences: IPM Strategies for hydroponic production of berry production
Issue 10 – April 2017	• Tomato potato psyllid interstate trade access • Native vegetation playing a role in IPM • Young Food Innovators program • 2018 Nuffield Scholarships open • Resources: Protected cropping and soil-less strawberry production
Issue 11 – May 2017	• Tomato potato psyllid: Update on WA fruit market access • Victorian Strawberry Forum • Resources: Transitioning from soil to growing media
Issue 12 – June 2017	• How well are we communicating with you? • See your levy in action! • Strawberry Strategic Investment Plan (SIP) for 2017-2021 • Resources: Shared lessons and experience - Tunnels, Substrates and Hydroponic production
Issue 13 – July 2017	• Australian growers competing with frozen strawberry imports • Seasonal Work Incentives Trial • How well are we communicating with you? • Resources: Horticulture Code of Conduct • Resources: Toolbox for Greenhouse Construction and Safe Operation
Issue 14 – August 2017	• 'Taste Australia' features in new export push • New varieties from the breeding program hit the market • Sterile Insect Technology to aid in control of QFF • Resources: Chemical free sanitation - Cold Plasma
Issue 15 – September 2017	• New import conditions for strawberries from Korea • Future forecasting -the rise of strawberry picking robots • See your levy at work in the new HORTLINK! • Resources: Shared lessons on substrate trial
Issue 16 – October 2017	• Hydroponic Farmers Federation farm walk – Sunnyridge Strawberry Farm • Australian Strawberry production – 2015/16 Census • Your levy hard at work – let Hortlink show you how • Resources: Best handling practices for fresh strawberries • Resources: Fruit fly management
Issue 17 – November 2017	• Korean strawberries granted access to Australian market • Strawberry Fund Annual Report 2016/17 • Outfoxing food decay • Masterclass in Horticultural business • Resources: Chemical free sanitation – Cold Plasma
Issue 18 – December 2017	• 2018 – the new year ahead! • War on strawberry waste • Your levy hard at work – let Hortlink show you how • Resources: Good Practice Guide • Resources: Minor use permits
Issue 19 – January 2018	• Strawberry Innovation Networking at BerryQuest • Funds for future strawberry industry leaders • Asia Gateway Vouchers for Victorian businesses • Resources: Managing your soil; crop rotation and soil amendments

Issue 20 – February 2018	• 'Berry' successful BerryQuest • Queensland Fruit Fly vigilance • Is HARPS required for my business? • Are you compliant with the Horticulture Code of Conduct? • Churchill Fellowship Scholarships in Horticulture • Resources: Fruit fly management in strawberries (webinar) • Queensland Fruit Fly identification poster
Issue 21 – March 2018	• One year on - tomato potato psyllid quarantine restrictions still hinder WA growers • Opportunity for Queensland strawberry growers to 'LEAD' • Victorian Young Farmer Scholarships • Horticulture Innovation Fund for Victorian growers • Stakeholder feedback sought - Hort Innovation Review of Performance • Resources: Good Practice Water Management • Resources: Lessons from the Field - Simon Dornauf, Hillwood Berries
Issue 22 – April 2018	• Fruit flies enlisted in fruit fly fight • Alternative soil fumigant approved • Latest horticulture stats out now • Export grants available • See your levy at work with the latest HORTLINK! • Resources: Farm biosecurity planning • Resources: 200+ Agricultural Apps and Software • Resources: A guide to succession
Issue 23 – May 2018	• Roll out of Sterile Insect Technology for Queensland Fruit Fly • TPP Surveillance Program • Are you HARPS ready? • Resources: Silicon for strawberry plant health • Resources: Guide to fresh fruit export requirements • Resources: Side effects database in app form
Issue 24 – June 2018	• Asian market research for Queensland strawberries • Vic Strawberry grower forum • Stingless bees as effective pollinators? • Resources: Good Practice - Pest management • Resources: Area wide management for Qfly
Issue 25 – July 2018	• 10-year Berry Export Strategy launched • Waste solution? • Biosecurity - Fruit Fly update • Share your thoughts on Hort Frontiers • HARPS Training and HACCP Refresher – Expression of Interest sought • Resources: Victorian Strawberry Forum presentations • Resources: Handbook for the Identification of Fruit Flies
Issue 26 – August 2018	• Australian Strawberry Breeding Program (ASBP) Phase II • A "coir" lot of waste • TasAgFuture Survey • Masterclass in Horticultural Business • Resources: Native vegetation insectariums for pest management • Resources: How Australia is being protected from plant pests
Issue 27 – September 2018	• Call for calm in the wake of the tampering issue • Queensland growers meet to discuss tampering issue • Government funding commitments to strawberry industry • Interim control measures for the export of fresh strawberries • Safeguarding Australia's horticultural industry • Hort Innovation 2018 AGM • Resources: How can I control pests? • Resources: Biosecurity basics: Make your own footbath
Issue 28 – October 2018	• Strawberry tampering incident update • Could the strawberry tampering incident end up helping the industry? • Sunny Ridge farm visit • AgriFutures Woman's Award • Resources: Thinking about succession planning or selling your business?

Issue 29 – November 2018	• Charcoal rot project update • Improving preparedness for Spotted Wing Drosophila • New Temperate node committee members sought for the National Strawberry Varietal Improvement Program • Bitter Harvest – Landline feature on the end of Queensland season • Improving ABS agricultural data • Fair Farms Initiative gains further funding • Masterclass in Horticultural Business – extended application date • Resources: Transitioning from soils to substrates in strawberry production – Webinar • Resources: Good Practice Guide: Postharvest handling
Issue 30 – December 2018	• Coir waste management project – Key findings • Quick diagnostic test for Queensland Fruit Fly larvae • Coordinated defence against Australia's most threatening plant disease • Changes to the Working Holiday Maker Visa (417 and 462) • Resources: Good Practice Guide: Nutrient management • Resources: Get your copy of the Strawberry Fund Annual Report now!
Issue 31 – January 2019	• Northern Tasmania declared fruit fly free • New EO for Berries Australia • Help enhance Australia's traceability framework • Improved market supply chain help available • AgriFutures Horizon Scholarship – Now open • Resources: Good Practice Guide
Issue 32 – February 2019	• Needle incident report available • Masterclasses to improve biosecurity for soil-borne disease • Your levy, your say, in your region • Project Green: sustainable packaging for the strawberry industry • Workplace compliance top issue for Fair Farms workshop • Resources: Post incident reflections – 2018 strawberry incident review • Resources: Transitioning to protected cropping – what are the costs and benefits?
Issue 33 – March 2019	• Horticulture Farmer of the Year award given to Queensland strawberry grower • National biosecurity award won by Yarra Valley strawberry grower • Strawberries to be included in Indonesian free trade deal • A focus on fragile fruit • Hort Connections: 2019 National Awards for Excellence – nominations now open • Resources: PMA Marketing Exchange – Fresh Produce; a world of opportunities – Webinar recording • Resources: Australian Strawberry Good Practice guide
Issue 34 – April 2019	• Strawberry prices 'could double' for consumers over the next 10 years • Brown marmorated stink bug update • For Victorian growers: Boost Your Business Round 3 • Fair Work Commission decision on overtime rates for casuals • Resources: Spotted Wing Drosophila preparedness – Webinar recording • Resources: El Niño update
Issue 35 – May 2019	• Strawberry shortage in south-east Australian supermarkets • What's all the buzz about? • New projects exploring IPM response to control spotted wing drosophila • Resources: Hort Frontiers – fruit Fly Fund • Resources: New technology in strawberry production • Resources: Soil Network of Knowledge (SNoK)
Issue 36 – June 2019	• Ceasing interim control measures for the export of fresh strawberries from Australia • Webinar on accessing export markets – tomorrow! • Temperate Strawberry Forum • Hort Innovation at Hort Connections • Resources: New strawberry variety information summary cards • Resources: How clean are our strawberries?

Strawberry innovation website

The Strawberry Innovation program website, strawberryinnovation.com, was developed to centrally house all project resources, events, news updates and other relevant information to the industry. The website was updated weekly and provided a repository for all communication outputs and knowledge transfer resources produced through the project. Key news items relevant to the strawberry industry were uploaded as latest news items, with 299 news items included, as presented in appendix 8. The resources section of the website was structured around the core thematic focus areas identified through the needs analysis, namely:

- Production
- Breeding
- Environment
- Markets
- Business
- People.

Social Media

A twitter account, @StrawberryInnov, was regularly managed to provide information and updates on project resources, events, demonstration sites and other relevant industry information. The twitter account had 297 followers and sent out 88 tweets as illustrated in Figure 8.

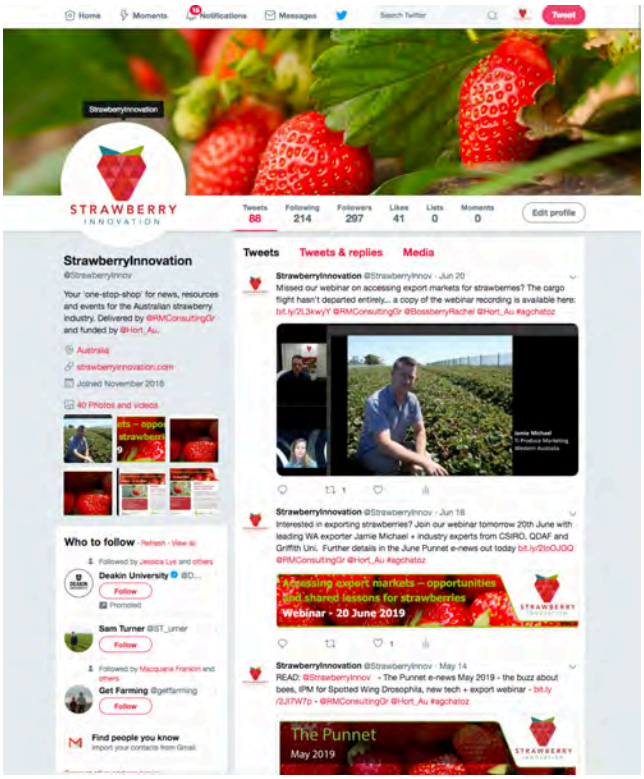

Figure 8: @StrawberryInnov twitter account

Outcomes

The project team continuously monitored and evaluated the project activities and outputs to ensure progress towards the desired outcomes in accordance with the program logic contained in the Monitoring and Evaluation Plan (outlined in Appendix 1). Being adaptive with annual planning cycles also allowed the project to continue to meet the needs of Australian strawberry growers and industry stakeholders.

The immediate (project) outcomes within the sphere of influence and measurement of the project were:

1. Improved industry awareness and knowledge of innovation and technology, breeding outcomes and safety and sustainability requirements.
2. Increased adoption of strawberry research and changes to on-farm decision-making and practices.
3. Increased opportunities for information exchange, networking and learning between growers and other industry members.

Evidence of achieving each of these project outcomes was collected through several sources including:

- Monthly workplan meetings with the regional IDOs
- Program Reference Group Meetings
- Mid-term program review
- Informal and formal direct feedback from growers and industry stakeholders
- Participation and engagement levels in industry activities
- Observed industry practice change and adoption.

Industry awareness and knowledge

Improved industry awareness and knowledge of innovation and technology, breeding outcomes, safety and sustainability requirements has been achieved through passive and active extension of targeted industry:

- Extension of timely and current industry research and development through several established channels, including:
  - Quarterly 24 page hard copy newsletter – Simply Red
  - Monthly, 3rd Wednesday of the month at 4.00pm AEST, e-newsletter – The Punnet
  - Strawberry Innovation website, updated weekly – strawberryinnovation.com
- Development of thematic targeted extension resources in multiple mediums including:
  - Technical Fact Sheets – x 21
  - Shared grower lesson case studies - x 5
  - Webinars – x 4
  - Posters – x 3
  - Varietal information summary cards – x 12
  - Strawberry Industry Pest Identification App
- Support for the regional delivery partners in the organization and coordination of face-to-face grower visits and delivery of targeted industry events, including training, forums, fields days and workshops.

Industry adoption

Increased adoption of strawberry research and changes to on-farm decision-making and practices has been observed through:

- Increasing industry transition to protected cropping
- Increased adoption of new strawberry varieties
- Increased adoption of integrated pest management practices
- Improved on-farm biosecurity management
- Increased interested in accessing export markets.

Several resources and extension materials have guided adoption practices, which are underpinned by the Good Practice Guide and associated fact sheets. The Good Practice Guide is a comprehensive resource and legacy document from the project that covers topics in relation to soil and land management, water management, pest management, nutrition management and postharvest handling.

Industry participation

Improved information sharing and knowledge exchange across the national strawberry industry was achieved through the development and delivery of communication products including the:

- Simply Red magazine – 12 editions - mail out distribution to 562 recipients
- Punnet e-Newsletter – 36 issues - email distribution to 389 subscribers
- Strawberry Innovation website – audience size of 11,600 unique visitors, 14,600 visits and 30,800 page views
- @StrawberryInnov Twitter Handle – 88 Tweets and 297 Followers.

Industry considerations

In assessing the outcomes achieved through the duration of the implementation of the program between March 2016 and June 2019, several key industry events and activities are important to note. These industry developments are important in the context of the support that was provided through the targeted delivery of the industry development project to facilitate greater adoption and practice change through the communication of research and development findings.

- **Industry leadership –** an absence of a peak industry body, namely Strawberries Australia, was present throughout the timeframe of the project implementation. Several unsuccessful attempts were made to engage with the skeleton executive of Strawberries Australia throughout the life of the project. The absence of an effective peak industry body resulted in a lack of industry emphasis and motivation on future research and development. The election of a new executive of Strawberries Australia in late 2018 and the formation of Berries Australia provide a positive direction for this challenge in the future.
- **Soil borne disease pressures** – the production impacts of the phaseout of the use of the soil fumigant, methyl bromide, since 2005 became increasingly evident during the implementation of the project. Without an effective alternative fumigant, maintaining healthy strawberry production in-field, free from soil-borne fungal diseases, nematodes and weeds has become challenging for the industry. The availability of land size of most strawberry producers has made behavioral practices, such as fallow break cropping, difficult. A study undertaken by the Victorian Strawberry Industry Development Committee in 2017 found the charcoal rot-causing fungus, *Marcophomina phaseolina*, present in 75% of Victorian strawberry properties. Subsequently, the only proven long term solution available at this stage to the industry is a transition to cultural control options through fruit production in soil-less media. A significant shift to soil-less production has been observed across the national industry during the life of the project. This has been supported through the development of targeted resources including fact sheets, economic assessments and webinars.

- **Industry R&D** – due to the small volume of strawberry relevant R&D (outside of the breeding program), the opportunity to broker new R&D information relevant to the strawberry industry has been limited. The Australian Strawberry Breeding Program, Phase I and II has been the flagship investment of the strawberry levy over the life of the industry development project. Key outputs from this project have been communicated through this project at every available opportunity. Communication of key research findings and their applicability to the strawberry industry have been undertaken from other leveraged projects including coir waste management, berry export strategy, spotted wing drosophila preparedness, SITplus, as well as the national charcoal rot management project. In the absence of defined strawberry industry R&D, partnerships have been established with research service providers and international research to ensure robust delivery of R&D to the Australian strawberry industry.
- **Food safety** - the 2018 intentional tampering incident of needles in strawberries, industry crisis management and post incident review highlighted several structural challenges and risks within the strawberry industry. The incident had immediate impacts on the market for strawberries, including the implementation of interim control measures for the export of fresh strawberries. A post incident report, commissioned by the Department of Health and delivered by Food Standards Australia New Zealand, identified several recommendations focusing on the need for improved communication during incidents, particularly those involving criminal matters, as well as a review of existing food incident protocols. The sub-tropical regional delivery partner was heavily involved in the response to this incident due to a lack of appropriate/available industry resources.

Monitoring and evaluation

The impact, appropriateness, effectiveness and efficiency and legacy of the project methodology was evaluated through internal monitoring by the project team for the purposes of continuous improvement throughout the life of the project delivery. An additional project team review meeting was held via skype in June 2019 to reflect on the successes and challenges of the project delivery and to make recommendations for future project design.

Specific evaluation questions addressed by the project team have included:

1. Impact: What has changed or is different as a result of the industry development undertaken, either positive or negative? e.g. extent of change to knowledge, skills, attitudes, management practices or businesses/organisations (operational or economic).
2. Effectiveness: To what extent were the planned industry development activities achieved?
3. Appropriateness: To what extent did the activities and the way they were undertaken align with stakeholder needs and expectations? To what extent has the innovation being tested contributed useful information to address the objectives? Which innovation practices or technology employed did not contribute to / deliver on outcomes? And why?
4. Efficiency: To what extent did the project achieve the desired result within budget and timeframes?
5. Legacy and sustainability: To what extent will the project have a lasting impact on the capacity of the Australian strawberry industry? What, if any, lessons have been learned that could improve the success of future projects?

A summary of the project achievements against the MERI framework is presented in Table 1.

Table 1: Achievement against project MERI framework

Evaluation Level	Outcome/activity	Achievement
Long-term outcomes	An industry that has increased production efficiency An industry that has an improved and effective operating environment	Not the responsibility of this project
Project outcomes	1. Improved industry awareness and knowledge of: – Innovation and technology – Breeding outcomes – Safety and sustainability requirements	Improved industry awareness and knowledge through development and communication of information on these topics. In particular: • Development of fact sheets and webinar on transitioning to protected cropping and new technology for the strawberry industry • Articles and postcards on outcomes of breeding program • Provision of sustainability guidelines in the Australian Good Practice Guide
	2. Increased adoption of strawberry research and changes to on-farm decision-making and practices	Adoption observed and reported by regional delivery partners
	3. Increased opportunities for information exchange, networking and learning between growers and other industry members	Increased industry participation and engagement with R&D outcomes as measured by recipients of industry R&D resources and attendance at industry events/activities
Activities	Develop online resource (website) providing information on R&D outcomes	strawberryinnovation.com developed and updated weekly
	Develop information products on new	21 Fact Sheets developed

Evaluation Level	Outcome/activity	Achievement
	techniques	3 Posters developed Strawberry Industry Good Practice Guide
	Prepare regular updates on national issues, runner production, variety trials and industry profiles	12 editions of Simply Red 36 issues of the Punnet
	Facilitate learning from leading growers e.g. 'stories of success' and case studies	5 Case Studies developed
	Develop and deliver regional training events, webinars and/or e-learning	4 webinars delivered Strawberry Industry Pest Identification App
	Develop and deliver master classes, think tanks and/or discussion groups	Support for regional masterclasses such as the VSICA Strawberry Academy
	Conduct workshops, field days, tours and/or other industry events to increase understanding of new practices	Support for regional events such as the Sub-Tropical Biannual Strawberry Field Day, Temperate Annual Strawberry Forum
	Undertake gross margin analysis to understand the cost: benefit of implementing new practices	Gross margin analysis of transitioning to protected cropping completed and communicated through fact sheet and Simply Red publications
	Establish and facilitate grower groups to encourage learning and practice change	Progress made – grower groups attempted, but not sustained
	Facilitate a community of practice to share ideas, lead change and provide feedback on the efficacy of the project	Progress made – community of practices established, but not sustained
Foundational activities/ inputs	Develop an appropriate program logic and work plan Design an appropriate risk management plan Design an appropriate communication and consultation plan Conduct data gathering and analysis to identify and understand industry needs Identify target audiences for particular activities Collaborate with the Project Reference Group and Delivery Partners Undertake annual program evaluation	Completed

Team reflection lessons

The summary points from a team reflection meeting on the project performance are outlined as follows.

What worked well

- Growth of grower engagement and participation in the project over time, including the rapid adoption of new technologies and practices
- The team environment, including the 'back of house' role of RMCG in providing national coordination and the 'front of house' role of the IDOs
- Increasing level of communication and collaboration between states.

What could have been improved

- Transition of role of IDOs from industry advocacy and association activity to research, development and extension
- Relationship with industry associations, particularly Strawberries Australia
- Better engagement with Western Australia industry and growers, including LOTE (language other than English) growers.

Recommendations

The national industry development program sought to overcome the former isolated and independent delivery of R&D activity/resources for the strawberry industry by state-based industry development officers by incorporating a national oversight role to avoid duplication of activities and improve communication nationally. While the communication components of this project have been achieved, several opportunities for improvement in the future delivery of such projects have been identified, including:

1. **Formal engagement of all states.** The resourcing of the program did not facilitate effective engagement or acknowledgement of existing resources within the WA industry. While the WA industry was geographically split between the two regional delivery partners (BS15003 and BS15004), distance and budget inhibited regular engagement of the employed regional delivery partners with WA growers. Furthermore, there was no formal resourcing provision for the existing industry development officer in WA employed by the WA Strawberry Growers Association. *Future projects should ensure contracted arrangements and resourcing for local IDO capacity in all major strawberry producing states.*
2. **Engaged national industry association**. Numerous attempts were made during the life of the program to engage and collaborate with the national industry association; however, these did not lead to an effective relationship. *Strengthening of the national industry association and improved governance would support a more effective industry development program.*
3. **Leveraging of state-based levy R&D**. The existence of the Victorian state-based levy and a reluctance to collaborate with the national R&D program results in a mis-match and duplication of effort for the common goal of strengthening the Australian strawberry industry. *Improved liaison with the VSIDC should be undertaken to harmonise state and national levy outputs.*
4. **Improved industry data**. The unwillingness of strawberry runner producers to provide data on the number and variety of runners produced on an annual basis for the project meant that basic industry information such as the size and value of industry has been difficult to collate and analyse. *Improved industry data collection would support better Industry planning and guidance on future investment.*
5. **More industry relevant research**. While there is a range of research currently conducted within the horticulture industry which has relevance to the strawberry industry, there are only a small number of research projects conducted on issues directly pertinent to the Australian strawberry industry. This resulted in a small level of R&D activity that could be reported through the national communication program. *Increased diversity of investment in industry R&D would enable a more holistic representation of industry R&D priorities to be met.*
6. **Improved project contractual arrangements and reporting**. The contractual arrangements for this project (where contracts for regional delivery is held between Hort Innovation and the state associations) led to confusion around the priority and appropriateness of regional delivery activities. Furthermore, in instances where delivery expectations were not being met, the contractual arrangements did not facilitate effective performance management. *A single contractual arrangement between Hort Innovation and the service provider would better facilitate performance management of national project delivery.*

Refereed scientific publications

None to report

Intellectual property, commercialisation and confidentiality

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

Acknowledgements

The RMCG team would like to acknowledge the Australian strawberry industry growers, advisors, industry associations, supply chain participants and other stakeholders who actively engaged in the national industry development project. We also wish to thank the collaborative support from the strawberry levy research and development service providers, in particular the Queensland Department of Agriculture and Fisheries research staff.

Finally, a special appreciation to the collaborative partnership with the state industry associations in the co-delivery of this national project, in particular the regional industry development officers, Jennifer Rowling from the Queensland Strawberry Industry Promotions Council and Angela Atkinson from the Victorian Strawberry Industry Development Committee.

Appendices

- Appendix 1: Project Plan
- Appendix 2: Annual Workplans – Year 1, 2 and 3
- Appendix 3: Fact Sheets
- Appendix 4: Case Studies
- Appendix 5: Good Practice Guide
- Appendix 6: Posters
- Appendix 7: Postcards
- Appendix 8: Strawberry innovation website news articles.

Appendix 1: Project Plan

RMCG

Environment | Water | Agriculture
Policy | Economics | Communities

May 2016

Facilitating the development of the Australian strawberry industry - BS15002

Program Plan

Horticulture Innovation Australia Limited

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ISO 9001
International Standards
Certifications

Document review and authorisation

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3.0	Final	19/5/16	K. Stirling C. Larsen D. Lucas	C. Muller	P. Mawson	A.M. Boland	milestones@horticulture.com	1 (e)

Note: (e) after number of copies indicates electronic distribution

Contents

1 Introduction

1.1 Driver and purpose of program

This program has been developed in response to a project brief from Horticulture Innovation Australia Limited (Hort Innovation) to undertake an industry development project for the Australian strawberry industry. The objective of this project is to enhance the adoption of innovation and technology in the Australian strawberry industry through brokering research and development (R&D) information and facilitating capacity building in the Australian strawberry industry. This will be achieved by:

- Providing national co-ordination and leadership for the successful development and delivery of innovative information products to the strawberry industry
- Building industry partnerships and networks
- Addressing market failure in strawberry industry regions and groups
- Delivering regionally specific activities.

The focus will be on improving knowledge and skills, and supporting practice change to achieve enhanced long-term sustainability and profitability of Australian strawberry businesses.

1.2 Purpose and structure of this plan

The purpose of this plan is to outline the following for the *Facilitating the development of the Australian strawberry industry* project:

- Purpose and brief background (this section)
- Program logic and monitoring, evaluation, reporting and improvement (MERI) framework (section 2)
- Risk management plan (section 3)
- Stakeholder consultation plan (section 4)
- Communications plan (section 5)
- Program design (section 6).

This plan describes what success looks like, how to measure it, how to mitigate potential risks, and when key activities will be undertaken with different target audiences.

1.3 Background

Case for Investment

During development of the current strategic plan for the strawberry industry[1] it was noted that industry adoption was a critical issue, characterised by concerns about effective communication. Emerging and remaining issues identified relating to research and development include:

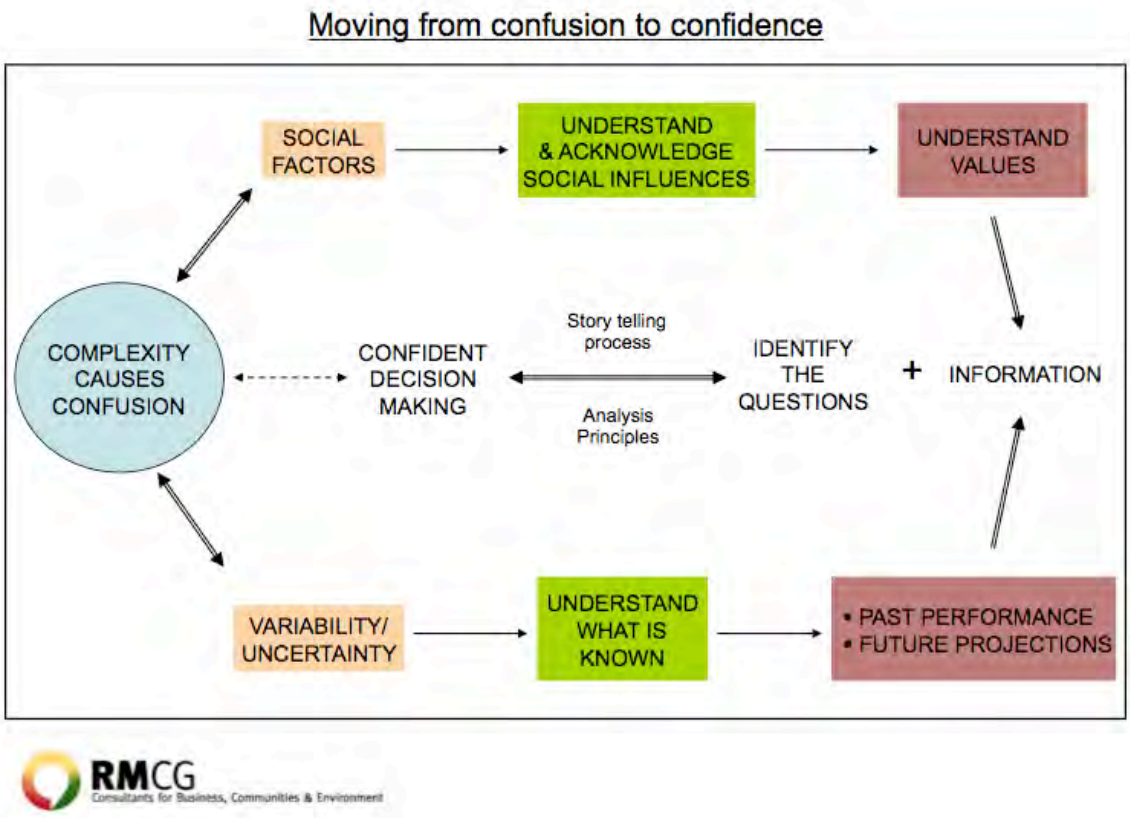
- The need for a national IDO to optimise the benefits of industry communication
- Two-way communication is poor with little opportunity to encourage feedback from growers
- National and state levy projects are not always communicated effectively
- Relevant new information needs to be captured
- Final reports should be produced in a form that encourages clarity
- Project milestones should be noted on the website.

The strategic plan and identification of research and development needs provide strong justification for a nationally focused development program and will inform the design and delivery of the development program for the strawberry industry based on the information needs and preferences of growers.

Critical features of the strawberry industry development program

RMCG's experience of working in horticulture for over twenty years strongly suggests that in order to resolve the issues identified in the strategic plan, the development program needs to properly understand the social and economic context for grower decision-making. Decision-making (such as adoption of new practices or value chain collaboration) can be paralysed by confusion if the approach is to simply provide more information, without understanding the actual questions or knowledge gaps that need addressing. If the context for the decision maker (grower) is ignored, the provision of information that is assumed to be required does not necessarily lead to positive change. These issues are illustrated in the diagram below. The diagram highlights the importance of understanding the interactions between social factors and values in complex decision-making.

[1] Strawberries Australia Inc. – Strategic Investment Plan 2012-2017



Our approach will be to ensure that the social factors and values, as well as the technical and economic uncertainty, is understood in the design and delivery of the development program for the strawberry industry.

2 Program Logic and MERI Framework

2.1 Program logic

The program logic forms the high-level framework for the Project Plan and governs the subsequent MERI framework. This includes considering the hierarchy and connection between:

- Vision: aligned to Australian Strawberry Industry Strategic Investment Plan
- Long-term outcomes (3-10 years): what the project will contribute to after completion
- Project outcomes (1-3 years): within the sphere of influence and measurement of the project timeframe, these include:
    i. Improved awareness and knowledge of: innovation and technology, breeding outcomes and safety and sustainability requirements within the strawberry industry
    ii. Increased adoption of strawberry research and changes to on-farm decision-making and practices
    iii. Increased opportunities for information exchange, networking and learning between growers and other industry members
- Activities: that will be undertaken annually
- Foundational activities: that will underpin and inform the implementation of annual activities.

The program logic for *Facilitating the development of the Australian strawberry industry* 2016-2019 is outlined in **Error! Reference source not found.** below.

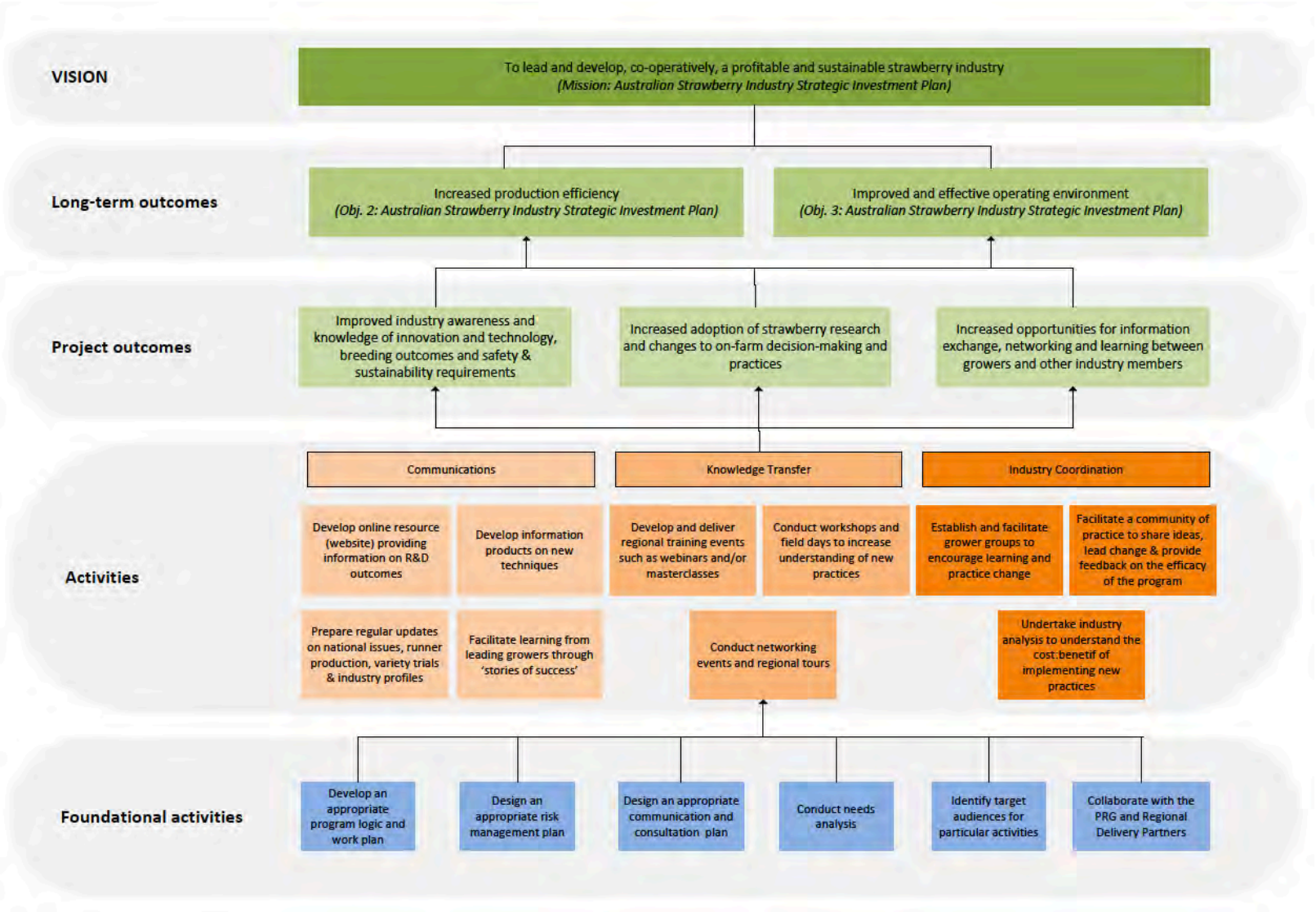


Figure 2-1: Program logic for the *Facilitating the development of the Australian strawberry industry* project 2016-2019

2.2 MERI framework

2.2.1 Key evaluation questions

The key evaluation questions (KEQs) are arranged by five key themes in accordance with best practice evaluation (DAFF and DSEWPaC 2011):

1. Impact: What has changed or is different as a result of the industry development undertaken, either positive or negative? e.g. extent of change to knowledge, skills, attitudes, management practices or businesses/organisations (operational or economic)
2. Effectiveness: To what extent were the planned industry development activities achieved?
3. Appropriateness: To what extent did the activities and the way they were undertaken align with stakeholder needs and expectations? To what extent has the innovation being tested contributed useful information to address the objectives? Which innovation practices or technology employed did not contribute to / deliver on outcomes? And why?
4. Efficiency: To what extent did the project achieve the desired result within budget and timeframes?
5. Legacy and sustainability: To what extent will the project have a lasting impact on the capacity of the Australian strawberry industry? What, if any, lessons have been learned that could improve the success of future projects?

2.2.2 Framework

The MERI process is imbedded in the project as part of the continuous improvement cycle undertaken by the project team. This is guided by the overarching program logic. The MERI framework is outlined below. This aligns the evaluation level and question with the associated sub-questions, monitoring data, and evaluation and reporting requirements. Annual evaluations will inform work planning.

Table 2-1: MERI framework

Level	Outcome / activity	Key evaluation question	Monitoring	Evaluation and reporting
Long-term outcomes (3-10 years)	An industry that has increased production efficiency	**Legacy and sustainability:** To what extent will the project have a lasting impact on the operating environment of the Australian strawberry industry? What, if any, lessons have been learned that could improve the success of future projects?	Type and extent of adoption of knowledge and skills, practices and technology contributing to increased production efficiency at the industry scale (demonstrated production efficiency) Surveys (annual and after training sessions, discussion groups, field days, workshops and other events)	Final project report and collation of monitoring and evaluation data Based on three project outcomes (1-3 years)
Long-term outcomes (3-10 years)	An industry that has an improved and effective operating environment		Type and extent of adoption of knowledge & skills, practices and technology contributing to an improved and effective operating environment at the industry scale (demonstrated production efficiency) Surveys (annual and after training sessions, discussion groups, field days, workshops and other events)	Final project report and collation of monitoring and evaluation data Based on three project outcomes (1-3 years)
Project outcomes (1-3 years)	1. Improved industry awareness and knowledge of: ▪ Innovation and technology ▪ Breeding outcomes ▪ Safety and sustainability requirements	**Impact:** What has changed or is different as a result of the strawberry industry development program, either positive or negative? e.g. extent of change to knowledge, skills, attitudes, management practices, technology adoption, industry cohesion or businesses/organisations (operational or economic)	Change in awareness, knowledge, attitudes, capacity and decision making of growers Changes in advice given to growers and used Appropriateness and effectiveness of practices and technologies for strawberry production (particularly tools to assist decision-making for breeding outcomes, safety and sustainability)	Surveys (pre/post), interviews and/or case studies annually Assessment of decision making tools or processes used **Focus:** growers and advisors
	2. Increased adoption of strawberry research and changes to on-farm decision-making and practices		Use of risk based economic information and industry analysis Change in decision-making and management practices by growers (number of growers, total area of adopted farms) Adoption of technology and efficiencies (number of growers, total area of adopted farms)	Surveys (pre/post), interviews and/or case studies **Focus:** growers and advisors
	3. Increased opportunities for information exchange, networking and learning between growers and other industry members		Type and extent of two-way information exchange e.g. between growers and other stakeholders (number of learning opportunities) Participation in information exchange opportunities (number of	Surveys (pre/post), interviews and/or case studies annually **Focus:** growers, advisors and

Level	Outcome / activity	Key evaluation question	Monitoring	Evaluation and reporting
			growers/stakeholders attending discussion groups, workshops etc.) Changes in knowledge, skills and management practices as a result of peer learning and information exchange	other industry stakeholders
Activities (annual)	Develop online resource (website) providing information on R&D outcomes	**Effectiveness:** To what extent were the planned industry development activities achieved?	Number and type of participants utilising the online resource	Website analytics Website material
	Develop information products on new techniques		Number and type of growers and stakeholders receiving information products Number and type of information products	Number of recipients Number of products Communication & engagement material
	Prepare regular updates on national issues, runner production, variety trials and industry profiles		Number and type of communication updates	Number of updates Location of updates Communication & engagement material
	Facilitate learning from leading growers e.g. 'stories of success' and case studies		Number and type of 'stories of success' and/or case studies	Number of communications Location of communications Communication & engagement material
	Develop and deliver regional training events, webinars and/or e-learning		Number and type of participants engaged and undertaking training	Attendance records Location and type of training Training material
	Develop and deliver master classes, think tanks and/or discussion groups		Number and type of participants in master classes/think tanks and/or discussion groups	Attendance records Location of events Event material
	Conduct workshops, field days, tours and/or other industry events to increase understanding of new practices		Number and type of events Number and type of event participants	Location of events Attendance records Event material
	Undertake gross margin analysis to understand the cost:benefit of implementing new practices		Type and extent of cost:benefit analysis	Cost:benefit data Communication & engagement material
	Establish and facilitate grower groups to encourage learning and practice change		Number and type of growers participating in groups	Attendance records Location of groups

Level	Outcome / activity	Key evaluation question	Monitoring	Evaluation and reporting
	Facilitate a community of practice to share ideas, lead change and provide feedback on the efficacy of the project		Number and type of participants contributing to 'community of practice'	Number of participants Communication & engagement material
Foundational activities/ inputs	▪ Develop an appropriate program logic and work plan ▪ Design an appropriate risk management plan ▪ Design an appropriate communication and consultation plan ▪ Conduct data gathering and analysis to identify and understand industry needs ▪ Identify target audiences for particular activities ▪ Collaborate with the Project Reference Group and Delivery Partners ▪ Undertake annual program evaluation	**Appropriateness:** To what extent did the activities and the way they were undertaken align with stakeholder needs and expectations? To what extent has the innovation being tested contributed useful information to address the objectives? Which innovation practices or technology employed did not contribute to / deliver on outcomes? And why? **Efficiency:** To what extent did the project achieve the desired result within budget and timeframes?	Completion of program logic and initial work plan Completion of risk management plan Completion of communication and consultation plan Completion of needs analysis Number and composition of relevant target groups identified Number of meetings with Project Reference Group (PRG) and Delivery Partners (DPs) and use of advice provided Type and extent of contribution from PRG and DPs Completion of annual evaluations and updated work plans	Program management reporting to project team, PRG, DPs and HIA Program design reporting to project team, PRG, DPs and HIA Baseline needs analysis desktop review Identification of target audience

2.2.3 Assumptions

The main assumptions identified for the project are outlined below. These will be monitored and considered throughout the duration of the project, and contribute to the adaptive management of project activities.

Table 2-2: Assumptions

Level	Assumption
	1. There is variation in production efficiencies and current operating environments within the Australian strawberry industry which requires a greater understanding of innovation and technology to achieve practice change.
Long-term outcomes (3-10 years)	An industry that has: ▪ increased production efficiency; and ▪ an improved and effective operating environment
	2. Individuals may not currently have sufficient knowledge or skills to make the best decisions about more efficient and effective operating environments **3. Practice change can be supported through brokering research and development (R&D) information and facilitating capacity building in the industry**
Project outcomes (1-3 years)	Improved industry awareness and knowledge of: ▪ Innovation and technology ▪ Breeding outcomes ▪ Safety and sustainability requirements
	Increased adoption of strawberry research and changes to on-farm decision-making and practices
	Increased opportunities for information exchange, networking and learning between growers and other industry members
	4. Growers, advisors and other industry participants are willing and able to be involved in the project activities
Activities (annual)	Online resource (website)
	Information products on new techniques
	Regular updates on national issues, runner production, variety trials and industry profiles
	Learning from leading growers e.g. 'stories of success' and case studies
	Regional training events, webinars and/or e-learning
	Master classes, think tanks and/or discussion groups
	Workshops, field days, tours and/or other industry events
	Gross margin analysis for implementing new practices
	Grower groups
	A 'community of practice' (to share ideas, lead change and provide feedback)
	5. Based on the needs analysis the suite of activities will be appropriate and effective in engaging different segments of the industry
Foundational activities/inputs	▪ Develop an appropriate program logic and work plan ▪ Design an appropriate risk management plan ▪ Design an appropriate communication and consultation plan ▪ Conduct data gathering and analysis to identify and understand industry needs ▪ Identify target audiences for particular activities ▪ Collaborate with the Project Reference Group and Delivery Partners ▪ Undertake annual program evaluation

3 Risk Management Plan

There are a number of risks requiring management if project outcomes are to be achieved.

The risks identified range across technical, biophysical, extension, partnerships and internal. The likelihood and consequence of these risks were analysed using the risk matrix outlined in Table 3-1 below.

Table 3-2 summarises these risks and how these will be managed (mitigation strategies). These risks will be reviewed at the Project Reference Group meeting with the mitigation strategies being the responsibility of the project team. The most important risk requiring management is the partnerships with advisors.

Table 3-1: Risk matrix

	Consequence				
Likelihood	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost certain	Low	Medium	High	Very High	Extreme
Likely	Low	Medium	High	Very High	Very High
Possible	Low	Low	Medium	High	High
Unlikely	Minimal	Minimal	Low	Medium	High
Very unlikely	Minimal	Minimal	Low	Low	Medium

Table 3-2: Risk management plan

ID	Risk description	Source of risk	Impact of risk	Likelihood of risk eventuating	Uncontrolled risk level	Acceptable/ Unacceptable	Potential mitigation strategies	Treated risk level	Acceptable/ Unacceptable	Responsible person
1	Partnership not developed with advisors and key influencers	Advisors and key influencers unwilling or unable to be engaged	Major	Possible	High	Unacceptable	Reputable project team members that are trusted and respected Early engagement with advisors and agrochemical sector Involvement in project activities Tailored advisor training Monitoring and evaluation of target audience response, to enable an adaptive and responsive approach. Focus of information will be on viable and economic options for strawberry producers.	Medium	Acceptable	RMCG Project Manager
2	Unable to identify good practices and tools to address industry needs	'Good practice' may not have been established for some issues / opportunities	Major	Likely	Very high	Unacceptable	Work with growers, advisors and experts to identify 'good practice' early in the project Identify gaps in knowledge to inform R&D	Medium	Acceptable	RMCG Project Manager
3	Unable to identify and involve key experts in strawberry production and identified needs	Expertise in a topic may be currently limited	Major	Likely	Very high	Unacceptable	Identify and involve experts early in the project Consider contribution from experts in other industries	Low	Acceptable	RMCG Project Manager
4	Growers and advisors not willing and/or able to participate	Extension activities not addressing issues of concern	Major	Possible	High	Unacceptable	Understanding of industry needs based on previous projects Established contacts and networks in industry Experience team in developing and delivering extension	Low	Acceptable	RMCG Project Manager

ID	Risk description	Source of risk	Impact of risk	Likelihood of risk eventuating	Uncontrolled risk level	Acceptable/ Unacceptable	Potential mitigation strategies	Treated risk level	Acceptable/ Unacceptable	Responsible person
5	Loss of key personnel	Key staff resign	Major Loss of key knowledge, experience and information	Possible	High	Unacceptable	Project staff trained with multiple skills. Regular meetings to ensure all staff are aware of project progress. Use of DropBox to protect against data loss	Low	Acceptable	RMCG Project Manager
6	Limited stakeholder 'buy-in'	Lack of consultation with key stakeholders. Poor understanding of stakeholder needs.	Major	Possible	High	Unacceptable	Develop and implement a stakeholder engagement plan. Focus the project on the needs of stakeholders; use appropriate engagement methods and consider the different levels of participation (inform, consult, involve, collaborate and empower).	Low	Acceptable	RMCG Project Manager
7	Project management risks (budget, time, quality, scope)	Budget: Budgets not regularly monitored; activities cost more than originally anticipated; lack of control over spending. Time: Schedule dominated by critical tasks; tight timeframes. Quality: Poorly skilled people; lack of reviews and monitoring; low commitment to quality standards. Scope creep: poor definition of expectations; poor documentation; lack of scope control measures.	Major	Possible	High	Unacceptable	Adhere to RMCG Quality Management System (QMS) Key personnel experienced in project management. Utilise a Project Advisory Group to inform project strategic direction.	Low	Acceptable	RMCG Project Manager

4 Stakeholder Engagement Plan

4.1 Overview

The key stakeholder groups for this project include:

- Fruit producers
- Runner growers
- Advisors and extension providers
- Industry associations
- Researchers
- Supply chain participants
- Project Reference Group.

These stakeholder groups are discussed and analysed further below.

4.2 Fruit producers

There are approximately 580 strawberry businesses across Australia concentrated in coastal regions. The majority of growers are in Beerwah in Queensland and the Yarra Valley in Victoria, as well as Wanneroo and Albany in Western Australia, the Adelaide Hills in South Australia, in the south and north of Tasmania, and the Camden region of NSW.[1]

Segmenting the industry is important for tailoring extension approaches. This is based on size and relative attitudes, knowledge and skills, as well as production system (or location). This approach has been previously used and will be tailored with a focus on the adoption of on-farm management practices. The industry has been segmented into the three main groups outlined in

[1] Australian Bureau of Statistics (2014) 71210DO001 Agricultural Commodities, Australia, 2012-13, Australian Government, Canberra

Table 4-1.

The majority (80%) of growers in the industry are mid-large and operate sub-tropical production systems in Queensland (40%) or temperate systems in Victoria (20%). There are fewer (18%) smaller producers and/or agri-tourism (e.g. pick-your-own) operators. The large corporate grower is Costa who grow, distribute and sell strawberries for the domestic market under the Driscoll's brand. Costa has eight berry growing sites around Australia (Atherton Tablelands QLD, Corindi NSW, Tumbarumba NSW, 9 Mile (Sulphur Creek) TAS, Dunorlan TAS, East Devonport TAS, Wesley Vale TAS, Gin Gin WA).

Table 4-1: Strawberry industry segmentation by number of growers

Production system	Corporate	Mid-large	Small / agri-tourism	Total
Sub-tropical (QLD)	0.3%	42%	3%	46%
Temperate (VIC)	0.0%	21%	7%	28%
Mediterranean (WA, SA)	0.3%	14%	2%	17%
Other temperate (NSW, TAS)	0.7%	3%	7%	10%
Total	**1%**	**80%**	**18%**	**100%**
Drivers and 'what's in it for me?' messages	▪ Industry leaders ▪ Increased supply chain efficiency ▪ New and improved variety breeding ▪ Improved production systems	▪ Increased production and profitability ▪ New and improved variety breeding ▪ Improved sustainability	▪ Ability to learn from leading growers ▪ Value-add and potential farm gate points of difference	
Knowledge access	▪ In-house R&D ▪ In-house agronomist Conduct trials and develop new production methods ▪ Closed loop marketing system	▪ Seek specialist advice ▪ Use online resources ▪ Some interested in new technologies, varieties and supply chain arrangements	▪ Open to new ideas and see the benefit of involvement with other people and researchers ▪ Have reasons other than profitability for participating in industry	
Interest in information	▪ Latest R&D ▪ New technologies, varieties and approaches ▪ Business efficiency	▪ Support to implement new technologies and practices	▪ Compliance ▪ Quality assurance ▪ Value-add	
Engagement in project through extension activities	▪ Regional demonstration sites/case studies ▪ Training events ▪ Master classes/think tanks/discussion groups ▪ Study tours	▪ Regional demonstration sites/case studies ▪ Information products on new techniques, topics and issues ▪ Regular regional updates on issues of relevance ▪ Training events (technology transfer activities, succession planning) ▪ Grower groups ▪ Grower and advisor networks ▪ Study tours ▪ Women in horticulture	▪ Information products on new techniques, topics and issues ▪ Regular regional updates on issues of relevance ▪ Training events (business management, succession planning, farm financials) ▪ Women in horticulture	

4.3 Runner growers

Runner growers play an integral role in providing quality certified runner stock to grower producers that are free from pests and diseases. There are currently a small number (3) of large certified runner growers nationally based near the main strawberry producing regions (Table 4-2). They produce upward of one million runners per annum. The key issues faced by runner growers include:

- Pest and disease control, particularly fumigation (e.g. methyl bromide exemption)
- New varieties and breeding program
- Supply management (e.g. fresh versus frozen) and growing to market demand
- Chemical usage and storage
- Rotations in the production system.

These issues will be addressed through engagement in similar extension activities to the mid-large grower producers above. They will also be included in the national communication program.

Table 4-2: Certified runner growers

Production system	Business, location
Sub-tropical (QLD)	Sweet's Strawberry Runners, Stanthorpe
	Red Jewel Nursery, Ballandean
Temperate (VIC)	Toolangi Certified Strawberry Runner Growers Cooperative Ltd, Toolangi

4.4 Advisors and extension providers

The project will work closely with the regional delivery partners in Queensland and Victoria, as well as involve other advisors and extension providers. They will be responsible for delivering the majority of the extension activities in the regions with the assistance and coordination of the RMCG team. The four main groups include:

- Two regional delivery partners (BS15003 and BS15004)
- Commercial resellers and agronomists, such as E.E. Muir & Son, Landmark, Elders, Campbell's
- Private agro-chemical companies and suppliers, such as Bayer, Syngenta, DuPont
- Specialist advisors, such as crop scouts, Integrated Pest Management (IPM) specialists and in-house agronomists for corporate growers.

Advisors and extension providers will be engaged predominately through training events (technology transfer activities) and grower and advisor networks. They will also be included in the national communication program.

4.5 Industry associations

Industry associations are critical to the success of the project. We will engage with the peak industry body Strawberries Australia to ensure that the activities and outcomes of the project are communicated with the broader industry. Their R&D priorities are:

- Pest and disease control
- Breeding and variety improvement

- Education and training
- Extension of national and international R&D outcomes.[2]

In addition, we will ensure those state-based industry organisations are aware of the activities being undertaken. This will require regular communication with industry groups including:

- Queensland Strawberry Growers Association (QSGA)
- Victorian Strawberry Industry Development Committee (VSIDC) and Victorian Strawberry Growers Association (VSGA)
- Agricultural Produce Commission (APC) Strawberry Producers' Committee Western Australia
- Fruit Growers Tasmania (FGT)
- Agribusiness Yarra Valley (VIC)
- Growcom (QLD).

Industry associations will be engaged in the project through the regional delivery partners in Queensland and Victoria. All states will also be included in the national communication program.

4.6 Researchers

Researchers address priority information gaps on technologies, varieties and practices for the strawberry industry. The main research organisations and topics include:

- Department of Agriculture and Fisheries Queensland (DAFQ): plant breeding, biotechnology, agronomy and crop management, entomology, plant pathology, pest and disease management[3]
- Department of Agriculture and Food Western Australia (DAFWA): new varieties, pest and disease management, Mediterranean fruit fly trapping and development of market access protocols, working with Vietnamese growers to improve their understanding and practice in irrigation and nutrient management[4]
- Tasmanian Institute of Agriculture (TIA): land suitability for assisting in site selection[5], connecting to industry and extension networks[6]
- University of California: breeding having developed over 80% of commercial varieties grown worldwide and R&D management.[7]

Researchers will be engaged in the project through the development of information products on new techniques, topics and issues as well as guest presenters at training events. They will provide up-to-date R&D information to be extended to industry stakeholders, and their engagement is important to ensure quality assurance, accuracy of information and recognition of intellectual property (IP). They will also be included in the national communication program.

4.7 Supply chain participants

Handling and processes in the supply chain have the ability to undermine fruit quality at the point of sale, even though the quality of farm-gate production has improved considerably. The main supply chain participants include:

[2] http://www.strawberriesaustralia.com.au/6858650/strawberries-australia-about-strawberries-austra.htm
[3] https://www.daf.qld.gov.au/plants/fruit-and-vegetables/fruit-and-nuts/strawberries
[4] https://www.agric.wa.gov.au/crops/horticulture/fruit/strawberries
[5] http://www.utas.edu.au/__data/assets/pdf_file/0007/351835/Strawberries-in-Tasmania-factsheet.pdf
[6] http://www.utas.edu.au/tia/centres/perennial-horticulture-centre/other-activity-areas/other-activity-areas/berries/berry-resources-and-links
[7] http://research.ucdavis.edu/industry/ia/industry/strawberry/

- Packing sheds
- Cool stores and cool chain managers
- Supermarkets
- Greengrocers.

Supply chain participants will be engaged through information products, regular regional updates on issues of relevance, as well as training events. They will also be included in the national communication program.

4.8 Project Reference Group

The project team will establish a Project Reference Group (PRG) to provide feedback, advice and input to work plans throughout the project.

The PRG is primarily concerned with monitoring and evaluating how the project is contributing to the desired outcomes. The Terms of Reference for this committee is outlined in Appendix 2. Membership of the PRG is outlined below.

Table 4-3: Project Reference Group members

Name	Role and organisation
Kristen Stirling	Senior Consultant, RMCG
Bianca Cairns	R&D Manager, Hort Innovation
Stuart Burgess	Portfolio Manager, Hort Innovation
Adrian Shulz (TBC)	Queensland strawberry grower
Grower #2 (TBC)	Victorian strawberry grower (preferably young and/or female)
Service advisor #1 (TBC)	DAF Researcher and/or Paul Jones (IPM specialist)
Service advisor #2 (TBC)	VIC/WA agronomist and/or research provider

5 Communications Plan

5.1 Overview

Communication is central to for the project to work towards improved awareness, knowledge, adoption and information exchange between growers and other industry stakeholders. It is therefore essential to communicate with people about topics that interest them on platforms where they already seek information.

The communications plan outlines:

- Target audiences and outcomes
- Mode, tools and purpose
- Options analysis.

These are outlined in turn below.

5.2 Target audiences and outcomes

The target audiences for project communications include the main stakeholder groups outlined in the engagement plan above. A desired outcome from communicating with each group is outlined below.

Table 5-1: Target audiences and outcomes

Group	Inform	Consult	Involve	Collaborate	Empower
Fruit producers					Improved awareness, knowledge and adoption
Runner growers					
Advisors and extension providers				Improved decision-making and provision of advice	
Industry associations			Increased co-hosting of events and co-branding of resources		
Researchers		Increased collaboration to develop information products and run training events			
Supply chain participants		Increased access to technical information and advice			
Project Reference Group			Increased awareness and advocacy of national project		
Funding bodies (HIA and federal government)	Increased information about return on investment				

5.3 Mode, tools and purpose

Project communication will involve a mix of face-to-face delivery by the two regional partners, as well as online, and both soft and hard copy resources. The different tools and purpose within each of these modes are outlined below.

Table 5-2: Mode, tools and purpose

Mode	Tool	Purpose
Face-to-face	Training events (workshops and field days)	To build knowledge and capacity of growers and advisors on specific topics or issues
	Regional demonstration farms/case studies	To showcase changes in practices from leading growers, host events, and/or understand the costs and benefits of change in practices
	Grower groups/grower and advisor networks	To foster collaboration and networks amongst growers in similar locations
	Master classes/think tanks/discussion groups	To collaborate and discuss cutting edge knowledge in an immersive and self-directed learning environment
	Study tours	To promote information exchange on varieties and best practice between growers and international researchers (e.g. University of California Davis Campus)
	Women in horticulture	To recognise the role women play in the Australian strawberry industry and promote information exchange through field days, study tours and dinners
Online	Website	To centrally house all project resources, events, updates and other information
	Facebook (if appropriate)	To promote and provide updates on regional activities, information and events and provide a forum for discussion (Queensland and Victoria)
	Twitter (if appropriate)	To provide regular information and updates on project resources, events, demonstration sites, and other relevant industry information
	E-newsletter	To provide regular regional updates on issues of relevance to national and state-based contact databases
Soft copy	Fact sheets	To prioritise and package the latest research and development for growers and advisors
	Articles and publications	To provide information on specific topics and/or project updates to industry
	Videos	To showcase changes in practices, understand lessons learnt and provide practical real-life examples of growers
Hard copy	Fact sheets	To prioritise and package the latest research and development for growers and advisors
	Articles and publications	To provide information on specific topics and/or project updates to industry

5.4 Options analysis

The strawberry industry currently has a number of state-based and national communication channels. It is important that this project uses these existing channels as much as possible to avoid duplication and ensure that information is being communicated in a fit-for-purpose way.

There are a number of options for each communication tool based on the current situation. These options are outlined below.

Table 5-3: Options analysis

Mode	Tool	Current situation	Options
Face-to-face	Training events	QLD: Farm visits, grower workshops, industry meetings VIC: Farm walks (e.g. IPM, rain cover/protection) (inactive)	Continue through regional delivery partners in QLD, VIC, WA, SA, TAS and NSW (as required)
	Regional demonstration farms/case studies	QLD: Field days (annual) VIC: On-farm evaluation trials of new varieties, cost of production development (inactive)	Establish through regional delivery partners in QLD and VIC
	Grower groups/grower and advisor networks	National: AGM dinner (Sep) QLD: Breeding program trial visits with DAFQ VIC: VSIDC AGM dinner, Horticulture Industry Network (DEDJTR)	Continue through regional delivery partners in QLD and VIC
	Master classes/think tanks/discussion groups	National: Annual General Meeting (Sep) QLD: Improving runner quality inspections VIC: VSIDC Annual General Meeting	Establish through regional delivery partners in QLD and VIC
	Study tours	QLD: Overseas study tour to coincide with International Strawberry Symposium (e.g. Florida 2012) VIC: Overseas study tour (e.g. California 2012), International Strawberry Symposium (e.g. Beijing)	Continue through regional delivery partners in QLD, VIC, WA, SA, TAS and NSW (as required) (e.g. VIII International Strawberry Symposium, Québec City, Canada, August, 2016)
	Women in horticulture	QLD: Field trip, links to Growcom Women in Horticulture VIC: Ladies Dinner (inactive)	Continue through regional delivery partners in QLD and VIC
Online	Website	National: http://www.strawberriesaustralia.com.au	The preferred option is to host a separate

Mode	Tool	Current situation	Options
		(inactive Sep-12) QLD: http://www.qldstrawberries.com.au (active May-16) VIC: http://vicstrawberry.com.au (inactive Nov-15)	national project website with a new URL (www.strawberryinnovation.com, using Squarespace). This would be independent of industry bodies and could be perceived as a beneficial 'fresh start' by the industry.
	Facebook	QLD: https://www.facebook.com/qldstrawberries (active May-16, 290 likes) VIC: https://www.facebook.com/VictorianStrawberries (active May-16, 1,269 likes)	Continue through regional delivery partners in QLD and VIC, as these already have an established following, particularly in VIC. RMCG would provide national and regional content (if required).
	Twitter	QLD: https://twitter.com/QLDstrawberries (inactive Sep-12, 102 followers) VIC: https://twitter.com/VicStrawberries (inactive Oct-15, 80 followers)	Continue through regional delivery partners in QLD and VIC only if required; however both accounts are not active and have limited followers. This demonstrates that strawberry industry stakeholders do not actively seek information via this channel.
	E-newsletter	National: Wild About Strawberries (bi-monthly, inactive May-09) QLD: Simply Red (quarterly, hard copy, distributed to QLD, WA and NSW, active Dec-15) VIC: Vic Strawberries (hard copy, inactive)	RMCG to develop national e-newsletter. However, access to an appropriate national contact database through Hort Innovation, QSGA and VSIDC will be an issue due to privacy restrictions. This needs to be addressed as a matter of priority to enable industry communication (e.g. only first name de-identified with email is needed for MailChimp platform). Continue distribution of 'Simply Red' as a hard copy newsletter but distribute nationally as this is well established and has broad readership. RMCG to assist in providing national and regionally tailored information for these newsletters.
Soft copy	Fact sheets	QLD: plant breeding, biotechnology, agronomy and crop management, entomology, plant pathology, pest and disease management[8] VIC: growing and caring tips, cost of production (2010/11), effects of irrigation on yield and water use, response to water deficit conditions[9] WA: new varieties, pest and	RMCG to host all relevant fact sheets on the national website platform. The direct PDF is preferred, however the URL link can be used if there are copyright issues with the state agriculture departments. Continue to develop new fact sheets on topics and issues of relevance based on R&D undertaken by DAFQ, DAFWA and TIA and distribute through the e-newsletter and to regional delivery partners. Regional delivery partners to tailor relevant content to their region and distribute

[8] https://www.daf.qld.gov.au/plants/fruit-and-vegetables/fruit-and-nuts/strawberries
[9] http://vicstrawberry.com.au/documents/

Mode	Tool	Current situation	Options
		disease management, Mediterranean fruit fly trapping and development of market access protocols, working with Vietnamese growers to improve their understanding and practice in irrigation and nutrient management[10] TAS: land suitability for assisting in site selection[11], connecting to industry and extension networks[12]	through social media channels.
	Articles and publications	QLD: R&D updates via special editions of Simply Red http://www.qldstrawberries.com.au/about-us/research-and-development/ (active Sep-15) VIC:	RMCG to host all relevant publications on the national website platform. The direct PDF is preferred, however the URL link can be used if there are copyright issues with the state agriculture departments. Continue to develop new publications on topics and issues of relevance based on R&D undertaken by DAFQ, DAFWA and TIA and distribute through the e-newsletter and to regional delivery partners.
	Videos	VIC: From Paddock to Plate https://www.facebook.com/VictorianStrawberries/videos/1235309439816422/?video_source=pages_finch_main_video	RMCG to promote existing and develop new videos as identified and needed by industry stakeholders e.g. learning from leading growers case studies have been successful in other industry development projects.
Hard copy	Fact sheets	Unknown	As above, distribute selected resources at face-to-face events through regional delivery partners in QLD and VIC.
	Articles and publications	Unknown	As above, distribute selected resources at face-to-face events through regional delivery partners in QLD and VIC.

[10] https://www.agric.wa.gov.au/crops/horticulture/fruit/strawberries
[11] http://www.utas.edu.au/__data/assets/pdf_file/0007/351835/Strawberries-in-Tasmania-factsheet.pdf
[12] http://www.utas.edu.au/tia/centres/perennial-horticulture-centre/other-activity-areas/other-activity-areas/berries/berry-resources-and-links

6 Program Design

6.1 Introduction

The program design outlines how we will engage with the Australian strawberry industry with further details on specific activities and communication provided in the annual work plan. It also provides details on:

- The project team (including regional deliverers and sub-contractors)
- The differing levels of service delivery across the Australian strawberry industry, reflecting the relative size of the industry within each state
- The key issues and priorities for the Australian strawberry industry and how we will address these within the work plan.

6.2 Overview

The RMCG project team will meet quarterly with the two regional deliverers to review the effectiveness and appropriateness of the activities. The project team is responsible for the detailed planning and improvement of the project. The program will be adjusted and refined on an annual basis to ensure the needs of the industry and growers continue to be met.

The key outputs from the project will be:

- Provision of national co-ordination and leadership for the successful development and delivery of innovative information products to the strawberry industry
- Development of industry partnerships and networks in conjunction with the temperate and sub-tropical regional delivery providers
- Addressing market failure in strawberry industry regions and groups
- Delivering regionally specific activities through the temperate and sub-tropical regional delivery projects.

The project team will also focus on communicating the outcomes of any existing or new information relevant to the Australian strawberry industry that may have been developed:

- From previous and current R&D projects
- The Victorian and Queensland strawberry associations
- International research projects and those within other agricultural industries

6.3 Approach

We have a strong belief at RMCG that a project of this type should adhere to proven principles of successful adult learning and information adoption. These stipulate that the content and delivery format must show participants:

- A relative advantage of adopting new information
- Compatibility (with existing systems, processes, techniques, capacity and attitudes)
- Observability (proof of benefits)
- Trial-ability (can be implemented in their operation/ business)
- A low degree of complexity, real or perceived.

We will recommend pathways and develop a national program that will ensure strawberry growers have the opportunity to access all relevant information.

Traditionally, it has been assumed that 'innovators' in an industry will automatically adopt a new technology or practice and lead 'followers', while 'laggards' show a reluctance to adopt. A more recent model for adoption advocates that the motivation to adopt R&D and innovation will depend on the differing needs and circumstances (i.e. social/cultural context) of growers. Differences in circumstance mean that growers will adopt the same innovation for different reasons. In some cases, growers will not adopt an innovation because they perceive that the particular innovation will not meet their needs better than their current practices or pose a business risk. This suggests that there are different reasons for why all growers in an industry do not adopt an innovation or react to the same delivery methods.

It is therefore critical that we understand the farming context and the potential incentives for individuals within certain contexts to adopt a management practice and/or technology. Provided, there is an understanding of the key drivers and barriers for a particular issue, it will be possible to tailor capacity building programs and tools to the needs of the individual business.

In the first part of Year 1 the priority will be to explore and define the impediments to industry development by building on previous work, and focussing on effective ways to overcome barriers. Areas of investigation will include:

- What are the market failures?
- What are the growers' expectations?
- What are the social contexts for strawberry production decision-making?
- What are the most effective ways to engage strawberry growers operating within different contexts?
- What is the economic context for strawberry production decision-making?

In the second part of Year 1 and in subsequent years the priority will be to work with the regional delivery partners (IDOs), using their regional understanding and industry expertise, to design and build the delivery infrastructure that addresses each of the above key issues.

Illustration of the proposed approach for the design and delivery of the Australian strawberry industry development program is provided in Appendix 2.

6.4 Specific activities

The following section outlines the specific activities to be conducted within the strawberry industry development program. The range of activities can be broadly grouped into:

- **Industry coordination** – these are activities that provide a framework for improving coordination and cohesiveness within the Australian strawberry industry
- **Knowledge transfer** – these are topic specific activities and events to address particular needs and/or issues within industry
- **Communications** – these activities are focused on informing industry on events, issues and the latest research and development.

6.4.1 Industry coordination

Learning from leading growers

The project team will develop relationships with leading/progressive growers who are implementing/trialling new techniques on their farm, which demonstrate best practice management.

These growers/farms (to be referred to as 'demonstration farms') will also be targeted based on their willingness to share information and work with the project team.

The main strawberry growing regions will be used to guide project delivery. It is anticipated that we would establish 2 demonstration sites in the main production regions of Queensland and Victoria and potentially one in SA and WA. Specific topics which may be addressed on the demonstration farms could include:

- Innovative quality assurance and supply chain management
- Best practice IPM and soil health management
- New production practices (such as hydroponics).

The demonstration farms will be used for field days, case studies and 'stories of success'.

Establish grower groups/'production clubs'

The analysis of grower segments has identified the interest of 'progressive strawberry growers' to work with like-minded growers. In some instances the use of grower groups will be a powerful means of developing learning and bringing about change in practices. However, these groups need to meet the specific needs of the grower and in some instances competition between growers may prevent their applicability.

There may be an opportunity to link in with established groups. The project team will collaborate with the regional deliverers to determine the level of interest in forming new grower groups and how to integrate with those that already exist.

Develop a Community of Practice

The project team will seek to establish a 'Community of Practice' for the Australian strawberry industry.

> *"Communities of practice are groups of people who share a concern or passion for something they do and learn how to do it better as they interact regularly."*[13]

Communities of practice are usually characterised by:

- The domain (the common area of interest), in this case the development of the Australian strawberry industry
- The community (these are industry members, who in pursuing their interest in the domain (strawberry industry) engage in joint activities and discussions, help each other, and share information). They build relationships that enable them to learn from each other.
- The practice (members of a community of practice are practitioners). They develop a shared repertoire of resources: experiences, stories, tools, ways of addressing recurring problems. This takes time and sustained interaction.

The project team will invite key practitioners within the strawberry industry (members who are regularly working with, and advising growers, such as researchers, agronomists, IPM consultants, agribusiness advisors) to join the community of practice. Developing the community will rely on establishing links and contacts with the broad range of advisors in the industry. We will collaborate with the regional delivers and other state industry bodies to establish this network.

We will provide a forum to enable members to share and learn from each other. Due to the geographic spread of the strawberry industry this will include both online tools (such as a website, webinars, skype

[13] Etienne Wenger. Communities of practice: a brief introduction.

meetings) and in the key regional production areas within Victoria and Queensland we will also conduct face to face activities on issues/topics of interest to the community.

Industry analysis

The project team will undertake industry analysis (using available industry statistics and economists within RMCG) to facilitate greater understanding of the costs:benefits associated with different production/business practices and assist industry in identifying opportunities to improve profitability.

6.4.2 Knowledge transfer

To assist industry in addressing particular issues the project team will also conduct regional activities via the regional deliverers such as:

- Workshops (utilising specialists such as Paul Horne and Paul Jones to provide information and assistance on managing particular issues)
- Master classes that involve a range of industry members
- Field days (to highlight innovative practices on leading/innovative grower properties and/or those conducting in-field trials on new varieties)
- e-learning opportunities such as topic specific webinars
- International or regional tours to other production regions (these would require additional funding)
- Industry networking events (such as the ladies dinner held annually in Victoria).

6.4.3 Communication activities

The project team will seek to develop a national communication platform that will inform and engage with all members of the Australian strawberry industry. Communication activities are discussed in more detail in the Communications Plan (section 5) but could include:

- Regular updates on issues and topics of interest via a monthly e-newsletter (format to be newsy, short and relevant with links to more detailed information as required, similar to that produced by Apple and Pear Australia Limited in *Industry Juice*)
- Nationally focussed website which links to relevant regional websites, and provides resources and the latest R&D updates for the strawberry industry (www.strawberryinnovation.com)
- Quarterly, hard copy newsletter as currently produced by Queensland Strawberries (Simply Red)
- Development of information products such as fact sheets and best practice guides as required
- Development of case studies ('stories of success') based on activities of leading/innovative growers within the strawberry industry.

6.5 Project team

To effectively build capacity within the strawberry industry RMCG will collaborate with a regional deliverer in the temperate and sub-tropical production zones to ensure that:

- Nationally available information is properly converted into relevant regional or industry specific packages utilising appropriate delivery formats
- The wide diversity of grower communities and geographic regions is tailored for, and the actual or perceived competition or synergies between regions, is understood and considered in the delivery approach.

The two regional delivery projects (BS15003 and BS15004) will be coordinated by RMCG but contracted through Hort Innovation. They will deliver against the national strawberry industry development program

logic and work plans. Ideally personnel (IDOs) delivering the regional delivery projects will have worked in the strawberry industry previously and have a depth of understanding of the key issues facing growers in that particular region. This understanding and experience will be used to inform the development of information products and extension activities. It is also expected that the IDOs will utilise existing (or newly developed) relationships with researchers in their regions to inform the development of information products and extension activities.

RMCG will subcontract IPM Technologies to deliver specific IPM related activities in Victoria during the project.

6.5.1 Team members

The project team roles and expertise are outlined below.

Table 6-1: Project team roles and expertise

Name	Expertise and Project role
RMCG	
Dr Kristen Stirling	▪ Project manager ▪ Pest and disease management ▪ Horticultural expertise ▪ Extension design
Clinton Muller	▪ Project manager (while Kristen Stirling on maternity leave) ▪ Horticultural expertise ▪ Stakeholder engagement
Donna Lucas	▪ Horticultural expertise ▪ Extension design and delivery ▪ ICP
Carl Larsen	▪ Communications ▪ Extension design and delivery ▪ Evaluation
Jaclyne Scally	▪ Project support ▪ Sustainable management practices ▪ Resource development
Dr Anne-Maree Boland	▪ Project oversight ▪ Stakeholder engagement ▪ Extension design
IPM Technologies	
Dr Paul Horne	▪ IPM expert ▪ Extension design and delivery ▪ Training
Jessica Page	▪ IPM expert ▪ Extension design and delivery ▪ Training
Sub-tropical Delivery Partner	
Jennifer Rowlings	▪ Regional delivery in sub-tropical region
Temperate Delivery Partner	
TBA	▪ Regional delivery in termperate region

6.5.2 Team governance

The governance arrangements for the Australian strawberry industry development program is outlined in Figure 6-1.

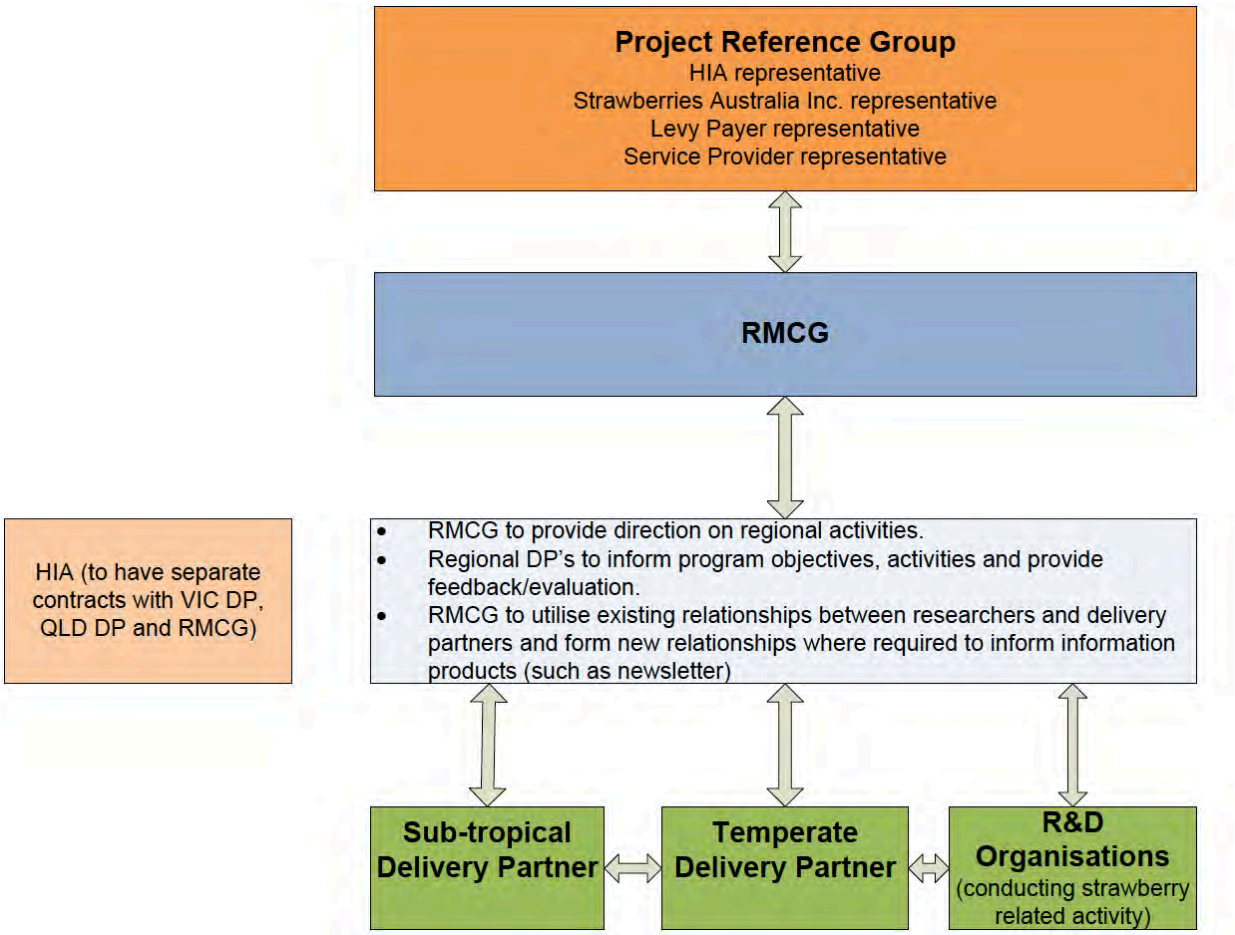


Figure 6-1: Program governance

6.5.3 Team roles and responsibilities

The roles and responsibilities within the program will be allocated as detailed in Table 6-2 below.

Table 6-2: Roles and responsibilities for Australian Strawberry Industry Development Program

Stage	Task	Deliverer
Stage 1	Needs analysis	RMCG with input from regional delivery partners
Stage 2	Program design (annually reviewed)	RMCG with input from regional delivery partners
Stage 3 - 5	Program delivery (annual)	RMCG and Regional Partners
3.1	Regional demonstration sites/case studies	RMCG and Regional Partners
3.2	Development of information products	RMCG and Regional Partners
3.3	Technology transfer activities (workshops,	Regional Delivery Partners

Stage	Task	Deliverer
	field days)	
3.4	Management of online media and communication	RMCG with input from regional delivery partners
3.5	On-going management of grower groups	Regional Delivery Partners
Stage 6	Evaluation and refinement	RMCG and Regional Delivery Partners
Stage 7	Project management and reporting	RMCG with input from regional delivery partners

6.6 Service Delivery

Strawberries are grown in most states of Australia. Production is concentrated in coastal regions, namely Beerwah in Queensland; the Yarra Valley in Victoria; Wanneroo and Albany in Western Australia; the Adelaide Hills in SA; and the Camden region in NSW. Queensland and Victoria are the primary strawberry growing states, with 76% of production distributed between them. Western Australia has 10% of production, SA 11% and the remainder between NSW and Tasmania. There has been a push to expand production in both northern and southern growing regions. There are in excess of 200 growers nationally, with approximately 60 opportunistic growers.

Production has increased significantly over the past three seasons with over 90,000,000 runners planted in the 2014/15 season, leading to an estimated Farm Gate Value well in excess of $400 million.

Strawberry production focuses on the domestic fresh fruit markets; however exports do occur on an opportunistic basis and are projected to increase as export market conditions improve.

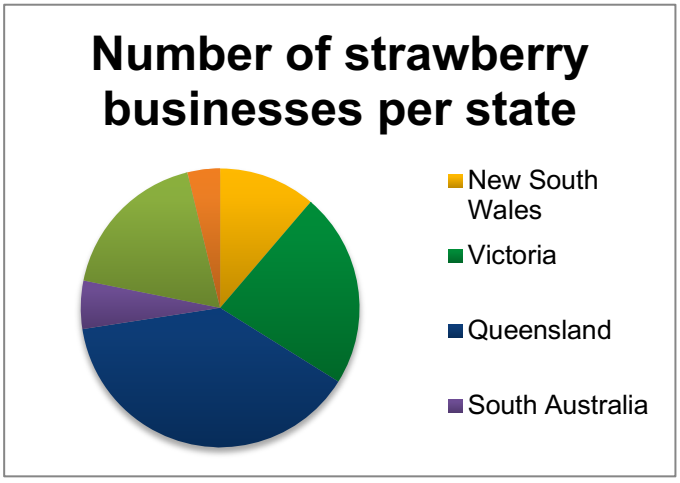


Figure 6-2: Number of strawberry producing businesses in Australia

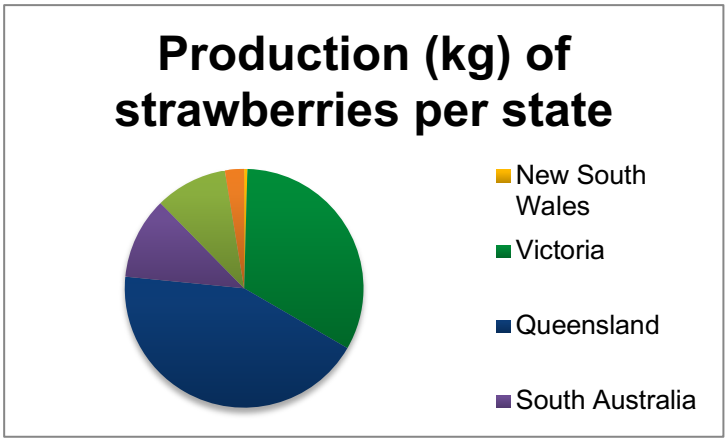


Figure 6-3: Production (kg) of strawberries in Australia

Table 6-3: Main strawberry growing regions used to guide project design and delivery[14]

State	Relative size of industry	NRM Region
NSW	<1%	Border Rivers-Gwydir
		Hawkesbury-Nepean
		Northern Rivers
		Southern Rivers
QLD	43%	Border Rivers Maranoa-Balonne
		Burnett Mary
		Mackay Whitsunday
		South East Queensland
		Wet Tropics
SA	11%	Adelaide and Mount Lofty Ranges (Adelaide Hills)
		South Australian Murray Darling Basin
TAS	3%	North
		North West
		South
VIC	33%	North East (Yarra Valley)
		Port Phillip and Western Port (Mornington Peninsula)
		Goulburn Broken
WA	10%	Perth
		South West
		Avon
		South Coast (Albany)

[14] Data from ABS Survey 2012-13

The level of service delivery will be dependent on the size and value of the strawberry industry within each state. This is discussed in further detail in Table 6-4.

Table 6-4: Service delivery by state

State	Service Delivery
Victoria	▪ Part of national communication program (website, emails, social media, online training events, national newsletter, information products) ▪ Part of tour/industry events (focussed on young growers and women in industry) ▪ Regional delivery of demonstration farms/case studies ▪ Regional delivery of grower groups ▪ Regional delivery of knowledge transfer activities
NSW	▪ Part of national communication program (website, emails, social media, online training events, national newsletter, information products) ▪ Part of tour/industry events (focussed on young growers and women in industry)
Queensland	▪ Part of national communication program (website, emails, social media, online training events, national newsletter, information products) ▪ Part of tour/industry events (focussed on young growers and women in industry) ▪ Regional delivery of demonstration farms/case studies ▪ Regional delivery of grower groups ▪ Regional delivery of knowledge transfer activities
Tasmania	▪ Part of national communication program (website, emails, social media, online training events, national newsletter, information products) ▪ Part of tour/industry events (focussed on young growers and women in industry)
WA	▪ Part of national communication program (website, emails, social media, online training events, national newsletter, information products) ▪ Part of tour/industry events (focussed on young growers and women in industry) ▪ Regional activities as required (to be delivered by either VIC/QLD delivery partner)
SA	▪ Part of national communication program (website, emails, social media, online training events, national newsletter, information products) ▪ Part of tour/industry events (focussed on young growers and women in industry) ▪ Regional activities as required (to be delivered by either VIC/QLD delivery partner)

6.7 Key issues and priorities for the Australian strawberry industry

A needs analysis for development of the Australian strawberry industry will be conducted by the project team, in conjunction with the regional deliverers, to establish the key issues and priorities to be addressed within the program. This analysis will inform the program design and annual work plans.

The key topics/issues commonly addressed in industry development programs are illustrated in the diagram below (Figure 6-4).

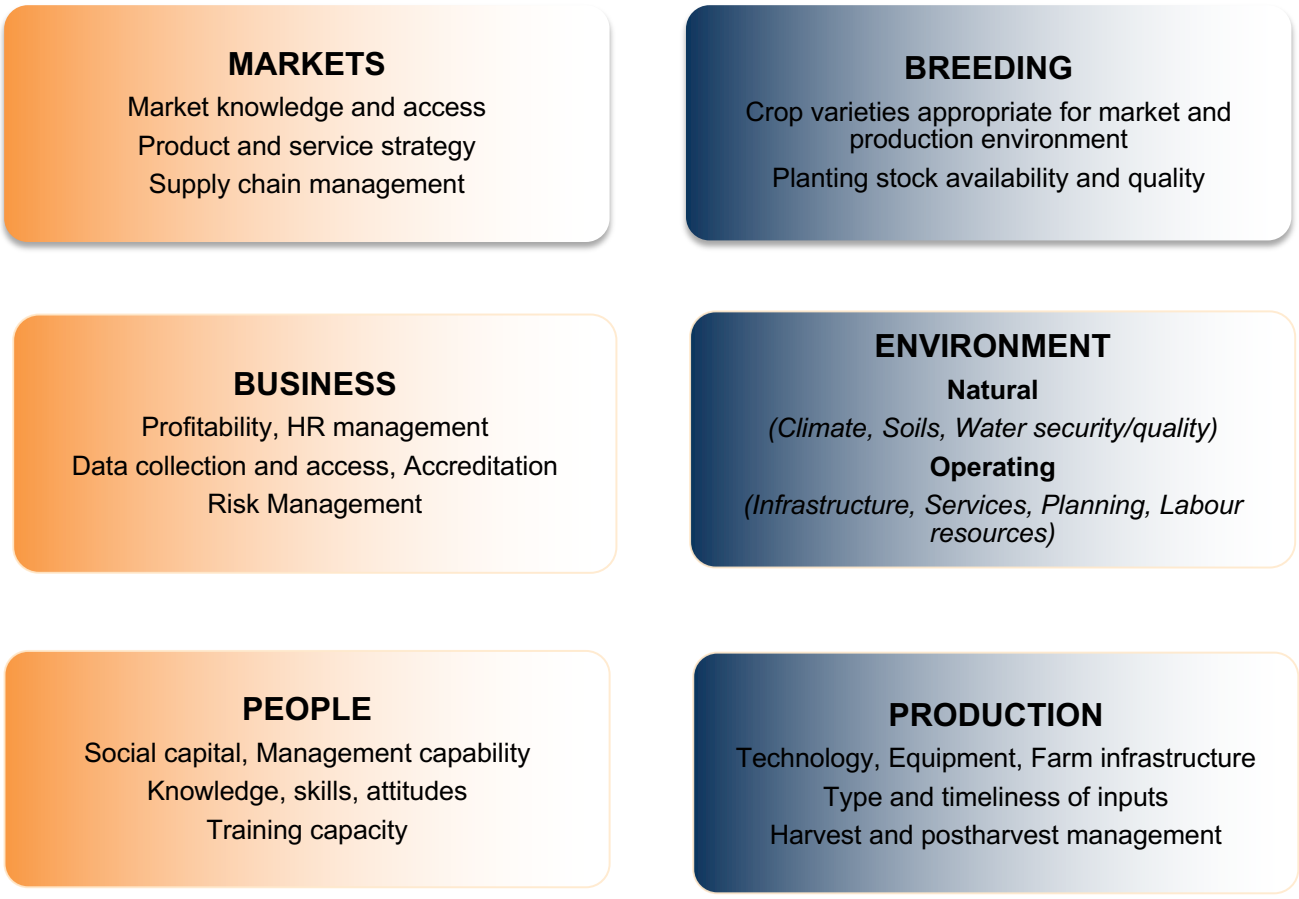


Figure 6-4: Topics commonly addressed within the industry development programs

Based on the initial needs analysis conducted for the Australian strawberry industry, and review of the Strawberries Australia Strategic Investment Plan 2012 – 2017, the program will initially focus on the issues outlined in Table 6-5 below. It is likely that these issues and topics will change as the program progresses and a greater understanding of the needs of the Australian strawberry industry is developed.

Table 6-5: Issues to be initially investigated and addressed within the Australian Strawberry Industry Development Program

Topic	Issue	Activity	Regional Delivery Partner (DP) Role	National Coordinator (NC) Role
Markets	Supply chain management	**Waste management:** In collaboration with Sunshine Coast Council and the Moreton Bay Regional Council, this activity aims to reduce the amount of fresh produce dumping which has a significant impact on the livelihood of strawberry producers. The project will include three phases: ▪ Phase 1 – Situation Analysis ▪ Phase 2 – Market assessment of products for the domestic and export markets ▪ Phase 3 – Initial new product development and scientific assessment	Sub-tropical DP will be involved in Phase 1 with some time spent sourcing, collating and assisting with the analysis of data. Temperate DP: TBA	NC to assess outcomes of activity in QLD and determine application for other production regions.
		Cool chain management: Extend through existing industry development networks the key best practice cool chain management processes throughout the supply chain. This could include: ▪ Identifying specific ongoing quality problems that can be attributed to each segment of the chain ▪ Investigate the need for developing best method summaries and extending previous DAFWA project information ▪ Determine how the industry could further influence better cool chain processes from growers to retail outlets	DP's to assess extent of issue within their region and identify opportunities to address issue by working with leading growers and through regional grower groups.	NC to provide support as required to delivery partners and communicate outcomes nationally.
	Market knowledge and access	**Export market development:** Assess interest by industry in further developing export market opportunities and the availability of government funds and resources to assist with this activity. Investigate application of existing resources (such as export readiness fact sheet developed for the vegetable industry) for the strawberry industry.	DP's to assess interest within region.	NC to liaise with DP's and federal organisations.

Business	Human Resource (HR) Management	Develop and promote activities and resources that will improve HR management within the strawberry industry. This could incluce: ▪ Investigation of alternative labour solutions (including NAIDOC model) and extend outcomes through national communication program. ▪ Investigation of existing resources and activities (such as vegetable industry project to identify innovative solutions to labour issues) for the strawberry industry. ▪ Investigate local opportunities to address labour issues (such as collaborative project with Sunshine Coast Council, Moreton Bay Regional Council, RDA Moreton Bay and Growcom).	DP's to assess extent of issue within their region and identify opportunities to address issue by working with leading growers and through regional grower groups.	NC to provide support as required to delivery partners and communicate outcomes nationally.
	Profitability	Scope interest within industry to conduct benchmarking activities (such as BizCheck) to assess varying levels of profitability within industry and use this information to identify ways to improve business management.	DP's to assess interest within their region by working with leading growers and through regional grower groups.	NC to provide support as required to delivery partners and communicate outcomes nationally.
	Data access	Assess options for improving level of data collection within industry and facilitate improved access to industry relevant data that will improve planning and development of industry as a whole.	DP's to identify data requirements and disseminate information within their region by working with leading growers, through grower groups, and knowledge transfer activities such as workshops.	NC to work with relevant organisations to investigate opportunities to improve the collection, analysis and dissemination of industry data.
	Risk management	Improve risk management within the Australian strawberry industry by identifying, promoting and improving uptake of accreditation and assurance schemes that will improve the sustainability and safety of industry. This could include:	DP's to develop and deliver activities such as workshops, grower group discussions) and resources such as case studies) to	NC to coordinate activities and resources for addressing risk management, provide support to DP's and

		▪ Facilitating participation in Quality Assurance Schemes such as Freshcare and ISO9001 Quality Assurance ▪ Developing and participation in Environmental Management Schemes ▪ Developing and promoting uptake of standardised production procedures (development of best practice guide) ▪ Work Health and Safety (use vegetable industry projects as a guide)	promote and improve uptake of risk management practices.	promote through national communications program
People	Study tours	To promote awareness of innovative practices in other regions and industries by facilitating the participation of industry members in study tours. This could include: ▪ Bundaberg Grower Tour (Sub-tropical industry) ▪ South Africa Study Tour (Sub-tropical industry) ▪ International Strawberry Symposium	▪ DP's to identify and promote opportunities to industry members within regions. ▪ DP's to organise and deliver regional study tours to other production regions or other industries as required. ▪ DP's to apply for additional funding for attendance to international events.	NC to identify and promote study tour opportunities through national communications program
	National recognition and networking	To acknowledge leaders within industry identify and promote opportunities for national recognition and networking. This could include the development of: ▪ National awards for a range of categories ▪ Development of national conference (with other berry industries and/or collaboration with other horticultural industries)	DP's to identify industry members suitable for national recognition.	NC to assess potential for development of national awards and national conference.
	Leadership training	To develop and promote leadership skills within the strawberry industry assess interest and organise opportunities for members to attend courses and events focused on leadership. Refer to vegetable industry programs	DP's to promote leadership training opportunities within	NC to liaise with training providers in other industries (such as Jill

		developed by Jill Briggs to assess potential for the strawberry industry.	their regions.	Briggs) to identify and coordinate opportunities for the strawberry industry.
	Young grower groups and women in industry groups	Assess opportunities to work with and develop particular sectors of the Australian strawberry industry such as young growers or women working in the industry. Activities could include development of specific grower groups, networking events (such as dinners) and use of social media.	DP's to manage and deliver activities for specific sectors of industry.	NC to provide support to DP's and promote through national communications program.
Breeding	Varieties	Ensure the outputs and outcomes of the national breeding program are extended to the Australian strawberry industry. Activities to include: ▪ Regular liaison with the breeding program to ensure development program is fully aware of progress and outcomes that can then be extended through national communications program ▪ Develop 'agronomic packages' to facilitate production of new varieties ▪ Ensure that breeders are fully aware of the list of preferred fruit attributes and link with the flavour and fruit quality research conducted by Prof Eddie Pang ▪ Identify the degree to which Australian varieties from the program are being taken up by growers. ▪ Further develop economic analysis conducted by QLD DAF on new varities	▪ Sub-tropical DP to liaise regularly with breeding program team and provide information to NC. ▪ DP's to assist in development and dissemination of 'agronomic packages'. ▪ DP's to liaise with industry members in their regions to identify commonly grown varieties.	▪ NC to promote outcomes of breeding program through communications program. ▪ NC to develop (with support from DP's) agronomic packages and promote through national communications program. ▪ NC to conduct further economic analysis on new varieties.
	Runner quality	Work with Victorian Strawberry Industry Certification Authority (VSICA), runner growers and industry members to improve runner quality and perceptions within industry.	DP's to liaise with VSICA and runner growers.	NC to promote better understanding of certification and runner production through

				dissemintation of information via communications program.
Environment	Natural environment	Improve the environmental sustainability of the Australian strawberry industry by promoting the uptake of sustainable production practices and facilitating participation in appropriate Environmental Management Schemes.	DP's to develop and deliver activities such as (workshops, grower group discussions) and resources (such as case studies) to promote and improve uptake of sustainable soil and environmental management practices.	NC to coordinate activities and resources for addressing environmental management, provide support to DP's and promote through national communications program
Production	Mechanisation	Identify research outcomes and innovation that will increase levels of mechanisation within the strawberry industry. In particular those associated with harvesting and post harvest that will reduce reliance on manual labour. This could include activities such as workshops, field walks, grower group discussions and the development of resources such as case studies that will promote awareness and facilitate uptake.	DP's to develop and deliver activities such as (workshops, grower group discussions) and resources (such as case studies) to promote and improve uptake of mechanisation.	NC to coordinate activities and resources for implementation of mechanisation, provide support to DP's and promote through national communications program
	Waste management	Investigate options for management of waste generated by the Australian strawberry industry. This could include: ▪ Project to address the issue of plastic waste in the Queensland strawberry industry, in collaboration with Sunshine Coast and Moreton Bay Councils.	Sub-tropical DP to investigate potential for manufacture of an implement that can separate plastic mulch from t-tape and clean both	▪ NC to promote outcomes of waste project through national communications program. ▪ NC to refer to

			when pulling up plastic. DP to also investigate funding opportunities should this prove to be a possibility.	vegetable industry projects on same issue.
	Soil health	Promote sustainable management of soil in the Australian strawberry industry through use of resources and activities conducted within the Soil Wealth and Integrated Crop Protection projects for the vegetable industry. Particular emphasis on cover cropping and use of compost.	DP's to develop and deliver activities such as (workshops, grower group discussions) and resources (such as case studies) to promote and improve uptake of sustainable soil management practices.	NC to coordinate activities and resources for addressing soil management, provide support to DP's and promote through national communications program.
	Precision agriculture	Identify research outcomes and innovation that will increase implementation of precision agriculture within the strawberry industry. This could include activities such as workshops, field walks, grower group discussions and the development of resources such as case studies that will promote awareness and facilitate uptake.	DP's to develop and deliver activities such as (workshops, grower group discussions) and resources (such as case studies) to promote and improve uptake of precision agriculture within strawberry industry.	NC to coordinate activities and resources for uptake of precision agriculture, provide support to DP's and promote through national communications program.
	Pest management	Address pests of concern to the Australian strawberry industry as required through identification of appropriate research and development activities. This could include: ▪ Investigation into alternative chemical control options for management of rats in Queensland	▪ DP's to advise industry on the latest minor use permits granted, SARP and existing avenues for support regarding chemical use (i.e. Jodie Pedrana at HIA).	▪ NC to coordinate and promote chemical access and use information through national communications program.

		▪ Development of Australian IPM Manual for the strawberry industry ▪ Miticide research in WA ▪ Liaison with Jodie Pedrana (HIA) regarding 'minor use' needs and the Strategic Agrichemical Review Processes for the strawberry industry ▪ Use of advisors/IPM specialists such as Paul Horne, Paul Jones and Lachlan Chilman to promote IPM within industry	▪ DP's to develop and deliver activities such as (workshops, grower group discussions) and resources (such as case studies) to promote and improve pest management within strawberry industry.	▪ NC to coordinate activities and resources for uptake of improved pest management, provide support to DP's and promote through national communications program.

Appendix 1: Project Reference Group Terms of Reference

Introduction

This Terms of Reference (ToR) describes the purpose and arrangements (chair, membership and meeting schedule) for the Project Reference Group (PRG).

Background

RM Consulting Group (RMCG) is delivering the Horticulture Innovation Australia (Hort Innovation) and levy funded project *Facilitating the development of the Australian strawberry industry* (BS15002). This project is being delivered in conjunction with two regional delivery partner projects in Queensland and Victoria (BS15003 and BS15004). The projects have many commonalities and therefore share a reference group to increase efficiency of resource use and impact.

Terms of Reference

Purpose

The PRG is a principal group responsible for providing guidance and information on project direction, plans, outputs and activities. The Group brings together key people with expertise and experience in the strawberry industry.

Scope

The scope of the PRG will be to provide input into planning and implementation of the project. This includes but not limited to:

- Strategic direction for the projects
- Ensuring that the projects meet the needs of the strawberry industry; this includes growers, runner growers, advisors and extension providers and other stakeholders
- Making sure that sound science is used
- Ensuring the projects stay focussed on required outcomes throughout their life.

Term

The PRG will operate during the life of the projects from March 2016 to February 2019. This Terms of Reference is effective from 1 June 2016 and will be ongoing until changed or terminated by agreement between the parties.

Membership

Name	Role and organisation
Kristen Stirling	Senior Consultant, RMCG
Bianca Cairns	R&D Manager, Hort Innovation
Stuart Burgess	Portfolio Manager, Hort Innovation
Adrian Shulz	Queensland strawberry grower (TBC)
Grower #2 (TBC)	Victorian strawberry grower (preferably young and/or female)

Name	Role and organisation
Service Advisor #1	DAF Researcher and/or Paul Jones (IPM Specalist)
Service Advisor #2	VIC/WA agronomist and or industry service provider (IPM, Fertiliser)

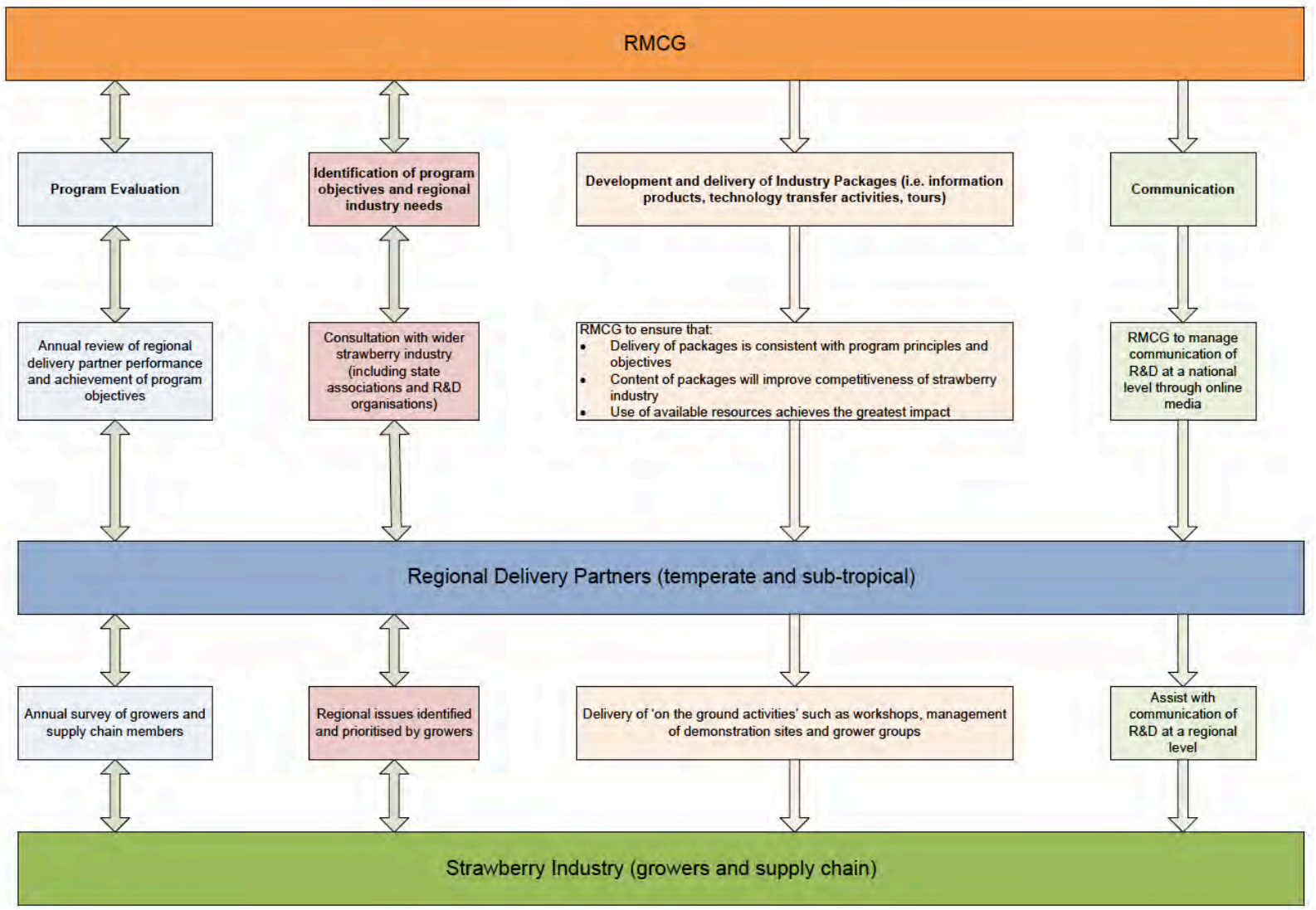
Roles and Responsibilities

The role of the PRG is to:

- Attend meetings by phone or in person and contribute experience and expertise to the projects
- Provide strategic advice on how to most effectively deliver the projects
- Act as a 'sounding board' to the project managers and key personnel
- Comment on the usefulness and appropriateness of activities as per the Monitoring, Evaluation, Reporting and Improvement plan
- Confirm that project outputs are 'fit for purpose', useful and relevant.

Meetings

- All meetings will be chaired by Kristen Stirling/Clinton Muller (RMCG)
- A meeting quorum will be three (3) non-RMCG members of the reference group plus one (1) RMCG member
- Decisions will be made by consensus (i.e. members are satisfied with the decision even though it may not be their first choice). If consensus is not possible, the reference group chair makes a final decision
- Meeting agendas and minutes will be prepared and distributed by RMCG:
  - Agendas and supporting papers at least three (3) days before meetings
  - Meeting minutes and relevant information one (1) week after meetings
- Meetings will be held quarterly. Meetings will mostly be held by phone, as face-to-face meetings may be difficult to arrange
- If required for a specific purpose, sub-group meetings may be arranged outside the quarterly meeting at a time convenient to sub-group members.



Appendix 2: Approach for the Australian Strawberry Industry Development Program

Appendix 2: Annual Workplans – Year One, Two and Three

Appendix 1

Strawberry Innovation Program Deliverables – Year 1 (2016/17)

March 2017

Activities delivered against the Annual Work Plan for the project between March 2016 to March 2017 are documented as follows in Table 1, with identification of activities undertaken and progressed work plan activities by the National Coordination Project (BS15002) and the Regional Delivery Partners in the Sub-Tropical (BS15003) and Temperate (BS15004) regions.

Program deliverables

Table 1: Annual Work Plan Deliverables – Year 1 of the Industry Development Program for the Australian Strawberry Industry

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
Stage 1: Needs analysis					
Needs analysis		Assessment of key industry needs and priorities within main production regions.	▪ Contribution and input into regional industry needs	▪ Contribution and input into regional industry needs	▪ Analysis of industry needs to inform program design (incl. program logic, stakeholder engagement plan and project risk management plan)
Stage 2: Program design					
Program design		Development of program design and annual work plans based on needs analysis.	▪ Contributed regional expertise to development of program design.	▪ Contributed regional expertise to development of program design.	▪ Program design and annual work plans developed based on needs analysis and contribution from delivery partners.

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
Stage 3: Program delivery					
Industry coordination	Learning from leading growers	Identify leading, innovative growers within each production region	▪ Lead growers in Sub-Tropical Region identified and engaged	▪ Lead growers in Temperate Region identified and engaged	▪ Supported process for identification of lead growers in region
		Provide support and resources to these growers to aid in the development of their businesses	▪ Lead growers supported as appropriate	▪ Lead growers supported as appropriate	▪ Resources maintained on Strawberry Innovation website and shared through The Punnet e-News monthly
		Develop case studies and conduct demonstration sites on leading grower properties to aid in the dissemination of information within industry on new practices and technology.	▪ Non-Soil Media; CS approval sought: - Pinata Farms - Schiffke/Stothart farm – approval received to track and document progress of first year tabletop production, with the view to publishing article in December issue Simply Red. ▪ Robotic Harvesting / Heat seal packaging – initial discussion Sunray Strawberries	▪ Soil Health – John and Annette Hasan (published Simply Red + website FS) ▪ Plug Plants – interview with growers (CS to be published) ▪ Native Vegetation Insectarium – Strawberry Springs insect pop. Monitoring + draft CS	▪ Soil Health case study published Simply Red – December 2016 ▪ Soil Health case study FS online
	Grower groups	Develop groups that meet the specific needs of the grower Link in with established groups and engage with the group managers to explore the potential for collaboration	▪ Scoping opportunities for new grower groups ▪ Meeting with Women's Network to discuss areas of interest – resulted in Women's Wellness Weekend ▪ Sustained liaison with existing industry groups including	▪ Scoping opportunities for new grower groups	▪ Promote thematic group areas and opportunities through communication platforms including website, Simply Red and The Punnet e-News, with targeted engagement to Regional IDO's

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
		Grower groups are being utilised by the project for delivery of activities, communication and information. Topics to be focused on within grower groups will be those outlined in Section 6.7 of Program Design and those of particular interest to group (i.e. benchmarking).	Food and Agribusiness Network Sunshine Coast, Innovation Centre, Tropical Horticulture group ▪ Local labour recruitment group established – meetings held throughout 2016 and ongoing to increase hire of local labour.		
	Community of practice (COP)	Identify and invite appropriate industry personnel to be part of COP. These could include advisors, researchers and growers (fruit and runner) Promote and advertise COP to increase membership Develop forum for COP and provide relevant resources and activities	▪ Coordinating engagement of relationships in breeding program, runner growers and Queensland industry ▪ Identifying and assessing relevant industry stakeholders for agri-tourism group ▪ Plastic waste COP developed to address and identify potential solutions to plastic waste problem. Article produced for Simply Red Dec 2016 edition. Continuing participation in steering committee meetings etc. ▪ Edible waste COP - collaborative project with Sunshine Coast and Moreton Bay Regional Councils, Regional Development Australia (RDA) Moreton Bay and DAF to identify potential	▪ Identifying and assessing relevant industry stakeholders for organic grower group ▪ Identifying and assessing relevant industry stakeholders for agri-tourism group	▪ Informal researcher community of practice group facilitated. Findings shared with industry through communication platforms including website, Simply Red and The Punnet e-News

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
			value add products to reduce edible waste in Queensland strawberry industry. ▪ Local labour hire COP – collaborative project (The Sweetest Job) to increase local labour hire. Members of COP include Growcom, Sunshine Coast and Moreton Bay Regional Councils, RDA Moreton Bay, The Job Show (service provider) and local labour hire grower group.		
	Industry analysis	Collation and economic analysis of industry data to enable better planning and development of Australian strawberry industry.	▪ Scope of work for collection and collation of runner data produced and identification of inhibiting challenges ▪ Report regarding quality of runners for sub-tropical growing regions produced and distributed, incorporating climatic challenges faced by runner growers and how runners have been affected eg. quality, numbers, expected harvest dates etc.	▪ Scope of work for collection and collation of runner data produced and identification of inhibiting challenges ▪ Ongoing consultation with Toolangi runner grower's co-op to collect and collate varietal and state-specific data ▪ Coordinating data collection across all Victorian properties through VSIDC Funded survey of incidence and severity of charcoal rot. Specific data made available to participating growers. Published findings to be shared across national industry.	▪ Coordination and review of runner data scope of works ▪ Industry survey (12 responses) of non-soil substrate culture for QDAF breeding program
Knowledge	Workshops and Master	Conduct workshops/masterclasse	▪ Stanthorpe region focussed pest management and soil	▪	▪ Workshop events advertised and communicated through communication

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
Transfer	classes	s on issues and/or R&D outcomes as required to meet needs of industry.	health Workshop – 12 July, 2016. 20 attendees ▪ Women's Wellness Weekend – 10-11 February, 2017. 30 attendees ▪ Local labour hire forums coordinated as part of The Sweetest Job campaign for local labour hire. Four forums held – 2 Sunshine Coast (7 and 22 June), 2 Moreton Bay (6 and 23 June). Over 500 in attendance over the 4 forums, include local labour hire grower group and project collaborators.		platforms including website, Simply Red and The Punnet e-News
	Field walks/Field days	Conduct field walks/field days on issues and/or R&D outcomes as required to meet needs of industry.	▪ Covered cropping and irrigation systems farm walk at Red Hill Berries in Stanthorpe – 11th March 2016. 8 growers participated. ▪ Farm walk coordinated at Sunray Strawberries as a component of Plastic Waste Challenge workshop. Attendees included growers, suppliers, policy makers, machinery manufacturers, waste management service providers and researchers – 31 October 2016. 30 attendees.	▪ Wandin Silvan Field Day – 15 October, 2016 ▪ VSGA Farm walk - 29 September, 2016, 40 attendees ▪ VSGA Farm Walk – 25 November, 2016. 16 attendees	▪ Field walks / Field days advertised and communicated through communication platforms including website, Simply Red and The Punnet e-News
	e-learning	Assess interest and opportunities to use e-	▪	▪ Encourage participation in webinars run through other	▪ Online resources and content populated on Strawberry Innovation website with traffic

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
		learning to disseminate outcomes of R&D i.e. development of webinars on new production techniques or pest management.		programs – ICP/SW including Biofumigation cover crops 31 January, 2017, and Nutrient Management and Pest Disease 28 February, 2017	directed via e-Newsletter ▪ Encourage participation in webinars run through other program – ICP/SW Rediscovering Cover Crops through the Punnet December, 2016. 6 unique clicks
	Study tours - international	Provide support to program team members and industry members to participate in international study tours.	▪ PD Attendance at the International Strawberry Symposium, Canada 13-17 August, 2016 ▪ Scouted interest for unsuccessful South Africa study tour, November 2016	▪	▪ Study tours advertised and communicated through communication platforms including website, Simply Red and The Punnet e-News
	Study tours – regional and national	Organise grower tours to other production regions to enable industry to learn from practices/technology in other regions and industries.	▪ Attempted study tour of Bundaberg farms for November, 2016 – challenged by lack of properties willing to host ▪ Study tour to Stanthorpe to view different runner harvesting systems of runner producers in Stanthorpe, plus visit strawberry farm for protected cropping and irrigation systems. 10-11 March 2016. 8 growers participated.	▪ Exploration of grower exchange between WA and Vic	▪ Study tours advertised and communicated through communication platforms including website, Simply Red and The Punnet e-News ▪ Agri-Bio Facilities, La Trobe University, 6 September, 2016. 4 attendees
	Industry networking events	Manage and/or participate in regular networking events that inform industry of activities occurring within Industry Development	▪ Qld Annual Dinner – May 2016. 250 attendees ▪ Program Reference Group meeting – Thursday 14 July, 2016. 11 attendees ▪ QSGA AGM – 7 February,	▪ Program Reference Group meeting – Thursday 14 July, 2016. 11 attendees ▪ VSGA AGM – 29 September, 2016. 40 attendees	▪ Industry networking events advertised and communicated through communication platforms including website, Simply Red and The Punnet e-News ▪ Program Reference Group meeting – Thursday 14 July, 2016. 11 attendees

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
		Program.	2017. 30 attendees ▪ Program Reference Group meeting – Wednesday 8 February, 2017. 11 attendees ▪ Pumicestone Healthy Waterways Catchment group meeting – 23 June 2016. Approx. 30 attendees. ▪ Bundaberg Fruit and Vegetable Growers Gala Dinner – 8th October 2016. 500+ attendees. ▪ PMA Fresh Connections conference – 17 – 18 May 2016.	▪ Victorian Women in Industry Dinner – 26 October, 2016. 80 attendees ▪ On-farm Biosecurity Meeting – 8 November, 2016 ▪ RABA AGM – 10 November, 2016, 50 attendees ▪ VSICA AGM – 29 November, 30 attendees ▪ Horticulture Industry Innovation Network (HIIN) Mtg 11 October, 2016 & 6 December 2016. 20 attendees ▪ Yarra Valley Pest Free Place of Production meetings 18 October, 2016 & 7 November, 2016. 10 attendees ▪ Program Reference Group meeting – Wednesday 8 February, 2017. 11 attendees	▪ QSGA AGM – 7 February, 2017. 30 attendees ▪ Program Reference Group meeting – Wednesday 8 February, 2017. 11 attendees
Communication activities	Website	Establish national website Populate and maintain website with relevant resources, events and news items	▪ Periodic submission of content for the website	▪ Periodic submission of content for the website	▪ www.strawberryinnovation.com.au established with relevant content including latest news, newsletters, resources and events ▪ Unique audience of 805, 1,434 site visits and 4,112 page views
	e-	Gain access to regional industry contact	▪ Updated email contact lists	▪ Updated email contact lists	▪ Development and Distribution of 9 e-

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
	newsletter	databases for national delivery of newsletter via email Develop template and protocols for monthly delivery of e-newsletter Seek content from industry service providers Develop content for e-newsletter Distribute monthly e-newsletter nationally to industry contacts	▪ Periodic submission of content for the Punnet ▪ Targeted email updates to Regional Growers as required	▪ Periodic submission of content for the Punnet ▪ Targeted email updates to Regional Growers as required	Newsletters ▪ Issue 1 – June 2016 – distribution as introductory "mock" to ~10 recipients for on-forwarding to industry contact databases for consent for contact sharing ▪ Issue 2 – July 2016 – distribution to 190 recipients with 66.5% open rate ▪ Issue 3 – August 2016 – distribution to 270 recipients with 68.3% open rate ▪ Issue 4 – September 2016– distribution to 267 recipients with 68.5% open rate ▪ Issue 5 – October 2016 – distribution to 273 recipients with 58.1% open rate ▪ Issue 6 – November 2016 – distribution to 277 recipients with 60.0% open rate ▪ Issue 7 – December 2016 – distribution to 278 recipients with 53.3% open rate ▪ Issue 8 – January 2017 – distribution to 275 recipients with 56.9% open rate ▪ Issue 9 – February 2017 – distribution to 282 recipients with 53.4% open rate
	Quarterly hard copy newsletter (Simply Red)	Gain access to regional industry contact databases to expand current distribution to all states Develop template and protocols for quarterly delivery of newsletter Seek content from industry service providers in all	▪ Advertising and Editorial of the Simply Red Newsletter ▪ Content development and sourcing	▪ Content development and sourcing	▪ Revised Simply Red newsletter template developed ▪ Distribution to grower and industry associate contact list of ~620 recipients Content development and sourcing of Simply Red ▪ Issues produced include: - Issue 42, July 2016 - Issue 43, September, 2016 - Issue 44, December 2016

Stage	Activity	Sub-Activity – Year 1	Sub-Tropical Regional Delivery Partner (BS15003)	Temperate Regional Delivery Partner (BS15004)	National Coordination (BS15002)
		production regions Develop content for newsletter Edit, print and distribute newsletter nationally to industry contacts			
	Information products	Develop new brand, logo and templates for industry development program Develop relevant information products based on outcomes of needs analysis.	▪ Support for National BMP Guideline Development ▪ Shortlisting of IPM Application development with QUT	▪ Support for National BMP Guideline Development ▪ Shortlisting of IPM Application development with QUT	▪ Developing National BMP Guidelines ▪ Shortlisting of IPM Application development with QUT
	Case studies	Develop case studies that promote outcomes of R&D and innovative new practices to industry	▪	▪ Grower Profile Case Study on Soil Health – John & Annette Hasan	▪ Strawberry Innovation logo and style guide branding developed ▪ Information products re-packaged and hosted on website: ▪ Growing Strawberries in WA ▪ Lessons from the Field – John Hasan

Appendix 2

Strawberry Innovation Program Reference Group – Minutes

Facilitating the development of the Australian strawberry industry – BS15002

11 am AEDT on Wednesday 8th February, 2017

Attendees:

- Adrian Schulz – Strawberry Grower / Deputy Chair QSGA
- John Hasan – Strawberry Grower / Chair VSIDC
- Neil Handasyde – Chairman, Strawberry Growers Association WA / Strawberries Australia
- Aileen Reid – IDO Strawberry Growers Assoc WA
- Paul Jones – Bugs for Bugs
- Bianca Cairns - Horticulture Innovation Australia
- Bradley Mills - Horticulture Innovation Australia
- Carl Larsen – RMCG
- Clinton Muller – RMCG

Observers:

- Jennifer Rowling – Strawberry IDO, Sub-Tropical Region
- Angela Atkinson – Strawberry IDO, Temperate Region

Apologies:

- Luciano Corallo – Strawberry Grower / VSICA Committee Member

Topic	Discussion
Welcome Recap from July, 2016 PRG Meeting Minutes	Clinton highlighted the minutes of the last PRG meeting on the 14th July, 2016, drawing attention to the Action points, namely: ▪ Working group to be established through IDOs to identify current runner data collection process, recommendation of any change (if necessary), implement consistent data collection process through IDOs

	- Jen provided an update of the Scope of Works prepared by the IDOs regarding runner data collection and next steps for the plan. This included providing industry updates of runner condition for the upcoming harvest, including the possibility of "Special care instructions" for handling of stressed runners ▪ National coordination and IDOs to establish opportunities for website harmonisation, with feedback from respective industry committees who operate current State Industry websites The strawberry innovation website provides a focus on industry research and development with links to other industry associations. Industry associations maintain the value of their industry association websites, consequently the current arrangement will continue.
Project Workplan update (*refer to Annual Workplan 2016/17 Document*) Overview of project objectives	Clinton presented a summary of the Project Workplan, outlining activities that have been delivered and those planned. Discussion focused on a number of key activities to be delivered, including: ▪ Revised National Best Management Practice Guidelines: - Aileen – need to ensure the difference between physical attributes and production practices between states is captured - Adrian – awareness of differentiation of chemical restrictions between states is unclear, this could be improved. Also important to ensure the information is accessible to all across the industry, including translation for LOTE growers - Carl – examples of LOTE extension materials through EnviroVeg Manual developed by AUSVEG could be used - Bianca – topics around harvesting and post-harvest handling should be included ▪ Non-soil substrate production. Increasing interest to explore non-soil based production, including hydroponics, substrates, protective cropping structures. Activities to be delivered through the program could include Grower Profiles, Case Studies, Workshops and Farm Walks and should be targeted based on State based requirements and climatic variability. Model farms and short videos/virtual tours may be a good tool to share the information. ▪ Brad noted the need to ensure workplan alignment to the new draft strategic investment plan (SIP) and current R&D projects. He also suggested the link between the project workplan and those of the two individual IDO's be made clearer and with the addition of delivery timeframes and responsibility columns. This way, the BS15002 PRG is also inadvertently approving the individual IDO's workplans. He also suggested a calendar of events for the program be developed and shared.

	ACTION: Alignment between the three project Workplans to be made clearer along with the addition of timeframes and responsibilities, linkage of workplans to SIP and calendar of events developed
Program Feedback from PRG Members (*refer to PRG TOR*) Endorsement of PRG Terms of Reference	Feedback from individual PRG members was shared in relation to what's working well and areas for improvement. ▪ John – Program going ok, too early to make strong recommendations. Calendar outlining activities would be good. ▪ Neil – Communication channels in the program are good to provide responsive feedback across the industry. Important to have channels for R&D but other industry issues as well (good example with recent backpacker tax). Useful tools around non-soil production for growers would be good. ▪ Aileen – Welcomed having a broader project team working on industry activities. Government service to horticulture is becoming limited, and the project is providing some of this information. A number of key threats are emerging within the industry (recent example biosecurity risks with green snail incursion), these risks should be better captured in the SIP. ▪ Adrian – communication and information sharing has been good, need to ensure it is quick and responsive to grower needs. ▪ Paul – information sharing on forecast risks to the industry will be important, particularly regarding runners this forthcoming season and the climatic challenges that have been faced. Will be providing a summary of the QLD runner condition and a similar one from Victoria would be good. ▪ Bianca – communication products have been good, just need to ensure alignment of workplans.
Other Business ▪ Other business ▪ Meeting dates / times	▪ Audio quality of the meeting was a key challenge – alternative teleconferencing platform to be explored for next meeting ▪ Next meeting to be scheduled in August, 2017

RMCG

REVISED Annual Work Plan – Year 2 (2017/18)

Strawberry Innovation (BS15002) – Horticulture Innovation
May, 2017

1 Strawberry Strategic Investment Plan

The release of the final Strawberry Strategic Investment Plan 2017-2021 has prompted a revision of the Annual Work Plan for the national industry development and extension program and regional delivery programs through Hort Innovation contracts BS15002, BS15003 and BS15004. The previous workplan was driven by the mechanism of delivery, this will be changed to reflect the new industry priorities identified within the SIP as illustrated in Table 1.

Table 1: Strawberry Industry Priorities - Strawberry Strategic Investment Plan 2017-2021

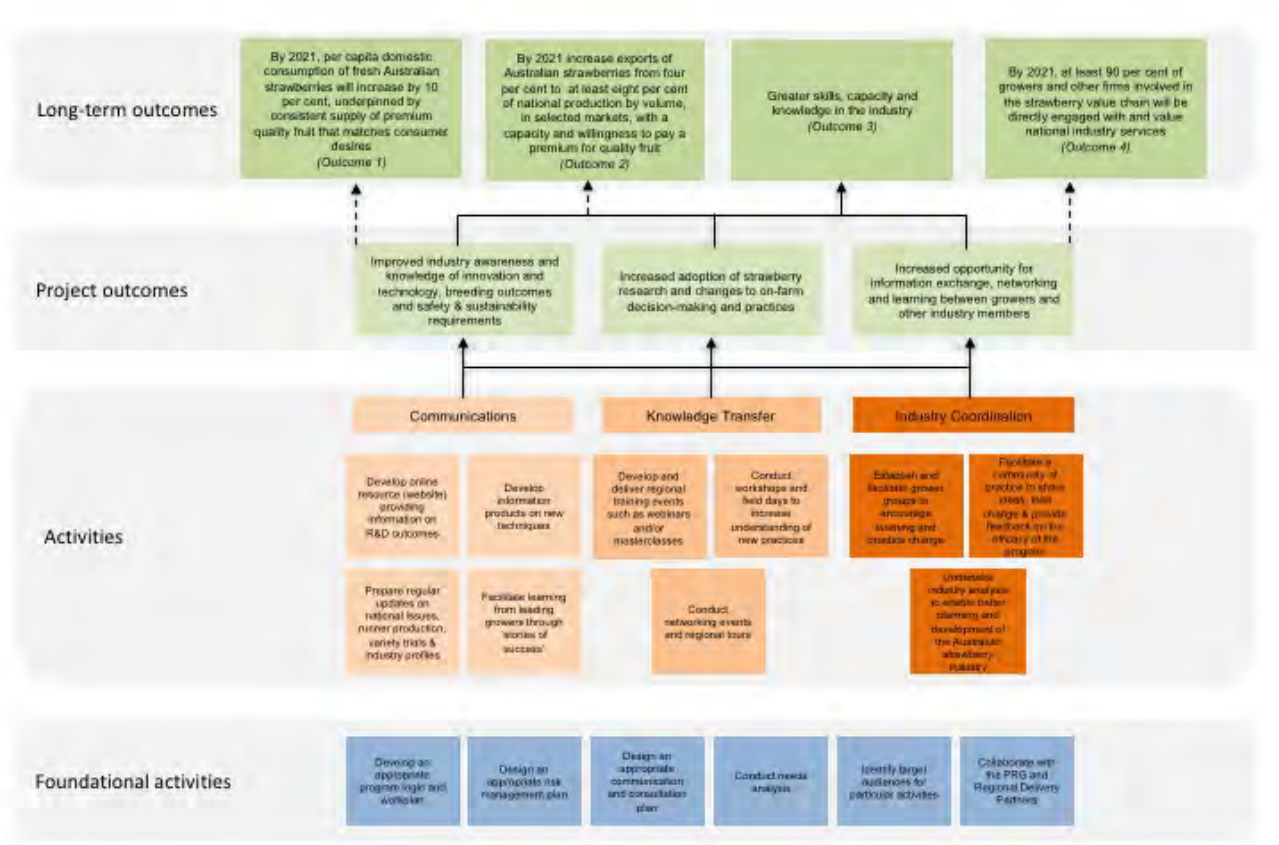
OUTCOMES	STRATEGIES
1. By 2021, per capita domestic consumption of fresh Australian strawberries will increase by 10 per cent, underpinned by consistent supply of premium quality fruit that matches consumer desires	Conduct regular consumer research to gather insights and monitor perceptions and expectations towards fresh Australian strawberries
	Establish a methodology to measure and monitor the incidence of where quality is below consumer expectations
	Establish evidence of product health attributes and national industry practices that bolster the reputation of Australian strawberry businesses and its products
2. By 2021 increase exports of Australian strawberries from four per cent to at least eight per cent of national production by volume, in selected markets, with a capacity and willingness to pay a premium for quality fruit	Develop a strawberry export strategy during 2017 by working with current and potential exporting businesses
	Pursue technical market access for the priority markets identified in the export strategy
	Market development program in priority markets
3. Greater skills, capacity and knowledge in the industry	Ensure that superior strawberry varieties that match consumer expectations are available to growers
	Identify the regulatory imposts and those proven technologies and good management practices with greatest impact and ease of implementation

OUTCOMES	STRATEGIES
	to reduce cost of production / increase productivity
	Inform strawberry growers on the emerging options, risks and opportunities afforded by protected cropping systems
	Continual improvement of integrated pest management (IPM) systems to meet pest and disease threats
4. By 2021, at least 90 per cent of growers and other firms involved in the strawberry value chain will be directly engaged with and value national industry services	Develop an informed and cohesive industry through direct two-way communications with strawberry businesses across Australia
	Provide timely information on industry production, forecasts and markets

2 Revised Program Logic

A revised program logic has been developed, as outlined in Figure 1, to demonstrate the relationship between the project outcomes of BS15002 with the longer-term outcomes of the Strawberry Strategic Investment Plan 2017-2021, primarily Outcome 3 – greater skills, capacity and knowledge in the industry.

Figure 1: Revised Program Logic



3 Revised Program Work plan

The revised program work plan, as presented in Table 2, documents activity delivery between March 2017 to March 2018 through the National Coordination Project (BS15002) and the Regional Delivery Partners in the Sub-Tropical (BS15003) and Temperate (BS15004) regions against the strategy outcomes of the Strawberry Strategic Investment Plan.

Deliverables within the Year 2 work plan will continue to evolve as industry needs and priorities are identified.

Table 2: Revised Annual Work Plan - Year 2 of the Industry Development Program for the Australian Strawberry Industry

SIP STRATEGY OUTCOME	MECHANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
3. Greater skills, capacity and knowledge in the industry	Communication	Develop online resource (website) providing information on R&D outcomes	▪ Maintain website content including news, resources and events on a minimum weekly basis	▪ Submit website content periodically	▪ Submit website content periodically
		Develop information products on new techniques	▪ Develop National BMP Guidelines (June, 2017) ▪ Desktop publish and print revised Australian IPM Poster for the Strawberry industry (May, 2017) ▪ Support IPM Application development with QUT, including information content (May, 2017) ▪ Desktop publish and print revised Australian Pesticide Guide (September, 2017) ▪ Communication and share information products through communication platforms including website, Simply Red and The Punnet e-News ▪ Develop and publish information resources for non-	▪ Review National BMP Guidelines and Grower Case Study Content (June, 2017) ▪ Progress IPM Application development with QUT (May, 2017) ▪ Develop information resources for non-soil substrate production and protective cropping (June 2017) ▪ Non-Soil Media Substrate Case Study series - CS to be developed: - Pinata Farms (3rd Qtr, 2017) - Schiffke/Stothart farm (4th Qtr, 2017)	▪ Develop revised Australian IPM Poster for the Strawberry industry (May 2017) ▪ Review National BMP Guidelines and Grower Case Study Content (June, 2017) ▪ Redevelopment of Australian Pesticide Guide (September, 2017) ▪ Develop information resources for non-soil substrate production and protective cropping (June 2017) ▪ Non-Soil Media Substrate Case Study series - CS to be developed: - Kristian Leith (2nd Qtr, 2017) - Scott Carter, Gippsland Strawberries (3rd Qtr, 2017)

SIP STRATEGY OUTCOME	MECHANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
			soil substrate production and protective cropping (June 2017) ▪ Develop, repackage and publish case studies through communication platforms including website, Simply Red and The Punnet e-News		- Mick Gallace (4th Qtr, 2017)
			▪ Provide editorial oversight of quarterly print Simply Red Newsletter. ▪ Publication schedule includes: - #45 - 27 March, 2017 - #46 – 26 June, 2017 - #47 – 25 September, 2017 - #48 – 11 December, 2017	▪ Develop and source relevant content for quarterly Simply Red Newsletter	▪ Develop and source relevant content for quarterly Simply Red Newsletter
		Prepare regular updates on national issues, runner production, variety trials & industry profiles	▪ Development and distribute the Punnet on the 3rd Wednesday of the month. Schedule includes: - March - 15 March, 2017 - April – 19 April, 2017 - May – 17 May, 2017 - June – 21 June, 2017 - July – 19 July, 2017 - August – 16 August, 2017 - September – 20 September, 2017 - October – 18 October, 2017 - November – 15 November, 2017	▪ Updated email contact lists ▪ Submit content for The Punnet as appropriate ▪ Targeted email updates to Regional Growers as required	▪ Updated email contact lists ▪ Submit content for The Punnet as appropriate ▪ Targeted email updates to Regional Growers as required

SIP STRATEGY OUTCOME	MECHANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
			- December – 20 December, 2017 - January – 17 January, 2018 - February – 21 February, 2018		
		Facilitate learning from leading growers through 'stories of success'	▪ Edit and populate case studies into project template ▪ Distribute case studies through communication channels including The Punnet e-News ▪ Publish case studies, as appropriate, in Simply Red magazine ▪ Upload case studies to strawberry innovation website	▪ Grower Profiles to be developed - Jemma & Grace (Bundaberg) – Female growers (2nd Qtr, 2017) - Ray Daniels - Robotic Harvesting / Heat seal packaging (3rd Qtr, 2017) - Pim Mens – Organic Farming (3rd Qtr, 2017) - Brendan Hoyle – Organic Farming (3rd Qtr, 2017) ▪ Non-Soil Media Substrate Case Study series - CS to be developed: - Pinata Farms (3rd Qtr, 2017) - Schiffke/Stothart farm (4th Qtr, 2017)	▪ Grower Profiles to be developed - Luciano Corrallo – Agribusiness / Tourism (2nd Qtr, 2017) - Dominic Spirli – Pest free place of production status and export market access (3rd Qtr, 2017) - Matt & Ruth Gallace – Value Addition / Agri Tourism (3rd Qtr, 2017) - The Strawberry Pick (Echuca) – AgriTourism, young growers (4th Qtr, 2017) ▪ Non-Soil Media Substrate Case Study series - CS to be developed: - Kristian Leith (2nd Qtr, 2017) - Scott Carter, Gippsland Strawberries (3rd Qtr, 2017) - Mick Gallace (4th Qtr, 2017) ▪ Plug Plants – Grower experiences, Toolangi Coop, VSICA (2nd Qtr, 2017)

SIP STRATEGY OUTCOME	MECHANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
					▪ Native Vegetation Insectarium – Strawberry Springs (2nd Qtr, 2017)
	Knowledge Transfer	Develop and deliver regional training events such as webinars and/or masterclasses	▪ Host Future Options for IPM in Strawberries Webinar, Coordinated by Sub-Tropical Region IDO (24 May, 2017) ▪ Advertise and communicate masterclasses and webinars through communication platforms including website, Simply Red and The Punnet e-News	▪ Stanthorpe region pest management and soil health Workshop (TBC Apr/May, 2017) ▪ Bundaberg region pest management and soil health Workshop (TBC Jun/Jul, 2017) ▪ Women's Network Post Season Workshop (TBC Oct/Nov, 2017) ▪ Future Options for IPM in Strawberries, presented by Paul Jones, Bugs for Bugs (24 May, 2017)	▪ Autumn Strawberry Forum (3-5 May, 2017) ▪ Yarra valley region soil health workshops (May/June, 2017) ▪ Support Future Options for IPM in Strawberries, presented by Paul Jones, Bugs for Bugs (24 May, 2017)
		Conduct workshops and field days to increase understanding of new practices	▪ Advertise and communicate outcomes of field walks and field days through communication platforms including website, Simply Red and The Punnet e-News	▪ Stanthorpe runner grower harvest inspection (15 March, 2017) ▪ Sunshine Coast Field Day (TBC July, 2017)	▪ Native vegetation insectarium farm walk – Strawberry Spring (4 May, 2017) ▪ Toolangi Coop Farm Walk for inspection of Plug Plants (5 May, 2017) ▪ Wandin Silvan Field Day (13-14 October, 2017)
		Conduct networking events and regional tours.	▪ Advertise and communicate industry networking events through communication platforms including website, Simply Red and The Punnet e-News ▪ Advertise and communicate regional and international study tours through communication platforms including website, Simply Red	▪ Facilitate Sub-Tropical grower participation in Temperate Autumn Strawberry Forum (3-5 May, 2017) ▪ Agro-Trend Bundaberg (5-7 May, 2017) ▪ QSGA Annual Dinner and Awards (12 May, 2017) ▪ Sandstone Point Hotel Strawberry Festival (20	▪ Women in Horticulture International Women's Day Dinner (8 March, 2017) ▪ Yarra Valley Pest Free Place of Production Meeting (14 March, 2017) ▪ VSGA Ladies Dinner (23 March, 2017) ▪ Horticulture Industry Innovation Network (HIIN) Meeting – Biosecurity (April, 2017)

SIP STRATEGY OUTCOME	MECHANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
			and The Punnet e-News ▪ Program Reference Group meeting (TBC August, 2017) ▪ Coordinate tour of Agri-Bio Facility at La Trobe University as part of Autumn Strawberry Forum (September, 2017) ▪ Program Reference Group meeting (TBC February, 2018)	August, 2017) ▪ Program Reference Group meeting (TBC August, 2017) ▪ Bundaberg Innovation Tour including export, value addition and automation (November, 2017) rogram Reference Group meeting (TBC February, 2018)	▪ Autumn Strawberry Forum (3-5 May, 2017) ▪ Fruit Growers Tasmania Conference (25-27 May, 2017) ▪ Horticulture Industry Innovation Network (HIIN) Meeting – New chemical registrations (TBC May, 2017) ▪ Program Reference Group meeting (TBC August, 2017) ▪ Assessing interest in International Strawberry Congress, Antwerp (6-8 Sep, 2017) ▪ WA grower exchange (December, 2017) ▪ Program Reference Group meeting (TBC February, 2018)
	Industry Coordination	Establish and facilitate grower groups to encourage learning and practice change	▪ Promote thematic group areas and opportunities through communication platforms including website, Simply Red and The Punnet e-News, with targeted engagement to Regional IDO's	▪ Follow up engagement and facilitation of Women's Network (post Women's Wellness Weekend - February, 2017) ▪ Sustained liaison with existing industry groups including Food and Agribusiness Network Sunshine Coast, Innovation Centre ▪ Continued scoping opportunities for new grower groups	▪ Assess opportunities and interest for Young Grower Group ▪ Continued scoping opportunities for new grower groups
		Facilitate a community practice to share ideas, lead change & provide	▪ Formalise researcher community of practice group to enabled structured sharing of research findings across industry through	▪ Continue coordinated engagement of relationships in breeding program, runner growers and Sub-Tropical industry	▪ Continue coordinated engagement of relationships in breeding program, runner growers and Temperate industry

SIP STRATEGY OUTCOME	MECHANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
		feedback on the efficacy of the program	communication platforms including website, Simply Red and The Punnet e-News	▪ Support community of practice of products growing strawberries in soil-less media and protected cropping	▪ Support community of practice of products growing strawberries in soil-less media and protected cropping
2. By 2021 increase exports of Australian strawberries from four per cent to at least eight per cent of national production by volume, in selected markets, with a capacity and willingness to pay a premium for quality fruit	Communications	Facilitate learning from leading growers through 'stories of success'	▪ Edit and populate case studies into project template ▪ Distribute case studies through communication channels including The Punnet e-News ▪ Publish case studies, as appropriate, in Simply Red magazine ▪ Upload case studies to strawberry innovation website	▪ Export experience Grower Profiles to be developed: - Di West – Pacific and New Zealand (3rd Qtr, 2017) ▪ Ray Daniels (3rd Qtr, 2017)	▪ Export experience Grower Profiles to be developed: - Dominic Spirli – Pest free place of production status and export market access (3rd Qtr, 2017) ▪ Jamie Michaels (3rd Qtr, 2017)
	Knowledge Transfer	Conduct networking events and regional tours.	▪ Advertise and communicate industry networking events through communication platforms including website, Simply Red and The Punnet e-News ▪ Advertise and communicate regional and international study tours through communication platforms including website, Simply Red and The Punnet e-News	▪ Assess interest in export orientated study tours	▪ Assess interest in export orientated study tours ▪ Assessing interest in International Strawberry Congress, Antwerp (6-8 Sep, 2017)
4. By 2021, at least 90 per cent of growers and other firms involved in the strawberry value chain will be directly engaged with and value national industry services	Communication	Prepare regular updates on national issues, runner production, variety trials & industry profiles	▪ Maintain centralised database on strawberry growers and industry associations	▪ Update centralised databased with new and revised grower and industry associate contacts	▪ Update centralised databased with new and revised grower and industry associate contacts
	Industry Coordination	Undertake industry analysis to enable better planning and development of	▪ Support data analysis as appropriate. ▪ Share analysed data and relevant information across national industry as	▪ Collect data on runner quality for 2017 season and distribute to growers ▪ Progress implementation of scope of work for collection	▪ Continued engagement with Toolangi Coop for improved data sharing. ▪ Collect data on runner quality from Toolangi for 2017 season

SIP STRATEGY OUTCOME	MECHANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
		the Australian strawberry industry	appropriate through communication platforms including website, Simply Red and The Punnet e-News	and collation of runner data through addressing challenges identified	and distribute to growers ▪ Coordinate data collection across all Victorian properties through VSIDC funded survey of incidence and severity of charcoal rot. Published findings to be shared across temperate region.
1. By 2021, per capita domestic consumption of fresh Australian strawberries will increase by 10 per cent, underpinned by consistent supply of premium quality fruit that matches consumer desires.	Communications	Prepare regular updates on national issues, runner production, variety trials & industry profiles	▪ Extension of consumer insight research and other health benefit information through hard and soft copy publications as available (including website)	▪ Submit relevant consumer insight research and other health benefit information to publications as appropriate.	▪ Submit relevant consumer insight research and other health benefit information to publications as appropriate.

Annual Work Plan – Year 3 (2018/19)

Strawberry Innovation (BS15002) – Horticulture Innovation
February 2018

The key activities planned for delivery through the Strawberry Innovation program (comprising of the National Coordination Project (BS15002) and the Regional Delivery Partners in the Sub-Tropical (BS15003) and Temperate (BS15004) regions) are documented in Table 2. These activities have been identified as priorities following consultation with industry members in the main production regions and based on feedback on activities delivered in Year 1 and 2 of the program.

The key priorities to be addressed within the work plan are outlined below with specific activities detailed in Table 2:

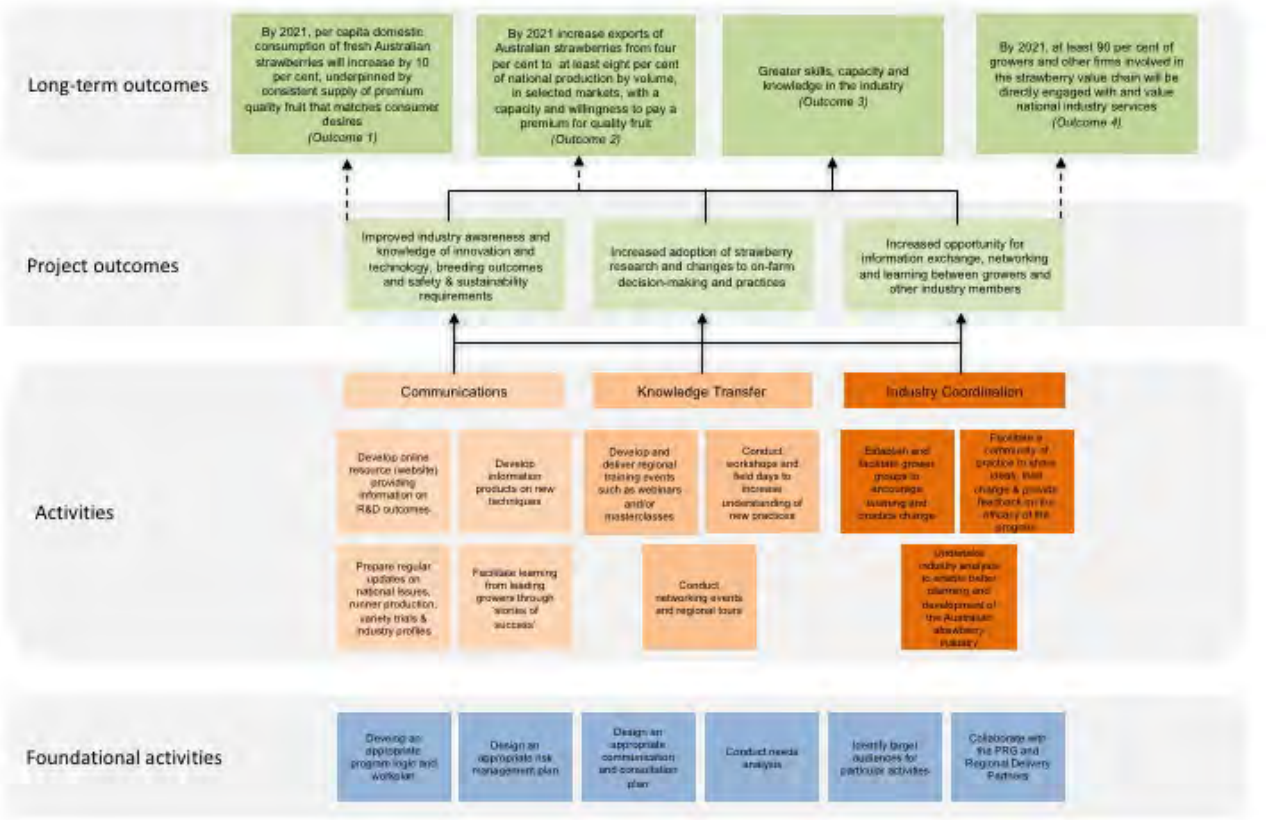
PRIORITY	APPROACH
Substrate production and protected cropping	Build capacity and support producers to transition into new production techniques by providing them with information on costs of production, production techniques and experiences of producers who have made the transition.
Market development opportunities (export)	Provide industry members with information (via work plan activities) on market development opportunities, how to realise opportunities and processes involved in accessing new markets.
Innovation	Provide industry members with information (via work plan activities) on the latest innovation and how this could be applied in their businesses.
Planting Material Quality	Liaise with industry organisations, runner growers and fruit producers to determine the best approach for ensuring consistent, high quality planting material for industry.
Waste management	Inform industry on options for second grade fruit, new technology which could be applied to value-add fruit and ways of managing plastic waste.
Biosecurity	Improve the biosecurity of the Australian strawberry industry through a proposed update of the Australian biosecurity plan, provision of information resources on key pests (both new and old) and delivery of webinars on management options for key pests.
Understanding regulatory requirements	Inform and engage with industry members on the regulatory requirements around sourcing and management of labour, Hort Code of Conduct and HARPS through delivery of workshops and information products.

Activities within the program for Year 3 are aligned with the Strategic Investment Plan (2017-2021) (Table 1) and the program logic (Figure 1) which demonstrates the relationship between activities and desired outcomes of the program. Deliverables within the Year 3 work plan will continue to evolve as industry needs and priorities are identified throughout the year.

Table 1: Strawberry Industry Priorities - Strawberry Strategic Investment Plan 2017-2021

OUTCOMES	STRATEGIES
1. By 2021, per capita domestic consumption of fresh Australian strawberries will increase by 10 per cent, underpinned by consistent supply of premium quality fruit that matches consumer desires	Conduct regular consumer research to gather insights and monitor perceptions and expectations towards fresh Australian strawberries
	Establish a methodology to measure and monitor the incidence of where quality is below consumer expectations
	Establish evidence of product health attributes and national industry practices that bolster the reputation of Australian strawberry businesses and its products
2. By 2021 increase exports of Australian strawberries from four per cent to at least eight per cent of national production by volume, in selected markets, with a capacity and willingness to pay a premium for quality fruit	Develop a strawberry export strategy during 2017 by working with current and potential exporting businesses
	Pursue technical market access for the priority markets identified in the export strategy
	Market development program in priority markets
3. Greater skills, capacity and knowledge in the industry	Ensure that superior strawberry varieties that match consumer expectations are available to growers
	Identify the regulatory imposts and those proven technologies and good management practices with greatest impact and ease of implementation to reduce cost of production / increase productivity
	Inform strawberry growers on the emerging options, risks and opportunities afforded by protected cropping systems
	Continual improvement of integrated pest management (IPM) systems to meet pest and disease threats
4. By 2021, at least 90 per cent of growers and other firms involved in the strawberry value chain will be directly engaged with and value national industry services	Develop an informed and cohesive industry through direct two-way communications with strawberry businesses across Australia
	Provide timely information on industry production, forecasts and markets

Figure 1: Program Logic



1 Strawberry Innovation Work plan

The program work plan, as presented in Table 2, documents activity delivery between March 2018 to March 2019 through the National Coordination Project (BS15002) and the Regional Delivery Partners in the Sub-Tropical (BS15003) and Temperate (BS15004) regions against the strategy outcomes of the Strawberry Strategic Investment Plan.

Deliverables within the Year 3 work plan will continue to evolve as industry needs and priorities are identified.

Table 2: Annual Work Plan - Year 3 of the Industry Development Program for the Australian Strawberry Industry

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
3. Greater skills, capacity and knowledge in the industry	Communication	Develop and maintain online resource (website) providing information on R&D outcomes	▪ Maintain website content including news, resources and events on a minimum weekly basis	▪ Submit website content periodically	▪ Submit website content periodically
		Develop information products on innovation and best practice within the strawberry industry	▪ Communicate and share information products through communication platforms including website, Simply Red and The Punnet e-News (ongoing) ▪ Develop and publish remaining chapters of national Good Practice Guide (ongoing) ▪ Develop and publish fact sheet on protected cropping structures for National Good Practice Guide (ongoing) ▪ Desktop publish and print revised Australian Pesticide Guide (April 2018) ▪ Desktop publish and print revised Australian IPM Poster for the Strawberry industry (May 2018) ▪ Support IPM App development with Uni of Qld (May 2018)	▪ Review and provide feedback on National Good Practice Guide, fact sheets and provide grower case study content as required (ongoing) ▪ Develop fact sheets on chemical management and waste management for National Good Practice Guide (ongoing) ▪ Develop information resource on Plug Plants – Grower experiences (April 2018) ▪ Finalise and publish IPM App with assistance from University of Queensland student (May 2018) ▪ Develop information resources on management of food and plastic waste – what are the	▪ Review and provide feedback on National Good Practice Guide, fact sheets and provide grower case study content as required (ongoing) ▪ Develop fact sheets on nutrient management and biodiversity management for National Good Practice Guide (ongoing) ▪ Develop information resource on Plug Plants – Grower experiences (April 2018) ▪ Develop revised Australian IPM Poster for the Strawberry industry (May 2018) ▪ Develop information resources on management of food and plastic waste – what are the options? What new technology

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
			▪ Develop information resources on management of food and plastic waste – what are the options? What new technology is available to assist with this issue? (May 2018) ▪ Develop fact sheets on key pests within strawberry industry (May 2018) ▪ Develop and publish information resources for substrate production and protective cropping (June 2018) ▪ Develop decision support tool on transition from field to substrate/protected cropping. Tool to discuss COP and ROI (August 2018) ▪ Develop resources on business management (September 2018) ▪ Develop information resources on new technology within the horticulture industry such as super-charged plasma and robotics (November 2018)	options? What new technology is available to assist with this issue? (May 2018) ▪ Develop information resources for substrate production and protective cropping (June 2018)	is available to assist with this issue? (May 2018) ▪ Develop information resources for substrate production and protective cropping (June 2018) ▪ Develop information resource on Native Vegetation Insectarium – Strawberry Springs (September 2018)
		Prepare regular updates on national issues, runner production, variety trials & industry profiles	▪ Provide editorial oversight of quarterly print Simply Red Newsletter. ▪ Publication schedule includes: - #49 - March 2018 - #50 – June 2018 - #51 – September 2018 - #52 – December 2018	▪ Develop and source relevant content for quarterly Simply Red Newsletter	▪ Develop and source relevant content for quarterly Simply Red Newsletter
			▪ Develop and distribute The Punnet on the 3rd Wednesday of the month. Schedule includes:	▪ Update email contact lists ▪ Submit content for The Punnet as appropriate	▪ Update email contact lists ▪ Submit content for The Punnet as appropriate

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
			- March - 21 March 2018 - April – 18 April 2018 - May – 16 May 2018 - June – 20 June 2018 - July – 18 July 2018 - August – 15 August 2018 - September – 19 September 2018 - October – 17 October 2018 - November – 21 November 2018 - December – 19 December 2018 - January – 16 January 2019 - February – 20 February, 2019	▪ Targeted email updates to regional growers as required	▪ Targeted email updates to regional growers as required
		Facilitate learning from leading growers through 'stories of success'	▪ Edit and populate case studies into project template ▪ Distribute case studies through communication channels including The Punnet e-News ▪ Publish case studies, as appropriate, in Simply Red magazine ▪ Upload case studies to strawberry innovation website	Develop substrate/protected cropping grower case study series: ▪ Schiffke/Stothart farm (June 2018) ▪ Pinata Farms (September 2018) ▪ Protected cropping in Australia – combined grower experiences (December 2018) Grower Profiles to be developed: ▪ Jemma & Grace (Bundaberg) – Female growers (June 2018) ▪ Ray Daniels - Robotic Harvesting / Heat seal packaging (September 2018)	Develop substrate/protected cropping grower case study series: ▪ Tasmanian growers (June 2018) ▪ Anthony Yewers WA (September 2018) ▪ Protected cropping in Australia – combined grower experiences (December 2018) Grower Profiles to be developed: ▪ Luciano Corrallo – Agribusiness / Tourism (June 2018) ▪ Westerway Farms (Tasmania) - Value Addition/Frozen berries (September 2018) ▪ Westerway Farms (Tasmania) - Robotics (December 2018)

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
	Knowledge Transfer	Develop and deliver on-line resources such as webinars or videos	▪ Host webinars and post on website ▪ Advertise and communicate videos and webinars through communication platforms including website, Simply Red and The Punnet e-News ▪ Organise webinar on transition from field cropping to substrate/protected cropping (featuring Klaas Walveren) (May 2018) ▪ Organise webinar on WFT and management of other key pests (featuring Biological Services) (October 2018) ▪ Scope potential for video on grower experiences with protected cropping/substrate production. Potential interviewees: (December 2018): – Shiffke/Taste N see – Anthony Yewers – Simon Dornauf/Roly	▪ Interview growers within region on protected cropping/substrate production experiences for video (December 2018) ▪ Assist in advertising, sourcing speakers and participate in webinars as required (ongoing)	▪ Interview growers within region on protected cropping/substrate production experiences for video (December 2018) ▪ Assist in advertising, sourcing speakers and participate in webinars as required (ongoing)
		Conduct workshops and field days to increase understanding of new practices and regulatory requirements	▪ Advertise and communicate outcomes of field walks and field days through communication platforms including website, Simply Red and The Punnet e-News	▪ Stanthorpe runner grower harvest inspection (March 2018) ▪ Organise workshop on labour management, labour hire company licensing and Hort Code of Conduct (March 2018) ▪ Organise workshop on food safety (April 2018) ▪ Organise workshop for Stanthorpe production region - topics TBC (June 2018)	▪ Organise workshop on Hort Code of Conduct for WA (March 2018) ▪ Organise workshop on Hort Code of Conduct and Fair Farms Initiative for Vic growers (April 2018) ▪ Organise Strawberry Academy training (in conjunction with VSIDC) March 2018 and ongoing) ▪ Organise farm walk at Blue Hills (protected cropping) (March 2018)

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
				▪ Organise workshop for Bundaberg production region - topics TBC (June 2018) ▪ Organise farm walk at Red Jewel (Sept 2018) ▪ Plug plan production in table tops – grower visit in September 2018 ▪ Bundaberg Innovation Tour including export, value addition and automation (November 2018) ▪ Organise workshop on biosecurity (featuring speakers such as Jess Lye from Ausveg) (November 2018)	▪ Organise workshop on HARPS (April 2018) ▪ Organise workshop on food safety (April 2018) ▪ Organise Strawberry Forum (May 2018) ▪ Organise workshop on biosecurity (featuring speakers such as Jess Lye from Ausveg) (July 2018) ▪ VSGA AGM and farm walk (October 2018) ▪ Wandin Silvan Field Day (12-13 October 2018)
		Conduct networking events and regional tours.	▪ Advertise and communicate industry networking events through communication platforms including website, Simply Red and The Punnet e-News ▪ Advertise and communicate regional and international study tours through communication platforms including website, Simply Red and The Punnet e-News ▪ Organise and chair Program Reference Group meetings (August 2018 and February 2019)	▪ Facilitate Sub-Tropical grower participation in Temperate Autumn Strawberry Forum (May 2018) ▪ QSGA Annual Dinner and Awards (May 2018) ▪ Sandstone Point Hotel Strawberry Festival (August 2018) ▪ Organise Ladies Event (October 2018) ▪ Participate in Program Reference Group Meetings (August 2018 and February 2019)	▪ Horticulture Industry Innovation Network (HIIN) Meetings Ongoing beginning 5-7 March 2018 ▪ Women in Horticulture International Women's Day Dinner (8 March 2018) ▪ VSGA Women in Industry Dinner - speaker Rachel McKenzie, Growcom (April 2018) ▪ VSGA Ladies tour to Agribio (May 2018) ▪ Hydroponic Farmers Federation 11th Biennial Conference 25-27 June 2018 ▪ Victorian Strawberry Ball and Industry Awards (July 2018) ▪ Participate in Program Reference Group Meetings

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
					(August 2018 and February 2019)
	Industry coordination	Establish and facilitate grower groups to encourage learning and practice change	▪ Promote thematic group areas and opportunities through communication platforms including website, Simply Red and the Punnet e-News, with targeted engagement to Regional IDOs.	▪ Engagement and facilitation of Women's Network ▪ Sustained liaison with existing industry groups including Food and Agribusiness Network Sunshine Coast, Innovation Centre ▪ Continued scoping of opportunities for new grower groups	▪ Establish Innovative growers group ▪ Re-establish Women in Industry groups
		Facilitate a community of practice to share ideas, lead change and provide feedback on the efficacy of the program	▪ Support and engagement of researcher community of practice group to enable structured sharing of research findings across industry through communication platforms including website, Simply Red and the Punnet e-News	▪ Continue coordinated engagement of relationships in breeding program, runner growers and Sub-Tropical industry ▪ Identify and engage relevant industry stakeholders for protected cropping/soil-less media CoP	Ongoing: ▪ Engagement of relationships in breeding program, runner growers, VSICA and temperate industry ▪ Biosecurity CoP - collaboration with AusVeg Biosecurity, Regional Fruit Fly coordinator, VegNet Gippsland and LGAs ▪ Yarra Valley QFF CoP - Biosecurity Centre of Excellence, DEDJTR, YV PFPP, Regional Fruit Fly Coordinator, soft fruit growers ▪ Regional solutions for waste management CoP - YV Agribusiness, Shire of Yarra Ranges, Recycling facilities New: ▪ Identify and engage relevant industry stakeholders for protected cropping/soil-less media CoP

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
2. By 2021 increase exports of Australian strawberries from four per cent to at least eight per cent of national production by volume, in selected markets, with a capacity and willingness to pay a premium for quality fruit	Communications	Facilitate learning from leading growers through 'stories of success'	▪ Develop resources on market development opportunities (October 2018) ▪ Edit and populate case studies into project template ▪ Distribute case studies through communication channels including The Punnet e-News ▪ Publish case studies, as appropriate, in Simply Red magazine ▪ Upload case studies to strawberry innovation website	Export experience grower profiles to be developed: ▪ Di West – Pacific and New Zealand (June 2018) ▪ Ray Daniels (September 2018)	Export experience grower profiles to be developed: ▪ Jamie Michael (September 2018)
	Knowledge Transfer	Conduct networking events, regional tours and e-learning.	▪ Organise webinar on market development opportunities and outcomes of export strategy (featuring Karl McIntosh) (July 2018) ▪ Advertise and communicate industry networking events through communication platforms including website, Simply Red and The Punnet e-News ▪ Advertise and communicate regional and international study tours through communication platforms including website, Simply Red and The Punnet e-News	▪ Organise workshop on market development opportunities (featuring QDAF, Karl McIntosh, outcomes of export strategy) (April 2018) ▪ Assess interest in export orientated study tours	▪ Organise workshop on market development opportunities (featuring Karl McIntosh, outcomes of export strategy) (June 2018) ▪ Assess interest in export orientated study tours
4. By 2021, at least 90 per cent of growers and other firms involved in the strawberry value chain will be directly engaged with and value	Communication	Prepare regular updates on national issues, runner production, variety trials and industry profiles	▪ Maintain centralised database on strawberry growers and industry associations	▪ Update centralised databased with new and revised grower and industry associate contacts	▪ Update centralised database with new and revised grower and industry associate contacts
	Industry Coordination	Undertake industry analysis to enable better planning and	▪ Consult with PHA and SAI on the development of a proposal for updating the national biosecurity	▪ Liaise with QSGA to extract industry data directly from fruit	▪ Continue engagement with Toolangi Coop for improved data sharing, as well as

SIP STRATEGY OUTCOME	MECH-ANISM	ACTIVITY	NATIONAL COORDINATION (BS15002)	SUB-TROPICAL REGIONAL DELIVERY PARTNER (BS15003)	TEMPERATE REGIONAL DELIVERY PARTNER (BS15004)
national industry services		development of the Australian strawberry industry	plan (collaborate with WA who are currently updating their biosecurity plan) (March 2018) ▪ Develop proposal on benchmarking within industry if sufficient interest (May2018) ▪ Support data analysis as appropriate ▪ Share analysed data and relevant information across national industry as appropriate through communication platforms including website, Simply Red and The Punnet e-News	producers through membership base ▪ Continue engagement with sub-tropical runner producers for improved data sharing ▪ Consult with industry members on interest in conducting benchmarking within strawberry industry (May 2018)	emerging nursery producers in Tasmania, SA and WA ▪ Consult with runner growers in temperate region on collation of runner data and ability to use it for industry analysis purposes ▪ Published findings of VSIDC charcoal rot project to be shared across temperate region ▪ Consult with industry members on interest in conducting benchmarking within strawberry industry (May 2018)
1. By 2021, per capita domestic consumption of fresh Australian strawberries will increase by 10 per cent, underpinned by consistent supply of premium quality fruit that matches consumer desires.	Communications	Prepare regular updates on national issues, runner production, variety trials and industry profiles	▪ Develop information sheets on strawberry varieties for use by industry members within both domestic and export markets (August 2018) ▪ Extension of consumer insight research and other health benefit information through hard and soft copy publications as available (including website)	▪ Develop pre-harvest runner inspection report on plant quality/issues for distribution to sub-tropical growers prior to planting (Feb/Mar 2018) ▪ Submit relevant consumer insight research and other health benefit information to publications as appropriate ▪ Liaise with Australian breeding program and runner growers to collate information for variety fact sheets (August 2018)	▪ Submit relevant consumer insight research and other health benefit information to publications as appropriate ▪ Liaise with Australian breeding program and runner growers to collate information for variety fact sheets (August 2018) ▪ Support VSIDC PR and marketing project, promoting Strawberry health benefits and the industry's sustainable practices

Appendix 3: Fact Sheets

1. Transitioning to protected cropping: What are the costs and benefits?
2. How can I control pests? Options for controlling sucking pests in strawberries
3. How can I control pests? Options for controlling fruit and foliar diseases in strawberries
4. How can I control pests? Options for controlling chewing and biting pests in strawberries
5. Organic strawberries: A small slice of Australia's billion-dollar organics industry
6. Managing foliar and fruit diseases in strawberries
7. Managing chewing and biting pests in strawberries
8. Managing soilborne diseases in strawberries
9. Managing sucking pests in strawberries
10. Silicon for strawberry plant health
11. Irrigation water quality for strawberries
12. Using recycled water for strawberry production
13. Minor use permits
14. Managing you soil: Taking soil tests
15. Keeping soil in its place: Improving soil cover and managing drainage
16. Managing your soil: Crop rotation and soil amendments
17. Growing strawberries in Western Australia
18. Developing Asian markets for Australian strawberries
19. Postharvest diseases and disorders of strawberries
20. New technology in strawberry production
21. Export Supply Chain – Queensland strawberries to Hong Kong.

Transitioning to protected cropping

What are the costs and benefits?

STRAWBERRY INNOVATION

Why transition to protected cropping?

Our close proximity to Asian markets, a favourable seasonal supply window and a growing consumer preference for clean, safe food have assisted Australian strawberry growers and exporters to establish a foothold in Asian markets in recent years. But as we consider our current export strategies in the face of growing competition from Korea, Spain, Egypt and the US, it is arguably a good time to consider not just marketing strategies but also improvements in production that will enhance our presence in these export markets.

Whilst market access to China continues to be an important step to boosting our export potential (especially from WA and QLD), there is a risk that any early gains may prove difficult to maintain without consistent supply from the south-eastern states. Predictions of greater fluctuations in weather conditions and more extreme weather events also contribute to the challenges of in-field production; particularly with a sensitive crop like strawberries.

Transitioning to protected cropping may be worthwhile for interested growers to consider, particularly if looking at longer-term supply to export markets. Greater control over fruit quality, increases in yields and a wider choice of varieties offered through protected cropping are advantages that could enhance our competitiveness in these markets. Asian buyers are renowned for demanding consistent quality and supply, and are very specific about appearance and taste.

Protected cropping is a means of delivering this. It could also assist the south-eastern states to extend their season beyond mid- autumn and reduce the impact of domestic market fluctuations on building longer-term export supply.

In short, the major benefits of protected cropping and growing in substrate for strawberries, include:

- Increased yield (through increased plant density and effective use of IPM)
- Increased quality (through better nutrient control and protection from pests and inclement weather)
- Increased productivity (through faster growing times and lower labour costs)
- Extending the supply window over more favourable market conditions.

What do I need to think about?

Given that cost is a major consideration, it is important to consider the potential benefits that could be generated by a transition to protected cropping for production of strawberries, particularly in the south eastern states.

We compared field production with two popular protected cropping options (retractable greenhouses and tunnels) by constructing a simple case study over a one-hectare production area.

Although high-tech glasshouses are another potential protected cropping option for strawberry growers, we did not fully investigate this option for a number of reasons. These include:

- Significantly higher establishment costs (approximately $\$250\text{-}\$350/m^2$)
- Variability of construction options (including heights, heating systems, and site preparation)
- Less severe climatic conditions in Australia compared to the production challenges that northern hemisphere producers face. Hence, the benefits of domestic supply in the winter months do not outweigh the significant capital establishment costs required for glasshouse production in comparison to field production.

This project has been funded by Hort Innovation, using the strawberry research and development levy and contributions from the Australian Government. Hort Innovation is the grower owned, not-for-profit research and development corporation for Australian horticulture.

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Production data

Our analysis highlights the important factors for growers to consider when deciding whether to invest in tunnels or retractable greenhouses, over one hectare. That said, it is impossible to cover every variable, as each individual grower will have unique drivers of productivity, primarily to do with their location. Therefore, we need to make some assumptions and hold some variables constant to make the evaluation worthwhile. Whilst assumptions relating to key production drivers include, plant density, yield, waste and overpack; it does not account for other production variables such as variety or production expertise. Variety is obviously a key driver of productivity, but also highly variable and difficult to standardise in terms of performance in this study.

Based on industry standards, Table 1 outlines the yield expected from the three production scenarios per square meter (m^2) based on one hectare (10,000m^2) of production. With assistance from industry sources, assumptions have been made regarding the planting density, yield and waste of each production method, per hectare (ha).

Table 1: Yield of strawberry fruit across three production scenarios

PRODUCTION TYPE	OPEN FIELD	RETRACTABLE GREENHOUSE / SUBSTRATE	TUNNELS / SUBSTRATE
Plant Density (no. of plants /ha)	65,000	82,000	76,000
Gross yield of large marketable fruit (kg/plant)	0.750g	1.10kg	0.950g
Gross yield of large marketable fruit (kg/plant (ha))	48,750	90,200	72,700
Downgraded/waste/ shrink- age/loss %	30%	10%	10%
Net yield of large marketable fruit (kg/plant (ha))	34,125	81,180	64,980
Net yield of large marketable fruit (kg/m^2)	3.41	8.12	6.50
Net yield of large marketable fruit (punnet/ m^2) + 10% overpack (25g)	12.41	29.52	23.63
Net yield large marketable fruit (punnet/ha)	124,091	295,200	236,291
Net yield of large marketable fruit (15 punnet trays/ha)	**8,273**	**19,680**	**15,753**

Fixed and variable costs

With the help of some 'ball-park' figures provided by suppliers, we have been able to estimate some of the key fixed costs of the protected cropping options considered. Variable costs are difficult to measure because of the customised nature of each individual farm, so assumptions have been included for both protected cropping examples and for field production.

The estimated cost data (provided in Table 2 below) can then be compared to the production data to achieve a cost comparison per punnet level for each production method.

Table 2: Fixed and variable cost data

PRODUCTION TYPE	OPEN FIELD	RETRACTABLE GREENHOUSE / SUBSTRATE	TUNNELS / SUBSTRATE
Land cost ($)	22,239	22,239	22,239
Structure cost ($) (tunnel/retractable greenhouse)	-	550,000	110,000
Fit-out cost ($) (gutters, substrate, irrigation)	120,000	315,000	290,000
Total capital cost ($)	**142,239**	**887,239**	**422,239**
Miscellaneous variable costs	89,927	180,400	144,400
Labour costs (plant, pick, pack)	84,382	140,516	120,508
Total variable cost ($)	**174,309**	**320,916**	**264,908**
Total variable cost ($) per punnet (see Table 1))	1.40	1.09	1.12

Photo: Tunnels at Hillwood Berries

For fixed costs:

- Land is estimated at $22,239 per hectare ($9,000 per acre).
- According to Director of Business Development for Cravo Equipment, Bede Miller, structural costs for retractable greenhouses can range from $30/m^2 to $70/m^2 depending on which retractable production system is appropriate for the crop and market requirements. We nominated $55/m² or $550,000/ha to cover framework and footings, covering, controller, associated electrical and all associated construction costs.
- Haygrove Australia stated structural costs for tunnels can range from $7m² to $12/m² depending on the wind ratings and other site dependent factors. As such, we have assumed $11/m² or $110,000/ha to cover the cost of framework and coverings, all labour and associated construction costs.
- Fit-out costs for field production are related to irrigation and land preparation costs only.
- Fit-out costs for both retractable greenhouses and tunnels can vary enormously according to the level of sophistication involved. For this study we have included gutters (slightly more for retractable where double gutters are often used), substrate, table tops and the fertigation and irrigation set- up.

For variable costs:

- All variable costs for field production calculated per QDAF Agrilink article "Economics for Strawberry production" and adjusted for inflation and increased volume *i.e. this example estimated labour costs at $36,800 for 1 ha, producing 90,000 x 250g punnets. Adjusted for inflation and increasing the volume to 124,091 x 250g punnets, this figure is now $84,382 for 1ha of field production.*
- Miscellaneous variable costs for both tunnels and retractable production estimated at approximately $2.00/kg of large marketable fruit, within specification. This is based on industry estimates ranging from $1.80 to $2.20 per kilo of marketable fruit.
- Labour cost for tunnel production is based on field costs, less an estimated 25% due to savings in harvesting at waist level, packing in field and less sorting and handling costs. Labour costs for retractable tunnels is estimated to achieve a 30% saving on field costs, due to the ability of labour to cover a larger area under a single roof structure.
- Freight or agents' commissions are not included in variable costs.

Extending the supply window

Another important consideration is the ability of protected cropping to extend supply beyond the seasonal field production supply window, thereby supplying domestic markets when sales prices are traditionally higher.

Figure 1: Average price ($) per punnet from Melbourne Market 2013 - 2018

*Sourced from Data Fresh, based on Melbourne Market estimated average wholesale sales prices only and does not include prices of fruit sold to larger chain-store retailers.

Figure 1 shows average weekly wholesale sales prices in the Melbourne Markets, less 12.5% commission, averaged per month from July 2013 to May 2018. Unsurprisingly, the months of April, May and June are the peak of the season whereas August and September consistently represent the lowest prices.

What are the benefits?

Based on the sales data, we looked at the effect protected cropping has on extending the seasonal supply window. The data in Table 3 show that by increasing more of the supply into April and May (i.e. 25% of the total crop compared to only 4% over that time period in the field), sales revenues could increase by over 35%, in addition to the gains in yield.

In this exercise, Table 3 also shows that the gross margin percentage is highest in the tunnels, primarily due to the lower structural cost calculated for the benefit of the study i.e. compared with tunnels, an additional $40K per annum is required under retractable greenhouses.

It is important to note, this comparison is based on the assumptions identified above and requires interested growers to undertake their own due diligence thorough investigation of costs and key production drivers for their business, including supply-chain influences such a freight and marketing costs and unique growing conditions.

When evaluating the various production options available, it is worth considering the advantages of each option, according to your own individual location, expertise and return on investment required. As a guide a summary list of some of the advantages of each option is presented in Table 4.

Overall, this investigation demonstrates the benefits protected cropping could have on the bottom line, through the key drivers of increasing yield, reducing waste and extending the supply window.

Protected cropping offers an option towards a more efficient method of production that supports future growth. Whilst the above analysis is simple in its approach, it highlights some of the important components of production that need careful consideration prior to proceeding with any commitment to invest. It is recommended that individual growers seek professional advice in making decisions on changes to their production system, and tailor future investments to individual business goals.

Table 3: Change in seasonal supply

MELB MARKET PRICE AVERAGE			OPEN FIELD			RETRACTABLE GREENHOUSE / SUBSTRATE			TUNNELS / SUBSTRATE		
Average Return $	Per 250g Punnet Large	Per 15 Punnet Tray	% of Crop	Volume (15p Trays)	Revenue ($)	% of Crop	Volume (15p Trays)	Revenue ($)	% of Crop	Volume (15p Trays)	Revenue ($)
Jan	$1.56	$ 23.33	10%	827	19,300	10%	1,968	45,913	10%	1,575	36,752
Feb	$2.01	$ 30.18	10%	827	24,963	10%	1,968	59,386	10%	1,575	47,536
Mar	$1.67	$ 25.05	14%	1,158	29,007	15%	2,952	73,934	15%	2,363	59,181
Apr	$2.15	$ 32.19	4%	331	10,651	15%	2,952	95,019	15%	2,363	76,058
May	$3.31	$ 49.67	0%	-	-	10%	1,968	97,742	10%	1,575	78,239
Jun	$2.00	$ 29.97	0%	-	-	0%	-	-	0%	-	-
Jul	$1.89	$ 28.30	0%	-	-	0%	-	-	0%	-	-
Aug	$1.25	$ 18.82	0%	-	-	0%	-	-	0%	-	-
Sep	$1.25	$ 18.79	0%	-	-	0%	-	-	0%	-	-
Oct	$1.64	$ 24.57	12%	993	24,391	10%	1,968	48,353	10%	1,575	38,704
Nov	$1.52	$ 22.75	20%	1,655	37,634	15%	2,952	67,145	15%	2,363	53,747
Dev	$1.60	$ 23.97	30%	2,482	59,488	15%	2,952	70,758	15%	2,363	56,638
Total/Ave.	$1.82	$ 27.30	100%	8,273	205,434	100%	19,680	558,249	100%	15,753	446,855
Total Variable Costs ($)					183,399			396,331			300,799
Gross Margin ($)					22,035			161,919			146,056
GM %					11%			29%			33%

Table 4: Advantages of each type of production system

OPEN FIELD	• Lowest set up cost • Less sophisticated • High light exposure • High pollination rates • Firm fruit with high brix levels (when weather is ideal) • Perceived as more natural by consumers
RETRACTABLE GREENHOUSE / SUBSTRATE	• Ability to increase sunlight and prevent excessive transpiration • Can reduce the humidity through both horizontal and vertical ventilation • Easier to control chill-hours • Pollination less restricted • More control over plant vigour and ability to optimise balanced plant development • More efficient harvesting at waist level supporting OHS and reducing harvest costs • More consistent supply keeps pickers employed • Less sorting and double handling of fruit with lower wastage & supporting in-field pick and pack • Reduction in foliar and fungal diseases • Greater control of plant nutrients • More water and nutrient efficient directing usage to plant demand • Can construct in regions with lower land values • Automated retractable roof closure and opening
TUNNELS / SUBSTRATE	• Lower set up cost. Semi-permanent structures that can be easily removed and installed into other areas/regions as necessary • Relatively low tech and therefore easier to learn to operate. Climatic variables can be adjusted by venting • Usually no planning permit required to build • No three-phase power required to operate but options for roller venting & doors are available

Acknowledgement

This information was developed by Karl McIntosh for the Strawberry Innovation project (August 2018). Further resources on production of strawberries under tunnels and with substrates is available at www.strawberryinnovation.com.au

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How can I control pests? Options for controlling sucking pests in strawberries

August 2018

STRAWBERRY INNOVATION

This table lists the major sucking pests that impact on strawberry production in Australia and available control options. For each pest, the registered and permitted pesticides are listed along with the active ingredient, insecticide group, withholding period (WHP), and conditions of use. All efforts have been made to provide the most current (August 2018), complete and accurate information on these registered and permitted pesticides, however we recommend that you confirm details at the APVMA website:

https://apvma.gov.au

PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
Wester Flower Thrip (*Frankliniella occidentalis*)	**Registered pesticides**	Abamectin (36g/L) e.g. Vantal Upgrade.	6	All states.	3	No more than 2 sprays/season.
		Cyantraniliprole (100g/L) e.g. DuPont Benevia insecticide (Suppression only).	28	All states.	1	No more than 2 sprays/season, at 7-10 day intervals.
		Spinetotram (120g/L) e.g. Success Neo insecticide.	5	All states.	1	No more than 3 sprays before alternating with a different insecticide group.
	Minor use permits	None				
	Non-chemical control	**Cultural control:** Removal of flowering weeds (especially white clover) in and around crop. **Biological control:** Predatory mites e.g. *Hypoaspis* sp. (*Stratiolaelaps* sp.) (pupae in soil), *Neoseuilus cucumeris*, *Typhlodromips montdorensis* (montys), Predatory beetles - *Orius tantillus.*				
Two Spotted Mite (*Tetranychus urticae*)	**Registered pesticides**	Abamectin 18g/L e.g. Vertimec, Sorcerer 18, Titan Abamectin 18.	6	All states.	3	No more than 2 sprays per season, minimum 7-10 days apart.
		Bifenazate e.g. Acramite.	20D	All states.	1	No more than 2 sprays per season, at interval of no less than 21 days. A different acaracide should be used between Acramite applications if required.
		Dicofol e.g. Farmoz Miti-Fol EC Miticide, David Grays Kelthane Miticide.	2B	All states.	7	No restrictions.
		Fenbutatin oxide e.g. Torque Miticide, Vendex Miticide.	12A	Qld, NSW, Vic, SA, WA, NT (not Tas or ACT).	1	Use lower rates if using biological control with predatory mites.
		Hexythiazox e.g. Calibre 100EC.	10A	All states.	1	1 spray per season. If no IPM program in place apply with Torque miticide.
		Milbemectin e.g. Milbeknock.	6B	All states.	1	No more than 2 sprays per season – not consecutive, i.e. alternative with other group miticide.

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PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
		Propargite e.g. Betamite 300 WG, Unimite 300 W.	12C	Vic, Tas, NSW, ACT, WA and Qld only.	3	No more than 3 sprays over 3-4 weeks.
	Minor use permits	None				
	Non-chemical control	**Cultural control:** Control weeds in and around crop. **Biological control:** Predatory mites e.g. *Phytoseiulus persimilis* and *Neoseiulus californicus.*				
Aphids	**Registered pesticides**	Cyantraniliprole (100g/L) e.g. DuPont Benevia Insecticide.	28	All states.	1	No more than 2 sprays/season, at 7-10 day intervals.
		Pirimicarb e.g. Titan Atlas 500 WG, Pirimor WG, Nufarm Tally 800WG Aphicide, Aphidex 500 WG.	1A	Qld, NSW & WA only.	2	No more than 2 non-consecutive sprays per season.
		Pyrethrins & piperonyl butoxide e.g. Amgrow Pyrethrum Insect Spray.	3A	All states.	1	No restrictions.
		Rotenone e.g. Gro Natural Derris Dust, David Grays Derris Dust.	None	All states.	1	Reapply at 10-14 day intervals.
		Sulfoxalor e.g. Transform.	4C	All states.	1	No more than 4 sprays/season at 7 day intervals.
		Emulsifiable botanical oils e.g. Eco-oil.	N/A	All states.	None	No more than 3 sprays in a 4-8 week period.
	Minor use permits	PER81810: Control of pest aphids on protected grown strawberries: Chess insecticide, Fulfill insecticide containing 500g/kg pymetrozine as the only active constituent.	9B	Tas only.	3	No more than 2 sprays per season with a minimum of 14 days between sprays.
		PER81573: Control of aphids in strawberries: Pirimor WG aphicide, 4farmers primicarb 500 insecticide, FARMOZ Aphidex 500 containing 500 g/kg primicarb as their only active constituent.	1A	Tas only - Driscoll's contracted growers only.	2	No more than 2 sprays per season.
		PER82598: Control of aphids, whiteflies and green mirid in strawberries: Mainman 500 WG insecticide containing 500 g/kg flonicamid as the only active constituent.	9C	All states.	1	No more than 3 sprays per season with minimum 7 days between sprays. Do not spray when bees are foraging.

How can I control pests? Options for controlling sucking pests in strawberries

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PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
	Non-chemical control	**Biological control:** Parasitoid wasps e.g. *Aphelinus abdominalis*, *Aphidius colemani*, *Aphidius ervi*; Ladybirds, lacewings.				
Rutherglen bug (*Nysius vinitor* & *Pachybrachius* spp.)	**Registered pesticides**	Pyrethrins/piperonyl butoxide e.g. Amgrow Pyrethrum insect spray.	3A	All states.	1	No restrictions.
	Minor use permits	PER13542: Control of Rutherglen Bug in strawberries: Fyfanon 440 EW insecticide plus other registered products containing 440g/L maldison as their only active constituent. Nufarm Maldison 500 insecticide plus other registered products Containing 500g/L maldison as their only active constituent. Hy-Mal insecticide plus other registered products containing 1150g/L maldison as their only active constituent.	1B	All states (except Vic*).	3	No more than 3 sprays per season, with minimum 7 days between sprays.
	Non-chemical control	**Cultural control:** Control weeds in and around crop. Overhead irrigation can help reduce numbers.				
Mirids	**Registered pesticides**	Sulfoxalor e.g. Transform.	4C	All states.	1	No more than 4 sprays/season at 7 day intervals.
	Minor use permits	PER82598: Control of aphids, whiteflies and green mirid in strawberries: Mainman 500 WG insecticide containing 500 g/kg flonicamid as the only active constituent.	9C	All states (except Vic*).	1	No more than 3 sprays per season with minimum 7 days between sprays. Do not spray when bees are foraging.
	Non-chemical control	None				
Greenhouse whitefly (*Trialeurodes vaporariorum*) **Silver leaf whitefly (*Bemisia tabaci*)**	**Registered pesticides**	Pyrethrins/piperonyl butoxide e.g. Amgrow Pyrethrum insect spray.	3A	All states.	1	No restrictions.

How can I control pests? Options for controlling sucking pests in strawberries

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PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
	Minor use permits	PER13331: Control of greenhouse whitefly and silver leaf whitefly on strawberries: Admiral insect growth regulator containing 100 g/L pyriproxyfen as the only active constituent.	7C	All states (except Vic*).	2	Max. 2 sprays/season, 30 days apart.
		PER82598: Control of aphids, whiteflies and green mirid in strawberries: Mainman 550 WG insecticide containing 500 g/kg flonicamid as the only active constituent.	9C	All states (except Vic*).	1	No more than 3 sprays per season with minimum 7 days between sprays. Do not spray when bees are foraging.
	Non-chemical control	**Biological control:** Parasitoid wasps e.g. *Encarsia formosa, Eretmocerus warrae.*				
Nematodes	**Registered pesticides**	None				
	Emergency use permits	PER85548: Permit to allow emergency use of a registered agvet chemical product for the control of foliar nematodes in strawberries. Peratec PLUS fungicide – 66320 plus other registered products containing 80g/L peroxyacetic acid and 320g/L hydrogen peroxide as their only active constituents.	N/A	All states except Vic* only registered for use by Driscolls staff or contractors.	1	No more than 4 applications/crop/season with a minimum re-treatment interval of 5-7 days.

IPM Compatibility of Pesticides	Growers using an IPM approach need to consider the IPM compatibility of any pesticide they apply. This means considering not only the efficacy of the product, but also its impact on the key beneficial insects and mites in each specific cropping system. Growers are encouraged to contact an IPM consultant for specific advice about the IPM compatibility of the pesticides listed in this fact sheet.
Updates and Further Information	Pesticide registration and permit information changes regularly. To access the most up-to-date information, check the Australian Pesticides and Veterinary Medicines Authority website at: http://apvma.gov.au, or InfoPest at: http://www.infopest.com.au This information has been compiled by the temperate Development Officer for the Australian strawberry industry. For further information, please contact: ido@vicstrawberry.com.au

***Minor use permits: Victoria is not included in these permits because their 'control-of-use' legislation means that a permit is not required to legalise off-label use in Victoria.**

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How can I control pests? Options for controlling fruit and foliar diseases in strawberries

August 2018

This table lists the major fruit and foliar diseases that impact on strawberry production in Australia and available control options. For each pest, the registered and permitted pesticides are listed along with the active ingredient, insecticide group, withholding period (WHP), and conditions of use. All efforts have been made to provide the most current (August 2018), complete and accurate information on these registered and permitted pesticides, however we recommend that you confirm details at the APVMA website:

https://apvma.gov.au

PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
Grey mould (*Botrytis cinerea*)	**Registered pesiticides**	Bacillus amyloliquefaciens strain QST713 e.g. Serenade Opti biofungicide.	44	All states.	None	Preventative only.
		Captan (900g/kg) e.g. Crop Care Captan WG fungicide, Farmoz Captan fungicide.	M4	All states.	1	Preventative and curative. No more than 5 applications per season. Apply every 10 days commencing at blossom stage.
		Copper as ammonium complex e.g. Liquicop Copper Fungicide.	M1	Vic, Tas, SA and WA only.	1	7-10 day intervals.
		Copper hydroxide e.g. Bayer Blue Shield DF copper fungicide.	M1	Vic, Tas, SA and WA only.	1	7-10 day intervals.
		Cyprodinil + Fludioxonil e.g. Switch.	9 & 12	All states.	3	Maximum 3 sprays/crop 7-14 day intervals.
		Fenhexamid e.g. Teldor 500 SC fungicide.	J	All states.	None	Do not apply more than 2 successive sprays before switching to a fungicide from a different group.
		Iprodione e.g. Rovral.	2	All states.	1	Do not apply more than 2 successive sprays before switching to a fungicide from a different group.
		Penthiopyrad e.g. Fontelis.	7	All states.	None	Do not apply more than 2 successive sprays before switching to a fungicide from a different group. Apply at 7-10 day intervals.
		Pyrimethanil e.g. Scala 600 SC fungicide, Predict 600 SC fungicide.	9	All states.	1	This is subject to a CropLife Australia Resistance Management Strategy which governs the maximum number of applications per season. Refer to www.croplife.org.au for more information.
		Thiram e.g. Thiragranz fungicide, Barmac Thiram DG fungicide.	M3	Qld, Vic, Tas, SA, WA only.	7	Apply as a protective spray at flowering at 10-14 day intervals.

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How can I control pests? Options for controlling fruit and foliar diseases in strawberries

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PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
	Minor use permits	None				
	Non-chemical control	Reduce background level of disease by removing plant debris and rotted fruit. Use optimal cultivation techniques.				
Powdery mildew (*Podosphaera aphanis*)	**Registered pesticides**	Myclobutanil e.g. Systhane 400 WP fungicide, Stamina Systemic fungicide.	3	All states.	None	Do not apply more than 2 successive sprays before switching to a fungicide from a different group.
		Penthiopyrad e.g. Fontelis.	7	All states.	None	Do not apply more than 2 successive sprays before switching to a fungicide from a different group. Apply at 7-10 day intervals.
		Potassium bicarbonate e.g. Ecocarb fungicide.	M2	All states.	None	7-10 day intervals.
		Sulphur e.g. Sulfostar DF fungicide, Fungisul 80 Wettable Sulphur fungicide.	M2	Variable, refer to label.	None	10-14 day intervals.
		Trifloxystrobin e.g. Flint 500 WG fungicide.	11	All states.	1	No more than 3 sprays/season. Alternate with a fungicide from another group.
	Minor use permits	PER83325: To control powdery mildew in strawberries: Thiovit Jet fungicide/miticide plus other registered products containing 800g/kg sulphur as their only active constituent.	Y	Qld, Tas, Vic - only registered for use by Driscolls staff and contractors.	None	Apply when the disease is first noticed and then at 10 – 14 day intervals during humid weather.
	Non-chemical control	Reduce background level of disease by removing plant debris and rotted fruit. Use optimal cultivation techniques – allow good air flow.				
Black spot (*Colletotrichum acutatum*)	**Registered fungicides**	Captan (900g/kg) e.g. Crop Care Captan WG fungicide, Farmoz Captan fungicide.	M4	All states.	1	Preventative and curative. No more than 5 applications per season. Apply every 10 days commencing at blossom stage.
		Thiram e.g. Thiragranz fungicide, Barmac Thiram DG fungicide.	M3	Qld, Vic, SA, Tas and WA only.	7	Apply as a protective spray at flowering 10-14 day intervals.
	Non-chemical control	Reduce background levels of disease by removing plant debris.				

How can I control pests? Options for controlling fruit and foliar diseases in strawberries

STRAWBERRY INNOVATION

PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
Crown and petiole rots (*Colletotrichum gloeosporioides*)	**Registered fungicides**	Cyprodinil/Fludioxonil e.g. Switch.	9 & 12	All states.	3	Maximum 3 sprays/crop 7-14 day intervals.
	Non-chemical control	Rotate crops and practice good hygiene.				
Crown rot (*Phytophthora* spp.)	**Registered fungicides**	None				
	Minor use permits	PER80064: For the control of Phytophthora in strawberries. Any registered product containing either 200 g/L, 300 g/L, 400 g/L, 460 g/L, 500 g/L, 600 g/L, 620 g/L or 625 g/L phosphorous acid as their only active constituent.	33	All states except Vic*.	0	Post-planting only. Apply after establishment and weekly for 2-3 weeks. Maximum 4 sprays only.
	Non-chemical control	Rotate crops and practice good hygiene.				
Leaf blight (*Dendrophoma obscurans*)	**Registered fungicides**	Captan (900g/kg) e.g. Crop Care Captan WG fungicide, Farmoz Captan fungicide.	M4	All states.	1	Preventative and curative. No more than 5 applications per season. Apply every 10 days commencing at blossom stage.
		Zineb e.g. Barmac Zineb fungicide.	Y	Qld and WA only.	7	As required.
	Non-chemical control	Reduce background level of disease by removing plant debris				
Leaf scorch (*Diplocarpon earlianum*)	**Registered fungicides**	Captan (900g/kg) e.g. Crop Care Captan WG fungicide, Farmoz Captan fungicide.	M4	All states.	1	Preventative and curative. No more than 5 applications per season. Apply every 10 days commencing at blossom stage.
		Copper oxychloride e.g. Ospray Copper Oxychloride WP.	Y	All states.	1	10-14 day intervals.
		Zineb e.g. Barmac Zineb fungicide.	Y	Tas only.	7	As required.
	Non-chemical control	Reduce background level of disease by removing plant debris.				

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PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
Leaf spot (*Mycosphaerella fragariae*)	**Registered fungicides**	Copper as ammonium complex e.g. Liquicop Copper fungicide.	Y	Vic, Tas, SA and WA only.	1	7-10 day intervals.
		Copper hydroxide e.g. Bayer Blue Shield DF copper fungicide.	M1	Vic, Tas, SA and WA only.	1	7-10 day intervals.
		Copper oxychloride eg. Ospray Copper Oxychloride WP.	Y	All states.	1	10-14 day intervals.
	Non-chemical control	Reduce background level of disease by removing plant debris.				
Fruit rot (*Gloeosporium* and *Phytophthora*)	**Registered fungicides**	Captan (900g/kg) eg. Crop Care Captan WG fungicide, Farmoz Captan fungicide.	M4	All states	1	Preventative and curative. No more than 5 applications per season. Apply every 10 days commencing at blossom stage.
	Non-chemical control	Reduce background level of disease by removing plant debris and rotted fruit. Use optimal cultivation techniques. Practice good hygiene.				

IPM Compatibility of Pesticides	Growers using an IPM approach need to consider the IPM compatibility of any pesticide they apply. This means considering not only the efficacy of the product, but also its impact on the key beneficial insects and mites in each specific cropping system. Growers are encouraged to contact an IPM consultant for specific advice about the IPM compatibility of the pesticides listed in this fact sheet.
Updates and Further Information	Pesticide registration and permit information changes regularly. To access the most up-to-date information, check the Australian Pesticides and Veterinary Medicines Authority website at: http://apvma.gov.au, or InfoPest at: http://www.infopest.com.au This information has been compiled by the temperate Development Officer for the Australian strawberry industry. For further information, please contact: ido@vicstrawberry.com.au

***Minor use permits: Victoria is not included in these permits because their 'control-of-use' legislation means that a permit is not required to legalise off-label use in Victoria.**

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How can I control pests? Options for controlling chewing and biting pests in strawberries

August 2018

STRAWBERRY INNOVATION

This table lists the major chewing and biting pests that impact on strawberry production in Australia and available control options. For each pest, the registered and permitted pesticides are listed along with the active ingredient, insecticide group, withholding period (WHP), and conditions of use. All efforts have been made to provide the most current (August 2018), complete and accurate information on these registered and permitted pesticides, however we recommend that you confirm details at the APVMA website:

https://apvma.gov.au

PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
Cluster caterpillars, *Heliothis*, Light brown apple moth, loopers	**Registered pesiticides**	*Bacillus thuringiensis* var. kurstaki e.g. DiPel DF biological insecticide, Delfin WG biological insecticide.	11	All states.	None	No restrictions.
		Cyantraniliprole (100g/L) e.g. DuPont Benevia insecticide.	28	All states.	1	No more than 2 sprays/season at 7-10 day intervals.
		Emamectin (as emamectin benzoate) e.g. Proclaim Opti Insecticide.	6	All states.	3	Maximum of 3 sprays/season at minimum intervals of 7 days.
		Flubendiamide e.g. Belt 480 SC Insecticide (field and protected cropping).	28	All states.	1	No more than 3 sprays/season at 7-14 day intervals.
		Methomyl e.g. Lannate, DuPont Marlin.	1A	LBAM, *Heliothis* – SA and WA only. *Heliothis*, looper, cluster caterpillar – Qld, NSW, Vic, Tas, WA and NT.	3 (fresh fruit) 10 (frozen fruit).	No restrictions.
		Nuclear Polyhedrosis Virus of Helicoverpa armigera e.g. Vivus Max Helicoverpa Biocontrol or Gemstar LC Biological Insecticide.	N/A	All states.	None	Retreatment may be required at 2-3 day intervals when eggs are present.
		Spinetotram (120g/L) e.g. Success Neo insecticide.	5	All states.	1	No more than 3 sprays before alternating with a different insecticide group.
		Trichlorfon e.g. Dipterex 500 SL, Lepidex 500.	1B	Variable, refer to label.	2	Do not spray when bees are foraging.
	Non-chemical control	Remove nearby infested host crop plants, if present e.g. tomatoes.				

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How can I control pests? Options for controlling chewing and biting pests in strawberries

STRAWBERRY INNOVATION

PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
Carpophilus beetles	**Registered pesticides**	None				
	Minor use permits	None				
	Non-chemical control	Pheromone and attractant traps with pesticide e.g. Carpophilus Catcha traps.				
Queensland fruit fly (*Bacterocera tryoni*) **Mediterranean fruit fly (*Ceritits capitata*)**	**Registered pesticides**	Maldison e.g. Fyfanon 440EW.	1B	All states.	3	Maximum of 6 sprays/season, minimum 7 days apart. Do not spray when bees are foraging.
		Spinosad e.g. Naturalure fruit fly bait concentrate.	5	All states.	None	Apply as band or spot sprays. Repeat every 7 days.
	Minor use permits	PER12486: Control of fruit fly on berry fruit: Dipterex 500 SL insecticide plus other registered products containing 500 g/L trichlorfon as their only active constituent.	1B	Qld, NSW, SA, WA, ACT, NT*.	14	Maximum of 3 sprays/season, minimum 7 days apart. Do not spray when bees are foraging.
		PER12927: Suppression of fruit fly on specified berry fruit: Success Neo insecticide containing 120 g/L spinetoram as its only active constituent.	5	Qld, NSW, SA, WA, ACT, NT*.	1	Maximum 4 sprays/season, 7-14 days apart. Suppression only.
Scarab beetles	**Registered pesticides**	None				
	Minor use permits	PER81745 control of Scarab beetles in strawberries: suSCon Green plus other registered products containing 100 g/kg chlorpyrifos as their only active constituent. suSCon Blue soil insecticide plus other registered products containing: 140 g/kg chlorpyrifos as their only active constituent.	1B	Qld only.	None	Apply during bed formation. Do not make more than one application.
Crickets (field and mole)	**Registered pesticides**	Chlorpyrifos Lorsban 500 EC insecticide	1B	QLD and WA.	None	Used as soil bait in newly formed beds or newly planted runners.

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PEST	TYPE OF CONTROL	CONTROL OPTIONS	INSECTICIDE GROUP	REGISTERED IN?	WHP (DAYS)	CONDITIONS OF USE
Mice	**Registered pesticides**	None				
	Minor use permits	PER14307: Control of mice in strawberry production: Rattoff zinc phosphide plus other registered products containing 25 g/kg zinc phophide as their only active constituent.		All states.	None	The bait sachets MUST be placed in fixed bait stations secured to the ground or fencing. Perimeter bait stations should also be placed around the perimeter of the crop at 35m intervals. DO NOT bait within at least 5 metres from crop boundaries or within native vegetation.
Snails	**Registered pesticides**	Iron EDTA complex e.g. Multiguard Snail and Slug Killer, Eradicate Snail and Slug Killer.		All states.	None	No restrictions.
Weevils	**Registered pesticides**	none				
	Minor use permits	PER14192: Control of whitefringed weevil and garden weevil in strawberries: DuPont Avatar insecticide containing 300g/kg indoxacarb as the only active constituent.	22A	All states except Vic*.	2	No more than 2 applications per season with a minimum of 7 days between treatments.
Earwigs	**Registered pesticides**	None				
	Minor use permits	PER85622: To control European earwig in hydroponic grown strawberries: Lorsban 500 EC insecticide plus other registered products containing 55g/L chlorpyrifos as the only active constituent.	1B	Tas only – only registered for use by Costa Exchange Pty Ltd staff or contractors.	None	Bait traps to be attached to hydroponic table legs. Broadcast bait evenly across soil surface under tables during non-fruiting periods. DO NOT expose strawberry plants to direct contact with clorpyrifos treated bait.

IPM Compatibility of Pesticides	Growers using an IPM approach need to consider the IPM compatibility of any pesticide they apply. This means considering not only the efficacy of the product, but also its impact on the key beneficial insects and mites in each specific cropping system. Growers are encouraged to contact an IPM consultant for specific advice about the IPM compatibility of the pesticides listed in this fact sheet.
Updates and Further Information	Pesticide registration and permit information changes regularly. To access the most up-to-date information, check the Australian Pesticides and Veterinary Medicines Authority website at: http://apvma.gov.au, or InfoPest at: http://www.infopest.com.au This information has been compiled by the temperate Development Officer for the Australian strawberry industry. For further information, please contact: ido@vicstrawberry.com.au

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Organic strawberries

A small slice of Australia's billion dollar organics industry

STRAWBERRY INNOVATION

Organic strawberries are a high value specialty crop, and with the ever-increasing rate of production of conventionally grown strawberries in Australia, many smaller growers may be looking at organics as an opportunity for alternative market access.

But is it as profitable as we think, and what are the challenges involved in growing a soft fruit like strawberries with soft control measures?

Australia's organic food industry

The demand for organic products in Australia and worldwide has experienced exceptional growth over recent years, driven by an increasingly wide availability of products and a consumer market who are becoming more aware of the perceived health benefits and environmental effects of their food choices. According to market analyst company, IBISWorld, Australia's organic food industry is valued at close to $1 billion with a growth rate of 17% over the last 5 years.

Fruit and vegetables continue to be the organic products that most Australians buy, and the industry is expected to continue to grow strongly as organic consumption becomes more mainstream. Woolworths and Coles now stock greater volumes and wider ranges of organic produce, making the purchase of organic products more convenient.

The demand for organic produce in Australia is seeing more growers make the switch from conventional to organic farming. This may see prices for organic produce drop slightly, however prices are expected to remain high for the foreseeable future. Organic food currently accounts for less than 5% of Australia's total food production by volume.

Premium price is about 1.5 to 2 times more for an organic product over a conventionally produced product. This will decline with more growers entering the market, but margins are still significantly higher. Much of the growth in organics has been driven by high income consumers who can afford to pay the premium prices, however additional surveys have found an evolving demand from consumers with strong values in the areas of personal health, community and planetary well-being, thanks largely to the availability of reasonably priced organic products in supermarkets.

So with all this talk of increasing demand and high profit margins, is it worth taking the leap into the world of organic strawberries?

Production challenges

Ashbern Farms in the Glasshouse Mountains is one of only a small handful of organic strawberry farms in Queensland, with 1.4ha (10%) of Ashbern's strawberries being produced and sold as certified organic. Jon Carmichael, co-owner of Ashbern Farms, started working with organic strawberries on the family farm, Strawberry Fields, back in 2003. Being both health and environmentally conscious, plus always keen for a challenge, Jon started working on organic strawberries at a time when there was very little available in the way of biological or soft approaches to pest and disease control. Coming up to 15 years later, IPM programs and biological controls are now much more commercially available, but at a cost.

Brendon Hoyle, Jon's previous farm manager at Strawberry Fields and now business partner in Ashbern Farms, says that the challenges associated with pests and diseases in their organic crop are ongoing and expensive. "We use a large range of beneficial mites for pest management, and a variety of simple but costly control measures for disease control."

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For example, grey mould can be treated with organically certified mould products (soaps) and powdery mildew products can be simple compounds such as sodium bicarbonate. But being organically certified and only supplying a relatively small market, the high cost of these products can significantly increase the expense associated with organic production.

"The best control measure is ensuring that the plant is strong and healthy which will ultimately make it more resistant to disease," said Brendon, "and you simply can't take your eye off them. Organic crops need to be managed with the utmost care and attention so smaller plant numbers are far easier to manage and maintain a consistent quality."

Weed control is important and costly, either being removed by hand or subdued by other expensive methods of control. The organic industry in general is highly labour intensive, and it is often the owner-operators who carries out a significant portion of the labour tasks required, rather than paying wages.

Yields in organically produced strawberries are also lower than conventionally farmed fruit, so a high quality product is essential to maintaining the high value of each punnet of strawberries produced.

Certification

According to "The World of Organic Agriculture" statistical yearbook for 2017, published by FiBL and IFOAM – Organics International, the main plank of the regulatory framework for organics in Australia is the National Standard. By law, produce exported from Australia and labelled as organic is a 'prescribed good' under the Exports Control Act 1982 and Export Orders, and must be certified in accordance with a standard at least as stringent as the National Standard by an organisation accredited with the Australian Government. Each accredited certifier can develop and apply its own unique standard, as long as it is compliant with the National Standard.

Strictly speaking, products sold domestically in Australia as organic are not required by law to be certified, but the National Standard and the mechanisms established for the export regime (accredited certifiers, certification, auditing and inspection) have proven attractive in the domestic market for consumers and the supply chain who want the assurance of certified produce. This is bolstered by the support of the major supermarkets, which have required certification under the provisions outlined in the National Standard.

The Australian Government currently accredits six certifying organisations:

- AUS-QUAL
- Australian Certified Organic (ACO)
- Bio-Dynamic Research Institute (BDRI)
- National Association for Sustainable Agriculture Australia Certified Organic (NCO)
- Organic Food Chain (OFC)
- Safe Food Production Queensland (SFPQ)

Organic strawberries produced by Ashbern Farms are certified with the Australian Certified Organic (ACO) organisation which is currently the most recognised Australian certifier in fresh produce with their green bud logo. The certification of primary production land to organic status usually takes up to 3 years, depending on prior history.

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Ongoing certification involves an annual auditing process, which Brendon does not consider a difficult or time consuming procedure, once it's been done a few times.

Despite the fact that the strawberry plants themselves are not produced organically, the 6 to 8 weeks between planting and fruiting is considered sufficient time for the plants to grow out of their non-organic status into organic status. However, written confirmation that there are currently no certified organic runners available in Australia must be provided by each of the runner growers as part of the certification audit each year.

The Market for Organic Strawberries

Whilst it is clear that the demand for organic produce is increasing worldwide, it is still growing slowly but steadily in Australia and organic producers have to be conscious of not flooding their own market. Because of the high input costs associated with organic production, a high return on the product is essential. By maintaining high quality and keeping supply in line with demand, the high prices received for organic strawberries will continue to make it a profitable option for producers.

Ashbern Farms sends their fruit to specialist organic market agents in Brisbane, Sydney, Melbourne and Adelaide, plus direct sales to a few niche organic outlets. Their strawberries are sold in the organic produce section of select Woolworths stores around the country. Other smaller organic producers sell direct to the public through local farmers markets, and into local fruit and vegetable stores who provide an organic range.

Direct contact with the consumer at local markets and/or the local grocer can go a long way towards supporting the authenticity of the product. The organic consumer likes to feel confident that they are buying a truly organic product that is locally-grown, and will continue to purchase at a higher price if they feel they know and trust the grower.

It is worth considering however, that organic produce is one of those things in life that people tend to amend depending on their financial situation. During tough times, conventionally produced fruit and vegetables will take precedence for many, at least until such time as the situation improves and the cost of organics can once again be justified. The cost of the produce also limits the quantities that the consumer is purchasing – if someone is buying organic strawberries, they are usually only buying one punnet at $7, not three punnets!

The consumer is ultimately looking for more affordable organic produce, and with affordability there will be significantly increased demand. This means that more growers will be needed within the organics sector to meet that demand but with a decrease in returns, the input costs associated with organic production would also need to decrease, with increases in efficiency and productivity.

It is clear that the demand for organic strawberries will continue to grow, and for those growers who have already made the transition, it would seem that the return on investment is worth the effort.

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Managing foliar and fruit diseases in strawberries

STRAWBERRY INNOVATION

This fact sheet summarises the information you'll need to get started on the sustainable management of some foliar and fruit disease threats to your crops. Many growers have implemented this Integrated Crop Protection (ICP) approach and achieved success in the management of these pests by using cultural control strategies that consider weather, irrigation timing, plant varieties and spacing and the use of biological control products. The most common foliar and fruit diseases of strawberry are fungi.

ICP considers the production system as a whole, including all pests (diseases, insects and weeds), the crops and soil health. Many growers have found that a useful starting point is working with a trusted and experienced ICP consultant or researcher. Good management will also be assisted by:

- A commitment to farm sanitation and biosecurity
- Monitoring – crop stage, disease symptoms and their distribution, weather (especially temperature, humidity and leaf wetness)
- The ability to detect early disease symptoms on your crops
- Use of resistant and tolerant varieties and appropriate crop rotation sequences
- Appropriate use of fungicides (including rotation of chemical groups).

What is the nature of these fungi?

There are many different fungi affecting strawberries, each having different life cycles and preferred climatic conditions. Foliar and fruit disease management requires a good understanding of:

- The fungi involved
- The periods during which the crops are most susceptible
- The environmental conditions that favour the pathogens.

ICP tips for managing foliar diseases

- **Read the pest management chapter in the Australian Good Practice Guide for Strawberries available here.**
- **Use resistant or tolerant varieties.**
- **Use certified runners.**
- **Implement high-level farm sanitation.**
- **Understand the influence of plant spacing and air circulation.**
- **Minimise free moisture and high humidity periods.**
- **Understand the implications of irrigation timing.**
- **Monitor crops regularly.**
- **Understand fungicide resistance and rotation of chemical groups.**
- **Maintain the efficiency of spray technology.**

There is a range of chemicals registered for controlling foliar and fruit diseases. Growers and nursery operators have variable success with chemical treatments because spray coverage and spray timing affect the level of control achieved, especially by non-systemic products.

Powdery Mildew (*Podosphaera aphanis*)

These fungi are very common in strawberry crops especially those grown under protective systems (cloches, greenhouses and/or tunnels). The fungi grow best at 20-25°C and the first symptoms appear in spring (for summer fruit production) or in autumn (for winter fruit production). Powdery mildew produces white patches of web-like growth that develop on both the lower and upper leaf surface. The edges of the leaves may curl upwards. Immature fruit may fail to ripen, become hard, crack and turn a reddish colour with raised seeds. Powdery mildew is favoured by warm, dry conditions

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followed by moisture on leaves from overnight dew or rainfall. Spores can be spread by wind and can over-winter in plant residue from the previous and current crops. To manage this disease:

- Remove and destroy plant residue at the end of the season
- Use plant runners from accredited runner nurseries
- Apply fungicides when conditions favour the disease.

Fungicides have been the most common method used to control powdery mildew. Apply fungicides at the first sign of disease (leaf distortion and discoloration). Always follow the instructions on the label. When disease pressure is high, rotate fungicide groups to avoid the pathogen developing resistance to the fungicides. Products registered for use in strawberries to manage powdery mildew can be found on the Australian Pesticides and Vetinary Medicines Authority (APVMA) chemical database (https://portal.apvma.gov.au/pubcris) and permit database (https://portal.apvma.gov.au/permits). Always read the label and observe withholding periods.

Under high tunnels, targeted, intermittent brief applications of overhead irrigation may help prevent the spread of this disease but need to be weighed up against the risk of increasing the incidence of grey mould. In general, avoid overhead irrigation and excessive use of nitrogen fertiliser.

Fruit affected with powdery mildew (right) with normal fruit for comparison (photo courtesy of Queensland Government Department of Primary Industries and Fisheries)

Leaf blotch and Stem-end rot (*Gnomoniopsis fructicola*)

Leaf blotch and stem-end rot diseases occur between flowering and harvest. The fungus first infects the calyx and then spreads into the fruit as a rot. Both green and ripe fruit may be infected. Infected fruit ripens early and turns pale red to brown and remains firm.

The fungus is spread by water (from rain or irrigation). Infected plant residues from previous and current strawberry crops left in the soil provide sources of infection. Leaf blotch and stem-end rot can be difficult to control and is favoured by cool, wet weather. To manage this disease, remove affected leaves and fruit during the season and do not leave infected plant and fruit material in the inter-rows where they can serve as sources of infection. There are no fungicides registered for fruit grown in the field, although the fungicides used to manage grey mould may assist in reducing the incidence of diseases caused by this pathogen.

Grey mould disease showing masses of grey spores of the fungus on the diseased area (photo courtesy of Queensland Government Department of Primary Industries and Fisheries)

Grey mould (*Botrytis cinerea*)

Grey mould produces fruit rot that can start at any time from early fruit development to after harvest. Fruit turns brown at the calyx end and the fungus produces a grey cotton-like growth on the surface. Grey mould is favoured by high humidity, mild temperatures and frequent rain. It can also attack flowers, stalks, leaves and flower buds. To manage this disease:

- Avoid fruit contact with soil
- Remove and destroy affected fruit and leaves

- Improve air movement around plants
- Prevent excess shading of the fruit due to thick foliage
- Avoid using overhead irrigation
- Apply fungicides when conditions favour the disease using a resistance management strategy.

How can I protect my strawberries from these diseases?

Get started by:

1. Ensuring runners are from accredited runner sources.
2. Cleaning up your production site and maintaining the highest level of sanitation in and around all blocks all year round. Ensure area is free of plant debris, and remove alternate host, including weeds that may harbour disease spores and serve as source of infection.
3. Modifying your irrigation practices to discourage disease spread.
4. Knowing the disease, monitoring and applying a program of protectant and systemic fungicides program as required.

Avoiding chemical resistance

Losing control over diseases due to excessive use of specific fungicides or fungicide groups may result in high crop losses and the need to use expensive alternative control products and methods. Using integrated management strategies such as those discussed above will reduce the development of resistance and also contribute towards the quality of the environment. When applying fungicides delay resistance development by rotating different active ingredient groups and restrict their use to certain periods of the year. If disease pressure is low, apply non-chemical fungicides that are registered for strawberry such as ecocarb for powdery mildew and Serenade® Opti for grey mould. Labels of some products place a limit on the number of times they can be applied. Adhere to these restrictions. Also avoid using mixtures of fungicides. For the fungicide resistance management strategy for managing powdery mildew and grey mould in strawberries go to: https://www.croplife.org.au/resources/programs/resistance-management/2017-strawberry-grey-mould-botrytis/

A selection of helpful resources

Available resources include:

1. Strawberry Problem Solver and Bug Identifier (2005) Neil Greer, Don Hutton, Noel Vock, Geoff Waite. Queensland Government Department of Primary Industries and Fisheries
2. Common insect pests of strawberries (2009) Primefacts. L. Ullio. NSW Department of Primary Industries https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/306314/Common-insect-pests-of-strawberries.pdf
3. Information on integrated practices for effective disease management in greenhouses. http://www.dpi.nsw.gov.au/agriculture/horticulture/greenhouse/pest-disease/general/idm
4. Powdery mildew of strawberries (2015) Aileen Reid. Department of Primary Industries and Regional Development https://www.agric.wa.gov.au/strawberries/powdery-mildew-strawberries

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Mega Pest fact sheets (2012) developed by Scholefield Robinson Horticultural Services Pty Ltd and Dr Chrys Akem, Agri-Science Queensland, DEEDI for the InnoVeg project

Apollo Gomez (2018) Research Scientist. Queensland Government Department of Agriculture and Fisheries

Powdery mildew of strawberries (2015) Aileen Reid. Department of Primary Industries and Regional Development

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Managing chewing and biting pests in strawberries

STRAWBERRY INNOVATION

Corn earworm and native budworm (*Helicoverpa* spp.), cutworms (*Agrotis* spp.) and scarab beetles (Scarabaeidae) are some of the chewing and biting pests that may impact on the health and profitability of your strawberry crops. This fact sheet summarises the information you'll need to sustainably manage these chewing and biting pests in your crops.

What is the nature of these pests?

The caterpillars (larvae) of these pests are difficult to control for a number of reasons including development of resistance to insecticides (particularly for corn earworm), rapid population increases, and the practical difficulties of achieving complete spray coverage.

A need for more affordable and effective control of heliothis (corn earworm and native budworm) has led growers to seek help and then trial and implement integrated management approaches. Integrated Crop Protection (ICP) considers the whole production system - all pest threats, beneficials, the crop, soil health and environmental influences. In ICP, the aim is not zero pests, but sustainable pest management to reduce damage to acceptable economic levels.

Mature corn earworm larvae (photo courtesy of Queensland Department of Primary Industries and Fisheries)

ICP tips for managing chewing and biting pests

- Read the pest management chapter of the Australian Good Practice Guide for Strawberries, available here.
- Identify and monitor populations of both pests and beneficials. Record observations of eggs, small larvae and adults.
- Don't rely on synthetic insecticides for control – understand all the available management options. Rotate between pesticide groups to avoid resistance.
- Know your acceptable limits of crop damage and identify when you may need to spray.
- If insecticide sprays are necessary, choose soft options to avoid disrupting natural enemies.
- Understand environmental conditions conducive to the survival and spread of pests and beneficials, and to biopesticide performance (biopesticides are pesticides derived from natural materials such as animals, plants, bacteria and certain minerals).
- Disrupt pest life cycles by targeting overwintering and survival sites.

The management of heliothis is complex. Knowledge of the beneficial organisms in and around your crops, and their relationship with the pests, is necessary in order to make effective treatment decisions. The pest pressure, the number of beneficials and their population trend (increasing or decreasing) can be determined through close monitoring and are the basis of pest management decisions at each crop stage.

What damage do they cause?

Heliothis (corn earworm and native budworm) burrow into fruit causing entry holes and the potential for internal rotting. Young cutworm caterpillars climb plants and skeletonise the leaves or eat small holes. As the larvae grow

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they begin to cut through stems at ground level and feed on the top growth of felled plants. Caterpillars that are almost fully grown often remain underground and chew into plants at or below ground level.

How can I protect my crop from these caterpillars?

Start early! Start looking! Record your observations.

Look at incoming runners and make sure they are clean and free of eggs and larvae, before planting. Slugs, cutworms and armyworms attack newly transplanted and emerging crops. Scout young crops regularly: turn over leaves and check for eggs, larvae, and recent damage, and also for the presence of beneficial organisms. Cutworms usually feed late in the afternoon or at night so this is a good time to look for them. By day they hide under debris or in the soil.

Weather monitoring is also critical because temperature affects the generation times of pests and beneficials that have been introduced. Heliothis eggs hatch in 3 to 7 days in warm weather. Larvae are mature after two to three weeks and pupate in the soil. Adults emerge after a further two weeks. The life cycle takes about 5 to 7 weeks in summer.

Scout crops regularly and know what to look for

Pheromone traps can be used to give early warning of the presence of some pests. Finding heliothis eggs should trigger crop protection activity. The appearance of the eggs provides predictive information useful in decision-making about the timing of the crop protection activity. Newly laid eggs are white in colour, brown eggs are nearing hatching, and shiny black eggs are parasitised and unlikely to hatch.

Soil monitoring

For strawberry crops grown during spring-summer, populations of over-wintering heliothis pupae in the soil can be monitored. In one-metre row lengths, dig carefully to expose emergence tunnels and look for pupae in the chambers. The pupae are usually found in the upper 10 cm. If more than one pupa is found in 10 m^2, cultivation to disrupt the pest's life cycle is recommended before planting runners.

Heliothis eggs (photo courtesy Brad Scholz Queensland Department of Primary Industries)

Implementing ICP - understanding the options

Predicting the potential effectiveness of ICP requires understanding of the damage thresholds and the targets of each ICP practice. The ICP approaches that consider both the pest life cycles and the stages at which crops are most at risk, are likely to be more effective.

The first step is to limit use of broad spectrum insecticides and instead use biopesticides and soft option insecticides. The nature of commercially available beneficials and biopesticides and their sensitivities need to be understood to ensure these options are used effectively. Important information on biopesticide application timing, rates and coverage appears on the product label along with additional guidelines, e.g. for *Bacillus thuringiensis* (Bt) applications, avoid overhead irrigation on the treated area for 24 to 48 hours to prevent wash-off; stickers that promote adherence to leaf surfaces and UV light inhibitors may enhance efficacy.

Beneficial organisms, like parasitoid wasps (such as Diadegma, Trichogramma and Telenomus), predatory bugs (such as shield bugs, damsel bugs and assassin bugs), tachnid flies and earwigs readily control eggs and caterpillars. Spiders, lacewings and ladybirds are more generalist predators which can also offer relief against some aphids and thrips. If beneficials are present they can often control low numbers of pests. However, if conditions favour the pests, their

populations may build rapidly and additional control methods (such as narrow-spectrum insecticides, biopesticides or introduced beneficials) may be needed to restore the balance. An excellent source of information on commercially available beneficials is the website (www.goodbugs.org.au).

Biopesticides include *Bacillus thuringiensis* (Bt), a bacterium that is applied as a spray (sold as Dipel® and Delfin®). Bt is effective against all caterpillar species that eat it including heliothis, cutworms and armyworm. Bt spray coverage needs to be complete and it should be applied at egg hatching and young larval stages as it is only effective on small grubs.

Trichogramma - an important egg parasitoid of moth eggs

The **nuclear polyhedrosis virus (NPV)** is another biopesticide. It is a viral pathogen that is species specific, i.e. Armigen® is a formulation of the Helicoverpa NPV and only effective when eaten by heliothis caterpillars. They are most effective against young caterpillars and therefore crop stages where egg laying is most prevalent should be targeted.

Soft option insecticides like spinetoram and related fermentation products of biological organisms (such as Success Neo®) affect the nervous system of heliothis, some thrips and beetle pests. Flubendiamide (Belt®) is specific to caterpillar pests. These technologies are safer to use and better for the environment. However, overuse of any one product may lead to the development of resistance.

Cultural control options for managing chewing and biting pests include:

- Managing weed levels to reduce cutworm populations. Weedy fields tend to attract more moths to lay their eggs. Annual planting and thorough pruning of second-year plantings reduce survival of overwintering larvae.
- Cultivating to a depth of 10cm at the end of winter helps to reduce the survival of over-wintering pupae and reduces the starting population of heliothis before the next planting in spring.

Chemical control options for managing chewing and biting pests can be found on the Australian Pesticides and Veterinary Medicines Authority (APVMA) chemical database (https://portal.apvma.gov.au/pubcris) and permit database (https://portal.apvma.gov.au/permits). Always read the label and observe withholding periods.

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Managing soilborne diseases in strawberries

STRAWBERRY INNOVATION

What are soilborne disease organisms?

There are hundreds of soilborne plant pathogens. The most common and important ones are fungi, and they often survive in the soil for long periods, in adverse conditions and even in the absence of their preferred weed and crop hosts. Most soilborne fungal diseases have a wide host range, while others may only infect particular crops.

Many of these fungi may be present together in cultivated soils; some also in virgin soils. Once present on your farm they will remain an on-going concern for as long as you are growing susceptible crops. The fungi can infect roots, stems and other plant parts. There are many factors that influence how seriously these fungi affect crops, and if losses are sporadic or occur every year. They include the genetics of the crop variety, environmental and climatic conditions, cultural practices and the types of other microbes present in the soil or root zone.

The diseases caused by these fungi are expensive and difficult to manage, especially when fungicide applications and/or soil fumigation may not provide total eradication. Such programs generally don't provide a consistent solution for most growers. The withdrawal of methyl bromide as a soil fumigant (except under certain limited conditions) has resulted in soilborne diseases such as crown rots and charcoal rot becoming more prevalent.

Why is their control difficult?

Inconsistent results with chemicals to treat soilborne fungi can be due to, a lack of effective chemistry, a build-up of bacteria that rapidly breakdown the chemical, and poor application (coverage, timing, placement). Despite these reasons, fungicides and chemical fumigants have remained a common approach to managing soilborne fungi. They are expensive, however, and increasing awareness of their environmental impact, have motivated many growers to explore alternative and more

Tips for managing soilborne diseases

- Read the pest management chapter of the Australian Good Practice Guide for Strawberries available here.
- Identify and understand the pathogen survival mechanisms and the crop and environmental conditions that favour disease development.
- Correctly identify the pathogen/reason for poor plant performance to assist in effective management.
- Implement farm sanitation practices to remove or reduce pathogen carryover - in weeds, crop debris and volunteer hosts.
- Consider your planting sequences. Rotation with non-host crops will limit the build-up of pathogen populations.
- Test soils for specific pathogens to identify heavily infested blocks before planting susceptible crops
- Use certified planting material and resistant varieties (if available).
- Manage soils to increase organic matter and improve soil health, while disadvantaging soilborne pathogens.
- Monitor blocks and keep records on crop and disease history to aid decision-making.
- Provide plants with optimum nutrition and water regimes.
- Remove and destroy infected plants to reduce disease spread within a crop and carryover to the next crop; similarly remove or deep-bury crop residues and allow time for them to decompose.

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sustainable and affordable, integrated crop protection (ICP) approaches. ICP when applied to pest management considers the production system as a whole, and includes all pests (diseases, insects and weeds), crop agronomy and soil health. ICP approaches aim to optimise chemical treatments and limit dependence on them.

A few alternative controls to chemicals, including biocontrol agents have been developed for controlling soilborne pathogens in Australia and overseas. Cultural practices such as rotation with non-host crops and biofumigation with Brassica green manure crops can effectively reduce populations of some soilborne fungal pathogens.

Biofumigation with brassica green manure crop

How can I protect my farm from these soilborne fungi?

If you are raising crops susceptible to soilborne pathogens, make sure you avoid inadvertent spread of the pathogens from infested to clean blocks. They may be introduced with water, on soil attached to equipment or vehicles, or on planting material. Use accredited planting material and compost/mulch from certified suppliers, and limit people and equipment movement around your property.

How can I manage these soilborne pathogens if I grow susceptible crops?

By knowing your crop's stages of susceptibility to the fungi and understanding the conditions that influence the pathogens' long-term survival and pathogenicity, the on-farm activities required to manage the crop and the diseases, will become clearer.

Three common fungi in strawberries and their treatment are described below.

Charcoal rot

Initial symptoms of charcoal rot in strawberry usually occur after the plants are well established and begin to produce fruit: the older leaves wilt, turn grey green in colour, and begin to dry up. Plants will stop growing and appear to be stunted when compared to healthy plants. As the disease progresses, virtually all of the foliage will collapse and dry up with the exception of the central, youngest leaves. Fruit production of infected plants may decrease prior to the development of disease symptoms.

Once the strawberry crop is planted, there are very few options if charcoal rot starts to occur. Management strategies

Wilting symptoms of strawberry plant infected with charcoal rot (photo courtesy of Apollo Gomez)

therefore rely mainly on prevention. These include:

- Avoiding planting into infested paddocks
- Rotating strawberries with other crops (not susceptible to charcoal rot)
- Minimising stress as much as possible by planting into well-prepared beds, irrigating appropriately and managing other pests.

If your farm is free of this organism, avoid its introduction! Be meticulous about nursery and farm hygiene. Restrict equipment, livestock, water and people movement around your production areas.

Phytophtora crown rot

Crown rot can cause heavy plant losses in a short period of time. The disease produces some wilting of leaves and eventual collapse of the plant. The roots can be affected and may turn black and rot. Fungi are spread by infected runners, water (irrigation or rain) and farm machinery. Crown rot development is favoured by warm, wet conditions and waterlogged soil.

Internal rotting caused by crown rot (photo courtesy of Apollo Gomez)

Wilting characteristic of crown rot disease (photo courtesy of Apollo Gomez)

Fusarium wilt

Fusarium wilt causes wilting, stunting and death of older leaves. Strawberry plants can eventually collapse and die. The inside of the plant crown will become dark to orange-brown. However the main roots will not become discoloured. Plants subject to stress due to weather extremes, water stress or heavy fruit loads are likely to be most severely affected.

Because the symptoms of charcoal rot, phytophtora crown rot and fusarium wilt are so similar (they all cause wilting), it is very important to have the cause correctly identified. Wilting may not be caused by a pathogen but due to stress (such as lack of water). If the wilting is due to disease then correct identification will assist with effective management and application of appropriate fungicides.

Cultural practices that assist in managing crown rot/fusarium wilt caused by Fusarium and Phytophothora include:

- Using accredited runners
- Rotation with non-host crops
- Roguing (i.e. removing and destroying) infected plants

- Minimisation of plant stress (environmental, nutritional or due to other pests or pathogens like fungus gnats, nematodes, *Rhizoctonia* spp. or *Pythium* spp.)
- Careful irrigation management (shorter and more frequent irrigation), planting into raised beds and use of nitrate forms of nitrogen fertilisers have been shown to reduce disease severity
- Avoiding movement of soil from infected to clean areas on machinery, footwear or animals.

Chemical control options include the use of pre-plant soil fumigants and fungicides. Products registered for use in strawberries can be found on the Australian Pesticides and Veterinary Medicines Authority (APVMA) chemical database (https://portal.apvma.gov.au/pubcris) and permit database (https://portal.apvma.gov.au/permits). Always read the label and observe withholding periods.

Helpful resources

1. Diseases of Fruit Crops in Australia (2009) Tony Cooke, Denis Persley, Susan House
2. Strawberry Problem Solver and Bug Identifier (2005) Neil Greer, Don Hutton, Noel Vock, Geoff Waite. Queensland Government Department of Primary Industries and Fisheries
3. Common insect pests of strawberries (2009) Primefacts. L. Ullio. NSW Department of Primary Industries https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0017/306314/Common-insect-pests-of-strawberries.pdf

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Managing sucking pests in strawberries

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Sucking pests include mites, thrips, mirids, jassids, aphids and bugs (such as Rutherglen bug). The feeding activity of sucking pests can damage plant buds, leaves, flowers and strawberry fruit directly. Calendar-based spray programs to control these pests are expensive, and often ineffective due to insecticide resistance amongst the pest populations. Certain pesticides can also be toxic to beneficial organisms, reducing their numbers, which can cause other pest populations to flare.

This fact sheet summarises the information you'll need to sustainably manage the sucking pests in your crops.

Integrated Crop Production (ICP) considers the production system as a whole, including all pests (insects, diseases and weeds), beneficials, soil and plant health.

Close-up of adult aphids (photo courtesy of Queensland Government Department of Primary Industries and Fisheries)

ICP tips for managing sucking pests

- Read the pest management chapter of the Australian Good Practice Guide for Strawberries at https://static1.squarespace.com/static/57285e9e59827e6e7a1467f2/t/5b1622f9575d1f3054d5e47d/1528177443631/Pest+Management+Chapterv2.pdf.
- Know your potential threats and the pests you are targeting.
- Know which beneficial organisms (natural and introduced) may be relevant.
- Know the impact of your potential treatments on beneficials.
- Maintain thorough site sanitation – remove and destroy weeds, infested plants and crop debris.
- Use clean runners – don't introduce pests and diseases on planting material, compost or growing media (coir/soil/potting mix).
- Monitor regularly. Early detections increase the chance of success. Track changes in pest and beneficial populations.
- Understand 'soft' treatment options and how to achieve maximum coverage.
- Use chemical insecticides only when necessary and do not rely on them.
- Understand resistance management and rotating chemical groups.
- Don't keep treating with something that is not working.

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Managing sucking pests in strawberries

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What is the nature of sucking pests?

These pests suck nutrients out of plants they feed on. Some whiteflies and aphids, like the green peach aphid, excrete a sugary sticky residue on which sooty mould later develops. Mirids cause damage by injecting toxic saliva into the plant as they feed. During feeding whiteflies, various aphids and thrips may also introduce viruses from their mouthparts to plants. Sucking pests can cause stunting, reduced yield and poor fruit size and quality.

To sustainably manage these pests it is important to know:

- how to identify and monitor the pests
- how to identify the symptoms of damage they cause and diseases they may carry
- all relevant management options.

Effective management also relies on understanding the pest's life cycle and environmental conditions that favour population increases of the pests and beneficials. You will need an integrated approach to monitor and manage the pests and their natural enemies, and the introduced beneficials.

Experts in tailoring strawberry ICP programs and their implementation are available in Australia. A review by experienced ICP researchers and consultants of your production system and the threats to it is worthwhile. The valuable and specific guidance provided will motivate change, as evidenced in the case study provided at the end of this fact sheet. Providers of biological control agents (predators and parasitoids) and ICP advice can be found on the website www.goodbugs.org.au.

How can I protect my crops from these sucking pests?

Growers have typically reported their most important steps toward ICP were seeking expert advice, and committing time, effort and resources to crop monitoring and planning.

Important early steps towards ICP

Clean up! Keep alert and keep scouting!

- Control broadleaf weeds and remove waste piles
- Create buffer areas or corridors of non-host vegetation around your sites
- Use clean plant material that has been certified
- Restrict people and vehicle movement onto your farm and into your crops
- Walk through your crops often to spot outbreaks, check pest and beneficial numbers, and effectiveness of all treatments.

Why use an ICP approach?

In general, growers have measured their ICP success in terms of:

- Improved pest control and more reliable reduction in crop losses
- Reduced costs (for labour and chemicals)
- Improved farm occupational health and safety through reduced use of chemicals
- Improved awareness of their pests and the biological balance needed in a crop
- Increased market acceptance even though pack-out in a few cases has been lower in the establishment years
- Increased personal satisfaction as a result of significantly reducing the environmental impact of their practices.

Sticky trap in a strawberry crop

If these sucking pests are already in my crops, what can I do?

Get started on an integrated management program. These programs utilise a range of management options and minimise reliance on chemicals. Take it step-by-step as suggested below.

Start monitoring. For thrips in young (not yet flowering) plantings, use sticky traps to monitor the number of flying adults. For all sucking pests check with a hand lens under the young leaves for adults and nymphs/larvae, and whitefly pupae. Make weekly inspections, increasing to twice weekly during Summer. Checking for adult whiteflies is best done in the mornings at the edge of blocks. Many beneficials are pollen feeders so flowers are a good spot to check for them, and their prey (such as adult and larval thrips). Start checking once flowering commences. Working with experienced ICP specialists can be helpful and rewarding. Discuss with them the results of your monitoring and inform them fully on your crop history and growing environment.

Persimilis (photo courtesy of Queensland Government Department of Primary Industries and Fisheries)

Spray only when necessary. Mirids, Rutherglen Bug and high numbers of Lygaeiids will need spraying from time to time. Try to get key beneficials established first and only spray when necessary. This allows beneficials to restore their populations between sprays.

Critical crop stages and pest thresholds that trigger a response action (such as introducing parasitoids/predators or using 'soft' pesticides for caterpillars, aphids and whiteflies) vary by pest. For example, damage by thrips to young green fruit is more serious than colouring fruit and therefore monitoring in flowers is particularly important.

The successful management of several sucking pests has relied on the introduction of specific predators and parasitoids. These are discussed further in the case study below and include the use of *Phytoseiulus persimilis* (Persimilis) for the control of Two Spotted Mite (TSM), and *Neoseiulus cucumeris* (cucumeris mite) and *Orius armatus* (minute pirate bug) for effective control of Western Flower Thrip (WFT) and onion thrips. Other useful general beneficials for managing strawberry pests (in particular aphids) include hover flies, ladybirds, lacewings, predatory thrips and parasitic wasps.

Chemical control options for managing sucking pests can be found on the Australian Pesticides and Veterinary Medicines Authority (APVMA) chemical database (https://portal.apvma.gov.au/pubcris) and permit database (https://portal.apvma.gov.au/permits). Resistance management is vital for maintaining effective crop protection options. Using integrated management strategies such as those discussed above will reduce the development of resistance and also contribute towards the quality of the environment. When applying insecticides delay resistance development by rotating different active ingredient groups and restrict their use to certain periods of the year. Labels of some products place a limit on the number of times they can be applied. Adhere to these restrictions. For the insecticide resistance management strategy for managing TSM and WFT in strawberries go to: https://www.croplife.org.au/resources/programs/resistance-management/2016-strawberries-ornamentals-two-spotted-mite-western-flower-thrips-2/.

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Managing sucking pests in strawberries

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Case study

The case study below (provided by Lachlan Chilman of Biological Services) shows how biological predators can be used as part of an integrated approach for managing pests such as WFT and TSM.

Adult western flower thrip (photo courtesy of Queensland Government Department of Primary industries and Fisheries)

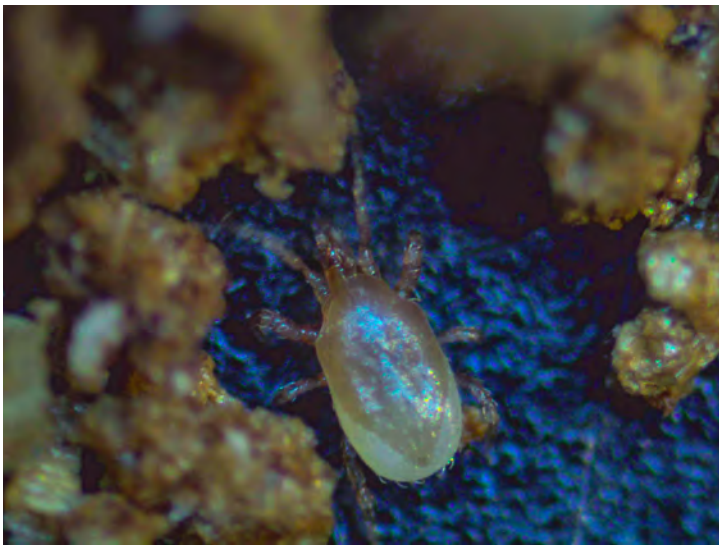
Western Flower Thrip (WFT)

The introduction of WFT to Australia caused a lot of problems for strawberry growers particularly in the southern growing districts of Victoria, South Australia (SA) and Western Australia (WA). Growers resorted to regular applications of broad spectrum pesticides to control WFT. Initial control was adequate but WFT very quickly developed almost complete resistance to these controls, causing a lot of damage. The regular spray applications also caused secondary outbreaks of TSM, which also developed resistance to the applied insecticides.

WFT was first detected in Perth, WA in 1993. It spread quickly in crops around the country despite quarantine measures. The first successful ICP program to combat WFT in strawberries was in Albany WA in 2003. WFT later became a very serious pest in strawberries in Victoria and SA. In 2007 Biological Services and IPM Technologies (Paul Horne) worked together to develop ICP strategies to successfully combat both of these serious pests by 2009. The program has been so effective that around 90% of the strawberry area in Victoria, SA, WA and Tasmania now utilise biological control to manage their key pests.

Prior to implementing an ICP program, it is important that growers contact their strawberry runner providers to ensure there are no residually toxic pesticides present in their plants that might affect their program.

WFT can cause considerable bronzing damage to strawberry fruit, and when uncontrolled down-grade fruit quickly and reduce shelf life. To control WFT, several predators are used in conjunction depending on the pest pressure at each site. A mixture of *Hypoaspis* species (*H. miles* and *H. aculeifer*) are released soon after planting, to control thrips pupae in the soil. This is important in the field as first year plants are usually planted into sterile fumigated ground which leaves no beneficial fauna behind.



Hypoaspis miles (photo courtesy of Lachlan Chilman)

At flowering, releases of *Neoseiulus cucumeris* (Cucumeris) are conducted to control young thrips which develop under the strawberry calyx. This is the main predator used to control WFT in uncovered strawberries. Three releases of Cucumeris a season are generally recommended in spring, early summer and early autumn. If chemical sprays are used to control other pests such as Mirids then further release of Cucumeris is recommended directly after these applications.

Strawberries grown under covered protection develop much higher levels of WFT as the increased temperatures and lower humidity is ideal for thrips development. In this situation releases of *Orius tantillus*, a predatory bug are utilised in conjunction with the Hypoaspis and Cucumeris. Orius not only

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control the juvenile stages but also feed on adult stages of WFT in the flower. Orius takes 4-6 weeks to establish properly and it is critical that good levels of flowers are present in the crop prior to introduction, and that this occurs early in the season prior to thrips being a problem.

Two-spotted mites (TSM)

TSM are present in every strawberry planting. They are extremely damaging to foliage and seriously damage plant health if not well controlled. The key to managing TSM using an integrated approach is to begin by introducing *Phytoseiulus persimilis* (Persimilis) predatory mites. Persimilis are highly effective predators that control all life stages of TSM. Good control of TSM with Persimilis can be achieved in both outdoor and covered strawberry crops. TSM breed faster in covered situations due to higher temperatures, lower humidity and sometimes dusty conditions, making it critical to monitor carefully and introduce Persimilis early and quickly. Obtaining good biological control of TSM is essential so that chemical miticide sprays are reduced or eliminated. When miticides are applied regularly it becomes difficult to properly establish the key predator Cucumeris (also a mite) to control WFT.

All life stages (eggs, nymph, adults and beetle predator) of two-spotted mite (photo sourtesy of Queensland Government Department of Primary Industries and Fisheries)

Helpful resources

1. Predatory Bugs Enhance Bio-control in Australia (2010) Goodwin, S. and M. Steiner, in Practical Hydroponics and Greenhouses, No. 110, Jan-Feb 2010: pages 41-46.
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Silicon for strawberries

A summary of research findings

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Silicon is an available nutrient for all plants grown in soil, with its content in plant tissue ranging from 0.1% - 10%. Silicon is a major inorganic constituent in plants, and a significant amount of evidence has been published showing the value of silicon in crop productivity.

In Australian soils, silicon deficiencies are common. This is due to the nutrient being 'locked up' by quartz and soil clays (e.g. kaolinite), that must weather over a number of years before the silicon is available to the plant as mono-silicic acid. Once it is available, if the silicon is not taken up by the plant, it may be bound to clay minerals or leached down the soil profile.

With nutrients regularly being removed through plant growth and crop harvest, and many common fertiliser inputs not replenishing this deficit, it is easy to see how silicon deficiencies may occur.

Studies have suggested that reducing deficiencies has a number of benefits for crop health and subsequent production. These include:

- Improved nutrient availability
- Management of powdery mildew
- Improved tolerance to environmental stress

The addition of silicon can improve nutirent regulation and aid in powdery mildew management in strawberry crops, leading to potential increases in yield and crop quality

KEY POINTS

- **The addition of silicon to crops has been shown to help plants resist environmental stresses.**
- **Silicon can also improve nutrient regulation and aid in powdery mildew management, leading to potential increases in yield and crop quality.**
- **Soil testing is the best way to measure the amount of plant available silicon in the soil.**
- **When choosing a silicon source, be sure to consider the solubility, nutrient profile cost and application method practicalities.**
- **Check silicon sources for heavy metals**

IMPROVED NUTRIENT AVAILABILITY

Silicon interacts with plant nutrients such as phosphorus and potassium, influencing their availability to the plant. Increased availability of cations such as potassium, magnesium and calcium would be a result of silicon's high Cation Exchange Capacity (CEC). Research has shown that silicon:

- Plays a role in regulating excessive toxic elements such as aluminium, iron, zinc and manganese
- Can increase phosphorus availability indirectly by decreasing the availability of iron and aluminium in the soil
- May also regulate the uptake of phosphorus in deficient or excess situations This is due to its disposition in root endodermal cells, acting as a physical barrier to decrease extreme P uptake by roots.

MANAGEMENT OF POWDERY MILDEW

Powdery mildew can reduce strawberry yields by up to 30%. Protected cropping systems (e.g. tunnels) also favours the disease. Producers are finding it increasingly difficult to control the fungal disease with longer production periods and the limited fungicides available.

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Silicon for strawberries: summary of research findings

STRAWBERRY INNOVATION

Silicon fertiliser can provide a management option.

Silicon is prominent in cell walls as solid amorphous silica, providing a barrier against pathogens such as fungal diseases. Silicon can delay and reduce the incidence of powdery mildew in strawberry plants. A recent study conducted in substrate/tunnel production showed silicon significantly reduced powdery mildew severity and led to a noteable increase in yield (Ouellette et al., 2017)

The use of silicon in an integrated disease management program for strawberry crops may decrease reliance on fungicides and slow down the build-up of fungicide resistance. Silicon fertilisers generally do not have a harvest withholding period, so producers can manage powdery mildew throughout harvest. It is important to note that silicon fertiliser is a preventative tool not a cure for powdery mildew and frequent applications may be necessary to maintain control.

IMPROVED TOLERANCE TO ENVIRONMENTAL STRESS

The presence of silicon aids plants by strengthening cell walls. This in turn can slow transpiration, alleviating drought and salt stress and improve wind, rain and heat tolerance. Further, this structural benefit is believed to play a role in relieving nitrogen stress through improved leaf structure and light interception.

Recent research has also suggested that weekly foliar or sub-irrigation application of silicon alleviates heat stress in strawberries. Heat stress can be particularly challenging as it restricts leaf development, flower development and photosynthesis in strawberry plants, with temperatures above 30°C reducing fruit size and weight.

AVAILABLE SILICON

Currently, there is limited data available to indicate the optimal levels for silicon in plant tissue and soil testing practices. Silicon concentrations vary widely across soil condition, plant species and soluble N concentration in the soil.

Despite the limitations in available testing, there are soil types and conditions that may benefit from silicon application, including:

- Soils that are highly weathered and have been subject to leaching in a humid environment
- Sandy soils with good drainage preventing silicon accumulation. Although these sands have high concentrations of silicon dioxide, this provides almost no soluble or plant available silicon
- High organic matter soils. As silicon is a very small component of soil organic matter, it may be deficient in soils high in organic matter.

APPLICATION METHODS

Silicon can be applied to the soil at pre-planting or directly to the plant through foliar or sub-irrigation application. The following tips are recommended:

- Frequent applications by root uptake (e.g. weekly) of silicon give best results against powdery mildew.
- Smothering leaves in silicon may reduce yields. Excess silicon is not harmful to the plant but it can block sunlight in extreme concentrations. White leaves are a good indicator of excess foliar application.
- The most practical approach for application is to add silicon during the liming process by using calcium silicate.
- The impact of silicon fertiliser will depend on soil type, pH, soil texture, electrical conductivity, silica content and nutrient availability. Strawberries in sandy soils and highly acidic soils tend to respond best to silicon fertiliser.

Powdery mildew can reduce strawberry yields by up to 30%, silicon fertiliser can be considered an alternative to a fungicide management strategy.

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- Some silicon fertilisers (e.g. K_2SiO_3) can block irrigation pipes.
- Some wetting agents already contain silicon. These will not block irrigation pipes and can be used as substitutes for silicon fertiliser if applied in high doses.
- Some studies have found potassium silicate (K_2SiO_3) to be more effective than sodium silicate (Na_2SiO_3) and calcium silicate ($CaSiO_3$) for reducing powdery mildew and tolerating heat stress.

PRODUCTS AVAILABLE

When looking for a silicon source to apply to your crop, it is important to consider the amount of soluble silicon.

Commercially available silicon can come in solid and liquid forms. When considering solid forms, the smaller the particle size, the more plant available the silicon. Sources include:

- Calcium silicate
- Magnesium silicate
- Potassium silicate
- Sodium silicate
- Silicon dioxide (Diatomaceous Earth)

In conclusion, there is an array of silicon sources available but it is important to consider your production systems, soil type and condition, crop type, cost, practicality of the application method and potential other benefits (soil amelioration through liming, other nutrients).

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Irrigation water quality for strawberries

STRAWBERRY INNOVATION

Overview

When irrigating strawberries, the use of poor water quality can affect both the crop and soil in which the plants are growing.

Water analysis is a valuable tool for determining potential or existing salinity problems, developing irrigation strategies, and verifying toxicities or mineral imbalances.

The standard irrigation water test for irrigating strawberries measures the following:

PROPERTY	COMPONENT
Salinity	Electrical Conductivity (EC)
	Sodium Adsorption Ratio (SAR)
	Total Soluble Salts (TSS)
Alkalinity	pH
	Alkalinity
	Calcium Carbonate
Macro-nutrients	Nitrate Nitrogen
	Total Nitrogen
	Total Phosphorus
	Potassium
	Magnesium
	Calcium
Micro-nutrients	Boron
	Chloride
	Copper
	Iron
	Manganese
	Molybdenum
	Sodium
	Zinc

The poor quality of irrigation water must be analysed by a competent laboratory, preferably NATA accredited.

All irrigation water contains variable quantities of ions, salts and nutrients, which in an extreme situation can cause production losses, soil degradation and affect irrigation equipment.

Use of poor quality irrigation water in strawberry production can cause:

ISSUE	RESULT
Salinity/ sodicity	Excessive sodium and total dissolved salts can affect the permeability or the drainage of the soil
Toxicities	Excess chloride, aluminum and boron can bring about phytotoxicity to growth or roots
Deficiencies	High pH water or the addition of certain elements can cause an imbalance or decrease the availability of essential nutrients
Damage	Irrigation equipment may corrode or become encrusted with salts

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Irrigation water quality for strawberries

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Water quality parameters you should know about

Salinity

Salinity is commonly measured by electrical conductivity (EC), with the higher the salt load, the higher the conductivity. The ability of the crop to tolerate salty water depends on many things, including the crop type, management of the soil type, the irrigation system and climatic conditions which prevail when irrigating.

Strawberries are very sensitive to salt. The presence of chloride will impact on yield, even at very low levels. The type of irrigation system, such as drip versus sprinkler; and the weather conditions, like high evapotranspiration, contribute to the effects of salinity on the crop.

ANALYTE	SATISFACTORY	PROBLEM	INTERPRETATION COMMENT
Chloride mg/L (using drip irrigation)	< 4	> 10	If levels exceed 4 mg/L leaf or tip burn may occur, especially if there are high evapotranspiration conditions
Electrical Conductivity dS/m	< 0.7	> 3	If > 0.7 avoid wetting leaves on hot dry days
Total Dissolved Solids (TDS) mg/L	< 450	> 2000	If > 450 avoid wetting leaves on hot dry days
Sodium mg/L (using drip irrigation)	< 3	> 9	If levels exceed 3 mg/L leaf or tip burn may occur, especially if there are high evapotranspiration conditions

Source: Haifa

1mg/L = 1 ppm
1 EC unit =0.64 ppm
EC unit = 1mS/cm =1dS/m

Managing water high in chloride and salinity can include:

- Finding an alternative water source
- Diluting with better quality water (shandy)
- Avoiding leaf wetting
- Irrigating at night
- Improving soil drainage
- Establishing crops using good quality water
- Installing desalination units for domestic use.

Soil permeability/sodicity

The sodium adsorption ratio (SAR) is a measure of the sodium hazard or imbalance of sodium ions relative to calcium and magnesium. When irrigation water has a high SAR level the permeability of the soil can be reduced and result in poor structure, infiltration, aeration and drainage. The SAR ratio for irrigation water used on strawberries should be under 3, otherwise specific management strategies need to be put in place such as the application of gypsum.

ANALYTE	SATISFACTORY	PROBLEM	INTERPRETATION COMMENT
Sodium Adsorption Ratio (SAR)	< 3	> 9	When SAR is high apply gypsum or provide better drainage

Source: Haifa

Alkalinity

pH is a measure of acidity or alkalinity. Alkaline water with high carbonate and bicarbonate levels can affect the plants ability to uptake calcium, magnesium and some trace elements. The use of high alkaline irrigation water will in time increase the soil pH and create deficiencies of zinc, iron and boron.

ANALYTE	SATISFACTORY	PROBLEM	INTERPRETATION COMMENT
pH (b)	5.5 - 8.5	< 5.5 or > 8.5	Low pH water tends to be corrosive. A pH > 8.5 may lead to increased scale formation. This is due to the high levels of calcium, carbonate and/or bicarbonate normally present in alkaline water
Carbonate meq/L (a)	0.1		High levels of carbonate can affect uptake of magnesium and some trace elements
Bicarbonate meq/L (a)	< 2		High levels of bicarbonate can affect uptake of magnesium and some trace elements

Source: (a) IncitecPivot "Water Manual Notes"
(b) NSW Department of Agriculture Advisory Bulletin 1

Irrigation water quality for strawberries

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Calcium Carbonate

The Calcium Carbonate index is determined from the relationships between pH, salinity, alkalinity and hardness of the water. It gives an indication of whether the water is going to cause corrosion to metal parts of the irrigation system, such as pumps, or is likely to cause blockages from encrusted salts breaking loose from within the irrigation system, blocking filters or drippers.

ANALYTE	SATISFACTORY	PROBLEM	INTERPRETATION COMMENT
Calcium Carbonate Saturation Index	-0.5 to + 0.5	< -1.5	Water within satisfactory levels is suitable for most situations. Little likelihood of corrosion or scale formation.
Water Hardness $CaCO_3$ mg/L	< 50	> 150	Soft water is suitable for irrigation purposes. In hard water, precipitate may form when phosphorus fertilisers and sulfate are injected into the irrigation water. Calcium phosphate, calcium sulfate and calcium borate may be deposited.

Source: Drip irrigation "A grape growers guide" NSW Agriculture

Macronutrients

In most cases macronutrients are very low in irrigation water sources, other than bores where calcium and magnesium can be found in high levels in hard water. In most cases nitrogen, phosphorus, potassium and sulphur would provide some minor benefit in the form of added nutrient for the growing crop.

ANALYTE	SATISFACTORY	PROBLEM	INTERPRETATION COMMENT
Nitrate Nitrogen mg/L (a & b)	< 5	> 30	Sensitive crops may be affected with increasing concentration up to 30 mg/L, above which severe problems may arise. Should be considered as a nutrient when applying nitrogen fertilisers.
Sulphur mg/L (a)	5	-	Metal corrosion may be increased by high sulphur levels. Application of large quantities of high sulphur water to the soil may be a factor in contributing to soil acidity.
Phosphorus mg/L (a)	0.2	> 0.25	Concentrations > 0.25 mg/L may encourage algal growth. Should be considered as a nutrient when applying phosphorus fertilisers.
Potassium mg/L (a)	15	-	Should be considered as a nutrient when applying potassium fertilisers.
Calcium mg/L (a)	< 100	> 200	High calcium concentrations in the water may compensate for high soil sodium levels and may reduce a potential soil sodicity hazard.
Magnesium mg/L (a)	< 100	-	High magnesium levels have a significant impact on the soil. Magnesium saturated clays tend to disperse on wetting and set hard on drying. Continual use of irrigation water high in magnesium may lead to a deterioration of soil structure, especially on poorly drained, heavy textured soils.
Aluminum mg/L (b)	< 1	> 5.1	High levels can affect sensitive foliage and continuous application to soils can fix soil phosphorus.

Source: (a) IncitecPivot "Water Manual Notes"
(b) NSW Department of Agriculture Advisory Bulletin 1

Micronutrients

Concentration of micronutrients such as zinc, copper and manganese are commonly very low in water samples. Iron and boron status can be high especially in irrigation water sourced from bores.

ANALYTE	SATISFACTORY	PROBLEM	INTERPRETATION COMMENT
Copper mg/L (a)	< 0.2	> 0.21	For irrigation purposes, problems are unlikely unless the concentration of the element in the water is high. Problems are more likely in situations where the soil concentration is already high for that element. The effect depends on soil and crop type.
Zinc mg/L (a)	2	> 2.1	As above.
Manganese mg/L (a)	0.2	> 0.21	As above.
Iron mg/L (b)	0.1 - 1	> 1	Where iron concentrations exceed 5 mg/L in irrigation, deposits of iron may discolor or shade foliage reducing photosynthesis.
Boron mg/L (b)	< 0.3	0.5 - 3	Sensitive crops may be affected with increasing concentration >3 mg/L, above which severe problems may arise. Damage to the crop can occur from both root absorption and foliar absorption of the boron and may occur even if the total salinity of the water is low.

Source: (a) IncitecPivot "Water Manual Notes"
(b) NSW Department of Agriculture Advisory Bulletin 1

Other water quality parameters to consider

Tests for algae, bacteria and turbidity can be undertaken by specific laboratories who provide the service.

Algae

Algal growth will occur at quite low concentrations of phosphorus; above 0.01 mg/L P, provided other conditions are favorable (such as water that is warm, still and relatively clear). Such conditions occur usually over summer during periods of low stream flow. The N:P ratio of the water will determine the type of algal growth.

Bacteria

Bacteria are usually associated with surface water supplies, including dams which are subject to contamination from inflows by sewage, decaying organic matter, manures or transmitted diseases. As a result, bacterial problems such as Paratyphoid (salmonellosis) may result from contaminated water. Certain bacteria may cause precipitation of iron or sulphur, or form slime in the system. This can result in blockages and inconvenience.

Turbidity

Turbid or murky water is due to the presence of suspended material such as organic matter, clay or silt particles, or even iron compounds. These tiny particles remain in a suspended state as they are negatively charged and have a large surface area compared to their weight. Turbid water is unsightly, can stain and affect irrigation equipment, block irrigation drippers or spray nozzles and reduce the efficiency of water softening units. Only rarely is the degree of turbidity so severe as to make the water unsuitable for irrigation. High levels of turbid irrigation water can leave a film of suspended particles, protecting micro-organisms from the effects of disinfection and can stimulate bacterial growth.

Further information on water analysis and its application may be obtained from your local water authorities. They will be able to direct you to a NATA accredited commercial water analysis laboratory.

Other helpful resources

- Environmental Assurance Guidelines – Horticulture for Tomorrow – Chapter 2: Water management
  http://hoho3216.staging-cloud.netregistry.net/environmental-assurance-guidelines/chapters/water-management/
- State government department websites such as:
  http://agriculture.vic.gov.au/agriculture/horticulture/vegetables/vegetable-growing-and-management/irrigating-vegetable-crops-with-water-high-in-soluble-salts
  https://www.daf.qld.gov.au/plants/fruit-and-vegetables/farm-management/effects-of-water-quality
- Managing water for yield and profit – A training guide for Irrigators in the Australian Vegetable Industry – AHR
  http://ahr.com.au/wp-content/uploads/2015/03/Managing-water-for-yield-and-profit_Training-guide.pdf
- Irrigation Essentials - updated 2012 – Research and innovation for Australian irrigators
  http://npsi.gov.au/products/npsi06121
- Using Recycled Water in Horticulture – A Growers Guide
  http://www.recycledwater.com.au/uploads/File/documents/Growers%20Guide%20web.pdf

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Using recycled water for strawberry production

STRAWBERRY INNOVATION

Overview

Recycled water is available in nearly all Australian states for horticultural production. Recycled water irrigation schemes offer a number of benefits, including:

- Providing an alternative source or supplement to conventional irrigation water
- Adding valuable nutrients
- Providing an alternative sustainable use for the community
- Security for investment where water is scarce.

There are four classifications of recycled water which must be approved and endorsed by Environment Protection Authorities and health departments, prior to local water authorities making it available to the community, industry and agricultural enterprises.

The four classifications are: A, B, C and D, which are based on the level of treatment and water quality.

Class A recycled water: Class A is the highest rating for recycled water used for irrigation and is equal to the most stringent guidelines worldwide. Australian standards for Class A recycled water exceed those recommended by the World Health Organisation for irrigation of food crops.

State Departments of Human Service and Environmental Protection Authorities (or the equivalent) set these strict guidelines to ensure the safety of producers irrigating with recycled water, as well as the produce grown with recycled water.

Class B recycled water: Class B recycled water may be used to irrigate sports fields, golf courses and dairy cattle grazing land. It can also be used for industrial wash down as well as for the uses listed for Classes C and D, but has restrictions around human contact.

Class C recycled water: Class C may be used for a number of uses including for cooked or processed human food crops including wine grapes and olives. It can also be used for livestock grazing and fodder and for human food crops grown over a meter above the ground and eaten raw such as apples, pears, table grapes and cherries. It can be used by councils for specific purposes but there are restrictions around human contact.

Class D recycled water: Class D has received the least amount of treatment of all four classes and may be only used for non-food crops such as instant turf, woodlots and flowers.

Strawberries can only be irrigated with Class A recycled water.

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A summary of the recycled water (also known as reclaimed water) classes and acceptable uses in horticulture crops is outlined in Table 1.

Table 1: Recycled water classes and acceptable uses in horticulture crops

REUSE CATEGORY	MINIMUM WATER CLASS	IRRIGATION METHOD	KEY MANAGEMENT CONTROLS FOR USE E.G. WITHHOLDING PERIOD
Raw human food crops exposed to reclaimed water			
Crops grown close to the ground and consumed raw (such as strawberries)	Class A	Unrestricted	
Root crops consumed raw (such as carrots, onions, radish)	Class A	Unrestricted	
Human food crops cooked (> 70°C for 2 minutes) or processed before human consumption, or consumed raw but with edible parts not exposed to reclaimed water			
Crops which are skinned, peeled or shelled before consumption (such as corn, peas, pumpkin, garlic, potato)	Class A Class C	Unrestricted Flood, furrow, drip, sub-surface	Produce should not be wet from reclaimed water irrigation when harvested Dropped produce not to be harvested
Non food crops			
Crops not for consumption (e.g. woodlots, turf growing, flowers)	Class D	Unrestricted	Restrict public access to application area. Harvested products not to be wet from reclaimed water when sold

Source: Use of Reclaimed Water EPA Victoria

The required reclaimed water grade for irrigation of human food crops (detailed in Table 1) depends on the potential for the edible portion of the crop to come into direct contact with the reclaimed water. This reflects both the irrigation method (such as spray, drip, flood, subsurface, or hydroponic systems), the crop involved (that is, whether the produce is grown in contact with the soil, or the produce has a protective and inedible covering), and the level of processing or cooking of the food prior to consumption.

Guidelines for recycled water

Extensive guidelines for use of recycled water have been developed and enforced by Environmental Protection Authorities and health departments in most states of Australia. These departments provide the endorsements, guidelines and regulations concerning the use, environmental impact, food quality and safety of recycled irrigation water.

This guarantees a particular water class has the appropriate water quality parameters to fit the purpose the water is intended to be used for, such as irrigating horticultural crops. The guidelines ensure the microbiological and chemical safety of recycled water, and the quality of food and vegetable crops grown with it.

Guidelines specify the minimum water quality treatment objectives. Minimum objectives per water quality class are summarised in Table 2.

Table 2: Water quality objectives and agricultural uses per class

CLASS	WATER QUALITY OBJECTIVES	RANGE OF AGRICULTURAL USES - USES INCLUDE ALL LOWER CLASS USES
A	< 10 E coli org/100mL Turbidity < 2 NTU pH 6 – 9	Human food crops consumed raw
B	< 100 E coli org/100mL < 30mg/L suspended solids pH 6 - 9	Dairy and cattle grazing
C	< 1000 E coli org/100mL < 30mg/L suspended solids pH 6 - 9	Human food crops cooked/ processed, grazing/fodder for livestock
D	< 10000 E coli org/100mL < 30mg/L suspended solids pH 6 - 9	Non-food crops including instant turf, woodlots, flowers

Source: Use of Reclaimed Water EPA Victoria

Using recycled water for strawberry production

STRAWBERRY INNOVATION

Potential issues with recycled water

Recycled water often has elevated salts and nutrients compared to conventional irrigation water. This can be helpful (through addition of extra nutrients) or can create potential issues such as increased soil salinity due to excessive sodium or chloride.

Salinity

Recycled water often has higher salinity levels e.g. sodium and chloride than surface or groundwater sourced irrigation water. It is important to remember that the salinity levels of recycled water must suit the crop grown, soil irrigated and the irrigation equipment used.

The presence of chloride will impact on yield even at very low levels. Chloride levels in water provided by drip irrigation should not exceed 145 mg/L.

High salinity in the water and soil can affect the ability of plants to extract water from the soil, especially in stressful conditions such as high temperatures. Recycled water may need to be shandied (mixed) with alternatively sourced irrigation water to reduce salt concentration.

Strawberries are very sensitive to salts.

Table 3 identifies the level at which salinity parameters can create issues. High salinity parameters in recycled water used to irrigate strawberries may affect soil health and the growth, production and quality of crops.

Table 3: Water quality and nutrient thresholds for strawberries

ANALYTE	PROBLEM ARISES
pH (water)	> 8.2
Chloride mg/L (using drip irrigation)	> 145
Electricity Conductivity µS/cm	> 700
Total Dissolved Solids (TDS) mg/L	> 450
Sodium mg/L (using drip irrigation)	> 70
Boron mg/L	> 0.75
Sodium Adsorption Ratio (SAR)	> 3

Source: Haifa

pH

A high water pH can reduce the ability of plants to absorb certain nutrients, such as zinc, iron, manganese, or expose plants to greater risk of toxicity from specific ions, particularly sodium, boron and aluminum.

Sodicity

Sodicity refers to the amount of sodium in the water or soil. This is usually measured in soil as the Exchangeable Sodium Percentage (ESP), which is the proportion of sodium as a percentage of all the exchange cations (such as calcium, magnesium, potassium).

The sodicity of water is measured as the Sodium Adsorption Ratio (SAR). In strawberry crops the SAR should not exceed 3 as this could lead to foliar damage or sodicity in the soil where soil structure and drainage issues may arise. To reduce high levels of sodium in soils gypsum applications are often used.

Boron

Higher concentrations of boron are often found in recycled water compared with bore and surface irrigation water. Strawberries should not be irrigated with water that has a boron concentration higher than 0.75 mg/L.

Using recycled water for strawberry production

STRAWBERRY INNOVATION

Nutrients

High levels of nutrients can be inadvertently applied when irrigating with recycled water. The amount depends on the source of the recycled water, treatment process (e.g. if nitrogen and phosphorus are removed) and amount of recycled water irrigated per crop. Table 4 shows a quick way of calculating the nutrients applied via irrigation water. If, for example, the irrigation water contains 10 mg/L of nitrogen and 5 mm of water is applied, then the amount of nitrogen applied to the soil is 0.5 kg/ha.

Table 4: Nutrient applied (kg/ha) in irrigation water (mm) of different nutrient concentration (mg/L) (note: mg/L = ppm)

WATER APPLIED	CONCENTRATION OF NUTRIENT IN WATER (MG/L)				
(mm)	1	5	10	15	20
1	0.01	0.05	0.10	0.15	0.20
5	0.05	0.25	0.50	0.75	1.00
10	0.10	0.50	1.00	1.50	2.00

Source: Good Practice Guide 2007 vegetablesWA

Further information

Each local water authority that supplies recycled water for irrigation of horticulture crops offers a monthly analysis rundown of the water quality which is available on their web site or from their office.

Further information is available through Environmental Protection Authority or your local water authority/supplier.

Resources

- Using Recycled Water in Horticulture: A growers Guide 2006 DPI Victoria http://www.recycledwater.com.au/uploads/File/documents/Growers%20Guide%20web.pdf
- Guidelines for Environmental Assurance. Horticulture for Tomorrow. 2nd Edition 2014 Chapter 2 Water Management, Horticulture Australia Limited http://hoho3216.staging-cloud.netregistry.net/manage/wp-content/uploads/2014/04/EAG-2014-Chapter-2-Water-management.pdf
- Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006 http://www.agriculture.gov.au/water/quality/nwqms/nwqms-australian-guidelines-water-recycling-managing-health-phase1

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Minor use permits

STRAWBERRY INNOVATION

Pesticides are a valuable tool for the strawberry industry. While the use of pesticides is being modified through the increasing uptake of integrated pest management, there is still a need for the strategic use of specific chemicals.

Pesticide companies submit use patterns for registration to the Australian Pesticides and Veterinary Medicines Authority (APVMA) and the strawberry industry is generally provided with significant registrations because of its major crop status. However, minor use permits are required in the strawberry industry where the market size is considered too small to generate adequate commercial returns for the research and development investment by the pesticide companies.

Below is a list of minor use permits for the strawberry industry, as of September 15, 2017. This information has been taken from the *Strawberry Fund Annual Report 2016/17*.

PERMIT ID	PERMIT DESCRIPTION (PESTICIDE/CROP/PEST)	DATE ISSUED	EXPIRY DATE	PERMIT HOLDER
PER12486 v5	Trichlorfon / Specified berry fruit / Fruit fly	06-Oct-11	31-May-21	Australian Blueberry Growers' Association
PER14598	Fenamiphos (Nemacur) / Strawberry runner production crops (only) / Leaf and bud nematode	01-Apr-14	31-Mar-19	Queensland Strawberry Growers Association (QSGA)
PER12927 v4	Success Neo (spinetoram) / Strawberries, rubus and rubus hybrids, and blueberries / Fruit fly (suppression only)	06-Oct-11	31-May-19	Strawberries Australia Inc (SAI)
PER12940 v6	Maldison / Strawberries, blueberries and rubus spp. / Fruit fly *NB: Use now registered – Fyfanon 440 EW, Cheminova*	06-Oct-11	30-Jun-18	Raspberries and Blackberries Australia
PER80064 v2	Phosphorous acid / Strawberries / Crown rot (*Phytophthora* spp.)	01-Nov-14	31-Oct-20	SAI
PER13331 v2	Admiral (pyriproxyfen) / Strawberries / Greenhouse and silverleaf whitefly	08-May-12	31-Oct-20	SAI
PER13377 v2	Emamectin (Proclaim) / Strawberries / Cluster caterpillar, heliothis, light brown apple moth and looper	08-Aug-12	30-Sep-20	SAI
PER13542 v2*	Maldison / Strawberries / Rutherglen bug	01-Jul-12	30-Jun-22	SAI
PER13697 v2*	Ridomil Gold 480EC and phos acid / Strawberry runners / Root and crown rot (*Phytophthora cactorum*)	28-Aug-12	30-Sep-22	SAI
PER13749 v3	Maldison / Strawberries (perimeter bait spray only) / Fruit fly *NB: Use now registered – Fyfanon 440 EW, Cheminova*	29-Oct-12	31-May-21	SAI
PER14483	Pyraclostrobin (Carbrio Fungicide) / Strawberry runners (non-fruiting) / Crown or petiole rot	29-Oct-13	30-Sep-18	QSGA
PER14192	Indoxicarb (Avatar) / Strawberries / Whitefringed weevil and garden weevil	24-Dec-13	30-Sep-18	SAI
PER14307 v2*	Zinc phosphide (Rattoff) / Strawberry / Mice	5-May-14	31-Jan-22	SAI
PER14577	Quinoxyfen (Legend) / Strawberry runner production / Powdery mildew	23-May-14	30-Sep-19	SAI
PER80670	Cyflufenamid (Flute) / Strawberry runner production only / Powdery mildew	8-Aug-15	31-Jul-20	SAI
PER80543	Bupirimate (Nimrod Fungicide) / Strawberry runner production only / Powdery mildew	11-Oct-15	31-Aug-20	SAI
PER81745	Chlorpyrifos (Suscon Green and Suscon Blue soil insecticide) Strawberries / Scarab beetles	21-Oct-15	30-Nov-18	SAI
PER81555	Sulfoxaflor (Transform) / Strawberries / Green peach aphid and green mirid	29-Apr-16	29-Apr-20	SAI
PER82598	Flonicamid (Mainman) / Strawberries (field and protected) / Aphids, whiteflies and green mirid	31-Mar-17	30-Nov-21	SAI
PER83871*	Fluazinam (Gem Fungicide) / Strawberry runner production / Leaf blotch	19-May-17	30-Jun-22	SAI

* During the 2016/17 financial year, renewals or applications for these flagged permits were prepared by Hort Innovation and submitted to the APVMA.

All efforts have been made to provide the most current, complete and accurate information on these permits, however it's recommended that you confirm all details on the APVMA website at portal.apvma.gov.au/permits. Details of the conditions of use associated with these permits can also be found on the APVMA site.

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Hort Innovation Strategic levy investment

STRAWBERRY FUND

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Managing your soil

Taking soil tests

Taking soil tests

Soil sampling and testing is usually done prior to planting your strawberry crop, however, specific in-crop testing can be useful, such as testing for available nitrate and ammonium.

Why test?

Your purpose for testing your soil must be clear:

- Are you doing predictive testing to check your soil fertility and make a more informed decision on your nutrient requirements?
- Do you want to monitor and assess the suitability of your management practices and make adjustments to your existing fertiliser programs?
- Are you looking for a diagnostic test to help determine the reason for poor growth?

In summary, there are several reasons why you would test your soil:

1. **To check general fertility indicators that influence nutrient availability and uptake such as organic matter, pH, electrical conductivity (EC) and cation exchange capacity (CEC)**
2. **To determine the level and ratios of nutrients in the root zone**
3. **To determine priorities for intervention if low or excess levels have been found**
4. **To prepare a nutrient budget and management plan based on the yield target and predicted crop removal**
5. **To monitor changes and trends in soil prperties and nutrient levels over time so that management inputs can be adjusted**
6. **To identify specific problems related to observations of poor growth**

Asking the question of why you are testing and what for, will help to determine the timing of sampling, where to sample, sampling depth(s) and the type of analyses you will need.

For intensive crops like strawberries annual soil testing is recommended at a minimum. In some instances more frequent testing could be beneficial to check the levels of mobile nutrients that can leach such as nitrogen (N). Plant testing should be used as an additional monitoring tool to soil testing to ensure nutrient uptake meets expectations.

Random, representative sampling

Look at the soils in the block you intend to sample. Submit a separate soil sample from each distinct soil zone in a paddock or block, if they are to be treated differently (e.g. by soil type or texture: clay, loam or sand).

Alternatively, only sample the predominate soil type or texture if you cannot treat areas differently. Two or more individual samples are needed from blocks with large areas that have been managed differently in the past (e.g. if two or more blocks have been combined), as this historical use may affect your fertiliser and management requirements significantly. For very large blocks, a representative sampling area of 1-2 hectares may be selected for sampling.

To obtain representative samples, do not sample from unusual sites such as:

- Gateways and headlands
- Close to dams
- Drainage lines
- Old fertiliser stockpiles

Soil cores should be collected along a fixed diagonal transect or zig zag path as illustrated in Figure 1. A map and plan of the soil sampling area is essential for interpreting results and any subsequent testing trends. Ideally keep waypoints via GPS or landscape markers of your sampling area and sampling points, the transect or zig zag pattern used for future reference.

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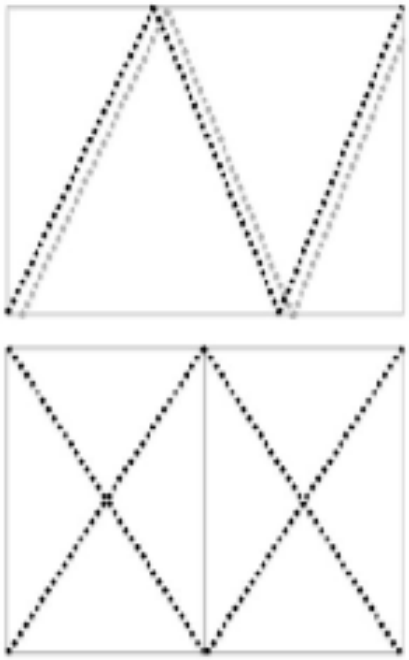
Taking soil tests

A couple of important points on sampling include:

- Use the same path (not the same points) the next time you sample.
- Always sample at the same time of year. This allows for re-testing and better monitoring of fertility trends than random sampling.
- Never sample straight after an application of fertiliser or soil amendments, unless you want to check how they may affect your soil fertility and nutrient levels.
- Avoid collecting surface material such as leaf litter or coarse, un-decomposed organic matter.

The sampling depth should give information about the main root-zone. Take two samples, one in the topsoil (0-15 cm) and one in the subsoil (15-30 cm) if the soil has not been tilled before sampling so that nutrient stratification can be detected. Alternatively, one sample in the 0-30 cm depth usually covers the main root-zone for strawberries and provides a good summary of soil fertility and potentially available nutrients in that zone. Deep soil N or N-check (available N) sampling can be done at either (i) 0-30 cm, (ii) 0-30 and 30-60 cm or (iii) 0-60 cm. If trends are important, sampling depths used previously should be maintained unless these were not representative of the root-zone.



Soil subsample collection patterns

TOOLS REQUIRED FOR SAMPLING

- Soil corer or spade
- Clean bucket(s)
- New plastic bags or sample containers (off the shelf or supplied by the lab)
- Labels and marker pens to identify the sample before or after it is collected and to make notes
- Record sheet or sample information labels to record sample details (such as site, depth, etc.). The format and type of information to provide is often prescribed by the lab.
- Notebook to record observations about the paddock, such as soil condition, weeds.
- Optional extras may include:
  - GPS to help determine the sampling path
  - Camera to take photos of soil profile, structure, colour of the paddock
  - A helping hand

A soil sample for lab analysis is made up of a set of separate sub-samples

For each sample to be sent to the lab, thoroughly mix a minimum of 20 soil cores (sub-samples) in one bucket. The more cores taken, the more reliable the test result. You may use a spade instead of a core sampler. However, a core sampler gives better results.

Fill a container or bag with 500 g of the well-mixed sample from the 20 or so cores in a sampling bucket. Make sure samples are clearly labelled and labels correspond with the record sheet accompanying them to the lab.

Once the samples have been collected they should be kept cold (fridge) and sent as soon as possible to the laboratory for analysis.

References

Blaesing D (2017) “Soil testing and interpretation for vegetable crops”, RMCG and AHR

Soil Wealth (2016) “Taking Soil Samples”, RMCG and AHR

Ullio L (2010) “Strawberry fertiliser guide”, primefacts fact sheet, NSW Government

Keeping soil in its place

Improving soil cover and managing drainage

STRAWBERRY INNOVATION

The movement of soil from strawberry farms can result not only in a loss of valuable top soil and available nutrients, but can also cause off-farm environmental impacts, particularly to waterways.

One of the main ways soil moves off farm is due to water erosion. Water erosion can occur when heavy rain or excess irrigation flows across exposed soils and/or soils with poor structure in farm blocks and tracks, or is captured without adequate drainage on hard surface areas such as protective cropping structures, packing sheds and buildings.

You might see evidence of water erosion on your farm, such as:

- Formation of rills, gullies and tunnels
- Turbid water in farm dams or leaving the property
- Built up soil on fence lines, adjacent roads to the farm or at the bottom of slopes

Water erosion

BEST PRACTICE GUIDELINES

Practices which can reduce and manage the movement of soil off-farm include:

- **Maintaining effective vegetated ground cover across the farm**
- **Establishing vegetation between strawberry rows and managing it to maximise root establishment and leaf density**
- **Preventing irrigation and/or rainfall run-off from hitting or moving over bare soil**
- **Creating stable pathways that slow run-off water and allow any nutrient-laden sediment to drop out before it leaves the property or enters watercourses or dams**
- **Using structures such as grassed headlands and buffers to intercept and treat run-off water**
- **Constructing and maintaining sediment traps to filter excess sediment out before run-off water leaves the farm**
- **Forming and maintaining good farm tracks**

Soil cover

Vegetation cover between rows

The establishment of grass in between strawberry rows is an effective way of managing soil movement. Vegetative grass cover holds together inter-row soil, while the top growth protects the soil surface from water droplets. It also slows and filters sediment from incoming rainfall or irrigation run-off, improves traffic movement, offers a cleaner environment for workers and promotes cleaner fruit by reducing soil splash.

Growers can stabilise soil between rows by:

- Establishing vegetation between strawberry rows and managing it to maximise root establishment and leaf density.
- Sowing a quick establishing grass between the rows and

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Improving soil cover and managing drainage

killing it off before planting. The residual mulch stabilises the soil between the rows. Other stabilisation options between rows include the use of sawdust or straw.

If the use of a grass inter-row is not an option, maintain vegetative cover in critical areas such as steep slopes and rows located closest to dams and watercourses, in conjunction with other drainage management strategies.

Oats and radish grown between strawberry rows

Drainage management

At times water runoff is unavoidable, and structures and management practices need to be employed to ensure soil and nutrient losses are minimised. You can do this by:

- Managing water run-off coming onto your property
- Preventing irrigation/rainfall runoff from hitting or moving over bare soil
- Creating stable vegetated drain lines that slow run-off water and allow any sediment to drop out before it enters watercourses or dams

A good way to understand your drainage needs is to observe water movement and review the performance of existing drains during a rain event. It is the ideal time to see whether your soil is moving off farm, whether the rate of run-off is greater than the capacity of your drainage system and whether intercepted water is being effectively delivered to drainage lines and watercourses.

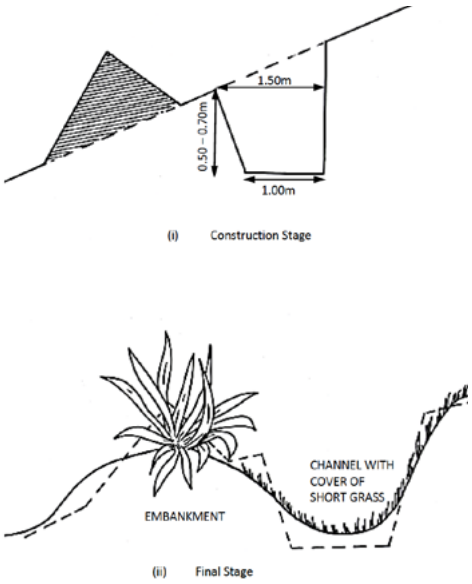
Grass headlands and buffers

When located above and below strawberry blocks, permanently grassed headlands and buffers can reduce the speed of water flow and filter sediment out of run-off. You can manage permanent headlands and buffers by:

- Determining headland and buffer width based on slope. The steeper the slope, the wider the headland or buffer will need to be.
- Locating headlands and buffers across the slope where water is concentrated, this includes around dams and adjacent to waterways. Buffers aren't as effective on slopes greater than 15%. Diversion banks should be used on steeper slopes.
- Sowing headlands and buffers with perennial grasses that are maintained (slashed) to encourage deep rooting and dense and vigorous growth. A swathe height of 15 cm is recommended for maximum filtration capacity. Grasses should be selected based on their ability to handle traffic, as well as wet and dry spells.
- Controlling broadleaf weeds in headlands and buffers using a selective herbicide.
- Minimising traffic on headlands and buffers, particularly when it is wet.

Cut-off drains and diversion banks

Cut-off drains and diversion banks intercept water and divert it away from the natural drainage course to protect cultivated or bare soil areas. They cut across the slope, intercepting run-off water flow and should discharge into grassed waterways or vegetated buffer strips.



Cross section of cut-off drain

Improving soil cover and managing drainage

The design and dimensions of cut-off drains or diversion banks will vary from site to site. They need to be built on a grade which will ensure water flows in the required direction, but not so fast that it erodes the structure, or so slow that sediment accumulates. They also need to be constructed so that they can cope with the volume of water that would be generated by a 1-in-10 year storm event.

Cut-off drains

When constructing cut-off drains:

- Use side slopes (batters) that are stable for the soil type and allow easy maintenance - preferably no steeper than 3 (horizontal): 1 (vertical). Make them wide with a flat floor, and establish good ground cover on the batters and floor.
- Direct drainage to a stable discharge area such as a vegetated waterway.

Diversion banks

A cut and fill or all-fill diversion or graded bank, sown to grass, is an alternative to grass headlands on steep slopes greater than 10%. Banks should be located more frequently across steeper slopes to ensure runoff water between one bank and the next does not develop an erodible velocity. Diversion banks can cause some inconvenience when working a paddock but can be constructed to accommodate traffic. The best shapes, for minimum interference, can be constructed using a grader. Direct water from a diversion bank to a stable discharge area, such as a vegetated waterway.

Grassed waterways

Grassed waterways (drainage lines), either built or naturally-occurring, carry run-off from up within the catchment or cut-off drains, diversion banks and other structures into farm dams or watercourses. They can also be used to safely direct water through a cultivated area if diversion of water around a block is impractical. Grassed waterways should be wide and shallow with a flat base. This form allows water to spread out and is easy to maintain.

- Where appropriate, establish wide, shallow grassed waterways to safely carry water to dams or water courses.
- Do not use grassed waterways as a road, this will make them prone to erosion.
- Maximise grass density in waterways by slashing. Control broadleaf weeds using a selective herbicide. It is recommended that grass height be maintained at 20 cm.
- Select grasses that can survive flooding and are suitable for waterlogging soils.

Grassed waterway

Sediment traps

Sediment traps hold run-off water long enough to reduce velocity and allow larger eroded soil particles and attached nutrients to settle out. Sediment traps should be used in conjunction with the other approaches as they will not prevent soil and nutrient loss by themselves.

- Traps should be designed to suit the soil type and catchment area to be treated
- Trap design should also consider your available machinery for periodic maintenance and cleaning of accumulated sediment deposits in dry weather.
- Runoff water from a sediment trap should flow along stable non-erodible pathways, such as a grassed waterway.
- ‘Treatment trains’ including several sediment traps, strategically sited within a well-planned erosion control system are better than a large single trap, acting as a last line of defense, at the bottom of the property.

Improving soil cover and managing drainage

The installation of sediment traps at the end of rows can significantly help to trap sediment and runoff while maintaining row access.

Farm tracks

The compacted and exposed nature of farm tracks make them vulnerable to erosion, and if not well designed, constructed and maintained, can be a significant source of sediment and nutrients discharged to dams and watercourses.

Track siting and design

- Build tracks on the most stable ground. Ideally, they should be located on ridge tops or on areas with little slope.
- Farm tracks should be gently crowned or sloped to shed water and minimise the time and distance water travels down them. They should also be supported by table drains to carry run-off from the track.
- On steep grades, place earthen banks (whoa-boys) 20-30 cm apart and build them on an angle across the track to avoid water ponding or concentrating and eroding trackside drains.
- Discharge diversion banks or run-off into drains or vegetated areas.
- Where possible, establish hard-wearing grass on low use tracks. On high use tracks, crushed rock or surface gravel should be used, even if only in steep sections.
- Restrict major traffic to designated hard-wearing tracks, particularly in wet weather.
- Wheel ruts concentrate water flow and start erosion. Change wheel tracks to prevent ruts forming.

Culverts or pipes

- Culverts must be large enough to handle peak flows. They should be spaced at an interval that will prevent water building up to levels that generate erosion (the steeper the track, the more culverts will be required). Culverts should also discharge into dense vegetated areas or sediment traps, to reduce the velocity of runoff, encourage infiltration and trap sediment.
- Sumps or box inlet structures can be used at the entry of culverts to prevent erosion around the culvert and reduce blockages from sediment build-up.

Maintenance

- Track maintenance should focus on keeping the road crown or slope and drains effective, avoiding V-shaped or U-shaped clearing of table drains and damage to discharge areas. Indicators for maintenance include eroding batters or track surface, wheel ruts, boggy patches and blocked culverts.

Culvert

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Horticulture for Tomorrow (2014) Guidelines for Environmental Assurance in Australian Horticulture

Queensland Department Primary Industries, (2008) Queensland Strawberry best soil, water and nutrient management practices

Managing your soil

Crop rotation and soil amendments

STRAWBERRY INNOVATION

Crop rotation

Cover crops

Rotating between cash and cover crops provides multiple benefits to your soil and crop health. Cover crops reduce soil erosion, break disease cycles, provide competition against weeds, and add organic matter and nutrients to the soil.

Cover crops are generally slashed or mulched prior to incorporation into the soil. As they break down, gums are produced that assist in binding the soil particles together to form stable soil aggregates with pores between them. This stabilises the soil and increases the water and nutrient holding capacity.

Cover crops can include grasses or cereals, such as oats and ryecorn, or legumes such as cowpeas and vetch. Cereal crops build organic matter, while legumes fix atmospheric nitrogen and convert it to a form which can be used by subsequent crops. Cereal and legume crops can also be grown together to get the benefits of both, for example a combination of ryecorn and peas.

Rotation with cover crops also helps to break the cycle of pest and disease build up, which can occur with continued planting of the same crop.

Ryegrass cover crop

To hear more about the benefits, application and issues of cover crops in Australian horticulture watch this webinar presented by Dr Kelvin Montagu and Julie Finnigan: https://www.youtube.com/watch?v=kd8IvoV73SE

IMPROVE YOUR SOIL HEALTH BY:

- **Rotating cash crops with cover crops. Cover crops can help to build organic matter, break disease cycles and reduce weed competition.**
- **Adding compost, mulch, animal manures and biochar to build soil organic carbon**
- **Using lime or dolomite to reduce soil acidifcation**
- **Using soil gypsum to reduce soil sodicity**

Biofumigant cover crops

Increasingly, biofumigant cover crops are being used as a methods of decreasing the incidence of soil borne disease, while also providing the benefits of a green manure crop. Much research is being done to evaluate their use as an alternative to chemical soil fumigation.

Biofumigant crops are species (particularly mustards and other Brassicas) that produce high levels of compounds call isothiocyanates (ITCs) when the plant tissue breaks down. The ITC compounds act as biocidal fumigants that can kill, or suppress, soil borne pathogens and weed seeds, much like chemical fumigants. There are several different commercially available biofumigant species, which have varying activities against a range of pathogens and weeds.

The biofumigant crop is grown as a cover crop, and is incorporated into the soil at flowering, but before seed is set, when the levels of the compound that is the precursor to the ITC is highest. In order to release the ITC fumigant compounds, the crop must be finely macerated and quickly incorporated into moist soil. The soil is then rolled, or

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covered, to contain the ITC compounds which are volatile gases, similar to chemical fumigants.

To read about a vegetable grower's experience of using Caliente (a biofumigant cover crop) click here: http://www.soilwealth.com.au/imagesDB/news/New-Leaf-the-Caliente-Story.pdf

Macerated biofumigant crop

Soil amendments

Good soil management practices, such as reducing compaction, returning organic matter to the soil and improving surface drainage, will often reduce the need for costly soil amendments.

Increasing soil organic matter, and therefore organic soil carbon, helps sustain healthy biological activity by providing a nutrient source for the soil's microbiological population. Soil biological activity is responsible for mineralising nutrients in soil organic matter and making them available to plant roots, as well as contributing to improved soil structure.

By increasing soil organic carbon, using carbon-rich soil amendments such as compost, mulch, animal manures and biochar, the physical, chemical and biological properties of a soil can be improved.

Soil amendments can also be used to address specific soil limitations such as a lack of nutrients, soil acidification or alkalinity, and sodicity.

Soil amendments

Compost

Compost is stable aerobically decomposed organic matter. With regular use, compost will build soil nitrogen and carbon, increase soil cation exchange capacity, increase water holding capacity, reduce bulk density and stabilise pH (Paulin, 2005).

Many commercial compost producers are members of Compost Australia, and should be able to provide information about their compost, such as a specification data sheet based on average quality measurements.

Not all composts are well suited to fresh fruit production, depending on the source of the organic material and processes used, and selecting a supplier should be based on the suitability of their products for use in your situation. For example, the Freshcare Code of Practice requires composted organic material to be produced in accordance with an Australian standard (AS4454-2012 Composts, soil conditioners and mulches), in order to be used on food crops that are consumed as fresh produce, without a 45-90 day withholding period.

Spreading compost

To hear from a vegetable grower on their experience of using compost click here: http://www.soilwealth.com.au/resources/videos-and-apps/compost-use-in-vegetable-production-a-growers-perspective/

For more information on using compost click here: https://www.freshcare.com.au/resources/compost-factsheets/

Crop rotation and soil amendments

Manures

Pasteurised and pelletised animal manures, particularly poultry manures, are commonly used as a pre-planting, slow-release fertilizer. Manures can be useful sources of carbon-rich organic material, to improve soil structure and health, in addition to providing nutrients for crops. As with composts, animal manure products must comply with AS4454.

Seaweed extracts and bio-stimulants

Seaweed extracts have been reported to assist plants in many ways, and are increasingly used as an aid to plant establishment. Benefits can include:

- Enhanced crop yield
- Improved root structures
- Improved plant development – flowering, leaf development, fruit set
- Enhanced disease and stress resistance

There are also benefits to soil structure, water holding capacity and improved soil microbiology.

Biochar

Biochar refers to carbon-rich charcoal produced by pyrolysis (heating in the absence of oxygen) of biomass, either plant material or animal manures. There is interest in biochar as a soil amendment to improve and maintain soil fertility, and increase soil carbon sequestration. Biochar can sequester carbon in the soil because of its stable nature and long turnover time in the soil.

Application of biochar / compost mix

Current methods of biochar incorporation use surface application, then mechanical incorporation into the topsoil, a method suitable for most annual and semi-permanent crops.

The adoption of biochar for use in strawberry production will depend in part on the extent to which increases in crop yield can reliably be achieved. At this stage there is little evidence as to the effect of biochar on the yield of horticultural crops.

Addressing specific soil problems

Acidification - lime or dolomite

Soil acidification can lead to reduced availability of nutrients and lower yields. At a pH of 5 many nutrients in the soil are not available to plants, and in some cases toxicities can also occur. Soil acidity can be naturally occurring and can be made worse by prolonged and heavy use of nitrogen fertilisers like sulphate of ammonia and MAP (mono-ammonium phosphate).

The speed at which soil becomes acidic depends on many factors, including soil type, soil texture (sandy soils become acidic more easily), organic matter, cation exchange capacity and the type of fertiliser used.

Lime or dolomite is usually added to maintain soil pH within a desirable range and can reverse the acidifying process in surface soils. Soil testing can help determine the correct rate to apply. Over-application can take years to remedy and can decrease uptake of nutrients by plants. It is easier to apply lime before planting with thorough incorporation improving results.

Soil acidity can also develop under drip irrigation where soils are highly leached. Flow-able lime that can be delivered through drip irrigation could be considered to maintain pH.

Nitrates are highly mobile under the influence of high rainfall or over-irrigation and will readily leach in permeable soils. This process can increase soil acidification. In addition, some nitrogen fertilisers can acidify the soil as the nitrogen is converted to a form the plant can take up. The potential of different fertilisers to cause acidification is as follows:

- Severely acidifying – ammonium sulphate and mono-ammonium phosphate (MAP)
- Moderately acidifying – di-ammonium phosphate (DAP)

- Slightly acidifying – urea and ammonium nitrate, and
- Non-acidifying – potassium nitrate, calcium nitrate and composted poultry manure

Further information on acid soils and how to manage them can be found here:

http://agriculture.vic.gov.au/agriculture/farm-management/soil-and-water/soils/acid-soils

Soil sodicity - gypsum

Sodic soils are not able to form stable aggregates as the clay particles cannot interact and hold together, causing an unstable structure. These soils are often called 'dispersing clays'. Sodicity can cause poor water infiltration, decreased ability to hold water, surface crusting, waterlogging and increased erosion. Run-off from sodic soils carries clay particles into waterways and dams, causing turbidity, or cloudiness.

Calcium, in the form of gypsum, is added to sodic soils to improve their structure. Gypsum can be applied to riplines to help stabilise fracture lines, or broadcast and either incorporated or left on the surface. The best option depends on the nature, depth and extent of soil sodicity. Other factors to consider are soil pH, soil salinity, irrigation water quality, drainage and irrigation systems.

Sodic soil

Gypsum adds to the overall salinity of soil water so under pre-existing saline conditions, large applications should be made after completion of the growing season. It is better to apply smaller amounts annually rather than large, infrequent applications; this reduces opportunities for structural decline. The amounts required depend on the quality of irrigation water and soil type.

Because there are many factors to consider when dealing with sodic soils, it is advisable that you seek professional advice.

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Standards Australia www.standards.org.au

Strawberries

Growing the Crop in Western Australia

STRAWBERRY INNOVATION

Author: Aileen Reid

Growing strawberries as a commercial crop needs attention to detail to achieve the best results. The information in this factsheet, as prepared by the Strawberry Growers Association of Western Australia, summarises advice on growing strawberries as recommended in WA.

Planting

If using four-row beds, plant strawberries in double rows 30 to 40cm apart. Within rows, the plants should be staggered and be from 25cm to 40cm apart, depending on the vigour of the variety and the mechanical aids used.

About 50 000 to 60 000 runners are required to plant one hectare in the Perth region. In southern regions, where inter-row paths are wider, about 40 000 plants are required.

Plant runners as soon as possible after received, before roots dry out. If planting is delayed, the runners should be cool-stored at 2°C until needed.

A medium-size paint scraper is used to push the plants down into the bed. The method may seem crude but trials have shown it places the plants at no disadvantage. First pierce a hole in the plastic sheet and holding the plants at a 60 degree angle, rest the end of the roots on the plastic. Place the scraper tip close to the ends of the roots, usually 3 or 4cm from the ends, and push down slowly and firmly until the plant crown is level with the surface of the soil. Withdraw the scraper and firm the soil around the plant.

Where plants are being established with overhead irrigation, make larger planting holes (8 to 10cm diameter) to allow good water penetration.

Strawberries growing under cloches

Pruning and cutting

Runners that develop during cropping should be removed as soon as they appear. Runner removal is generally not considered to be worthwhile late in the season.

If an autumn crop is desired, cut bushes to within 2cm of the crowns between March and May in Perth and between May and July in the south and remove all old leaves. Top removal can be aided by slashers, modified lawn mowers, hedge clippers or sharp knives. New growth will emerge quickly, followed by flowers.

Tops should not be removed in hot weather as the crowns can be damaged. If the weather is warm, irrigate regularly after top removal. To reduce disease build-up, rake up all leaves and burn them.

Growers harvest the autumn crop from early April to June, as the autumn crop may be extended into winter with the use of plastic cloches.

Tunnels

Plastic tunnels (cloches)

Cloches protect the crop from wind, hail and heavy rain during winter and warm the air and soil. They encourage vigorous growth, early fruiting and more even colouring of berries.

Construct cloches by erecting wire hoops about 2m apart across the beds and covering them with a continuous sheet of clear polythene. Attach the polythene so that it can be easily rolled up to allow watering, harvesting and pest control.

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Uncover the cloches on hot days to avoid scorching of leaves, and also in warm weather for pollination. The temperature inside the cloche should not exceed 33°C.

High tunnels (Haygrove™)

Some growers are using these for added crop protection and worker comfort. Trials comparing cloches with high tunnels show variable results depending on year and variety. The variety Albion shows more consistent results under high tunnels. Marketable yield will be higher in years with cool rainy weather early in the season.

Given the erratic nature of weather conditions in recent years (for example, summer hail storms), the reduced risk associated with tunnels is worth considering. Since these tunnels do not cover completely to ground level the risks of storm damage to the tunnels are less than with traditional tunnels.

Hydroponic strawberry production

Few growers have adopted hydroponic production to date in Australia. There are high capital costs to establish hydroponic production and prices for strawberries in recent years have been declining due to oversupply.

Weed control

The black plastic mulch controls most of the weeds in the rows. Weeds between the rows are usually controlled with a contact herbicide such as Spray Seed®. Apply this with a hooded sprayer. Do not allow drift to contact strawberry plants.

Alternatively, a ryegrass cover crop can be planted between the rows and that will help stabilise the soil and prevent dust blowing onto the fruit. There are a number of selective herbicides registered for use in strawberries. Consult the APVMA website for the latest information.

Harvesting

While strawberries are available throughout the year, supply is heaviest during spring. Crops in the Perth region are heaviest from September to December and southern crops from October to March. Autumn crops may be produced by cutting back plants as described earlier. First year plants yield later than established plants by about a month.

Strawberry beds should be picked over regularly, especially during hot weather when berries mature very quickly. The degree of fruit colour will vary according to the variety, but generally fruit should be picked when half to three-quarters red.

Harvest berries for the fresh fruit market with sepals attached. The stem should be very short or absent. Reject fruit that doesn't have sepals or is damaged.

Strawberries spoil rapidly, so they must be removed from the field at regular intervals and cooled promptly, preferably using forced air cooling. Fruit should be shaded and protected from winds while it is held in the field. When possible, pick fruit in the cool of the day.

A cool room is essential. Cool berries before packing and store at 0°C. Market as soon as possible after harvest. Only pack fresh, sound fruit of uniform colour. Berries showing even slight damage should be rejected, as these can deteriorate rapidly and spoil the entire pack.

Strawberries are most often packed in clear plastic-lidded punnets. The most popular size holds about 250g of fruit but fruit may also be sold in 500g trays or loose. Two sizes of 250g punnets exist, one designed to be packed firmly, the other to have the fruit placed in without packing, thus saving on labour costs. Mark the punnets with a sticker stating the grower's name, address and the minimum weight of the pack. The sticker should be approved by the National Measurement Institute before printing.

Two-hundred and fifty gram punnets are marketed in cardboard trays, which normally hold 12 punnets.

Strawberry punnets

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What's the current situation?

Close proximity to Asian markets, a favourable seasonal supply window and a growing consumer preference for clean, safe food has assisted Australian strawberry exporters to establish a foothold in Asian markets in recent years. And if consumer trends continue, increasing growth in the berry category could lead to steady demand for Australian strawberries across many retail markets both domestically and abroad.

West Australian (WA) producers have led the way in recent times, supplying over 80% of the total volume of exported strawberries (3,010t) in 2016 and successfully establishing long term trading relationships in Asia and the Middle East. In addition to its locational and seasonal advantages of supply, WA producers have also been successful in growing varieties preferred by Asian consumers and consistently supplying volumes that fill retailer commitments.

Queensland's (Qld) export growth has been bolstered due to increased overall production of quality fruit and relatively close proximity to international flights out of Brisbane airport. Success in supplying the New Zealand (NZ) market and a focus on export is becoming more important as volumes increase and more direct flights to Asian markets become available. Victorian growers have exported in the past, however a stronger domestic focus and the timing of production has resulted in varieties and costs of production that are not conducive to new export market development. Often the variability in quality and production over the southern summer period makes export competitiveness on price, quality and reliability of supply from this region extremely difficult.

Tasmania's Queensland Fruit Fly (QFF) free status opens up more market development opportunities for producers and a shift to substrate production under tunnels will assist with providing the consistent quality demanded in export markets. But recent QFF outbreaks in Tasmania suggest that relying on fruit fly-free status alone as a strategic advantage may be tenuous.

The export of strawberries in 2016 from each state to current export markets is shown in Figure 1 and demonstrates that the majority of export is from Western Australia and Queensland[1].

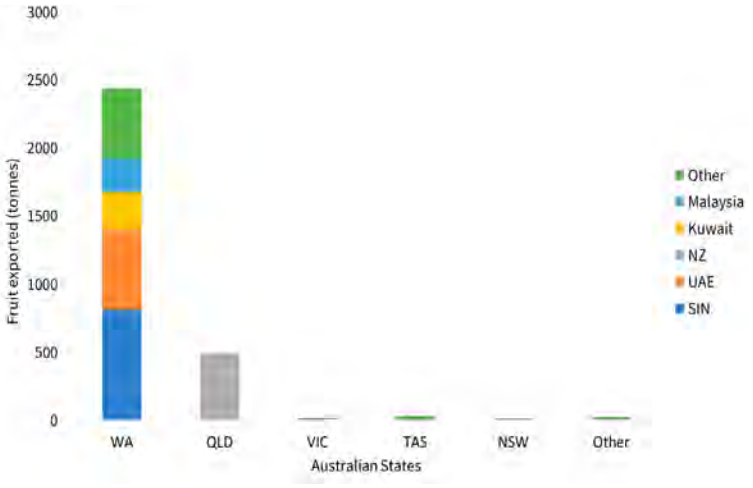

Figure 1: Fruit exported by state in 2016

KEY MESSAGES

When thinking about exporting consider:

- **Are the varieties right for the market?**
- **Can I supply consistent volumes at the right time?**
- **Do I have a branding strategy?**
- **Does the fruit meet the QA specifications required?**
- **Can I get it there in time?**
- **Do I know my customer and market?**

[1] 2015/16 Australian Horticulture Statistics Handbook

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Working together as an industry

As with many other Australian fresh produce lines, when we look to increase our export capabilities and grow our market share in Asia, relying solely on our close proximity and clean-green image is not a viable long term competitive advantage. Mounting competition from the US, South Korea, NZ and Egypt will quickly erode access gains unless we can implement a strategic approach to developing strawberries that fit Asian export markets.

The success of other horticultural products in Asian markets, particularly in China demonstrates that the interest and demand is definitely there and leads to the question 'why don't we push for direct access to China for Australian strawberries?' The short answer is that if it is not done right, in the long term, it could actually do more harm than good. The old adage, 'you only get one chance to make a first impression' is a simple but important consideration here, particularly when entering new markets, where a co-ordinated approach that builds on the gains that have been made in other produce categories is the right approach.

Hort Innovation's new 'Taste Australia' Retail Program is an example of how a coordinated, collaborative approach across multiple markets can achieve greater outcomes than focussing on a single commodity.

For approximately 10 fruit lines and vegetables, the program aims to first understand consumer preferences, then build collaborative relationships, set a high standard and then improve supply chain efficiencies, across ten Asian Markets.

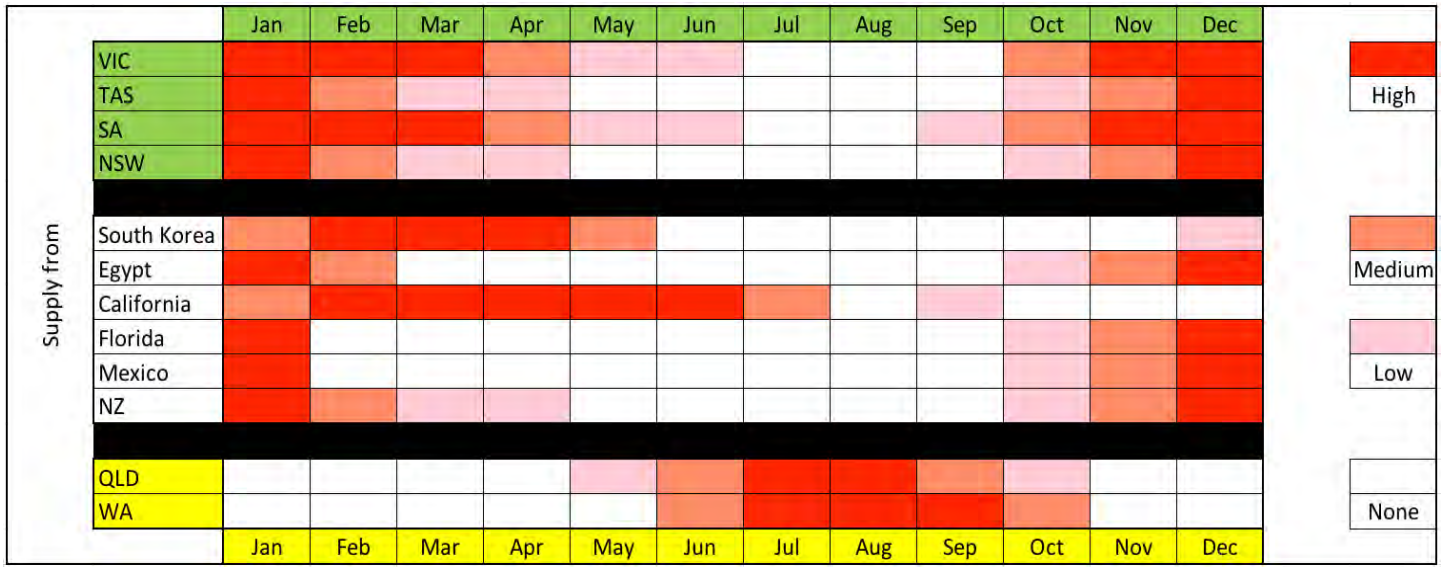
Further information on the 'Taste Australia' program is available here. The Berry Export Strategy (available here), provides important insights on Asian markets and recommendations on how the industry can best build export capabilities.

When considering Australian producers' supply window compared with some of our competitors (see Table 1), sub-tropical producers and temperate producers face very different challenges in developing export capabilities.

Building on its current competitive advantage of counter-seasonal supply, sub-tropical producers in WA and QLD need to focus on expanding the supply window beyond July to September and look to enter new markets. This will require greater collaboration between these two states to provide markets with scheduled, consistent volumes and quality so that a consistent brand can evolve from both production areas.

In temperate regions, protected cropping is potentially the only real alternative that will deliver consistency in the quality and efficiency needed to compete in export markets. Branding is important here too, to promote the provenance of the Australian product, off the back of consistent quality from the sub-tropical season.

Table 1: Seasonality of Supply



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Developing Asian markets for Australian strawberries

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Key considerations

As we look to grow the market share of Australian strawberries in Asian markets, these important questions need to be considered:

1. Have we got the right varieties?

Korean strawberries are well renowned for their sweetness and impeccable quality, which is an important positioning attribute to consider, particularly in Malaysia and Indonesia, where sweetness is paramount. Appearance too is important, especially for the retailer at point of arrival, so varieties that are bright red in colour with white shoulder will be favoured over darker red varieties. There is a common view that varieties often preferred in Australia are not compatible with preferences in most Asian markets and therefore consideration needs to be given to commitment to changing production to suit Asian consumers.

2. Have we got capacity?

This question is obviously underpinned by capacity to supply the right varieties at the time the market is demanding the fruit. Whilst WA producers and marketers have made exceptional inroads into developing long lines of premium export quality fruit, being relatively concentrated in the Wanneroo/Bullsbrook region means it is vulnerable to adverse weather conditions. Increases in export out of Queensland help to ensure continuity of supply in periods of low production out of WA, but there is also a risk that oversupply during the peak season could result in falling prices and erode value in export markets. It is difficult to grow export markets when commitments are potentially disrupted by shortfalls in supply and subsequent price increases in the domestic market. There is arguably a greater need for WA and QLD growers to work more closely together, with a targeted approach to volume commitments and promotional activities in Asian markets.

As Korean strawberry producers continue to extend their supply window using protected cropping, Australian producers also need to consider their ability to supply preferred varieties between July and September, to ensure that it's branding position is not lost. This is where temperate supply could play a greater role but it is dependent on producing the right varieties, committing to consistent supply and the strength of the Australian brand in the market. A transition to protected cropping could also help to drive efficiencies and quality consistency resulting in greater cost competitiveness.

3. What do we do about branding?

A branding strategy that captures the benefits of provenance and positions Australian strawberries at the premium end of the market will provide strength in the longer term. There also needs to be consideration given to multiple branding strategies such that different brands can be supplied from different growing regions and used in competing markets, if necessary. Like most fresh produce lines, branding is a critical component of being able to add value across multiple supply channels by driving demand from the end user. In a mature product category like strawberries, the ability of Australian strawberries to differentiate themselves from the competition and avoid being traded as a commodity is crucial to longer term success. But effective branding requires strict adherence to specifications, which would be improved by greater collaboration across the industry.

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4. Have we got the right standards in place?

A greater focus on quality assurance and adherence to specification requirements by growers serving the major Australian chain store retailers has increased the level of confidence in the food safety of Australian fresh produce by Asian consumers. Furthermore, some Asian retail outlets would prefer supply from producers who currently service the major Australian retailers as it demonstrates an ability to comply with strict specifications and food safety requirements, as well as the capacity to meet programmed order commitments and support promotional activity. Broadening producers' quality assurance capacity to meet specific retail requirements (such as HARPS or Global Gap), and to enhance the integrity of the brand is also beneficial.

5. Have we got efficient supply chains in place?

Improvements in communications technology have made it easier for buyers to engage with Australian growers directly, and to even trade directly in certain markets across e-trading platforms such as HiveXchange. Increasing numbers of flights to Asia are also providing more opportunities for growers to supply overseas customers directly by loading airfreight consignments on a regular basis out of the major Australian airports. Freight forwarders too are now often accredited with AQIS to provide phytosanitary certificates and import permits required for certain markets. They can receive, treat, store, label, strap and load produce in time to meet flights on a regular basis. But interruptions to this supply chain due to treatments (such as fumigation) or trans-shipping stock from one airport to the next, have the potential to undermine export efforts particularly if it compromises quality or interrupts consistent supply.

6. Are we building the right relationships?

Trade shows such as Asia Fruit Logistica and rapid use of WhatsApp and WeChat have made it easier for buyers to engage with Australian growers directly, and to even trade directly in certain markets across e-trading platforms such as HiveXchange. But it is important to understand what is driving demand. Is it a genuine long-term interest in regularly stocking the Australian product or is it just a short-term interest due to price or lack of supply from elsewhere? Engaging with an experienced, Australian based export consolidator (or even an exporter of another product to the same market) to discuss the intricacies of the market or prospective customer can provide valuable information in the short term that saves a lot of money in the longer term. Greater collaboration across production regions could provide opportunities to supply volume commitments, extend branding and target markets more strategically according to location advantages.

Effectively there are six interrelated components that would enhance export market development for strawberries in Asia as highlighted in Figure 2.

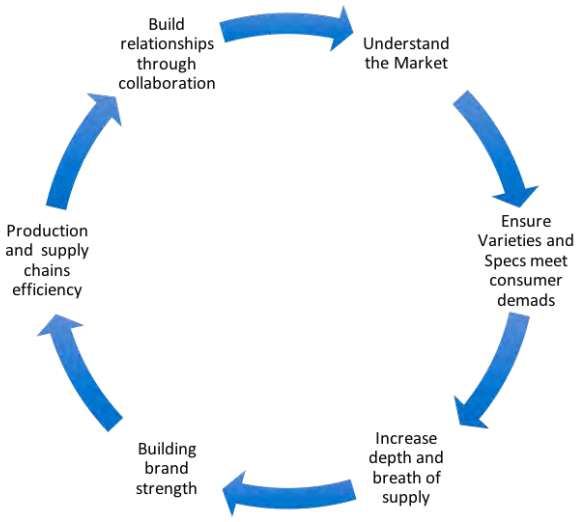

Figure 2: Six components to enhance export market development

In summary, a cohesive export strategy that encompasses these components is not without risk but will potentially help build a stronger position for Australian strawberries for the longer term. The alternative of continually building economies of scale through increased production to supply a relatively small domestic market with limited retail competition, is arguably a higher risk, particularly for smaller producers. Rather, building on the strengths already gained across the broader horticultural industry to take a strategic, measured approach, will help to drive demand for Australian strawberries in Asian markets for the longer term.

THIS INFORMATION WAS DEVELOPED FOR THE STRAWBERRY INNOVATION PROJECT BY KARL MCINTOSH, EXPORT DEVELOPMENT CONSULTANT AT RMCG, AUGUST 2018. FOR FUTHER INFORMATION CONTACT KARL ON 0429 981 394

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Postharvest diseases and disorders of strawberries

STRAWBERRY INNOVATION

This fact sheet provides information on a range of postharvest diseases and disorders that occur in strawberry production. As there are currently no postharvest fungicides available for strawberries, management involves a range of tasks that are to be undertaken throughout the production cycle. It's important to note that pre-harvest factors like plant spacing, weed pressure, air flow between plants, correct application of fungicides, and postharvest factors like handling and storage, all have the ability to contribute to a disease incursion. The correct management of these factors can significantly reduce the likelihood of infestation, and result in a profitable harvest.

For information about how to manage strawberries during and after harvest please refer to the chapter on postharvest handling of strawberries in the Good Practice Guide.

Grey Mould

The most common decay is grey mould, caused by *Botrytis cinerea*. This disease may be present in the field and symptoms not apparent until later, or it may begin postharvest. The fungus will grow at 0°C, but slowly.

Symptoms may occur on blossoms or on fruit at any stage.

Figure 1. Botrytis developing on a strawberry in the field

Temperatures between 18-25°C favour the disease and >85% humidity is required for infection. *Botrytis* is generally not a problem for strawberries grown under high tunnels where the foliage and fruit remain dry. Under low cloches the disease will be more prevalent on the edge rows which are often subject to drips when covers are raised and lowered.

The disease is characterized by grey fluffy mycelium on the fruit surface (see Figures 1 and 2). There is no leakage with botrytis infection. Lesions have no distinct border and the disease will progress until it involves the whole fruit and they may become mummified.

Figure 2. Botrytis on strawberries postharvest

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Rhizopus soft rot

Rhizopus rot or 'leak', caused by the fungus *Rhizopus stolonifer*, is a common postharvest disease of strawberries usually associated with handling damage. First signs of infection may be leakage of juice from packed fruit, and on inspection a white mould with black fruiting bodies is often seen.

Although Rhizopus rot is generally a problem after harvest, it can also occur in the field.

Rhizopus is usually a disease of over-ripe fruit, which are easily damaged and become invaded by the fungus in warm moist conditions. Infected fruit collapse and rapidly lose juice that leaks from the fruit in the field or container.

Figure 3. Affected fruit quickly collapse and become covered with black spore masses

When picking fruit, be sure to remove the whole fruit from the stem and not leave behind the fleshy receptacle of the fruit which can serve as a site for invasion by the fungus. Rhizopus is a good saprophyte, living on dead tissue, so field hygiene is also extremely important. All ripe fruit, plant material and waste berries should be removed and discarded. Spores are airborne and carried by insects.

To control soft rot, handle fruit carefully to avoid bruising, cool rapidly and maintain the cool chain during transport and distribution. Spore germination cannot occur below 6˚C.

Leather rot

Leather rot, caused by the fungus *Phytophthora cactorum*, is usually of minor importance as a postharvest disease. However, the leather rot organism also causes crown rot, a more common disease in the field.

Symptoms of the disease on fruit can be quite subtle and it is possible that infected fruit are picked and packed unknowingly. This is an issue as infected fruit have a very bad taste, even a small lesion will result in the whole fruit having an unsavoury taste.

Figure 4. Typical field symptom on immature fruit. Note the black leathery look of the affected fruit.

Fruits may be affected at all stages from blossom to maturity.

Infected areas of immature fruit are dark brown, while infected areas on ripe fruit appear bleached in colour. After harvest, a white fuzzy growth may appear on fruit under humid or moist conditions.

Rainy weather promotes infection by splashing of the fungal spores along with soil particles onto flowers or fruit. Maturing fruit in contact with wet soil may also become infected. Dew may supply adequate moisture for the spores to cause infection.

Control of leather rot is assisted by adequate plant spacing and weed control to promote good air flow and rapid drying of plant surfaces. Plastic mulch covering the raised bed will greatly reduce the incidence of leather rot. In addition, straw mulch should be put between the rows to prevent maturing fruit from becoming contaminated by rain-splashed soil on the surface.

When conditions are very wet, and leather rot is a problem in the field, fungicide sprays may be needed. Effective fungicides for leather rot control include phosphite.

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http://www.calstrawberry.com/en-us/Pest-Management/Diseases

Images sourced from the Strawberry problem solver and bug identifier developed by the Queensland Department of Primary Industries and Fisheries and Apollo Gomez, research scientist, at the Queensland Department of Primary Industries and Fisheries.

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New technology in strawberry production

STRAWBERRY INNOVATION

A wide range of technologies have emerged in horticultural industries in recent years. These technologies can improve strawberry production through reducing inputs and increasing efficiency in a range of on and off farm tasks. A number of these technological advancements have had direct impact on strawberry production, with a sample of these technologies, including those related to breeding, production, labour savings/people, and markets, explored in this fact sheet. These recent developments have helped address a number of issues facing the industry, especially to do with changing consumer habits, the shelf life of produce, labour availability and affordability and a range of agronomic practices.

KEY MESSAGES

- New and emerging technologies have had a significant role in advancing the strawberry industry. These technologies continue to support increasing the profitability and on farm efficiencies of growers through improving produce quality, reducing inputs and helping increase market access.
- New strawberry varieties have emerged in recent years and have played a significant role in increasing consumer interest in strawberries, as well as helping growers reduce reliance on chemicals through greater disease resistance.
- An increase in production efficiency, through the development of new products and chemicals has helped growers overcome barriers in the form of reduced access to chemicals and increased efficacy of chemicals used.
- Automated technologies have emerged globally that focus on the ever-growing issue of labour availability and affordability.
- A range of new technologies has assisted growers in being able to access new markets, increase produce shelf life, as well as improve the traceability of produce.

BREEDING

Some major advances in the strawberry industry have come from the development of a wide range of new varieties. Varieties have been developed that not only focus on increasing consumer demand through fruit characteristics that are more robust, attractive and flavourful; but also varieties that are increasingly more disease resistant, reducing reliance on chemical inputs. A notable recent global development has been the collaboration between Israeli start-up, NRGene and Japanese car manufacturer, Toyota, which resulted in the decoding of a leading commercial strawberry variety in Japan. Toyota has been involved in developing various crop varieties over the years, partnered with NRGene to increase breeding efficiency and develop more productive strawberry varieties for the Japanese market. It's hoped this research will help advance not only Japan's strawberry industry, but also the world's.

In Australia, the Queensland Department of Agriculture and Fisheries (QDAF) Strawberry Breeding Program, has been established to create a more profitable strawberry industry through:

- Delivery of new varieties with more efficient production of robust, attractive, flavourful fruit;
- Meeting changing market and environmental demands; and
- Targeting temperate, subtropical and Mediterranean production areas and needs.

The program is funded by Hort Innovation through the strawberry research and development levy and contributions from the Australian Government and QDAF. The program has released a number of varieties to date, including 'Suncoast Delight', 'Red Rhapsody', 'Sundrench', and 'Parisienne Kiss'. All have different attributes which aim to benefit not only the grower but also the end consumer.

CLICK HERE for more information on QDAF's breeding program

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PRODUCTION

There has been a gradual shift within the industry over recent years from conventional strawberry production in-ground, to growing in substrate under controlled environments. This shift is becoming increasingly more popular due to the potential of controlled environments to reduce the impact of soil-borne diseases, as well as provide protection from weather, pests, weeds and various other diseases.

In-ground production still comprises the majority of production in Australia. With increasingly limited access to effective soil fumigants, agricultural companies have been developing alternatives to control soil-borne pest and diseases. An example is Ethanedinitrile (EDNTM FUMIGAS), a broad-spectrum soil fumigant promoted as a replacement to the now banned methyl bromide. The soil fumigant was originally developed by CSIRO in 1996 and is now available for use in the Australian strawberry industry. Ongoing research is investigating the use of combinations of new and currently available fumigants to increase effectiveness in disease control.

Another development in soil fumigation practice is the use of Totally Impermeable Film (TIF) . TIF increases the retention of fumigants within the soil profile, increasing their efficacy, reducing the concentration needed and reducing fumigant loss into the atmosphere. TIF has proven to be highly successful and is now widely available to growers throughout Australia. Other fumigant practices available include steam disinfestation, microwave disinfestation and biofumigant cover crops.

CLICK HERE for further information on Totally Impermeable Film

TIF used to improve chemical efficacy (source: VSCNews)

Another example of advancements in production has been the adoption of pulse irrigation, which can be used for both in-ground and substrate production. Due to the low water holding capacity of substrates, pulse irrigation is commonly used to irrigate crops as required. Pulse irrigation systems give several short bursts of water to satisfy the crops needs, resulting in more efficient use of water and optimising plant growth.

LABOUR SAVINGS/PEOPLE

Increasing costs and staff availability make labour one of the largest overheads in strawberry production and the single biggest challenge for businesses to deal with.

Labour pressures have resulted in increasing interest and demand for automated technologies to aid with harvest. Companies like AGROBOT, Harvest CROO and Octinion are developing a range of automated robotic systems for the strawberry industry that work either autonomously or semi-autonomously to pick fruit in both field and tabletop production.

The controlled production environment under protected cropping and tabletops is leading the way with advancements in the automated picking space. Octinion's Rubion robot is an advanced example of a system near commercialisation stage, offering significant advancements in the picking hand for even pressure distribution of ripe fruit.

CLICK HERE to learn more about the Octinion's Rubicon Robot

Meanwhile, the challenges with in-field harvesting is being explored with examples such as AGROBOT's E-Series, a fully autonomous robotic harvester for both conventional in-ground and tabletop production. The autonomous robot, which has the ability to harvest two conventional rows and four tabletop rows of strawberries, moves through the growing area picking the desirable fruit by analysing for ripeness, shape and size. Unlike other robotic harvesters, the E-Series picks the fruit by cutting above the calyx to prevent fruit damage. Once the fruit is picked it is then transferred, with one of its 24 robotic arms, to trays which are located in the centre of the machine and then taken back to the packing sheds.

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STRAWBERRY INNOVATION

A highly publicised automated in-field harvesting system is being developed by Harvest CROO robotics, to address migrant labour shortages in the US and global market, whilst continuing to work with current grower practices. The robot operates, similarly to the E-series, in that it covers multiple rows at once and picks fruit with a mechanical arm, specifically in field production. However, it uses a mechanical arm to hold up the leaves of the strawberry plant to expose the fruit, which is then scanned with a series of different sensors to determine the ripeness of fruit. The fruit is then picked and added to a packing tray to be sent back to the packing shed.

AGROBOT's E-Series robot (source: AGROBOT)

CLICK HERE to find out more information on robotics in the strawberry industry

MARKETS

A number of recent technology advancements have resulted in improvements with sanitation methods, a longer shelf life for fruit and production of better-quality fruit. These developments have the potential to move the industry forward in both profitable and sustainable ways and have ultimately increased grower returns through opening up new markets and extending shelf life.

Cold Plasma treatment is one of those advancements that has the potential to increase market access and extend produce shelf life. Cold plasma is created by applying an electric current to normal air or a gas. This produces reactive gaseous species found to have broadspectrum antimicrobial activity. Cold plasma is effective at temperatures slightly above ambient, which means produce can be treated without being heated. The potential benefits to be achieved through Cold Plasma technology include improving food safety and reduced postharvest losses due to decay; reducing treatment time of a few seconds to minutes and providing energy efficient treatment with zero chemical residue. The technology is yet to be commercialised, but the research is showing promising results.

CLICK HERE to learn about a Hort Innovation funded project exploring the use of cold plasma technology

The packaging of fresh produce has changed greatly over the last 20 years with a variety of different options now available to growers and packers to increase produce shelf life and marketability . With single-use plastics becoming less appealing to consumers, fully recyclable and recycled packaging is becoming a more viable option. Recyclable and recycled packaging, consisting of PET, cardboard, and compostable starch-based materials, enables packers and retailers to market produce, but also keep up with a consumer demand towards more sustainable packaging options. Packaging still has a place within the fresh produce supply chain, especially when it comes to food safety, something consumers are much more aware of after the 2018 strawberry tampering crisis. Different types of packaging, namely tamper-proof packaging, enables packers and retailers to guarantee that there has been no contamination of the produce along the supply chain.

Compostable strawberry punnet: CKF inc (source: FreshPlaza)

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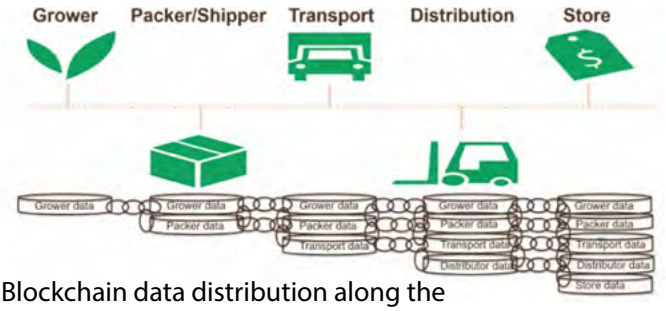
New technology in strawberry production

STRAWBERRY INNOVATION

Supply chain traceability is becoming more important for growers, packers, retailers and consumers, to guarantee place of origin and safety of products. Blockchain is a future technology that has become increasingly popular as it addresses this need, along with improving other supply chain efficiencies. The technology records a chain of information relating to the transaction history of a product and enables all those involved in the products' supply chain to have knowledge of the transaction history. Blockchain is unique as it is a non-destructive way to track changes within a supply chain – meaning that it is a more accurate and safer way of tracking products along the supply chain. The decentralised nature of blockchain also means it significantly reduces the risk of product tampering throughout the supply chain.



Blockchain data distribution along the supplychain (source: pma)

CLICK HERE to read about the use of blockchain in fresh produce

Development of new mobile apps have helped increase the marketability of produce and provide a direct connection between growers and buyers. Australian-based company HiveXchange has developed a mobile app that helps both growers and buyers connect through an easy-to-use platform that not only makes selling and buying produce easier, but also improves supply chain efficiencies. HiveXchange's app 'HiveXpress' enables growers to reach national buyers in three simple steps:

1. Take a photo of the produce that is being sold, either through the app or uploaded from your phone's library;

2. Outline the offer – provide details of what is being sold, which market it's being sold into and when it expires; and

3. Once the produce is purchased by the buyer, preview and post it to its destination.

HiveXpress only allows certified wholesale buyers and sellers in the market and provides both parties with a range of new opportunities.

CLICK HERE to find out more about the HiveXpress mobile app

REFERENCES AND FURTHER INFORMATION

NRGene and Toyota collaboration to develop new strawberry varieties: https://www.nrgene.com/nrgene-toyota-collaboration-strawberry/

National Strawberry Varietal Improvement Program: https://www.horticulture.com.au/globalassets/laserfiche/assets/project-reports/bs12021/bs12021---final-report-complete.pdf

Draslovka Group introduces EDN Fumigas to Australian farmers: https://www.goodfruitandvegetables.com.au/story/5308616/new-fumigant-ready-for-aussie-soils

Totally impermeable film retains fumigants, allowing lower application rates in strawberry: http://calag.ucanr.edu/Archive/?article=ca.E.v065n04p211

AGROBOT – Strawberry harvester: http://agrobot.com/

Harvest Croo Robotics: https://harvestcroo.com/

Octinion – Engineering the future: http://octinion.com/

In-package atmospheric pressure cold plasma treatment of strawberries: https://www.sciencedirect.com/science/article/abs/pii/S0260877413005384

Fresh produce on the Blockchain: https://apal.org.au/fresh-produce-blockchain/

HiveXchange – Australia's national wholesale produce market: https://hivexchange.com.au/

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Export supply chain

Queensland strawberries to Hong Kong

STRAWBERRY INNOVATION

Business in Hong Kong

Hong Kong is an import-dependent market with 95% of food and beverage products imported from around the world with zero tariff charged on most imports. The Australian market penetration into Hong Kong is low with the whole Australian strawberry industry providing 4% of the Hong Kong fresh strawberry market which in total is approximately 7,689 tonnes.

Hong Kong has a relaxed regulatory environment for imported food and beverage products with transparent and efficient customs clearance procedures. The Hong Kong market for Queensland strawberries has open market access and is a free trade port which means there are currently no duties or tariffs imposed.

In Hong Kong, the wet markets are strong in fresh foods, while supermarkets are strong in processed, chilled, frozen, high-added value and canned food products. The competition between the wet markets and supermarkets has intensified in recent years. While both the wet market and supermarket sales are increasing, supermarkets particularly those from the Dairy Farm Group and AS Watson Group account for 75% of the supermarket turnover with greater than 580 stores between the two groups.

Transport Recommendations

Direct transport for fresh strawberries is always the best option because the more movements, the higher the risk of a change of temperature and therefore a potential reduction in fruit quality. Other strategies include:

- Pre-cool produce to desired temperature: 0-2° Celsius
- Use refrigerated transport to the airport
- Pack boxes of produce as densely as possible
- Protect produce from direct sun or other heat sources
- Use insulated aircraft pallets wherever possible or cover pallets with flexible insulating material
- Utilise data-loggers so that temperature maintenance can be viewed in real time.
- Use dry ice (solid CO_2 that at atmospheric pressure has a temperature of approx. -79° C. The evaporisation is residue free, and it is also non toxic, non flammable, inert, tasteless and odourless).

This fact sheet is available at www.qldstrawberries.com.au or contact Clinton McGrath or Bron Ford at DAF on 13 25 23.

Hort Innovation Strategic levy investment | STRAWBERRY FUND | QUEENSLAND STRAWBERRIES | Queensland Government

Queensland strawberries to Hong Kong

STRAWBERRY INNOVATION

From 1 March 2019, all fresh produce (including strawberries) being exported from Australia will undergo compulsory security screening via x-ray or metal detector. Exporters from Australia have two options:

1. Use an Australian Government approved and accredited air cargo agent who can examine their air cargo at piece-level
2. Be approved as a Known Consignor, so they can secure air cargo originating from their business. A Known Consignor is a business that:

- Originates international air cargo
- Meets approved security measures designed to prevent the introduction of an unauthorised explosive into cargo
- Is approved by the government
- Is responsible for securing air cargo that originates from their business until that air cargo is provided to another regulated business.

Consumer trends

Opportunities for Queensland fresh strawberries fall into the following categories:

1. Daily consumption of the fruit – increasing demand for foods that are time saving, yet healthy (driving forces are demographic changes, busy lifestyles and food safety incidents)
2. Fruit that is marketed as having additional health benefits - increasing trend towards the consumption of healthy, quality, functional and organic foods. The ageing population and a rise in health consciousness is creating a commercial environment for products that aid the maintenance of health and means consumers will pay 10-30% more for these products including those that are marketed as "organic".
3. Premium fruit as a popular gift. Gift giving is all year round, however there are specific international events that are also highly celebrated in Hong Kong particularly between October and April including Christmas, Western New Year, Chinese New year, thanksgiving and Easter. To the Chinese, "red" is a happy and prosperous colour.
4. Food service: this includes for use in salad bars, decorative cakes (Maxim's Catering), and hotel and catering industries both in Hong Kong and Macau.

The demand for various kinds of convenient food items is increasing and consumers are becoming more conscious about nutritional values, traceability and food safety. The result is an increasing trend towards naturally healthy, functional, quality and sustainable food choices.

There is a strong preference for strawberries in a single layer-flat punnet which protect the fruit and avoids bruising and also allows for the whole punnet of fruit to be easily viewed for imperfections.

The supply of strawberries is very competitive. As such, there is no brand or business loyalty from the wholesale or retail customer unless the supplier provides product consistency in terms of branding, fruit quality and size and supply.

There is enormous opportunity for Queensland strawberries to be provided in the Korean counter season from May through to November.

This fact sheet is available at www.qldstrawberries.com.au or contact Clinton McGrath or Bron Ford at DAF on 13 25 23.

Hort Innovation Strategic levy investment | STRAWBERRY FUND | QUEENSLAND STRAWBERRIES | Queensland Government

Appendix 4: Case Studies

1. Grower profile: Vanessa and Brenton Sherry: Harvest the Fleurieu
2. Grower profile: Sunny Ridge Strawberry Farm
3. Grower profile: Simon Dornauf: Hillwood Berries
4. Grower profile: Paul Mancarella – Silvan, Victoria
5. Grower profile: John Hasan: Wandin, Victoria.

Grower profile

Vanessa and Brenton Sherry: Harvest the Fleurieu

STRAWBERRY INNOVATION

A family business

Vanessa and Brenton Sherry have been growing strawberries commercially for a number of years in South Australia. The family began Kuitpo Forest Strawberries in 1999, servicing the Adelaide Produce Market and interstate markets in WA, QLD and NSW, as well as a faithful following at the Willunga Farmers' Market and Adelaide Farmers' Market.

Over the years, Vanessa has been heavily involved in the Strawberry industry, representing South Australian growers on the peak industry body Strawberries Australia, and the South Australian Strawberry Growers Association.

Vanessa, Brenton and Ryan Sherry

In addition to Kuitpo Forest Strawberries, the Sherry family operates a pick your own berry farm at Mt Compass on the Fleurieu Peninsula. 'Harvest the Fleurieu' is a popular destination for tourists and locals, including school and community groups. The pick your own berry patch operates from mid-October to late May, depending on the weather.

Recently, the family has added a Market Hall and Café, which showcase produce and products from the Fleurieu Peninsula, as well as the family's strawberries.

'Harvest the Fleurieu' is very much a family business, with the entire Sherry family involved. Sons Adam and Ryan manage all of the farm production and plant health, along with Brenton. While daughter Megan manages the market hall and administration with Vanessa.

'Harvest the Fleurieu' is all about bringing the freshest produce to the public. The produce grown on the property is made available in the market hall, either as fresh produce, or used in value-added products such as jams, chutneys and sauces, or their delicious strawberry ice-cream made with freshly picked strawberries and Fleurieu Peninsula cream and milk. In addition to their own produce, the market hall stocks a large range of produce and products from other farms on the Fleurieu Peninsula. The café has a comprehensive menu including platters of local artisan produce, and breads and sweet treats baked on site.

The Market Hall and Café, along with the pick your own berry patch, has become a 'destination' for visitors to Victor Harbor and the Fleurieu Peninsula, and has been featured in the media and on travel websites.

The family plans to increase the variety of produce available at 'Harvest the Fleurieu' over the coming years, but their focus is still on producing amazing, full flavoured strawberries, and offering pick your own produce to the public. The opening of the café and Market Hall has been a very successful expansion into value-addition for this busy strawberry-growing family business.

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Grower profile

Sunny Ridge Strawberry Farm, Vic

STRAWBERRY INNOVATION

Transitioning from soil to substrate

The Gallace family have been farming at Sunny Ridge since 1964, but in the last couple of years Sunny Ridge has transitioned from a family run business to a professional business managed by a board of directors. Mick Gallace is still involved in the business as a director and advisor. Sunny Ridge has properties at Main Ridge, Boneo, Seville East and on the Sunshine Coast at Wamuran. The Main Ridge farm also offers pick-your-own berries and has a café and farm shop selling many locally made berry products.

Daniel Rolek, Head of Farming Operations

Daniel Rolek is Head of Farming Operations for all the Sunny Ridge properties, and works closely with his colleagues Orlin Atanasov at the Boneo farm, and Scott Carter in Seville East. Before joining Sunny Ridge in 2014, Daniel worked in the UK for ten years for part of the Berry Gardens group, growing hydroponic berries.

Transitioning to soil-less production

Strawberry production at Sunny Ridge has traditionally been field grown, but recently they have made the transition to growing in substrate under tunnels. According to Daniel, Sunny Ridge now grows more than 8 hectares of strawberries in substrate and under tunnels. The hydroponic system at Sunny Ridge is in their second season of production, having been commissioned in winter 2016.

One of the main reasons for the transition to substrate was the increase in planting density that could be achieved. Previously Sunny Ridge were growing about 37,000 plants/hectare, but with the current system they are growing around 93-94,000 plants/hectare. At a farm scale, this has seen the Boneo property increase from growing 250,000 plants to growing 1 million.

Other advantages of growing in substrate in raised gutter systems include the efficiency and ease of picking (a significant saving in labour expense), the potential to increase yield, uniformity and productivity, as well as improved hygiene.

Daniel is intending to implement nutrient recycling in the future.

The system is not without its challenges, however, which include the increased skill required to grow in substrate, the loss of the buffering capacity of the soil and the need for varieties suited to this method of production. It is capital intensive to set up and planning permission is generally required for protective structures.

Sunny Ridge mostly grows the Driscoll's variety Amesti at the Boneo farm, which is an ever-bearer, purpose bred for

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Sunny Ridge Strawberry Farm, Vic

growing in substrate and under cover. It is well suited to the temperate conditions in Victoria and is also the predominant Driscoll's variety grown in Tasmania. Daniel says Amesti works well for them as it produces fruit consistently throughout the season, unlike some of the other varieties they have trialled, which stop producing fruit for a period in January. This means they can retain their pickers throughout the season.

The tunnels and gutter systems used at Sunny Ridge were developed by Daniel and Quiedan Australia several years ago. The gutter system is designed to be strong and flexible so it can take bags, sausages, troughs or pots, providing future proofing options for the business in the future.

The current growing system uses 8 litre bags filled with coir, with 4 plants per bag. This gives a density of 10 plants per metre. The bags are covered, with holes for planting, which provides better control of weeds and moisture than open bags.

Irrigation and nutrients

Irrigation water and nutrient solution are delivered to the plants via a single 1.2 litre dripper in each bag. The delivery is controlled by a PRIVA Nutrijet fertigation system, programmed to provide the correct EC, pH and nutrient levels throughout the different growth stages of the crop. The recipe used has been developed specifically for the variety Amesti. The controller is linked to a weather station, and irrigation cycles are controlled by radiation sum, that is, the sunnier the day the more irrigation cycles. On a hot day, for example, there may be up to 10 irrigation cycles. Drainage run-off is used to check irrigation efficiency.

At this stage, the nutrients are not recycled and drainage goes to waste, but Daniel is intending to implement recycling in the future. More skill is required to recycle nutrients, but it will lead to more efficient use of resources.

In terms of yield, the aim is 900g/plant of first class fruit over the season, from late October/early November through until the end of May. On average wastage is around 2%.

Strawberries grown under cover can have different pest and disease problems compared to those grown in the field. Under cover aphids can be a bigger problem than in the field, as they are sensitive to wind, and prefer the softer tissues of plants grown under cover. Powdery mildew can be a problem for the same reason, though Daniel says it is rarely a problem at the Boneo farm. Two-spotted mites and Western flower thrips can be a problem as they are in field grown strawberries, but are effectively controlled with a good IPM program.

Daniel's new pride and joy is the state-of-the-art packing shed which has come into operation this season, in fact the day I visited was the first run through of the new shed. Punnets are mostly packed in the field and then checked, weighed and put through a metal detector in the shed, making the whole process more efficient.

Overseeing operations across all the states means Daniel is busy travelling as well as growing berries, so taking time out to share his knowledge with industry, and hosting events such as the Hydroponic Farmers Federation farm walk in October is greatly appreciated.

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Grower profile

Simon Dornauf: Hillwood Berries

STRAWBERRY INNOVATION

Growing from 'labour pains'

The Dornauf family has farmed in the Meander Valley, north of Launceston, for three generations. Their involvement with berries began 30 years ago, when Simon's father, Robin, began growing raspberries for domestic and export markets. Simon has since been involved in the berry industry for several years, including representing Tasmania on the peak industry body, Strawberries Australia.

Simon Dornauf, Hillwood Berries Farm Manager

Transitioning to soil-less production

Accessing and retaining labour became a pivotal turning point for the business, especially as other farms in the area moved to growing in substrate on table tops. Hillwood began to find the competition for seasonal workers to pick in-field strawberries too great to not change.

Living by Simon's mottos of "don't die wondering" and "why not have a crack?" Hillwood made the decision at the end of the 2016 season to convert 13 ha of strawberries to 10 ha of tabletops and 3 ha of raspberries.

The initial transition wasn't without its challenges. This was largely due to delays in ordering plants which resulted in a late start to production, with the first season's plants in substrate achieving a yield of only 900 grams of fruit per plant.

Production with table tops, however, has since made a big difference, including an increase in planting density from around 50,000 plants per hectare to 76,000 plants per hectare, and more more predictable crop availability when plants are grown under cover in substrate. Over the last 5 years, the first day of picking each season has been within a window of around 9 days.

SIMON'S ADVICE

For anyone wanting to move to protected cropping and substrate: 'You'll need a strong stomach'

Elevation of the plants on the table tops makes other aspects of crop management, such as pest control, simpler as the crop is easier to monitor.

Pest and disease problems still occur, such as powdery mildew early in the season, and botrytis later when temperatures drop and humidity increases, but having the plants at waist height makes it easier to control.

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Simon Dornauf: Hillwood Berries

STRAWBERRY INNOVATION

Simon has implemented a comprehensive integrated pest management (IPM) program, including releases of Persimilis to control two spotted mites, and Orius for Western flower thrip (WFT). Growing in substrate, Simon also adds Hypoaspis to the grow bags for beneficial biological activity, including the control of WFT larvae. Hillwood exclusively grow the Driscoll's variety Amesti. All fruit is field graded, weighed and packed and uses barcode traceability for quality control. Packed fruit is cooled on farm before distribution by Driscoll's.

Simon's advice to anyone wanting to move to substrate production under tunnels is to do as much research as you can, travel to see what is being done around the world, and a word of caution that you'll "need a strong stomach".

Simon recalls during one weather event watching 2 hectares of tunnel being "smashed in front of his eyes", including a 40 metre tunnel "turned into a pretzel".

Investing in people

Hillwood berries have not looked back from the decision to transition to soil-less production under Haygrove tunnels, which has helped them to source their labour through the seasonal worker program.

Hillwood first used the program via a labour provider, but have since moved to directly managing the seasonal worker program themselves. Simon says by managing the program he can have more control over the workers they hire and can also look after their workforce better. The business has also been pro-active in sourcing accommodation for their seasonal workers, which is provided in Launceston around 20 minutes from the farm.

In addition to having a strong focus on the quality of their product, Hillwood continues to invest in their team. Simon has forged a strong relationship with University of Tasmania, and has two full time agronomists on his team – which is

TIMELINE OF PROTECTED CROPPING PRODUCTION AT HILLWOOD BERRIES

2011: 2 ha of in-ground strawberry production established

2016: 18 ha developed for berry production on table tops with substrate

2017: 34 ha developed for berry production on table tops with substrate - including 1,200 tonne strawberries

In-field packing and quality control at Hillwood berries

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Grower profile

Paul Mancarella - Silvan, Victoria

STRAWBERRY INNOVATION

Paul Mancarella has been growing strawberries in Silvan, in Victoria's Yarra Valley for 43 years, in rich red soil, among gently rolling hills. The hilly nature of the Silvan area poses challenges for growers who want to minimise erosion and loss of soil from their farms. Additionally, many properties in this area have stream or river frontages, and it is important to minimise the environmental impact of soil and silt run-off into waterways to maintain water quality. Paul and his sons, John and Michael, recognise that their soil is an asset, and in 2015 they partnered with the Melbourne Water Rural Land Program, to improve their drainage management as to minimise the loss of their valuable topsoil and nutrients, and reduce their impact on Stringybark Creek at the bottom of their property.

PAUL SAYS

Soil is an asset. To help protect it, we participated in a program with Melbourne Water to improve drainage management and minimise the loss of valuable topsoil and nutrients as to reduce off-site impact on an adjacent creek

The aim of the project was to improve drainage and intercept the run-off from the property, prior to entering the waterway. Using a series of pits and stormwater drains to direct run-off and a sediment trap to slow the flow of water, the project has allowed sediment to settle before discharged into the creek. The on-ground works were co-funded by Melbourne Water, who provided the design and materials, while the Mancarellas provided the labour for earthworks and construction.

Before the project with Melbourne Water began, run-off from the strawberry blocks and farm tracks travelled downhill and discharged directly into Stringybark Creek. After heavy rainfall this run-off carried large amounts of sediment directly to the waterway, and the speed of the run-off caused erosion gullies which, according to Paul, could be as much as 1.2 metres deep.

The first part of the Melbourne water project was to direct the flow of run-off water using a shallow grassed drainage line to a newly constructed concrete pit. This pit was connected by 55 metres of 450mm stormwater pipe to a second concrete pit further down the slope. This allows effective drainage without causing erosion along surface drainage lines. These pits are designed so that sediment can collect in the pit without obstructing the flow, and can be cleaned out periodically. The covers are strong enough for tractors to drive over.

Next, a sediment pond was constructed downhill from the second pit. The sediment pond slows the velocity of the run-off and allows soil particles to settle out. It is around 2 metres deep, and can hold a large amount of soil before it needs to be cleaned out. Soil and silt settle in the pond, and the resulting clear water flows into a large diameter outlet at the pond surface and is discharged downstream onto rock beaching, before continuing down the natural watercourse to the creek. This ensures that the water discharged to the creek is free of sediment. There is a smaller outlet in the sediment pond which takes overflow water to the dam in very heavy downfalls.

Michael, John and Paul Mancarella

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Paul Mancarella - Silvan, Victoria

STRAWBERRY INNOVATION

PAUL FOUND

In situations where no structures are in place to intercept run-off, the heavy rainfall caused the movement of large quantities of soil in dams and waterways

Many parts of Victoria, including the Yarra Valley, experienced a major rain event over the first weekend of December 2017. The Mancarella's farm, like most in the surrounding areas, received in excess of 100mm of rain over the course of the weekend. Photos taken after this rain show the amount of sediment intercepted by the sediment pond, and the beached rock outlet, that would otherwise have finished up in the Stringybark Creek. The overflow from the sediment pond runs directly into the dam, which is used for irrigation, and this remained relatively clean after the rain. In contrast, in situations where no structures are in place to intercept run-off, the heavy rainfall caused the movement of large quantities of soil into dams and waterways.

In addition to the drainage works with Melbourne Water, Paul and his sons maintain good vegetated ground cover between the rows in their strawberry blocks, helping to hold the inter-row soil together, protect the soil surface and slow run-off from rain or irrigation to avoid erosion.

It is inevitable that heavy rain, particularly when blocks are empty or are being prepared for planting, will wash soil downhill. The advantages of managing runoff using

The sediment pond settling out suspended sediments in the water before overflowing through the outlet pipe (insert)

the type of structures the Mancarellas have put in place include keeping valuable topsoil on farm, and improving the water quality in both dams that catch run-off and waterways. Soil which collects in the sediment pond can be removed during maintenance and returned to the paddocks.

The project at the Mancarella's farm is a good example of how landholders can manage sediment run-off, protecting both their farms and adjoining waterways, by partnering with Melbourne Water under the Rural Land Program. This is an ongoing program, and interested landholders in the Yarra Valley are encouraged to contact Rowan Hore from Melbourne Water on 0428 709 708 or email rowan.hore@melbournewater.com.au

Visual comparison of water quality in Paul Mancarella's dam (left) with a dam on another strawberry property (right) following run-off after a major rain event in December, 2017

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Grower profile

John Hasan: Wandin, Victoria

STRAWBERRY INNOVATION

John Hasan is a second generation strawberry grower, whose family has been growing strawberries and other produce in Wandin since the 1930s. John is also the Chairman of the Victorian Strawberry Industry Development Committee (VSIDC), and involved in many other aspects of the industry. He and his wife Annette have grown strawberries on their farm for 26 years.

While not large growers, John and Annette grow a high quality product that finds its way to independent retail outlets and farmers markets, where their fruit commands premium prices. John attributes a lot of this success to his focus on the health and biology of his soil.

JOHN ASKS

'If you haven't got good soil, how can you grow good fruit?'

Over the years, John has worked with agronomists and industry to find new ways to improve soil health. John rests his soil, with a break of a year or more between crops, rotating with a green manure crop, such as Italian ryegrass. The benefits of this practice include returning organic material back to the soil, replacing the nutrients removed by the strawberry crop, and helping to break the life cycle of disease-causing organisms in the soil.

An innovative approach that John has taken to increasing his soil health is to use regular applications of soil additives that contain beneficial microorganisms (bacteria and fungi). Fumigation of the soil destroys disease-causing microorganisms, but it can also kill the beneficial fungi and bacteria, that play important roles in forming good soil. The application of beneficial microorganisms improve soil structure, and hence water-holding capacity, improve drainage and air movement in the soil, and break down organic material in the soil to release nutrients and produce humus.

In addition, beneficial microorganisms in the soil can protect the plant's root system against disease-causing organisms in the soil, much in the way that beneficial insects used in an IPM program work.

Even in the first year of using biological soil additives, John saw a difference in the health of his plants, and by the second year he saw a "massive" improvement in plant health and fruit yield. The plants also suffered less from stress in the hot weather last summer.

John and Annette

JOHN BELIEVES THAT

In the same way transitioning to using IPM to control insect pests in the crop is not immediate, using beneficial microorganisms is not an instant fix, as it takes time return the soil to health.

Some patience is needed, but John has seen major improvements in plant health and fruit production with subsequent seasons.

As well as working to increase the biological health of his soil, John also has regular leaf analyses done to help determine

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John Hasan: Wandin, Victoria

STRAWBERRY INNOVATION

the optimum inputs of fertilisers for his crop. This season, John will be working closely with an agronomist to really fine tune his fertilisation program.

USING THIS APPROACH

Of looking after his soil health and optimising fertiliser use, combined with a comprehensive IPM program, John believes he has more than halved his chemical use, and his use of pesticides has decreased by 85%.

While tying up useable land in rotation with green manure crops may appear to be detrimental to overall production, John disagrees. He says that even though he plants only half the plants he grew in the past, his fruit production is only down by 20%, because his healthier soil grows healthier and higher yielding plants. This coupled with the high quality of fruit commanding a price premium, means that John's business remains profitable.

With increasing pest and disease pressures in the industry, and increasing interest in producing clean, green food, John feels that looking after the soil, and decreasing chemical usage will become increasingly important in the future. While he acknowledges that the industry is changing, with an increase in the size of farms and amount of fruit produced, he feels there will still be room for smaller growers, but they will have to "do it better".

John's take home message – **"look after your soil, use IPM and grow quality fruit".**

John's farm

This project has been funded by Hort Innovation, using the strawberry research and development levy and contributions from the Australian Government. Hort Innovation is the grower owned, not-for-profit research and development corporation for Australian horticulture.

Appendix 5: Good Practice Guide

STRAWBERRY INNOVATION

Australian Strawberry Good Practice Guide

ACKNOWLEDGEMENTS

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- Kristen Stirling (Program Coordinator - Australian Strawberry Industry Development Program)
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- Lachlan Chilman (Managing Director – Biological Services)
- Apollo Gomez (Research Scientist - Queensland Department of Agriculture and Fisheries).

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Contents

Introduction

Like most horticulture in Australia, the strawberry industry is driven to deliver high quality product, whilst operating in a sustainable and profitable manner. Doing this isn't easy! To help those that may be new to the industry or those seeking a reminder of best practice, we have put together a resource which provides clear guidelines and practical advice on the best management practices associated with the production of strawberries in Australia.

We hope the Australian Strawberry Good Practice Guide also provides a useful reference to those outside of the strawberry industry, which demonstrates that Australian strawberries are produced in an environmentally sustainable manner.

This Guide has been developed by the Strawberry Industry Development Team with input from technical specialists as required. It outlines the key principles of effectively managing resources (such as water, soil and fertiliser), how to deal with pests and finally keeping your strawberries looking good once harvested. Each chapter provides clear objectives, recommended practices, signposts to other helpful resources online and a checklist of actions required to achieve your goal.

Further resources and electronic copies of each chapter are provided on the good practice page of the Strawberry Innovation website at www.strawberryinnovation.com.au.

We trust you share our vision of continual improvement within the industry and that you will find the Guide useful in achieving good practice.

Land and soil management

OBJECTIVE

- Improve soil performance
- Minimise soil loss and degredation

WHY IS IT IMPORTANT?

Soil structure

Good soil structure is vital for maximising soil water intake and plant growth, and minimising soil erosion.

Well-structured soils have a high proportion of large clusters of soil particles (water-stable aggregates) which are held together by organic matter. Bigger pores or air-filled spaces exist between individual aggregates of a well-structured soil (as seen in Figure 1-1). These pores remain open to receive water and nutrients and as a result, less water runs off the soil surface and plants thrive.

To promote good soil structure, care must be taken to minimise aggregate breakdown and encourage high organic matter levels. Frequent cultivation, faster tractor ground speed and heavy machinery all contribute to the destruction of soil aggregates and the break-down of soil stabilising organic matter. Working on soil that is too wet or too dry makes the problem worse.

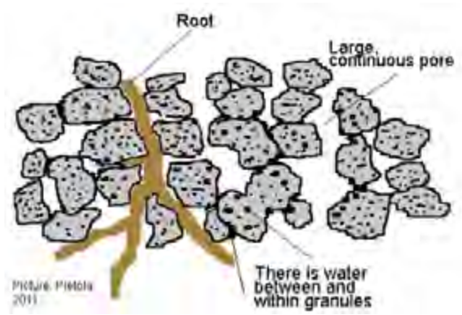

FIGURE 1-1: WELL STRUCTURED SOIL

To maintain and improve good soil structure you should establish an appropriate crop rotation, increase organic matter in the soil and follow good tillage practices, such as controlled traffic o minimum tillage programs.

Keeping soil in its place

Soil can move from your farm as a result of water erosion, when water comes in contact with exposed and/or unstable soils (soils with poor structure). Erosion can happen as a consequence of heavy rain, excess irrigation, or when drainage water from paddocks, farm tracks, protective cropping structures and areas around sheds and buildings moves across the land.

When water, either as rainfall or irrigation, falls faster than the soil can absorb it, it begins to flow over the soil surface. Flowing water, particularly when concentrated down bare slopes, has the potential to pick up and transport detached soil particles and associated nutrients. If the soil is covered with vegetation or mulch, raindrops are intercepted and soil particle detachment and splash are avoided.

Evidence of water erosion may include:

- Rills, gullies and tunnels
- Turbid water in farm dams or leaving the property, and
- Soil build up on fence lines or at the bottom of slopes.

To manage soil erosion caused by water, identify sites on your property that are at risk and if necessary, put control measures in place. Control measures include maintaining soil cover, controlling run-off water, improving soil structure and establishing

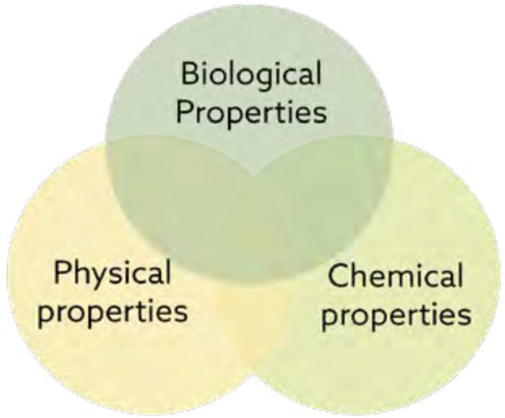

FIGURE 1-2: THREE COMPONENTS OF SOIL HEALTH

Increasing soil organic matter

Increasing soil organic matter is central to improving soil performance. Soil organic matter contains carbon which is the energy source for microbial activity in the soil.

Soil properties can be grouped into three components, physical, chemical and biological (Figure 1-2).

All three components must be managed to maintain or improve soil health. Soil organic matter is the most important component of your soil. It has potential to improve both the physical and chemical components of soil whilst improving:

- Crop performance and crop quality
- Nutrient and irrigation efficiency
- Infiltration and reducing compaction
- Nutrient holding and reducing nutrient leaching
- Pesticide efficiency

Improving soil performance through increased organic carbon, will improve strawberry productivity and help address environmental concerns.

Land and soil management

Soil organic carbon can be increased by the use of:

- Composted organic amendments
- Cover crops
- Reduced and alternative cultivation practices
- Selective ‘safe’ pesticides.

RECOMMENDED PRACTICES

Soil testing

Soil testing is a practical way to get a snapshot of soil health on your property. Soil testing is often done prior to planting a crop. It is also useful to conduct regular testing to follow changes in soil properties over time and under different management practices.

The results from soil testing can be used to optimise plant growth or assist in solving soil-related problems. Soil test results can be useful to guide management practices, such as deciding

whether to fertilise. They can also indicate problem areas in your soil, such as excess salts, high or low pH, problematic soil texture and adverse nutrient levels.

It is important to remember that a soil test report is only as good as the care taken in sampling, with the sampling method effecting the usefulness of any results.

Further information on soil sampling and testing can be accessed from the good practice page of the Strawberry Innovation website.

Management of cultivation and traffic

Frequent cultivation, fast tractor speed and heavy machinery all contribute to the destruction of soil aggregates and the break-down of soil stabilising organic matter. Working on soil that is too wet or too dry increased the problem.

Implementation of a minimum tillage approach is best practice. Minimum tillage is the minimum soil manipulation necessary for successful crop production. Key elements of minimum tillage in strawberry production include:

- Reducing cultivations to the minimum essential number through the establishment of permanent or semi-permanent beds
- Minimising the number of passes by combining operations such as hilling up and ripping wheel tracks
- Controlling traffic in the block to specific traffic lanes or rows
- Avoiding steep slopes and/or degraded areas
- Choosing tyned and non-inverting implements that are sharp and correctly adjusted.

The moisture level of your soil during tillage has a major effect on soil structure. Using heavy machinery when soils are too wet or dry should be avoided. Ideal moisture levels depend on soil type and texture. Cultivation should occur when moisture content makes the soil feel friable.

Land and soil management

Soil cover

Soil cover protects the soil from erosion by reducing the displacement (movement) of soil particles caused by rain or overhead irrigation droplets, and by slowing the movement of water across the site. It also slows and filters sediment from incoming rainfall or irrigation runoff, improves the movement of traffic, offers a cleaner environment for workers and promotes cleaner fruit by reducing soil splash.

Types of soil cover include:

- Grassed waterways on drainage and sump areas
- Inter-row groundcovers between strawberry mounds
- Green manure/cover crops planted between (in space and time) commercial crops
- Organic mulches, plastic, slashed inter-row material or crop residues spread over the exposed soil, and
- Products such as PAM (polyacrylamide), PVA (polyvinyl acetate) or molasses that bind soil together.

Drainage management

At times water runoff is unavoidable and as a result structures need to be positioned to ensure soil and nutrient losses are kept to a minimum. Controlling the direction of flow, volume and speed of water run-off on site can reduce soil erosion.

Types of soil cover include:

- Minimise the volume of external drainage affecting the site
- Prevent irrigation/rainfall runoff from hitting or moving over bare soil
- Create stable pathways that slow runoff water and allow any nutrient-laden sediment to drop out before it leaves the property or enters watercourses or dams
- Evaluate the need for and design of various drainage management strategies (grass headlands and buffer, cut-off drains, diversion banks, and grassed waterways).

Careful design, construction and maintenance of farm tracks is also essential to minimise sediment and nutrient movement. The compacted and exposed nature of farm tracks makes them vulnerable to erosion. Good planning and design at the outset can prevent many problems later.

Remedial action

If a hard pan or compaction layer is present, then additional cultivation may be needed. If the condition is not due to sodicity (high sodium content), cross-ripping when soils are friable will help to shatter the pan, loosening and breaking clods that will break down further when exposed to the weather. The benefits of deep ripping can be short term (around 1 year) unless actively growing roots enter the fracture lines.

Areas of active erosion should be managed through restricted access, reduced water flow and soil stabilisation through the establishment of vegetative cover.

Further information on managing cultivation and traffic, soil cover, and drainage can be accessed from the good practice page of the Strawberry Innovation website.

Land and soil management

Crop rotation

Rotating crops can improve soil structure, with crops such as grasses and legumes increasing the pore spaces through your soil. Deep-rooted crops can also recycle excess soluble nutrients like nitrate and sulphur from deeper in the soil profile and these crops add organic matter as the deep roots eventually break down. Roots help break up the soil and create pores to assist with movement of water through the soil.

Using green manure crops to increase organic matter will provide soil structure benefits through better soil aggregation. Decomposing plant material or organic matter produces gums and resins which assist in binding soil particles together to form aggregates and pore spaces. This helps optimise the soil's water-holding capacity, ability to hold nutrients, workability and water infiltration.

Soil amendments

Soil organic carbon provides many benefits for soil health including improved soil structure and aggregate stability, improved nutrient availability and providing a food source and habitat for organisms that live in the soil.

The organic carbon content of soil is the balance between inputs of carbon rich material (plant growth and additional material) and losses through decomposition, erosion and product removal. Where inputs are greater than losses, soil organic carbon increases.

Land and soil management

Soil organic carbon is influenced by a range of management practices that provide carbon inputs (including increasing biomass production, retaining crop residue and crop rotation/green manure crops) or decrease carbon losses from the soil (including reducing erosion and cultivation).

Applying high carbon soil amendments such as compost, biochar and some manures is also an effective way to increase soil organic carbon. Soil amendments can also be used to address specific soil limitations such as a lack of nutrients.

Selective 'safe' pesticides

In focusing on developing soil carbon levels, the use of pesticides is an important consideration. Soil biology is critical to managing soil organic carbon and can be seriously disrupted by a range of pesticides, including herbicides.

Further information on crop rotation and soil amendments can be accessed from the good practice page of the Stawberry Innovation website.

Land and soil management

There is an increasing number of selective pesticides which include biologically active material such as the bacterial caterpillar control chemistry based on Bacillus thuringensis. These 'softer' pesticides have reduced knockdown capability compared to some conventional pesticides and therefore should be integrated into a pest management program.

Herbicides can also be detrimental to soil biology and particular care in selecting 'safe' chemicals will be an important element of using and managing cover crops.

To read about how John Hasan is managing his soil health, go to the good practice page of the Stawberry Innovation website.

LAND AND SOIL MANAGEMENT PRACTICE CHECKLIST

The following checklist provides a quick, easy and actionable way to assess how well you are aligning your land and soil management to the recomended best practice.

TABLE 1-1: LAND AND SOIL MANAGEMENT PRACTICE CHECKLIST

RECOMMENDED PRACTICES	YES	NO	N/A	ACTION REQUIRED IN THE NEXT 12 MONTHS
Do you:				
Test the soil regularly (for pH, organic matter, nutrient levels, salinity, sodicity)?				
Implement a minimum tillage approach and time cultivation with ideal soil moisture levels?				
Rotate crops to include additional cash crops, green or biofumigation crops?				
Apply soil amendments such as compost, biochar or manure?				
Maintain soil cover within cash crops and between cash crops?				
Have safe stable pathways that slow runoff water?				
Improve the condition of eroded or degraded soil?				
Use selective 'safe' pesticides?				

HELPFUL RESOURCES

Healthy Soils for Sustainable Vegetable Farms: Ute Guide (Anderson, Kelly and McKenzie, 2007): http://www.hort360.com.au/wordpress/wp-content/uploads/2015/03/Healthy-soils-for-sustainable-farms-Ute-Guide.pdf

Soil Wealth and Integrated Crop Protection Website: www.soilwealth.com.au

Building Soils for Better Crops: http://www.soilwealth.com.au/resources/article-publication/building-soils-for-better-crops/

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PHOTO CREDITS

Image 1 and 5: Marty McCarthy 2015 ABC Rural

Image 4: Green Lake Sanitary District 2017

Image 6: Josiah Hunt 2010

STRAWBERRY FAST FACTS

The best sites for soil-grown strawberries:

- Are well drained with at least 25cm of soil above any impeding layer
- Have a soil pH in water between 6.5 and 7.0
- Have salinity less than 1 dS/m (EC of saturated extract).

Water management

OBJECTIVE

- Maximise water use efficiency
- Maintain water quality on-farm and downstream

WHY IS IT IMPORTANT?

Water quantity

Water is becoming increasingly scarce and expensive, therefore using water in the most efficient way is an important part of business management. Poor irrigation practices are usually the biggest culprit in inefficient water use. Improving irrigation practices will facilitate water savings and lead to better long-term environmental outcomes.

Irrigation efficiency can be maximised by:

- Checking that irrigation systems are operating to design specification and applying water as evenly as possible.
- Ensuring that the timing, or irrigation schedule, is based upon crop water needs and a clear understanding of the soil's water holding, infiltration and drainage capacity.

Good irrigation management is also essential to maximise yield and manage product quality. Strawberry plants have a relatively shallow and fibrous root system with the majority of roots in the top 30 cm. Moisture stress can seriously impact on strawberry plants in the form of reduced yields, small fruit size and poor quality. Conversely over-watering can impact on yield through reduced soil aeration, increase in root diseases and reduced fruit quality. It is important to keep soil moisture at optimum condition,

especially when the plant is flowering and developing fruit quality. The steps to maximising irrigation efficiency are discussed further in this chapter.

Water quality

The quality of water used for strawberry production should:

- Be suitable for the intended purpose
- Not negatively impact on downstream users and the environment

Using poor quality water on-farm can lead to problems associated with salinity (high total soluble salt content), sodicity (high sodium content), toxicity

(high concentration of specific salts in the soil) and blue-green algae (which may be toxic, clog irrigation equipment and cause corrosion of pipes and other equipment). Irrigation water for strawberries must be excellent quality, as strawberries are very sensitive to salts. The presence of chloride will impact on yield, even at very low levels.

Poor irrigation practices, such as over-watering, can result in more water being applied to the crop than the root-zone can hold. The excess water either runs off the surface of the property, potentially entering wetlands and waterways; or infiltrates below the rootzone to deep drainage. If this water is of poor quality (contains contaminants such as heavy metals, agricultural chemicals or high salt levels) it can cause disruption and damage to surrounding ecosystems.

Effective management of water quality relies on regular monitoring of water quality entering and leaving the farm. Establishing buffers around dams and waterways is also an effective way to filter sediment and nutrients from water before runoff enters waterways.

These techniques and others are discussed further in this chapter and in the land and soil management chapter.

> Strawberries can be grown using recycled water if it is available in your production area but it must be of Class A quality to meet food safety requirements. Further information on using recycled water is available on the good practice page of the Strawberry Innovation website.

RECOMMENDED PRACTICES

Irrigation efficiency

The key steps to improving irrigation efficiency include:

1. Knowing your soil (and how much water it can hold)
2. Designing an efficient irrigation system (use an expert)
3. Developing a water budget (have you got enough?)
4. Developing an irrigation schedule (monitor soil moisture)
5. Monitoring and maintaining irrigation system performance (is it doing what it should?)
6. Maintaining an appropriate water quality (how will crops, irrigation equipment, and the surrounding environment be affected?)

Water management

1. KNOWING YOUR SOIL

The type and texture of your soils will affect the amount of water readily available for crops and also the rate that water infiltrates the soil. A well-designed irrigation system increases water efficiency by minimising evaporation and avoids soil erosion by ensuring the application rate of the system is slightly less than the infiltration rate of the soil.

The infiltration rates of different soil types are shown in Table 2-1. To determine the texture of your soil using the ribboning technique refer to the good practice page of the Strawberry Innovation website.

For optimum water usage, it is important to be aware of the soil water-holding capacity in the root zone of a crop.

This is the amount of water in the soil between 'field capacity' (the point at which the soil cannot hold any more water) and the 'refill point' (the point at which soil moisture is so low that it slows crop growth and stresses the plants). Thus, the water-holding capacity of the soil indicates how much water is readily available for the crop.

The water-holding capacity or amount of 'Readily Available Water (RAW)' will vary with soil type (as shown above), crop rooting depth and irrigation system used.

Further information on how to calculate RAW can be found in the healpful resources section at the end of this chapter.

TABLE 2-1: BASIC INFILTRATION TYPES AND WATER-HOLDING CAPACITY FOR VARIOUS SOIL TYPES
(Adapted from tables by Brouwer et al (1998) and Ramsey (2007))

SOIL TYPE	BASIC INFILTRATION RATE (mm/hour)	READILY AVAILABLE WATER (mm/metre)
Sand	>30	30-40
Sandy loam	20-30	45-70
Loam	10-20	50-90
Clay loam	5-10	30-80
Clay	1-5	25-70

Soil moisture monitoring equipment can be used to estimate the water holding capacity of a particular soil type. Using soil moisture monitoring equipment is discussed in the section on 'Developing an Irrigation Schedule.'

2. DESIGNING AN EFFICIENT IRRIGATION SYSTEM

Ideally strawberry plants should be watered via combined systems of overhead and drip irrigation in conjunction with mulch to reduce evaporative losses. This combined system has the benefits of using less water, avoiding chemical wash-off, reducing leaf and fruit diseases, reducing fruit impact damage and allowing for effective fertigation. Drip irrigation is recommended throughout the season and overhead irrigation is recommended to assist the establishment of young plants, as a pest and disease suppressant or as a protection measure against heat.

Overhead irrigation

Overhead irrigation can be used to establish young plants (5 - 12 days after transplanting) and cool plants during times of severe heat.

When new runners arrive, they have no active roots. Reducing plant stress (wilting) by overhead irrigation promotes quicker root establishment and the take up of nutrients, enabling good plant growth. The frequency and duration of overhead irrigation will depend on the weather and condition of the runners at planting. Compact runners with smaller leaves require less irrigation as they have less leaf area than long large-leafed runners that lose water more readily.

If transplanting during hot temperatures (>30°C), cooling may be required 1–4 times an hour during the heat of the day until roots are established and drip irrigation becomes more effective. Irrigation at this level uses a lot of water. As the goal is cooling rather than irrigation, using low output micro-sprinklers can reduce water use by up to 60 per cent compared to impact sprinklers.

Drip irrigation should be used in addition to overhead irrigation during establishment to promote root establishment and prevent soils from drying out between planting holes.

Use a designer

Irrigation efficient systems work best when the pipe sizes, mains, valves, laterals and filtration and fertigation systems all synchronise as part of an overall scheme rather than being simply added on. Irrigation Australia Limited (IAL) Certified Irrigation Designers (CID) have the technical expertise and an up-to-date understanding of the latest water management practices to design, install, manage and maintain a wide variety of irrigation systems. To find a CID near you, and to find more information on irrigation system design in general, visit the IAL website: **www.irrigationaustralia.com.au**

3. DEVELOPING A WATER BUDGET

A farm water budget will help to determine if you have sufficient water to cover crop needs over the production season. Water requirements need to be budgeted using measurement of:

- crop water demand at different times of the year
- the irrigation system, and
- knowledge of the soil water holding capacity

Individual farm data is best, but average crop water demands can also be used. The total crop water requirement for strawberries has been estimated at 4.5-7 ML/ha depending on the irrigation system used.

This total water requirement consists of 3.5-4.5 ML/ha for seasonal crop usage and 1-2.5 ML/ha for establishment watering (*Growcom – Water for Profit*).

An example of a water budget can be seen in Table 2-2.

4. DEVELOPING AN IRRIGATION SCHEDULE

Scheduling irrigation requires an understanding of how much water your soil can hold and how much of that water your crop can use.

Evapotranspiration (dependant on sunshine and wind) and the impact of rainfall are altered by plastic mulch and structures such as protective cropping tunnels. Therefore, stand-alone evaporation-based irrigation scheduling does not work well for strawberries produced under these growing conditions. To determine how much and when to apply water to strawberry crops, it is best to monitor soil moisture. This can be done using a variety of soil moisture monitoring tools such as tensiometers, gypsum blocks or capacitance probes.

TABLE 2-2: EXAMPLE OF A WATER BUDGET
(Source: Lovell (2006))

AN EXAMPLE OF A WATER BUDGET: PROPERTY NAME: YEAR: INTENDED CROP:			
Crop	**Variety**	**Crop area (ha)**	**Water requirements/ha**
Strawberry	Red Rhapsody	1	4 x 1 ha = 4 ML
Strawberry	Rubygem	2	5 x 2 ha = 10 ML
Strawberry	Camarosa	0.5	6 x 0.5 ha = 3 ML
Total water requirement for the property			17 ML
Total water allocation for the property			20 ML
Sufficient water availability to grow intended crops?			Yes

When the soil is wet, the porous tip of the tensiometer or gypsum block allows water to move from the soil into the sensor, decreasing suction pressure or resistance. As the soil dries, water is sucked out, increasing the vacuum within the tensiometer and the resistance within the block. A reading of zero indicates saturated soil while below zero indicates a drying soil. Using this information, irrigations can be spaced to prevent tensions falling below desired levels.

Positioning of soil moisture probes is very important. If using drip irrigation, place sensors midway between a plant and a dripper. Probes will over estimate soil moisture if placed directly under a dripper. Place probes in a representative area of the crop and move them to different locations to confirm the reading before a final site is selected. A good setup is to have at least three probes, one measuring the top 15cm, one at 15–30cm and one below the root zone at 30–60cm (DAF, 2016).

In general, applying smaller volumes of water more frequently is far more effective than occasional heavy applications. Irrigation should commence when the 15cm tensiometer reaches -15kPa on lighter soils and -18 kPa on heavy soils. Irrigation should be stopped when the 30cm probe responds. This will help to minimise deep drainage.

There is a range of equipment that can be used to monitor soil moisture. These include tensiometers, gypsum blocks, neutron probes, capacitance probes and synthetic blocks amongst others. They vary in cost, ease of use and ability to log data continuously. As with irrigation system design it is best to discuss your needs with a professional to determine what equipment will work best for you.

5. MONITORING AND MAINTAINING IRRIGATION SYSTEM PERFORMANCE

Irrigation systems should be regularly checked and maintained to make sure they are operating at maximum efficiency. Key performance indicators that should be monitored include irrigation water use, system outputs, distribution uniformity and soil readily available water holding capacity.

> Further information on maintaining a drip irrigation system is available in the helpful resources section at the end of this chapter.

6. MAINTAINING APPROPRIATE WATER QUALITY

The key steps to maintaining or improving water quality include:

- Checking the quality of water entering and leaving the farm
- Protecting local watercourses
- Minimising soil erosion
- Protecting water quality - how is crop management impacting on water quality?

Individual farm data is best, but average crop water demands can also be used.

Water quality entering and leaving the farm

Check the quality of water used for irrigation particularly if starting a new enterprise. Good data should be available from your water supply provider. If using dam water consider doing a water test to determine salt levels. Remember that water quality will change throughout the year. Further information on the quality of water required for irrigation is provided in the fact sheet 'Irrigation water quality for strawberries'.

It is also worthwhile checking the drainage and run-off water leaving your property. If the water is high in nutrients and turbidity (water cloudiness), consider how crop management may be impacting on your water quality. This is discussed further in the section on protecting water quality.

Water quality entering and leaving the farm

Naturally waterlogged low-lying areas like drains, wetlands and vegetated areas along waterways (riparian area) should be retained and protected. These naturally-occurring zones trap, remove or treat a range of pollutants, including organic particles, suspended solids (SS), nutrients, pathogens, heavy metals and other toxic particles. A vegetated buffer strip consisting of dense perennial grass or native grasses, shrubs and trees also slows down runoff and reduces the erosion potential of water entering the adjoining water course or stream. It is recommended that vegetated buffer strips are also established between cultivated areas and waterways as well as on drainage lines that feed farm dams. Further information on protecting local watercourses can be found in the land and soil management chapter.

Minimising soil erosion

Minimising erosion of soil helps to protect soils and maintain water quality. High turbidity of run-off indicates soil loss is occurring and is most common after intense rainfall. Buffer zones or grassed areas can help to filter run-off and storm water.

> For further information on techniques to minimise soil erosion refer to the soil management chapter and associated fact sheets available on the good practice page of the Strawberry Innovation website.

Protecting water quality

There are a number of crop management aspects which have the potential to negatively impact on water quality.

These include:

- Nutrient management (ensure that nutrients stay in the plant root zone by applying fertilisers appropriately. This is discussed further in the nutrient management chapter and associated factsheets).
- Agricultural chemical management (store and apply chemicals properly – do not apply chemicals where they could drift into water).
- Pollution from fuels and oils (store and clean up fuel and oil spills appropriately – further information is provided in the chemical management chapter and associated factsheets).
- Packing shed water (monitor and if necessary filter used packing shed water to remove organic matter and chemicals before it is released back into waterways).

Further information on irrigation water quality can be accessed from the good practice page on the Strawberry Innovation website.

The following checklist provides a quick, easy and actionable way to assess how well you are aligning to the recommended best practice.

TABLE 2-3: WATER MANAGEMENT CHECKLIST

RECOMMENDED PRACTICES	YES	NO	N/A	ACTION REQUIRED IN THE NEXT 12 MONTHS
Do you:				
Know the water holding capacity and infiltration rate of your cropping areas?				
Use an IAL Certified Irrigation Designer to design and install your irrigation system? The proper design of sprinkler and drip systems ensures that the rate of application does not exceed the soil infiltration rate.				
Have a water budget for annual production?				
Know if your irrigation system can meet seasonal and peak water requirements?				
Undertake irrigation scheduling using continuous soil moisture monitoring with defined fill and refill points?				
Monitor irrigation system performance including measuring irrigation water use, system outputs, distribution uniformity and soil readily available water holding capacity?				
Check the quality of water entering and leaving your property?				
Retain existing drains, wetlands and riparian vegetation?				
Establish vegetated buffer strips between cultivated paddocks and waterways and on drainage lines that feed farm dams?				

Water management

HELPFUL RESOURCES

Irrigation Best Practice. Water Management of Soil and Substrate-Grown Crops. A Guide for Top and Soft Fruit Growers: http://www.ukia.org/pdfs/water%20management%20of%20soil%20and%20substrate%20grown%20fruit%20crops.pdf

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Water for Profit Fact Sheets. GrowCom: https://www.growcom.com.au/land-water/water-for-profit/resources-water-for-profit/

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PHOTO CREDITS

Image: Green Lake Sanitary District 2017

STRAWBERRY FAST FACTS

- Strawberries have shallow root systems with the majority of roots in the top 30cm of the soil profile. They respond better to frequent, smaller volumes of water rather than occasional heavy applications.
- Monitor soil moisture using three probes, one measuring the top 15cm, one at 15-30cm and one below the root zone at 30-60cm.

Nutrient management

OBJECTIVE

- The productive capacity of the soil is maintained without detriment to the environment

WHY IS IT IMPORTANT?

Most Australian soils are naturally low in nutrients. Nutrients such as nitrogen, phosphorus and potassium are essential for strawberry plant growth and fruit production. However, application of excessive nutrients can be detrimental to the production of quality fruit, harmful to the environment and a waste of money. By carefully managing nutrient application and soil fertility, production targets can be achieved without environmental harm. This can have the added benefit of improving efficiency and reducing costs.

Impacts on productivity and quality

Inappropriate management of plant nutrients can reduce productivity and the quality of fruit produced – including poor colour, flavour and texture.

Nutrient deficiencies are not the only potential issue. Over-fertilisation of strawberry plants with nitrogen can also lead to excessive leaf growth which has implications on fruit yield, fruit firmness, fruit ripening, the effectiveness of applied sprays and disease control.

Impacts on the environment

Environmental impacts from nutrient overload include degradation of groundwater and surface waterways, increase in soil acidity, salinity and sodicity problems and contamination of soil.

The nutrients most at risk of causing off-farm impacts are nitrogen and phosphorus. Nitrogen and phosphorus in dams, streams and rivers results in eutrophication causing dense growth of plant life such as water weeds and algae which degrades aquatic habitat.

Nutrient movement away from the production area must be avoided. Most nutrient loss results from:

- Inaccurate application
- Leaching past the root zone and into groundwater
- Moving as dissolved nutrients in surface water leaving farm paddocks
- Attaching to soil sediments and within organic particles in surface water leaving farm paddocks
- Attaching to wind-eroded soil particles, and
- Evaporation into the atmosphere.

Costs to farm businesses

For effective management of nutrient inputs it is important to determine the amount and type of nutrients to apply for each cropping situation rather than using recipe-type application rates. This can be done through soil testing and nutrient budgeting.

Inappropriate management of nutrients can lead to a range of costs to the farm

business, including:

- Loss of productivity and reduced yield
- Reduction in fruit quality
- Excessive and unnecessary application of fertilisers.

RECOMMENDED PRACTICES

Soil health

Good soil health is vital to ensure that plants are able to take up nutrients efficiently, as well as delivering a range of other long-term benefits. Good soil structure and root distribution as well as appropriate soil moisture management are prerequisites for any nutrition program. Organic matter management should also be considered to improve soil health and structure.

If soil structure, root growth and/or irrigation water quality are below optimum, nutrient availability and/or uptake will be affected. Further information on best practice for soil management can be found in the soil and land management chapter of this Guide.

Nutrient requirements

Understanding the nutrient requirements for a growing cycle will help to inform a nutrient management program. Objective methods such as soil testing and leaf analysis, combined with information on soil type, variety, yield data and visual assessments of crop health, provide the basis for good fertiliser management.

Fertilisers should be applied efficiently, taking seasonal conditions into account. This means applying just enough nutrients for good crop growth without providing excess nutrients that may be lost off farm into groundwater and surface waterways.

Soil test results and optimum soil nutrient levels should be discussed with an agronomist or soil consultant. Based on this interpretation and consideration of soil type, cropping history, specific crop needs and agronomy, a written fertiliser recommendation should be provided. This may include recommendations for adding lime, dolomite or gypsum.

Nutrient management

Leaf analysis can help to assess the nutrient status of berry plants in order to more accurately determine fertiliser requirements. The analysis provides an indication of the nutrient concentrations within the plant tissues, helping to identify deficiencies to guide nutrient applications. Visual assessment of plants can also provide information on nutrient status – see Table 3-1.

IMAGE 3-2: STRAWBERRY LEAF DISPLAYING SYMPTOMS OF IRON DEFICIENCY

TABLE 3-1: VISIBLE SYMPTOMS OF PLANT NUTRIENT DEFICIENCIES

Symptoms	Potential causes
Leaf symptoms	
Uniform yellowing	Nitrogen or sulphur deficiency (or poor soil drainage)
Yellowing with green veins	Zinc, manganese or iron deficiency
Dark and/or purpling foliage	Phosphorous deficiency
Leaf scorch	Potassium or magnesium deficiency (or spray burn and salt toxicity)
Growing points damaged with restrictive growth	Calcium or boron deficiency
Fruit symptoms	
Bumpy or misshapen fruit (poor pollination)	Boron deficiency (or: frost damage, high temps during flowering)
Hard/tight seed, small fruit	Calcium deficiency
Soft, poor colour and flavour	Potassium deficiency

IMAGE 3-1: TYPICAL SYMPTOM OF CALCIUM OR BORON DEFICIENCY. IT IS DIFFICULT TO DIFFERENTIATE BETWEEN THESE DEFICIENCIES IN THE FIELD.

IMAGE 3-2: TYPICAL SYMPTOM OF POTASSIUM OR MAGNESIUM DEFICIENCY. IT IS DIFFICULT TO DIFFERENTIATE BETWEEN BETWEEN THESE DEFICIENCIES IN THE FIELD.

Sap testing can also be used to develop nutrient uptake graphs, so fertiliser applications can be timed to the appropriate growth stage of the crop. Samples for sap testing need to be collected carefully and tissues analysed by an accredited laboratory.

For further information on how to collect leaf samples for analysis and new tissue nutrient reference levels for Victorian day neutral strawberries cv. "Albion" please refer to the Strawberry Innovation website.

Nutrient budgeting

Nutrient budgeting can help growers better understand the whole nutrient cycling and transformation system. This can lead to the design of more sustainable, integrated nutrition strategies. Nitrogen, phosphorus and other major nutrients are the main elements considered in nutrient budgeting. Along with soil, leaf and sap testing and visual assessments, nutrient budgeting is another tool for fine-tuning the nutrient management program. A nutrient budget should be prepared for a 3–5 year rotation.

A nutrient budget is like an accounting system for nutrients. It involves capturing information about the nutrients coming in and out of the system (see Table 3-2).

Nutrient management

The aim of the budget is to help ensure the appropriate levels of nutrition are available to support plant growth and fruit development through well-timed fertiliser applications. By understanding the level of uptake and removal in the target crop at a target yield (e.g. see Table 3-3), alongside the inputs/outputs outlined in Table 3-2, appropriate levels of additional fertiliser application can be calculated.

Nutrients that may be easily lost have to be applied as frequently as possible and amounts should be matched to the crop growth curve (rapid growth = higher demand) – so the timing/frequency of inputs may vary through the growing season. Trained agronomists should be able to help interpret the results of soil testing and provide guidance on target yields given local growing conditions. The guidance can help growers develop a reliable nutrient budget.

Nutrient application

Timing of applications

Applying fertilisers correctly is as important as using the correct amount and type of fertiliser. Effective fertiliser application involves the right rate, frequency, time and placement.

TABLE 3-2: LEVEL OF NUTRITION IN THE SOIL BASED ON LEVEL OF NUTRIENTS EITHER ALREADY EXISTING, ADDED AND REMOVED FROM THE SOIL

Budget	Types of inputs / outputs
Existing nutrient pool	• Available nutrients in soils (based on soil results)
Inputs	• Nutrient applications — calculate the amount of nutrients already applied to the paddock (such as fertilisers, manures etc) • Irrigation — calculate the amount of nutrients (especially nitrogen) that will be applied with irrigation water (50 ppm nitrate in irrigation water will add about 1 kg N/ha with every mm of irrigation water applied)
Outputs	• Uptake and removal by the target crop and the previous crop (in kg per tonne of grown crop) • Environmental losses — estimate the amount of nutrients that will be lost to the environment (through run off, leaching, erosion, gaseous losses etc.)

TABLE 3-3: EXAMPLE DATA ON THE REMOVAL AND UPTAKE OF MICRO-NUTRIENTS BY OPEN-FIELD OR PROTECTED STRAWBERRY CROP

		N	P_2O_5	K_2O	CaO	MgO
Removal (kg/MT fruits)		6-10	2.5-4.0	10-15	3.7-4.9	1.1
Yield level	**Uptake & removal by yield levels (kg/ha)**					
8 MT/ha	Plants uptake	49	21	83	29	6
	Yield removal	15	5	26	9	2
	Total recommended application rate	59	68	108	15	6
16 MT/ha	Plants uptake	81	34	138	48	9
	Yield removal	30	10	51	18	3
	Total recommended application rate	97	83	179	24	9
25 MT/ha	Plants uptake	118	48	200	68	13
	Yield removal	47	15	80	27	5
	Total recommended application rate	142	100	260	34	13
30 MT/ha	Plants uptake	129	51	218	75	14
	Yield removal	57	18	96	33	6
	Total recommended application rate	155	104	283	38	14
35 MT/ha	Plants uptake	147	59	250	85	16
	Yield removal	66	21	112	38	7
	Total recommended application rate	176	113	325	43	16

Generally, applying small amounts regularly is less likely to cause off-site losses from leaching and run-off. Fertiliser applications should be scheduled according to seasonal conditions, cropping cycle and periods of greatest use by the crop.

† Source: La Malfa, 1992 and Haifa NutriNet

See Figure 3-1 which outlines the 4R principle of nutrient stewardship.

Nutrient management

FIGURE 3-1: 4R PRINCIPLES OF NUTRIENT STEWARDSHIP

Pre-plant fertilisers

Pre-plant fertilisers should be incorporated. If there is a likelihood of heavy rain, minimise the amount of pre-plant fertiliser applied to reduce risks of fertiliser loss through leaching and soil wash from paddocks into nearby waterways. Band fertilising, or applying fertiliser to the top of prepared beds

prior to planting is preferred to general broadcasting, as it delivers the fertiliser close to plant roots.

Fertigation

Use fertigation (the application of dissolved fertiliser through a trickle irrigation system) to apply macro elements (nitrogen, phosphorus, potassium, calcium and magnesium). Applying nutrients close to the plant root zone during the growing period in this way, ensures plant nutrient uptake is maximised and nutrient loss is minimised. Banded, slow-release fertilisers are also useful to extend nitrogen availability to the plant and reduce the nutrient leaching potential

Restrict foliar applications of fertiliser to trace elements (boron, manganese, zinc and iron) unless specific macro deficiencies are evident.

Bulk organic or inorganic fertilisers

If bulk organic or inorganic fertilisers are used, they should be incorporated immediately if possible (e.g. animal manures), or stored for the shortest time possible, far away from dams and water. If stored, use the same carefully selected, dedicated storage area all the time

and don't disturb stored heaps. Use a relatively impermeable site and minimise drainage movement into and from these sites by using diversion banks, cut-off drains and grassed buffers. Preferably protect the stored heaps from rainfall.

Equipment

Fertiliser application equipment needs to be carefully calibrated and maintained to make sure it is capable of spreading fertiliser evenly at the correct rate. Refer to the manufacturer's specifications when carrying out calibration.

Detailed soil mapping can support precision application of nutrients using specialised equipment. This helps to identify areas within a field that require higher or lower nutrient inputs, allowing variable application rates to be used.

Record keeping

It is recommended that an accurate record be maintained of all fertiliser applications, including foliar applications and fertigation. This applies both to organic (e.g. sheep, cattle, chicken manure) and inorganic fertilisers (e.g. superphosphate). Detailed, accurate records of fertiliser applications will help to construct an up-to-date nutrient budget.

Soil test results for the paddock and sap and leaf tests for the crop should also be kept to support these fertiliser records. Fertiliser application records are essential for nutrient budgeting.

Nutrient management

CHECKLIST

The checklist below provides a practical way to easily determine how you are tracking with nutrient management in relation to best practice recommendations.

TABLE 3-4: NUTRIENT MANAGEMENT CHECKLIST

RECOMMENDED PRACTICES	YES	NO	N/A	ACTION REQUIRED IN THE NEXT 12 MONTHS
Do you:				
Test the soil, plant tissue and plant sap prior to nutrient application?				
Prepare a nutrient budget for a 3-5 year rotation?				
Keep fertiliser records to assist future fertiliser management decisions?				
Implement appropriate application of fertilisers and amendments (type, rate, frequency, timing and placement fertilisers and amendments)?				
Store fertiliser in a way that lowers the risk of seepage into surface waterways and groundwater?				
Ensure spreaders are correctly calibrated prior to use?				
Implement appropriate application methods of fertilisers and amendments (banding, fertigation)?				

Nutrient management

HELPFUL RESOURCES

Further information on nutrient requirements, budgeting and application include:

The Haifa Strawberry Crop Guide

https://www.haifa-group.com/crop-guide/vegetables/strawberry-fertilizer/crop-guide-strawberry-1

The Strawberry Fertiliser Guide by NSW Department of Industry and Investment

https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0020/333362/Strawberry-fertiliser-guide.pdf

Crop nutrient replacement: Calculator for fertiliser requirements

https://www.dpi.nsw.gov.au/agriculture/horticulture/tropical/fertilising/replacement

Horticultural fertigation – techniques, equipment and management
https://www.dpi.nsw.gov.au/agriculture/horticulture/tropical/fertilising/replacement

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PHOTO CREDITS

Image 3-1: Ting

Image 3-2: Strawberry problem solver and bug identifier by Queensland DPI 2005

Image 3-3: Strawberry problem solver and bug identifier by Queensland DPI 2005

Image 3-4: Strawberry problem solver and bug identifier by Queensland DPI 2005

STRAWBERRY FAST FACTS

- Good nutrient management can help to improve plant productivity and fruit quality, protect the environment and save money
- It is important to understand the nutritional requirement of your plants, and the level of nutrients available to them from their environment (e.g. through the soil, irrigation, and fertiliser applications)
- This information can help to develop an appropriate nutrition management plan, based on local conditions
- Agronomists or other suitably qualified experts can help to interpret soil test results and develop a nutrient budget

Pest management

OBJECTIVE

- Manage established pests in a cost effective and environmentally and socially responsible way

WHY IS IT IMPORTANT?

Harmful pests can impact on food safety, trade, market access, market development and, ultimately, the profitability and sustainability of plant industries. Australia is relatively free from many of the plant pests which seriously impact on agricultural industries in other countries. Through the absence of many pests commonly found overseas, Australia's plant industries have a valuable competitive advantage in terms of securing market access and maintaining lower production costs. If these pests found their way into Australia, the economic viability of Australia's plant industries could be directly threatened.

Once pests (any harmful insects, diseases and weeds) are established, the methods used to manage them are also important. Integrated Crop Protection (ICP) also known as Integrated Pest Management (IPM) considers all available pest control techniques and other measures that discourage the development of pest populations, while minimising risks to human health and the environment. For growers, ICP is the best combination of cultural, biological and chemical measures to keep weeds, insect pest numbers, disease pressure, and other crop production problems low enough to prevent significant economic loss.

By adopting management practices that effectively implement site-specific strategies for plant biosecurity and ICP, strawberry growers can contribute to the long-term protection and profitability of the industry. Working towards sustainable agriculture by implementing cost-effective, environmentally sound and socially acceptable ways of managing established and emerging pests and diseases will in the long run be beneficial to all growers.

RECOMMENDED PRACTICES

Biosecurity

Plant biosecurity is a set of measures designed to protect a crop from emergency pests. Farm biosecurity involves a set of management practices and activities that are carried out on-farm to protect a property from the entry and spread of pests. Key elements of plant biosecurity at a farm scale should include:

- Prevention: use simple biosecurity measures to protect the industry by keeping crops pest free and preventing movement of pests between regions.
- Awareness: make sure you, your farm workers and contractors are familiar with local and common pests and the most important strawberry pest threats (emergency/notifiable pests) for your region so that any new pests can be identified.
- Training: conduct biosecurity training sessions on your farm, during induction and refresher training; and use photos or posters to explain hygiene practices for workers, equipment and vehicles.
- Know your sources: ensure all propagation material (runners) and farm inputs are fully tested and pest free. Keep records (batch numbers, source) and retain a sample of your farm inputs. Be especially careful with second hand packaging, bins and machinery movements.
- Keep it clean: practicing good sanitation and hygiene will help prevent the entry and movement of pests onto your property. Workers, visitors and even you can spread pests, so make sure to clean dirt and plant material from any footwear, equipment or vehicles at point of

entry to your farm. Restrict the movement of people, vehicles and machinery on your farm.

- Use signage: inform visitors and contractors and remind staff of your biosecurity and hygiene measures and identify any problem areas on your farm to prevent weeds or pests from spreading.
- Check crops: monitor your crops frequently. Knowing the usual crop appearance will help you recognise new or unusual pests or plant symptoms. Keep written and photographic records of all unusual observations. Constant vigilance is vital for early detection of any exotic or new endemic pests.
- Abide by the law: support and be aware of laws and regulations established to protect the strawberry industry and other horticultural industries in your region, and
- Familiarise yourself with the Strawberry Industry Biosecurity Plan. The Strawberry Industry Biosecurity Plan is available from the Plant Health Australia website at www.planthealthaustralia.com.au

Pest management

> To find out more about how you can protect your farm, go to the farm biosecurity website at www.farmbiosecurity.

Integrated crop protection

Cultivated crops are exposed to pressures from pests (insects, weeds and diseases) and the general or manipulated environment. Pest pressures can be reduced by using an integrated approach to crop protection. Integrated Crop Protection (ICP), also referred to as Integrated Pest Management (IPM), focuses on the whole system including pests, the crops, the environment and soil (or growing media) health.

Good decision-making on crop protection requires consideration of the:

- Crop
- Potential and present pests (weeds, insects and diseases)
- Beneficial organisms (such as *Orius*, *Persimilis* and *Cucumeris*)
- Growing environment and wider environment
- Farm workers
- Market requirements

The ICP approach provides practical alternatives to conventional pest control, this means proactive monitoring and management of your crop rather than reliance on synthetic pesticide application on a calendar basis. This section outlines the:

- Key ICP principles
- Components of ICP
- Specific ICP steps
- General management tools and options in ICP.

For specific information on managing soilborne diseases, foliar diseases, chewing/biting insects, sucking insects (which sometimes carry and transmit viruses), and some stories of producers who have successfully applied ICP, see the fact sheets available on the good practice page of the Strawberry Innovation website.

Why adopt ICP?

Producers have reported that adopting ICP strategies has allowed them to:

- Regain control over chemical-resistant pests
- Minimise worker and environmental impacts
- Minimise synthetic pesticide use and residues
- Satisfy consumers and the marketplace
- Reduce costs
- Meet quality assurance requirements

Implementation of the basic principles of ICP (below) with the assistance of ICP experts is your best starting point. Embedding the principles into your practices, will maximise the benefits. Examples of where ICP has helped manage pest populations in strawberries are discussed in the factsheets on managing soilborne disease, foliar disease, chewing/biting pests and sucking pests available on the good practice page of the Strawberry Innovation website.

What is 'integration'?

Integration means combining two or more different management practices that are compatible, i.e. practices that work well together, not against each other. For example, an effective ICP system might include cultural measures like changing varieties or planting times, the release of beneficial organisms and the use of 'soft' pesticides. The aim is not zero pests, but rather sustainable pest management.

The most appropriate and effective crop protection programs are developed by teams that include producers, researchers and/or consultants experienced in ICP. They have specific knowledge and understanding of the stages of crop growth, key threats, impact of environmental conditions, and options available for protecting a crop from adverse events and organisms.

IMAGE 4-2: CHILEAN PREDATORY MITE PHYTOSEIULUS PERSIMILIS

Pest management

Producers and their advisers recognise prevention efforts are preferable to eradication attempts, and that biological balance is more sustainable than a 'zero pest' environment. Take steps that allow specifically-targeted decisions and actions.

ICP programs are unique to each season, each crop, and each region. You and your advisers will become skilled in evaluating the relative importance of pest variations year-to-year on your property, and what strategic adjustments are required to ensure continued improvement and timely responses.

The key components of an ICP Program

Knowledge – Learn about the key pests, their enemies and how they enter, grow, establish, spread, survive and affect your crop, in your growing environment.

KEY ICP PRINCIPLES

- Gain confidence in ICP through education, observation and action. Seek trusted, qualified advisers to get you started.
- Be proactive – aim for prevention rather than eradication. Don't wait for a crisis in pest control before you act.
- Access training in ICP principles for yourself and your staff.
- Commit time, effort and resources to ICP implementation. Use available resources – consultants, researchers, books, factsheets, internet.
- Know the history and nature of the pests in the seedling nursery and on your farm.
- Pests have natural enemies. Preserve and increase them. If they are available from an insectary, consider releasing reared natural enemies (known as 'beneficials').
- Make sanitation an on-farm priority.
- Monitor your crops and growing environment often.
- Record crop and pest observations eg. populations of pests and beneficials, susceptible varieties and stages of growth, weather events.
- Review treatment effectiveness: chemical coverage, performance, and resistance development.
- Understand why the 'integrated' approach increases your chance for success.

Pest management

Prevention and minimisation – Learn about the other factors that affect the relationship of the pests and the crop planting time and location, variety planted, crop rotations, and irrigation and nutrient management. Make decisions that reduce the potential impact of the pest, while promoting the crop's chance to avoid, tolerate or resist it, and economic levels of damage.

Monitor and Observe – Look at your crop often and learn how, when and where to look for signs of the pest, symptoms of disease, the pest itself, and its natural enemies.

Respond – Keep records of what you observe and learn how to interpret them. Know the relevant response options (including synthetic and soft pesticide treatments), the treatment thresholds (i.e. conditions or potential damage levels that indicate a treatment is required) and the critical timing of the responses.

Some key steps along your ICP pathway

Plant biosecurity is a set of measures designed to protect a crop from emergency pests. Farm biosecurity involves a set of management practices.

Knowledge:

- Know your suppliers (runners) and keep good records.
- Know your pests – have their identity confirmed, know their biology and behaviour, how they compete and their competitors, and the conditions conducive to their presence and spread.
- Understand and practise high-level site sanitation and worker and equipment hygiene.
- Know the effect of registered pesticides (chemicals used to control pests, including synthetic or biologically-derived biopesticides) on natural enemies and beneficials.
- Know the block history – previous crops, soil health, and the impact of pests, nematodes, weeds and diseases.

Prevention:

- Conduct pre-plant soil tests for soilborne pests, when appropriate.
- Only plant suitable material.
- Recognise 'normal' and 'abnormal' organisms, plant appearance, and responses to treatments.

Pest management

- Minimise plant stress – optimise soil preparation and soil health, water and nutrient applications.
- Avoid mechanical damage to plants.
- Remove plant debris, non-commercial vegetation and weeds that harbour pests.

Monitor and observe:

- Understand the weather forecasts of relevance.
- Monitor your crops and use experienced crop scouts to follow populations of pests and beneficials, and to identify and assess severity of diseases.
- Use sticky traps, pheromone traps, leaf wetness sensors, disease prediction models, and insect development models to assist in collecting data.

Respond:

- Set your goals! Plan and define your measures of 'success' and 'failure'.
- Consider planting schedule and crop sequence changes.
- Protect the environment – maintain and protect soil and water resources.
- Use pesticides only as needed. Do not rely solely on them.

What management options are available?

Cultural, physical or mechanical options – These options assist crops in avoiding, resisting or delaying interaction with the pest. They include site selection, fallow periods, crop-free periods on a regional level, planting date changes that consider pest flights and/or weather, minimising old/new crop overlaps, resistant varieties, crop rotation, roguing (removal of sick/dying plants), insect screens, positive greenhouse pressure, removal of pest habitats, establishment of refuges for beneficials, and/or restricted people movement.

Chemical options – These options involve using natural, biological, 'soft' or narrow-spectrum chemicals to alter pest behaviour, to attract pests for early warning and predictive purposes, to reduce the presence or impact of pests, and/or to change the attractiveness of the host crop. 'Chemical' options suited to ICP include pheromones, *Bacillus thuringiensis* (Bt) and biofumigation.

Pest management

Variety options – Resistant varieties limit the impact of pests and should be used whenever available and horticulturally acceptable.

To identify chemical options available for managing pests in strawberries, refer to the Strawberry Chemical Guide, available on the good practice page of the Strawberry Innovation website.

Biological options – These options rely on natural enemies or introduced organisms that limit the impact of a pest. Introduction of biological control agents also require the integration of crop management practices that boost or extend the habitats and populations of beneficials, parasitoids, antagonists and predators. Beneficials include all predatory insects, mites and spiders; parasitic wasps, nematodes and flies; and fungi or bacteria that attack pests or outcompete them for potential infection sites. Commonly seen beneficials include: ladybird

Pest management

beetles, *Orius* (a predator of thrips), *Eretmocerus* (a wasp that parasitises whiteflies), *Persimilis* predatory mites (which attack spider mites such as red spider mite or two spotted mite), and brown lacewings. These beneficials all play a significant role in ICP. There are a number of commercial suppliers of biological control agents and providers of ICP advice for strawberry pests.

For further information on integrated crop protection please visit the good practice page of the Strawberry Innovation website.

These include (but are not limited to):

- Bugs for bugs

  www.bugsforbugs.com.au

- Biological Services

  www.biologicalservices.com.au

- IPM Technologies

  www.ipmtechnologies.com.au

PEST MANAGEMENT CHECKLIST

The following checklist provides a quick, easy way to assess how well you are implementing best practice pest management and will help to identify any actions to improve your pest management.

TABLE 4-1: PEST MANAGEMENT CHECKLIST

RECOMMENDED PRACTICES	YES	NO	N/A	ACTION REQUIRED IN THE NEXT 12 MONTHS
Do you:				
Understand and recognise the major pests (insects, weeds and diseases) that affect strawberry crops?				
Ensure appropriate sanitation and hygiene practices occur on your property and when moving plant and equipment?				
Monitor for pests and beneficial organisms on a regular basis? Or use a consultant to monitor and advise for you?				
Manage pests in accordance with legal requirements?				
Use an ICP program to manage your farm, crops, native vegetation and other pest hosts to minimise the risk of pests establishing and spreading?				

Pest management

HELPFUL RESOURCES

Strawberry problem solver and bug identifier – Queensland Department of Primary Industries and Fisheries

Common insect pests of strawberries (Primefact 891 NSW Department of Primary Industries – https://static1.squarespace.com/static/57285e9e59827e6e7a1467f2/t/59b891a764b05fc68d92be42/1505268136670/Common-insect-pests-of-strawberries.pdf

Keep It CLEAN – Reducing costs and losses in the management of pests and diseases in the greenhouse. Download from the following link: http://www.dpi.nsw.gov.au/agriculture/horticulture/greenhouse/pest-disease/general/preventing/keep-it-clean

Controlling Invertebrate Pests in Agriculture. 2012. Book by Paul Horne and Jessica Page of IPM Technologies Pty Ltd. Order from CSIRO Publishing via the following link: http://www.publish.csiro.au/pid/6734.htm

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PHOTO CREDITS

Image 3-1: Photo courtesy of National Pork Board and the Pork Checkoff. Des Moines, IA USA

Image 3-2: Photo courtesy of Strawberry problem solver and bug identifier. Queensland Department of Primary Industries and Fisheries

Image 3-3: Photo courtesy of Dr Kristen Stirling. RMCG

Image 3-4: Photo courtesy of Dr Kristen Stirling. RMCG

Image 3-5: Photo courtesy of Strawberry problem solver and bug identifier. Queensland Department of Primary Industries and Fisheries

Image 3-6: Photo courtesy of Strawberry problem solver and bug identifier. Queensland Department of Primary Industries and Fisheries.

ABOVE: PREDATORY LADYBIRD BEETLE *HARMONIA CONFORMIS* FEEDING ON APHIDS

LEFT: BROWN LACEWING *MICROMUS TASMANIAE*

Postharvest handling of strawberries

OBJECTIVE

- Maintain fruit quality from farm gate to consumer
- Maximise fruit shelf life

WHY IS IT IMPORTANT?

Strawberries are highly perishable fruit, requiring careful handling and strict adherence to appropriate postharvest management practices to maintain optimal fruit quality after harvest. For maximum shelf life, strawberries require rapid removal of field heat, low temperature storage (0 to 1°C) and maintenance of cool storage during transport and distribution.

With optimal postharvest care and the appropriate cultivar, strawberries can have a shelf life of 7 to 10 days. To realise this potential, attention must be given to all aspects of product handling, packaging, and postharvest temperature and relative humidity management.

Good postharvest temperature management is the single most important factor influencing strawberry shelf and fruit quality.

It's important to realise that poor postharvest handling at any stage will reduce quality and shelf life. You cannot undo bad practice.

This chapter on strawberry postharvest handling has been developed for strawberry growers in Australia, to provide comprehensive technical information and recommendations on all aspects of postharvest care of strawberries.

RECOMMENDED PRACTICES

In the field

Agronomic practices

Rain events are associated with a higher level of fruit damage either due to fungal infection or snail and slug damage. Growers who produce under low cloches should install the cloches so that hoops are away from the edges of the raised beds. This means when the covers are raised and lowered the fruit on the outside rows stays dry instead of being subject to drips from the covers. Many growers are moving to high tunnels for this reason.

Other management practices including over-irrigation and over-fertilising can adversely impact fruit quality. Trials in Western Australia showed that levels of nitrogen in excess of 450kg/ha on sandy soils were attributed to poor fruit quality[1]

Hygiene

Good field hygiene impacts product quality in the field and continues through to the packing shed. Diseased or damaged fruit should not be left in the field, either on the ground between rows or in a heap elsewhere on the property. Reject fruit in the field serves as a source of inoculum, enabling the spread of disease onto both plants and

1 Hulcup & Phillips (2000) Nitrogen nutrition of strawberries in a temperate production system. DAFWA.

fruit. Overripe fruit left in the field can provide a breeding ground and habitat for unwanted pests such as fruit fly and stable fly. To help prevent the spread of disease from infected or rotting fruits to healthy fruit, pickers should use a separate container to store discarded fruit.

Ideally, workers removing damaged and diseased fruit should be different from those picking fruit for sale.

Harvesting

Strawberries should be harvested in the coolest part of the day where possible. Fruit should be dry to touch, as wet fruit is prone to develop postharvest fungal problems.

Growers in Australia use a variety of cultivation methods and produce at different times of the year. Those growing in rainy periods and without protected covers need to be particularly vigilant.

Strawberry fruit intended for export should not be picked when the pulp temperature exceeds 25° C. On hot days pulp temperatures may reach up to 30-35°C, as a rule of thumb however, pulp temperature is normally a few degrees less than ambient air temperature.

Warm fruit bruises more easily than cool fruit, as well as requiring more energy and cooling capacity to remove the field heat after picking.

Some strawberry varieties are particularly susceptible to bruising and must be picked at an earlier stage to avoid damage especially if being shipped.

Harvest frequency depends on many factors including the time of year and may be daily in warm weather. Early in the season when volumes are low it may be once or twice a week. Every three or four days is common in winter growing areas.

Strawberry fruit are very delicate and easily damaged. Since the harvest crew is responsible for grading, packing, and gentle handling, their training is critical to packing a quality product.

Trials in Western Australia evaluated the effect of normal commercial handling versus careful handling on the quality and shelf life of strawberries. Figure 5-1

Postharvest handling of strawberries

shows the difference in fruit quality one week after picking.[2]

Bruising as a result of commercial handling while picking and packing fruit is second to incorrect temperature control as the major cause of poor quality fruit in the market.

Growers face major limitations in this regard due to their dependence on regard due to their but there is still scope for improving fruit handling either through better training and education or by giving employees more ownership of the problem – for example, by rewarding better handling practices through a different system of remuneration.

Maturity

Strawberries are considered as non-climacteric fruit and in general do not ripen after picking.

2 Bhat & Reid (2010) Increasing the shelf-life of Australian strawberries. DAFWA.

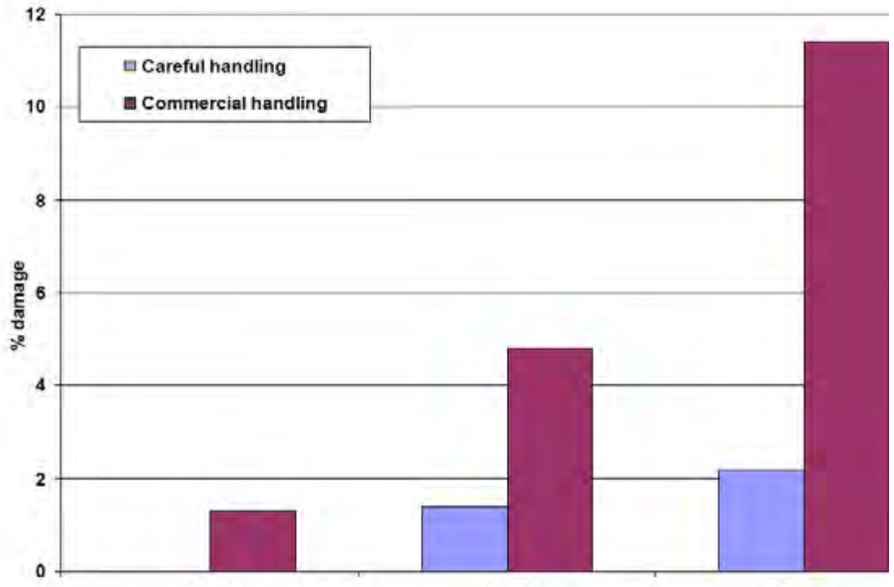

FIGURE 5-1: COMPARISON OF COMMERCIALLY PICKED AND CAREFULLY PICKED STRAWBERRIES AFTER ONE WEEK OF STORAGE (BHAT AND REID 2010)

However, some varieties can be harvested at 3/4 colour and will ripen sufficiently postharvest.

While maturity is commonly assessed by surface colour, trials as illustrated in Figure 5-2 have shown that colour is not always a good indication of flavour (favourable sugar/acid levels). Flavour varies between varieties and is also affected by a range of factors including sunshine hours, crop load and fertiliser program. Not all of these are within the producer's control.

Composition of Ripe Strawberry
Harvested at different stages.
Held at 70°F (21°C) to complete color change.

Maturity	% SS	% Acid	Ratio
25% color	4.28	0.80	5.35
50% color	4.56	0.79	5.77
75% color	4.98	0.68	7.32
100% color	5.48	0.59	9.28

FIGURE 5-2: RIPENING STAGES AND MATURITY INDICES OF STRAWBERRIES. CLOCKWISE FROM TOP LEFT: 0%, 25%, 50%, 75% AND 100%.
CREDIT: MARITA CANTWELL UC DAVIS

IMAGE 5-4: EXAMPLES OF PICKING TROLLEYS USED IN WESTERN AUSTRALIA

Postharvest handling of strawberries

IMAGE 5-3: COVERED WAGON USED FOR TRANSFER OF HARVESTED STRAWBERRIES FROM THE FIELD TO SHED

The best time to pick fruit may be based on external factors such as market preference and shipping time, consequently fruit are not always picked with full colour. Each variety will have its unique characteristics such as a white shoulder even when fully ripe. The depth and speed of colour changes will also vary with variety.

Picking aids

Most growers use some form of picking cart as a harvest aid. The carts are designed to be pushed in front of the picker and each holds up to about 20 trays of fruit.

Picking trolleys have a range of designs and many growers design their own to suit their particular planting configuration using locally and readily available materials as illustrated in Image 5-2.

Picking trolleys allow both hands of the picker to be used for harvesting, enabling greater worker efficiency. Fruit is subject to less bruising which ultimately assists shelf life.

As picking trolleys are filled, the trays of fruit are transferred onto racks for transfer to the packing shed as illustrated in Image 5-3.

Fruit should not be left in the sun. Trials using hessian to shade racks proved counterproductive due to reduced air flow. Fruit should be transferred to the packing shed as quickly as possible. It may be useful to impose time limits for the period that picked fruit is left in the field.

Field packing

If field packing, pickers should be properly trained to pack and grade the fruit directly into the final retail container at the time of harvest. The container must be large enough to easily hold the required weight of fruit without squashing or damaging it.

Over-ripe, under-ripe, diseased, or insect damaged fruit must not be packed. Grading fruit directly into the retail container at harvest time reduces the number of times fruit is handled, minimising bruising, improving quality, and minimsing costs.

Monitoring the harvesters and careful field supervision is critical to the success of the operation and the quality of the fruit. Picker performance can be extremely variable and workers may need to be reminded to handle the fruit with care. Pickers should not squeeze the berries and should place them gently in the market container.

IMAGE 5-4: EXAMPLE OF IN-FIELD PACKING AND QUALITY ASSURANCE IN TASMANIA

All fruit should pass through a final check to ensure correct weight and grading as demonstrated in Image 5-5. Where necessary, individual, poor quality fruit in some of the containers may have to be removed and replaced with good quality fruit. However, if field workers are properly trained in field packing, this should be minimal. Cartons should be kept in the shade and protected from the wind. An efficient system should be developed for inspecting the cartons prior to frequent delivery of the cartons to the cooler/cold storage facility.

Postharvest handling of strawberries

Transfer to shed

To maintain optimum quality and marketable life, fruit should be placed in a coolroom within one hour (or less) of picking.

The receiving area should be covered to shade the fruit from direct sunlight and protect against rain. The flow of product can be made more efficient by using conveyors, pallets, and hand pallet-jacks for moving the cartons from one area of the cooler/cold storage facility to another. If individual containers were not weighed in the field packing/inspection station, they will need to be check-weighed, prior to cooling.

In the shed

Quality requirements

Australia has no legislated standards for strawberries however quality standards are often set by the buyer. Quality criteria may cover aspects including:

- Appearance (colour, size, shape, freedom from defects and disease)
- Firmness
- Flavour (soluble solids, titratable acidity and flavour volatiles)
- Nutritional value (Vitamin C)
- Sugar content (does not increase after harvest). For acceptable flavour, a minimum soluble solids content of 7% and a maximum titratable acidity of 0.8% are recommended (Kader 1999).

Minimum requirements may require that the fruit be:

- Intact and undamaged
- Sound (produce affected by rotting or deterioration such as to make it unfit for consumption is excluded)
- Clean (practically free of any visible foreign matter)
- Fresh in appearance but not washed
- Practically free from pests or pest damage
- With the calyx and the calyx and stalk (if present) fresh and green
- Free of abnormal external moisture
- Free of any foreign smell and/or taste
- Sufficiently developed and displaying satisfactory ripeness.

The development and the condition must be such as to enable them:

- To withstand transportation and handling, and
- To arrive in satisfactory condition at the place of destination.

Postharvest handling of strawberries

Packaging

Strawberries are highly sensitive to compression and vibration damage and very susceptible to water loss, as a result packaging needs to provide physical protection to the fruit.

Strawberries are packed into a variety of container types and sizes. Materials used include polyethylene terephthalate (PET), recycled polyethylene terephthalate (RPET), polypropylene (PP), or PVC (poly vinyl chloride). Clamshells with a clip-on lid are most common, but heat seal plastic is also used. Plastic film wrap is less common. Net volumes are usually either 250 or 500g, but the actual punnet size may vary. The bottom of the clamshell (more usually 500g sizes) may be padded with bubble wrap to minimize vibrational damages. Larger punnets are used by some grower. They are easier to pack as staff don't need to be trained and less bruising occurs but logistically can be less efficient.

Clamshells are always vented to allow air circulation. This facilitates air movement and helps prevent condensation within the punnet which promotes postharvest diseases such as botrytis. The vents also allow effective forced air cooling.

Punnets (primary packaging) are placed in either cardboard cartons or returnable plastic trays and palletised for transport. Most trays hold 12 - 15 punnets.

Palletised strawberry cartons require some type of strapping or corner strips to stabilize the pallet load and prevent load shift in transit. It is very important to avoid overloading the pallet. Cartons should never extend beyond the edge of the pallet, because this will cause the cartons at the base of the stack to collapse, and possibly lead to the collapse of all cartons.

Cooling and refrigeration

Strawberries are extremely perishable. Begin cooling within one hour of harvest to avoid loss of quality and reduction in the amount of marketable fruit. Temperature management by cooling is the single most important factor in minimizing strawberry deterioration and maximizing postharvest life.

Postharvest handling of strawberries

The incidence and severity of decay, mainly caused by Botrytis and Rhizopus, can be reduced by around 25% if the fruit is properly pre-cooled. Cooling extends shelf life by reducing:

- respiration rates
- water loss
- ethylene production
- sensitivity to ethylene
- microbial development (spoilage).

Fruit which is not cooled after harvest deteriorates rapidly and may only have a shelf life of 1-3 days. A delay of 4 hours before refrigeration will result in one-third of fruit becoming unmarketable after seven days (Figure 5-3).

Once fruit is cooled it should be kept cool because cycles of warming and cooling produce condensation on the fruit leading to Botrytis and other storage diseases. Any break in the cold chain (0 to 1° C) will decrease shelf life significantly.

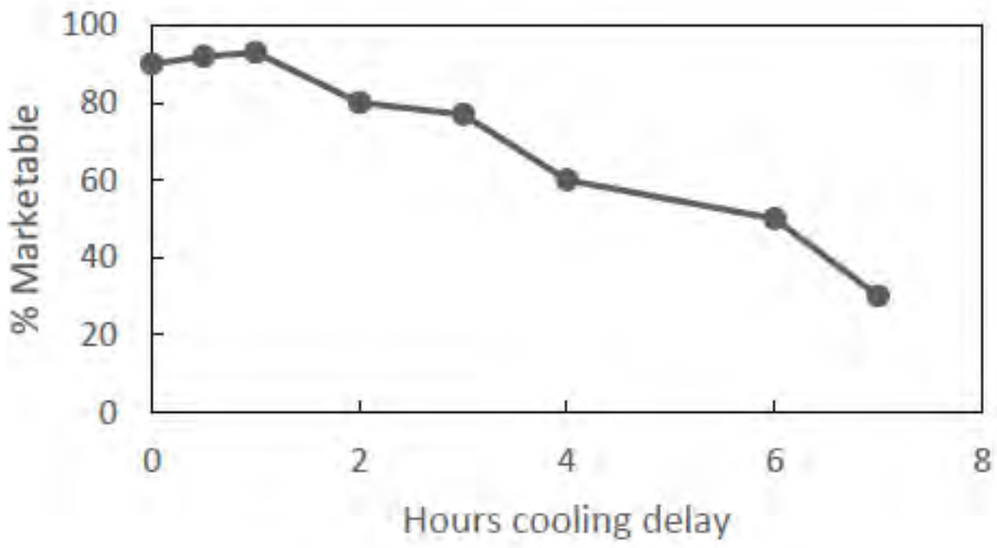

FIGURE 5-3: EFFECT ON COOLING DELAY AFTER HARVEST ON THE MARKETABILITY OF STRAWBERRIES (REDRAWN FROM MITCHAM ET AL 1996)

Postharvest handling of strawberries

The packing shed should be designed for a smooth and rapid flow of product from the field to the grading and packing area, into the forced-air cooler and then to the coolroom at 0 to 1°C.

Packing sheds can be insulated and cooled. Evaporative cooling is useful, particularly when ambient humidity is low. Packing and grading areas may be air-conditioned or even refrigerated to about 15°C.

Refrigerated storage

Strawberries lose water rapidly after harvest. To prevent fruit shrivelling and wilting or dehydration of the green calyx it is important to maintain a high relative humidity (RH) during postharvest handling. The optimum RH for strawberries is 90 to 98 %.

Strawberry fruit can be stored for up to 7 days at 0 °C depending on disease pressure. Strawberry flesh freezes at between 0.6°C and -0.8°C, depending on total soluble solids content.

Many strawberry growers do not use humidified coolrooms. Their reasoning is that fruit is highly perishable and never held long enough for humidification to make a difference.

There are various way of maintaining a high RH during storage. They range from wetting the floor, or having open containers filled with water. Both are inexact methods and not advisable from a food safety point of view. A better method is to use an automatically controlled fogging or humidification system.

Ethylene Production and Sensitivity

Strawberries produce very low amounts of ethylene (<0.1 µL kg-1 h-1 at 20°C). They do not respond to ethylene. However, the removal of ethylene from storage air may reduce disease development.

Transport

Cartons should be removed from the coolroom and loaded into a pre-cooled refrigerated truck (near 0°C) without breaking the cold chain. Ideally, strawberries should be transported to the market destination the same day they are picked.

IMAGE 5-7: COMPARISON OF NON-INSULATED (LEFT) AND INSULATED (RIGHT) BERRIES AS RECEIVED IN SYDNEY

Cooled strawberries that are allowed to re-warm will have condensation on the inner surface of the plastic container and the fruit. This will increase their susceptibility to fungal decay and reduce transit are essential to minimize post-harvest decay as highlighted in the comparison quality photos in Image 5-7.

Temperature logging in transit

Maintenance of the cold chain and temperature monitoring should be an integral part of quality control. fruit shelf life. Even a small amount of botrytis can spread rapidly from one infected fruit in the container to all adjacent healthy fruit throughout an entire carton. Low temperatures during Temperature records can be used to support any potential claims on arrival or due to delivery delays. Temperature recorders are usually placed 1.5 m above the floor (for ease of checking) about two-thirds the way to the back of the vehicle. They should not be placed in a cold area such as near the air discharge of the refrigeration unit.

Thermal blankets

Another method used to maintain the cold chain during transit is to over-wrap the stack of cartons on the pallet with a foil laminated thermal blanket (Image 5-8). The external foil surface of the thermal blanket reflects ambient heat while the air pockets inside the insulation material keep out heat. Thermal blankets can maintain a temperature of 3°C within the cartons for up to 36 hours.

Thermal sea transportation

Trial overseas shipments of pre-cooled and insulated fruit consignments from Perth to Singapore have been encouraging. Fruit arrived in very good quality, even after 12 days of sea transit, and compared very favourably with inappropriately handled fruit that arrived within a day by air at Freshmart Singapore from Perth.

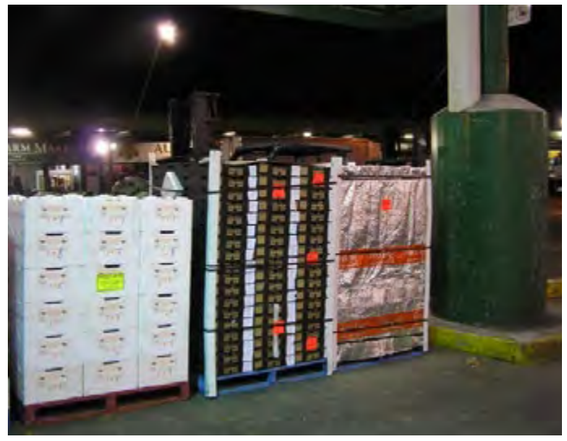

IMAGE 5-8: PALLETS WITH FOIL LAMINATED THERMAL BLANKET

Postharvest disenfestation treatments

Methyl bromide fumigation is routinely used for strawberries shipped to Tasmania or exported to certain overseas countries such as Thailand.

CA-04 is the quarantine standard for fumigation with methyl bromide and is available from the interstate quarantine website:
http://www.interstatequarantine.org.au

Effective fumigation in an approved fumigation chamber takes two hours and has a time versus temperature relationship as shown in Table 5-1.

Methyl bromide fumigation has a detrimental effect on strawberry quality and shelf life. Berries are softer and darker in colour than unfumigated berries and the calyx browns prematurely. There is an increased incidence of leak and decay. This may be partly due to having to delay fruit cooling prior to fumigation. Fruit is not generally cooled and then warmed prior to fumigation as this promotes condensation on the fruit surface. Wet fruit is subject to increased damage from fumigation.

TABLE 5-1: TIME AND TEMPERATURE RELATIONSHIP OF EFFECTIVE FUMIGATION

Temp °C	Rate g/m³
10-10.9	56
11-15.9	48
16-20.9	40
21+	32

Irradiation

Queensland is the only state with a facility large enough to treat commercial quantities of fruit however irradiation is not yet permitted for strawberries in Australia as a postharvest treatment.

Irradiation is far superior to methyl bromide for controlling postharvest rots however irradiated fruit also softens noticeably after treatment. The response of strawberries to irradiation varies markedly with cultivar with some cultivars able to withstand higher rates of irradiation than others without a decline in quality.

Postharvest diseases and disorders

Information on postharvest diseases and disorders is available on the good practice page of the Strawberry Innovation website.

Postharvest handling of strawberries

HELPFUL RESOURCES

USDA ARS Agriculture Handbook Number 66. Revised February 2016. The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks

https://www.ars.usda.gov/northeast-area/beltsville-md-barc/beltsville-agricultural-research-center/food-quality-laboratory/docs/ah66/

Kitinoja L and Kader AA. Postharvest Horticulture Series No. 8E July 2002. Slightly revised November 2003. Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops (4th Edition)

http://www.fao.org/docrep/009/ae075e/ae075e00.htm

California Strawberry Commission 2011. Maintaining Quality of Fresh Strawberries.

http://www.calstrawberry.com/en-us/promotional-resources/retail

CHECKLIST

The following checklist provides a quick, easy and actionable way to assess how well you are aligning to the recommended best practice.

TABLE 5-2: POSTHARVEST HANDLING OF STRAWBERRIES CHECKLIST

RECOMMENDED PRACTICES	YES	NO	N/A	ACTION REQUIRED IN THE NEXT 12 MONTHS
Is the fruit being picked out of the withholding period for pesticides?				
Are pickers adequately trained to pick fruit of the appropriate stage and quality?				
Is the time between fruit being picked and transported to cool storage less than one hour?				
Are packers trained to handle fruit with care and inspect for defects and foreign bodies?				
Is the packing shed set up to enable efficient product flow?				
Are temperature fluctuations in the coolroom and transport kept to an absolute minimum?				

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https://infostore.saiglobal.com/en-au/Standards/ASHRAE-HDBK-REFRIGERATION-2014-1850821/

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https://content.ces.ncsu.edu/forced-air-cooling

http://www.trj-inc.com/forcedAirCool.html

http://www.postharvest.net.au/postharvest-fundamentals/cooling-and-storage/cool-rooms/

This chapter on postharvest handling of strawberries has been developed by Aileen Reid, Strawberry Industry Development Officer for Western Australia.

STRAWBERRY FAST FACTS

For best quality fruit:

- Remove field heat as soon as possible
- Do not allow fruit to cycle between warm and cool temperatures.
- Keep fruit as close to 0°C as possible.

STRAWBERRY INNOVATION

Australian Strawberry Good Practice Guide 2019

Appendix 6: Posters

1. Queensland Fruit Fly Identification
2. How ‘clean’ are our strawberries?
3. Want to identify major strawberry pests and beneficials?

QUEENSLAND FRUIT FLY

Have you seen any of these?

Well-developed larvae of Queensland fruit fly.

Soft, water-soaked area. Typical of fruit fly infestation.

...If yes, please report it to your manager.

Photos courtesy of: Biosecurity Queensland's ICA-34 Operation Procedure, Hort Innovation, Angela Atkinson.

Who to contact for more support

Tasmania	Exotic Plant Pest Hotline	1800 084 881
South Australia	Fruit Fly Hotline	1300 666 010
Western Australia	Pest and Disease Information Service	1800 084 881
Victoria (Yarra Valley)	Regional Coordinator Agriculture Victoria	0490 381 999 13 61 86
Queensland	Department of Agriculture & Fisheries	13 25 23

STRAWBERRY INNOVATION

Hort Innovation Strategic levy investment | STRAWBERRY FUND

This poster has been funded by Hort Innovation, using the strawberry research and development levy and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for Australian horticulture.

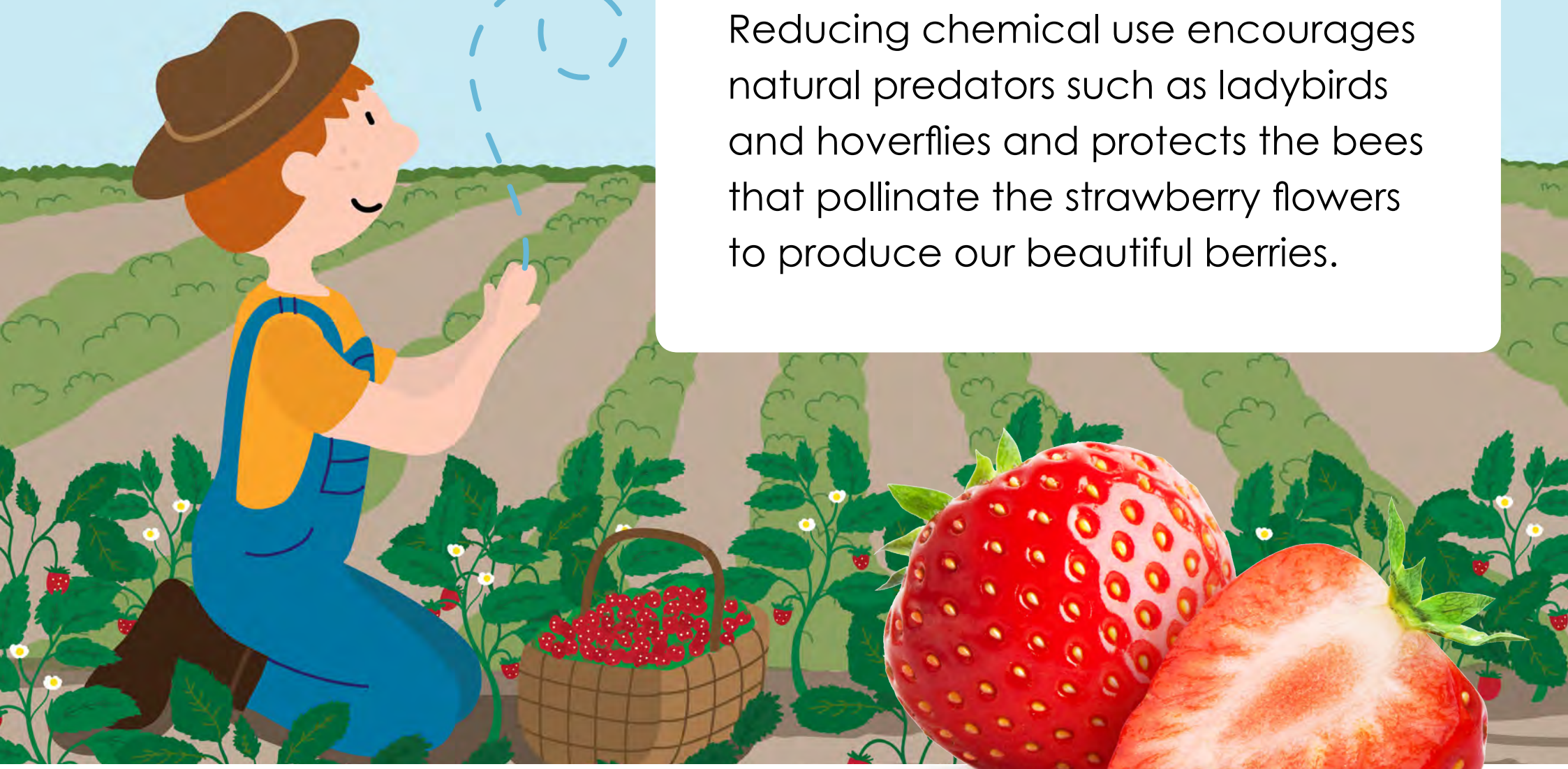
How ‘clean’ are our strawberries?

As growers, we are often asked how we control pests and diseases in our strawberries.

In Australia, strawberry growers use **Integrated Pest Management (IPM)** to control insect pests in their crops. An important part of IPM is using ‘good bugs’ to control ‘bad bugs’.

Instead of using chemical pesticides, strawberry growers buy ‘good bugs’ and release them into their strawberry fields.

Reducing chemical use encourages natural predators such as ladybirds and hoverflies and protects the bees that pollinate the strawberry flowers to produce our beautiful berries.



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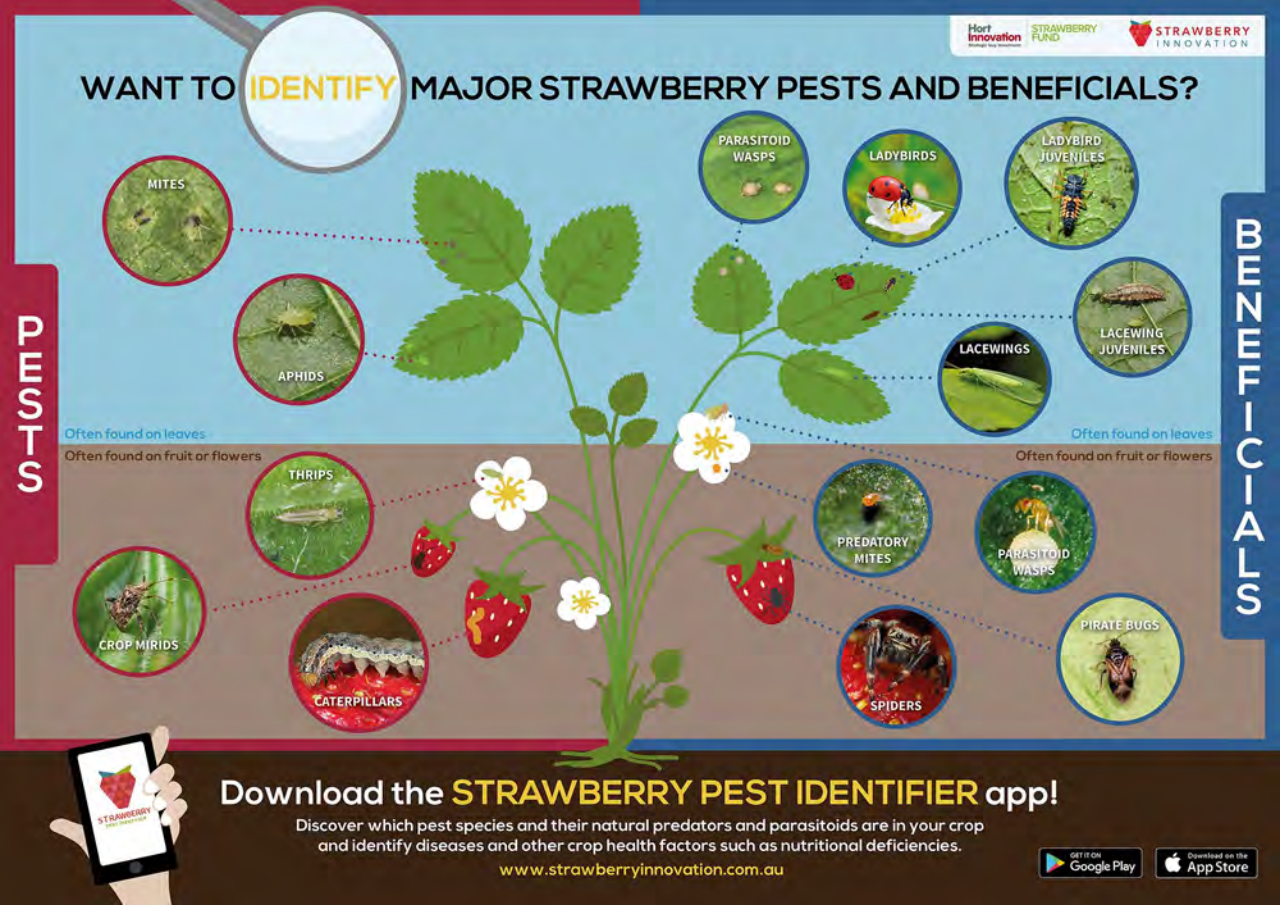
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STRAWBERRY FUND
STRAWBERRY INNOVATION
WANT TO IDENTIFY MAJOR STRAWBERRY PESTS AND BENEFICIALS?
PESTS
BENEFICIALS
MITES
APHIDS
PARASITOID WASPS
LADYBIRDS
LADYBIRD JUVENILES
LACEWING JUVENILES
LACEWINGS
Often found on leaves
Often found on fruit or flowers
THRIPS
CROP MIRIDS
CATERPILLARS
PREDATORY MITES
PARASITOID WASPS
PIRATE BUGS
SPIDERS
Often found on leaves
Often found on fruit or flowers
Download the STRAWBERRY PEST IDENTIFIER app!
Discover which pest species and their natural predators and parasitoids are in your crop and identify diseases and other crop health factors such as nutritional deficiencies.
www.strawberryinnovation.com.au
GET IT ON Google Play
Download on the App Store

Appendix 7: Postcards

1. Red Rhapsody – Export
2. Red Rhapsody
3. QHI Sugarbaby
4. Sunglow ASBP
5. Venus ASBP
6. Parisienne Kiss
7. Sundrench
8. Meadowsong
9. Suncoast Delight
10. DPI Rubygem
11. Scarlet Rose ASBP
12. Ausiegem.

RED RHAPSODY

Class: Export (250 gm flat pack punnet)

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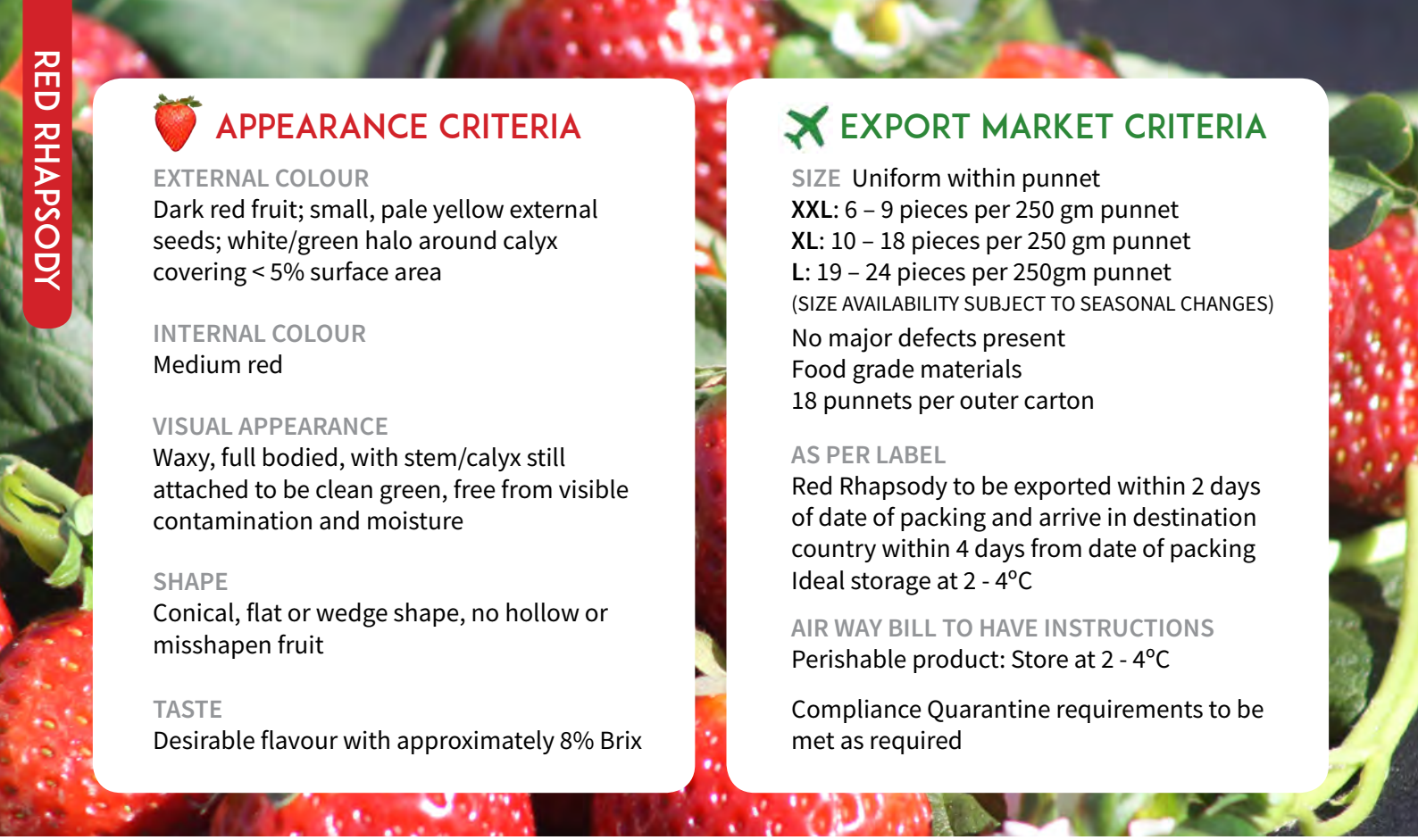
RED RHAPSODY



APPEARANCE CRITERIA

EXTERNAL COLOUR
Dark red fruit; small, pale yellow external seeds; white/green halo around calyx covering < 5% surface area

INTERNAL COLOUR
Medium red

VISUAL APPEARANCE
Waxy, full bodied, with stem/calyx still attached to be clean green, free from visible contamination and moisture

SHAPE
Conical, flat or wedge shape, no hollow or misshapen fruit

TASTE
Desirable flavour with approximately 8% Brix

EXPORT MARKET CRITERIA

SIZE Uniform within punnet
XXL: 6 – 9 pieces per 250 gm punnet
XL: 10 – 18 pieces per 250 gm punnet
L: 19 – 24 pieces per 250gm punnet
(SIZE AVAILABILITY SUBJECT TO SEASONAL CHANGES)
No major defects present
Food grade materials
18 punnets per outer carton

AS PER LABEL
Red Rhapsody to be exported within 2 days of date of packing and arrive in destination country within 4 days from date of packing
Ideal storage at 2 - 4°C

AIR WAY BILL TO HAVE INSTRUCTIONS
Perishable product: Store at 2 - 4°C

Compliance Quarantine requirements to be met as required

FOOD SAFETY Produce is grown under and packed under a HACCP based food safety program that is subject to an annual third party audit. A copy of current certification certificate is available on request. All chemicals used pre/postharvest are registered and approved for use in accordance with the requirements of the APVMA regulatory system. Residues, Contaminants and Heavy Metals to comply to the FSANZ Food Standards Code ML's and MRL's. Will be modified to suit any differences in import country or customer requirements.

RED RHAPSODY

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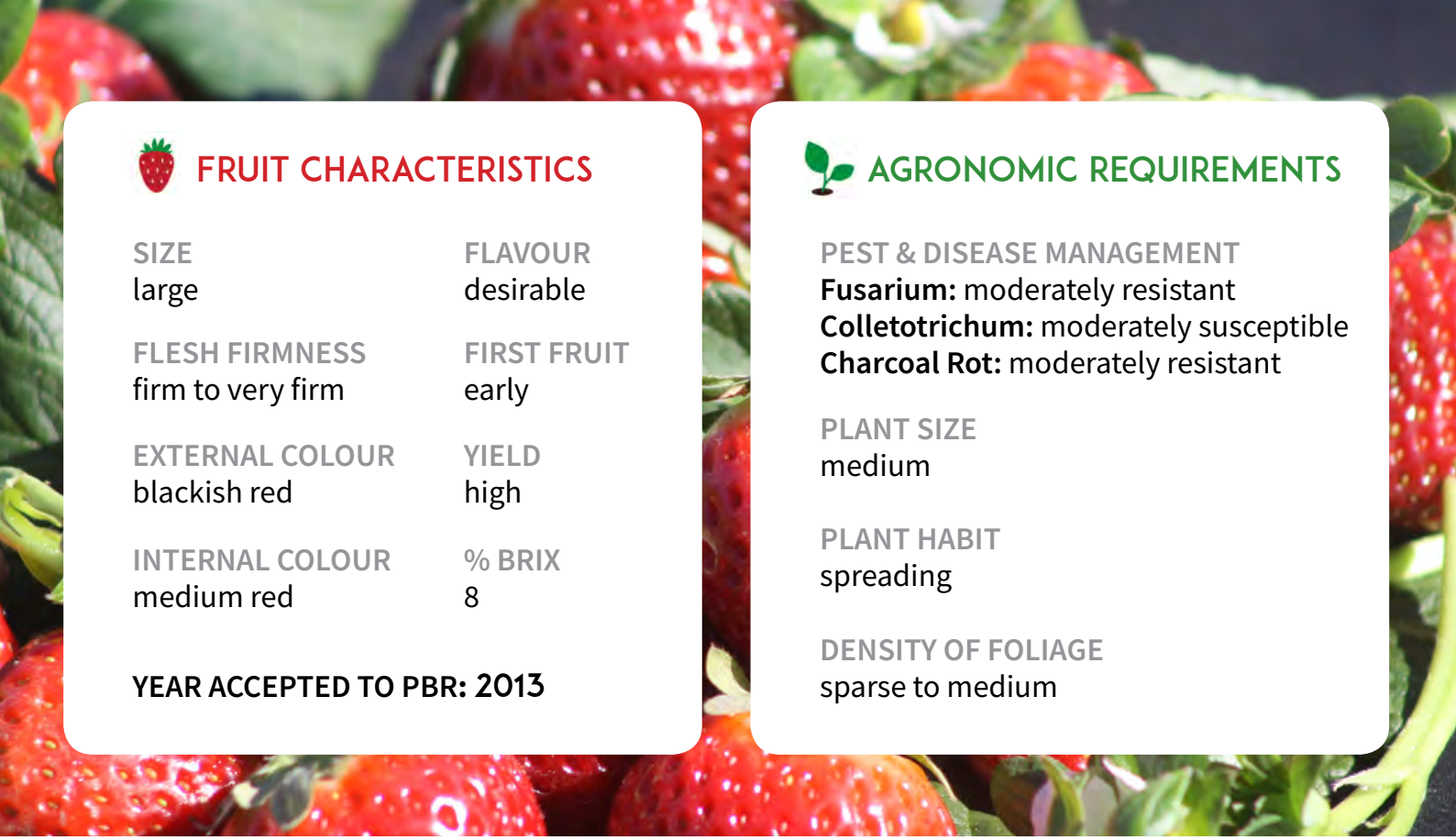
STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
large

FLAVOUR
desirable

FLESH FIRMNESS
firm to very firm

FIRST FRUIT
early

EXTERNAL COLOUR
blackish red

YIELD
high

INTERNAL COLOUR
medium red

% BRIX
8

YEAR ACCEPTED TO PBR: 2013

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: moderately resistant
Colletotrichum: moderately susceptible
Charcoal Rot: moderately resistant

PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
sparse to medium

RED RHAPSODY

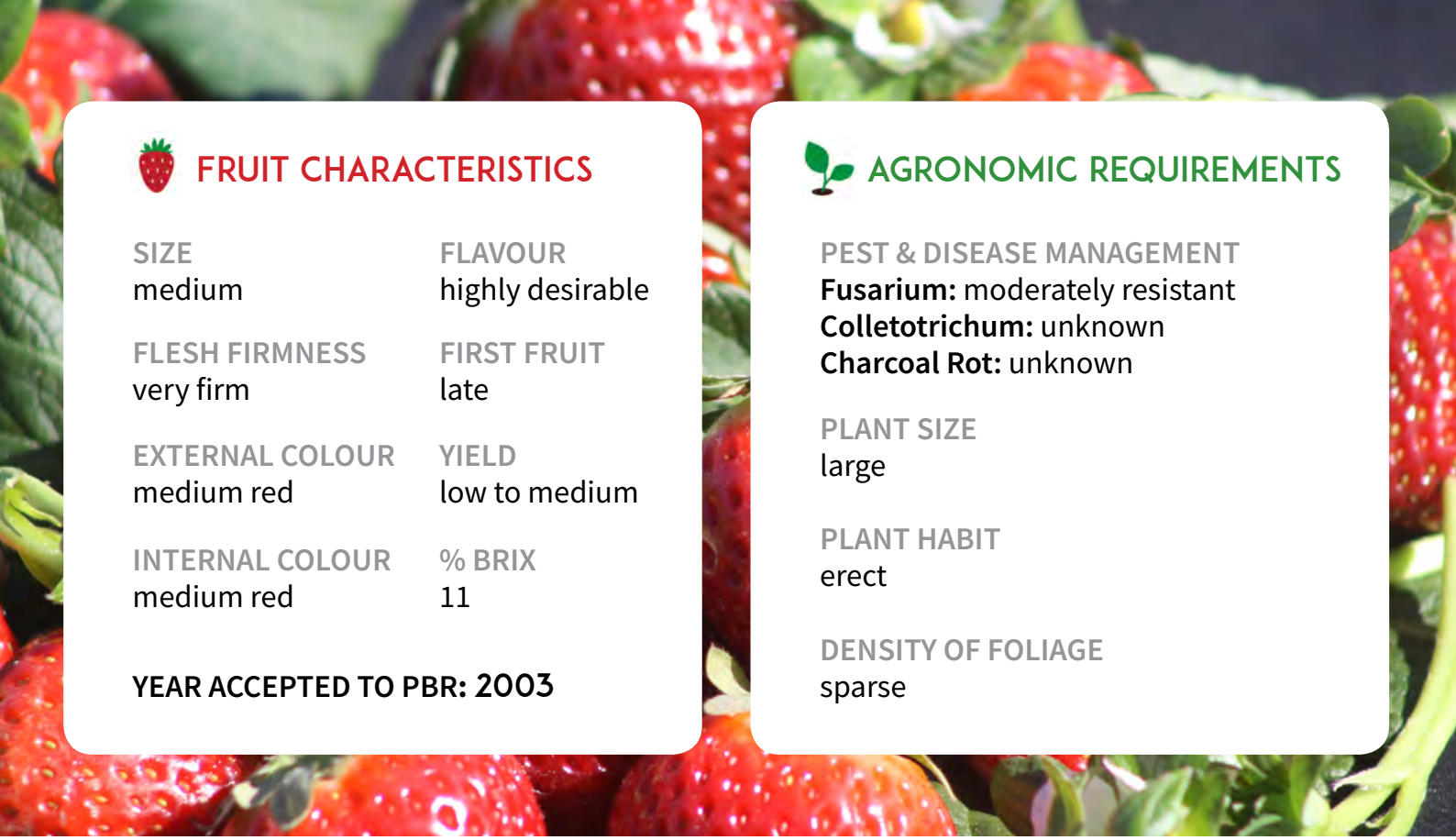
QHI SUGARBABY

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
medium

FLAVOUR
highly desirable

FLESH FIRMNESS
very firm

FIRST FRUIT
late

EXTERNAL COLOUR
medium red

YIELD
low to medium

INTERNAL COLOUR
medium red

% BRIX
11

YEAR ACCEPTED TO PBR: 2003

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: moderately resistant
Colletotrichum: unknown
Charcoal Rot: unknown

PLANT SIZE
large

PLANT HABIT
erect

DENSITY OF FOLIAGE
sparse

QHI SUGARBABY

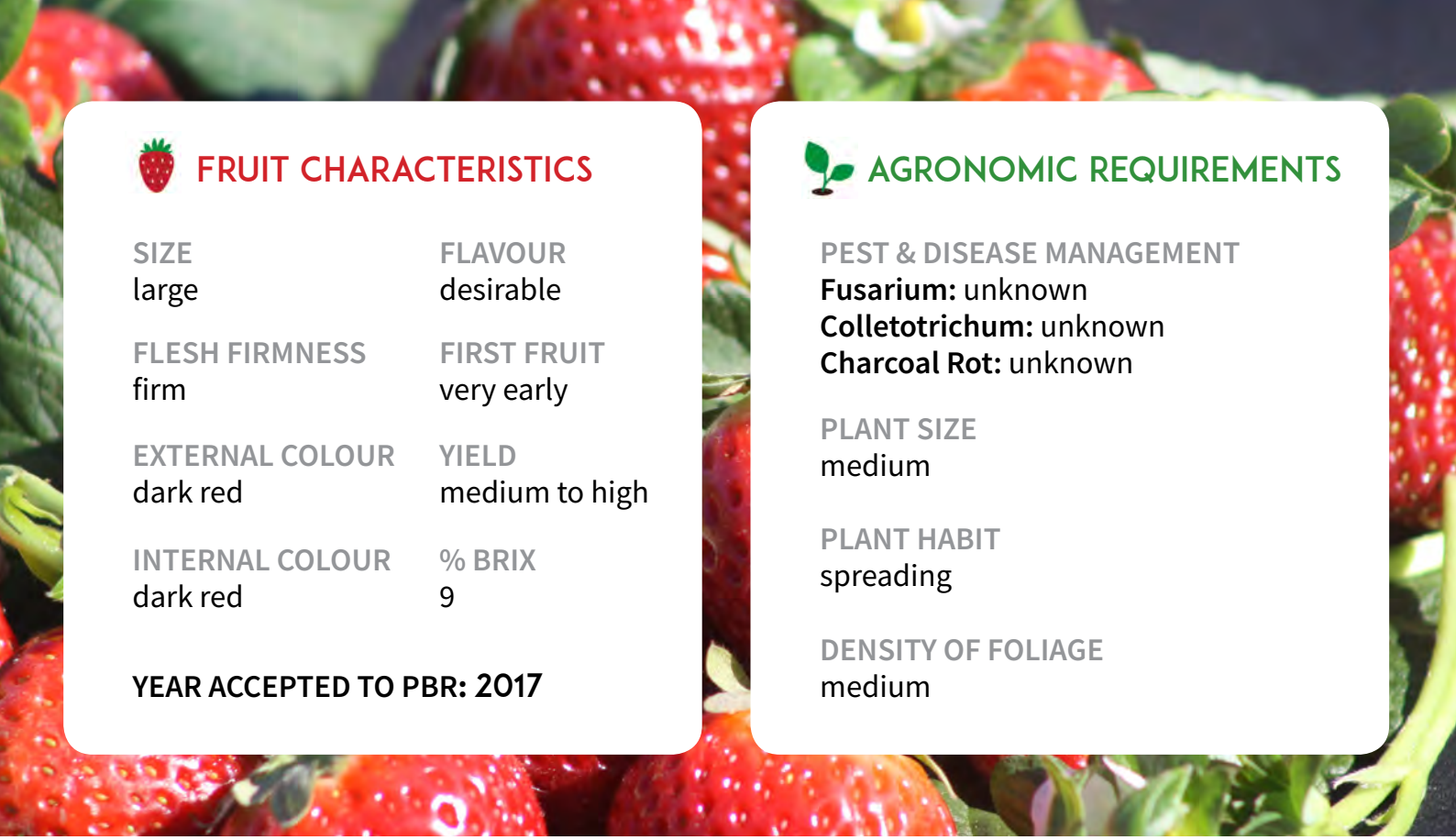
SUNGLOW ASBP

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
large

FLAVOUR
desirable

FLESH FIRMNESS
firm

FIRST FRUIT
very early

EXTERNAL COLOUR
dark red

YIELD
medium to high

INTERNAL COLOUR
dark red

% BRIX
9

YEAR ACCEPTED TO PBR: 2017

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: unknown
Colletotrichum: unknown
Charcoal Rot: unknown

PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
medium

SUNGLOW ASBP

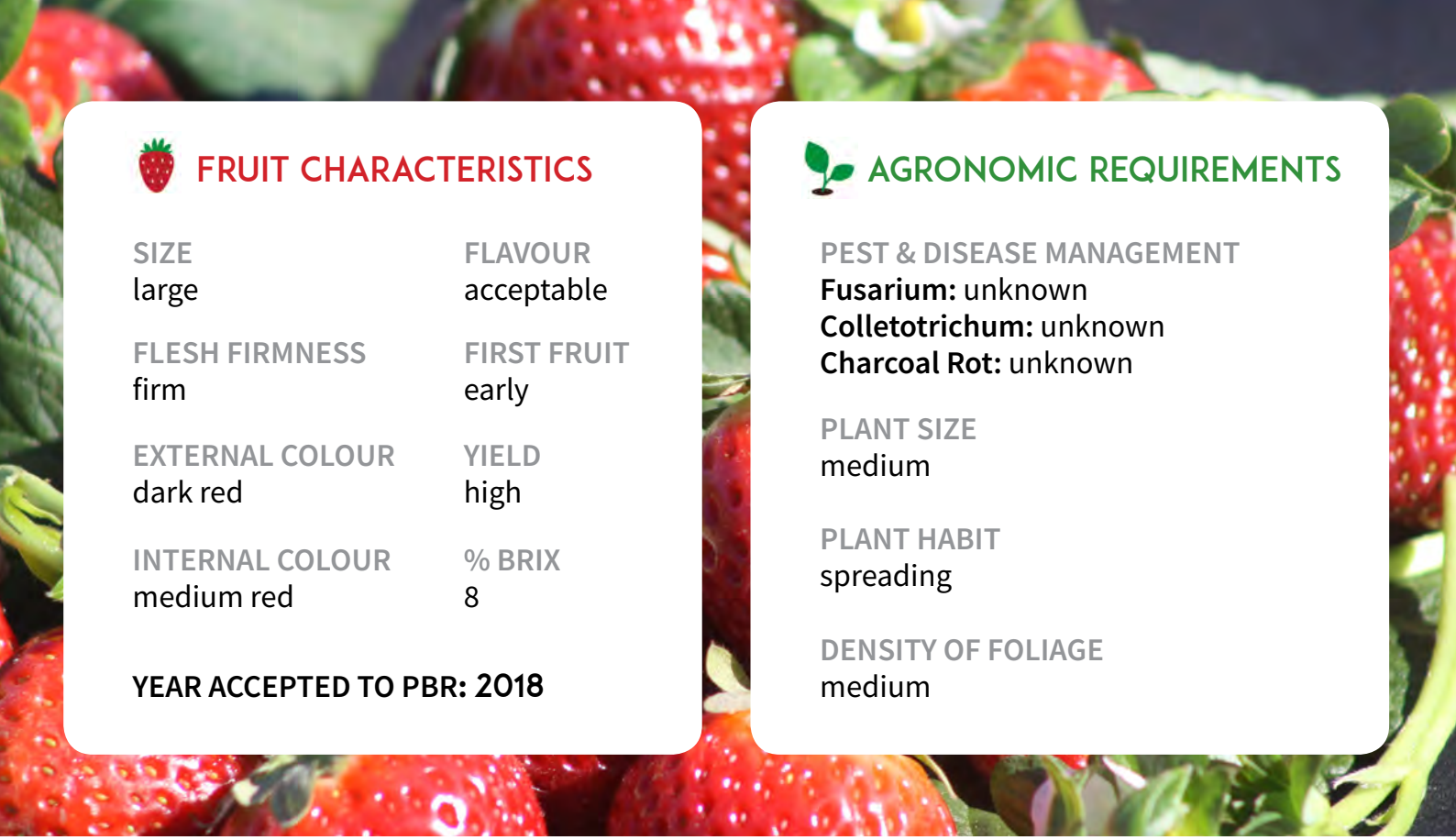
VENUS ASBP

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
large

FLAVOUR
acceptable

FLESH FIRMNESS
firm

FIRST FRUIT
early

EXTERNAL COLOUR
dark red

YIELD
high

INTERNAL COLOUR
medium red

% BRIX
8

YEAR ACCEPTED TO PBR: 2018

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: unknown
Colletotrichum: unknown
Charcoal Rot: unknown

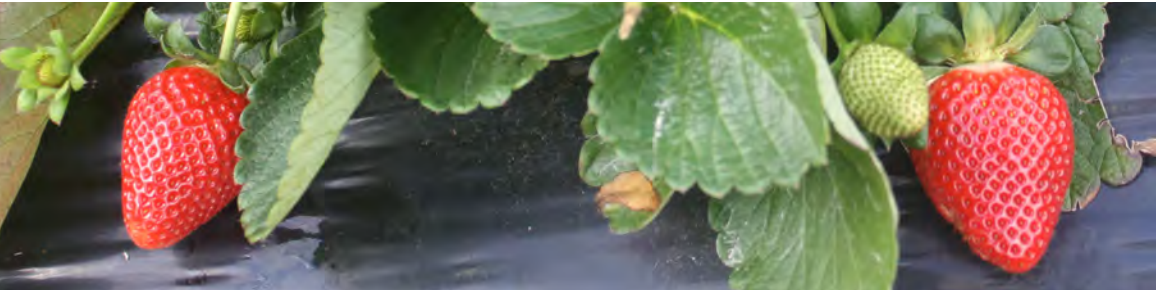
PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
medium

VENUS ASBP

PARISIENNE KISS

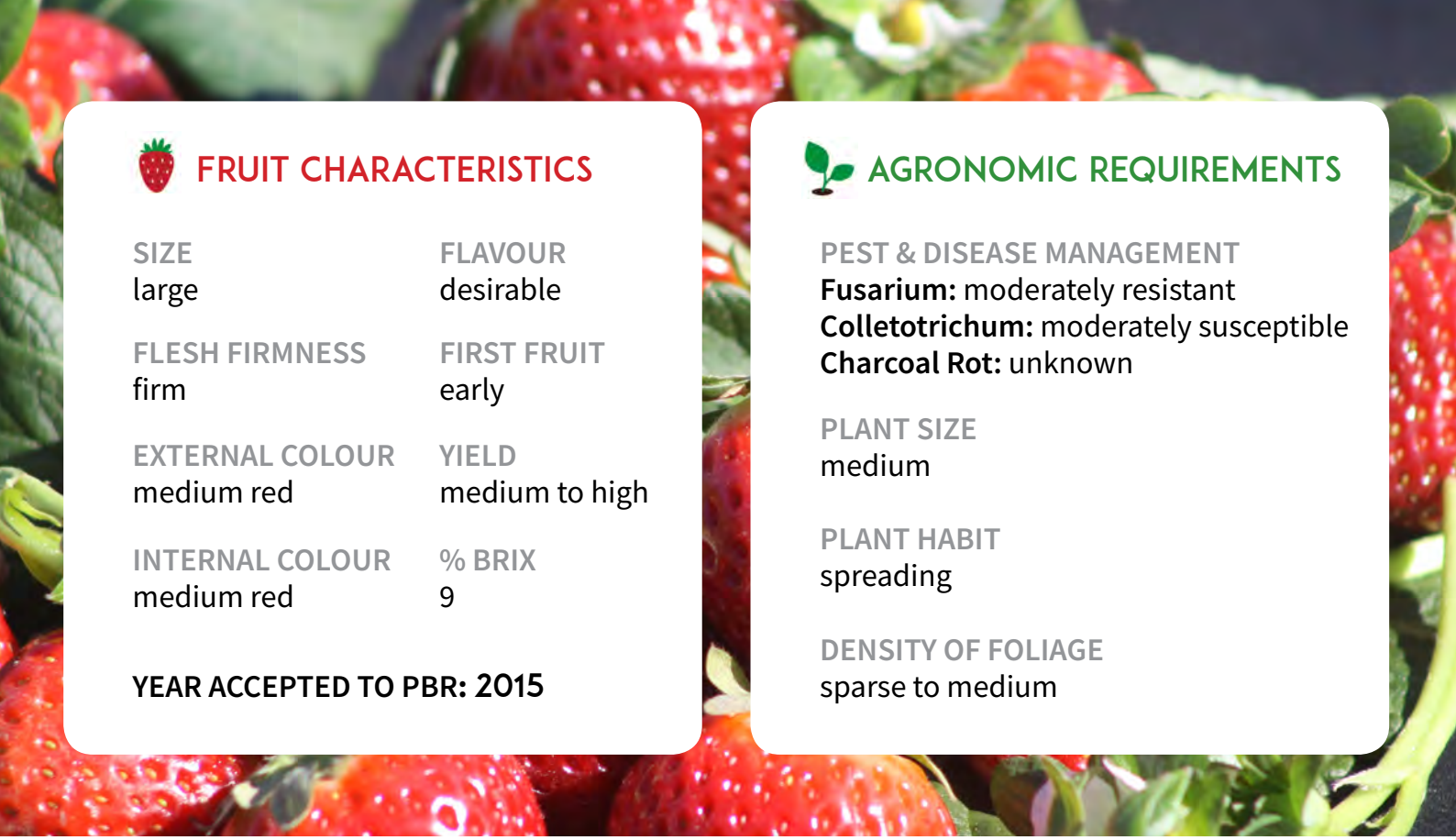


Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
large

FLAVOUR
desirable

FLESH FIRMNESS
firm

FIRST FRUIT
early

EXTERNAL COLOUR
medium red

YIELD
medium to high

INTERNAL COLOUR
medium red

% BRIX
9

YEAR ACCEPTED TO PBR: 2015

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: moderately resistant
Colletotrichum: moderately susceptible
Charcoal Rot: unknown

PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
sparse to medium

PARISIENNE KISS

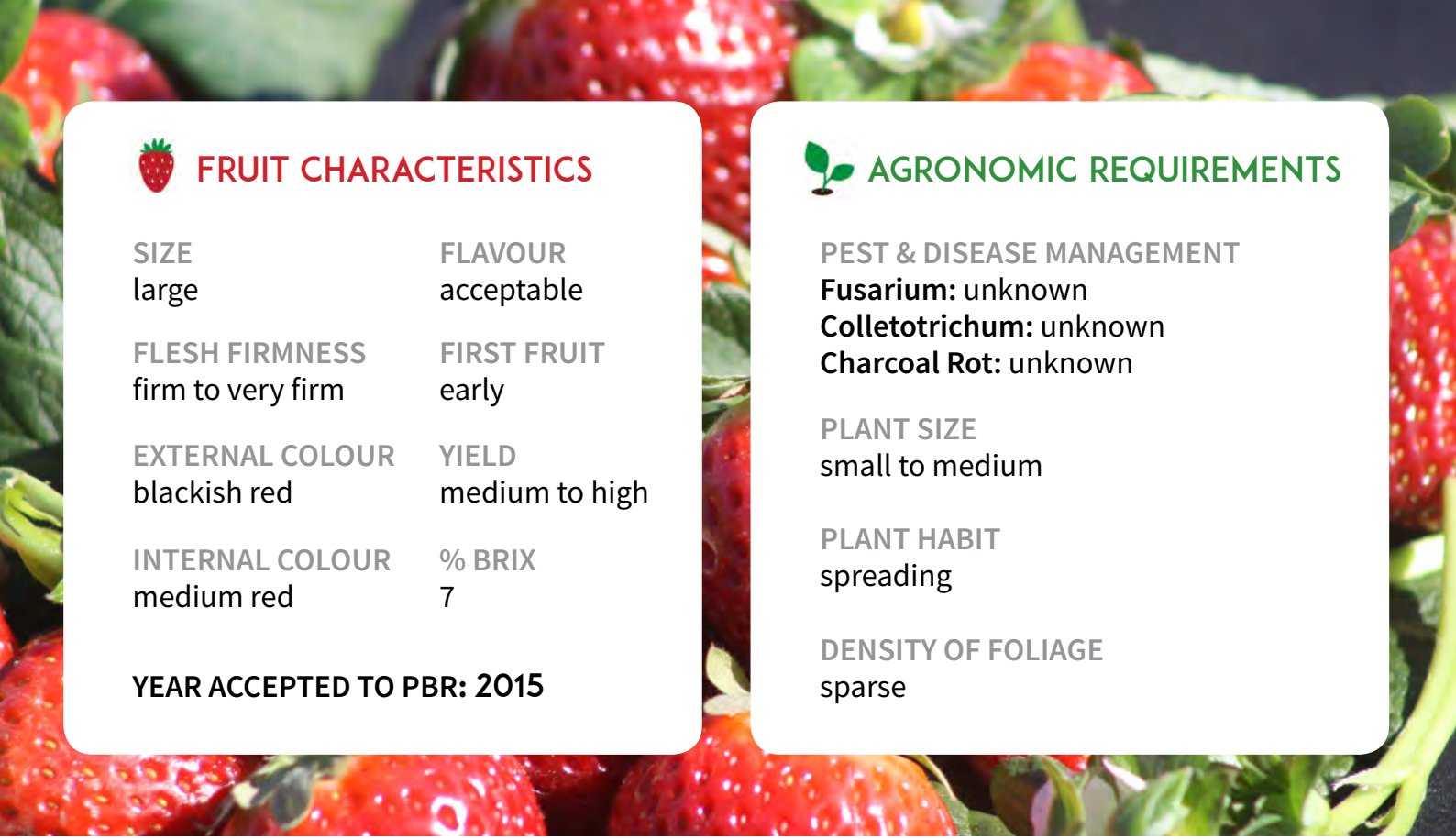
SUNDRENCH

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
large

FLAVOUR
acceptable

FLESH FIRMNESS
firm to very firm

FIRST FRUIT
early

EXTERNAL COLOUR
blackish red

YIELD
medium to high

INTERNAL COLOUR
medium red

% BRIX
7

YEAR ACCEPTED TO PBR: 2015

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: unknown
Colletotrichum: unknown
Charcoal Rot: unknown

PLANT SIZE
small to medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
sparse

SUNDRENCH

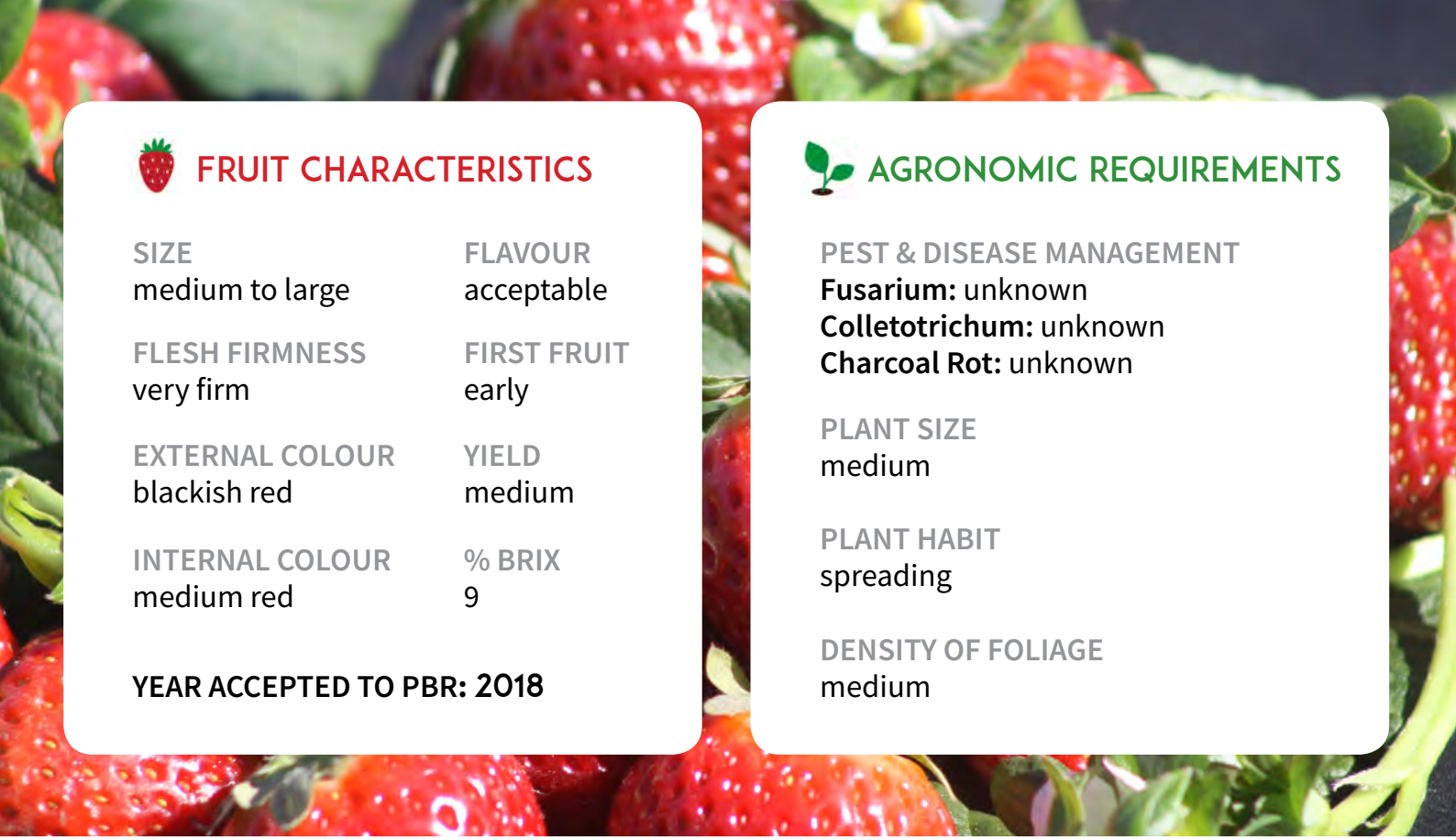
MEADOWSONG

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
medium to large

FLAVOUR
acceptable

FLESH FIRMNESS
very firm

FIRST FRUIT
early

EXTERNAL COLOUR
blackish red

YIELD
medium

INTERNAL COLOUR
medium red

% BRIX
9

YEAR ACCEPTED TO PBR: 2018

AGRONOMIC REQUIREMENTS

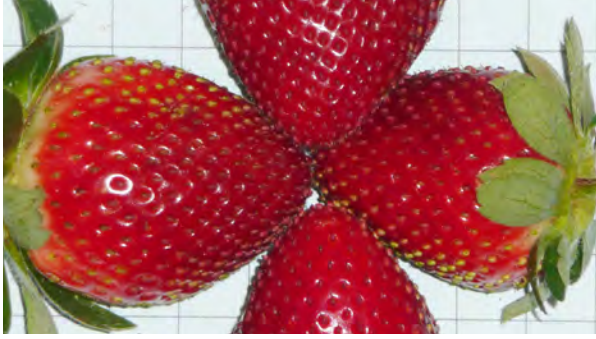
PEST & DISEASE MANAGEMENT
Fusarium: unknown
Colletotrichum: unknown
Charcoal Rot: unknown

PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
medium

MEADOWSONG



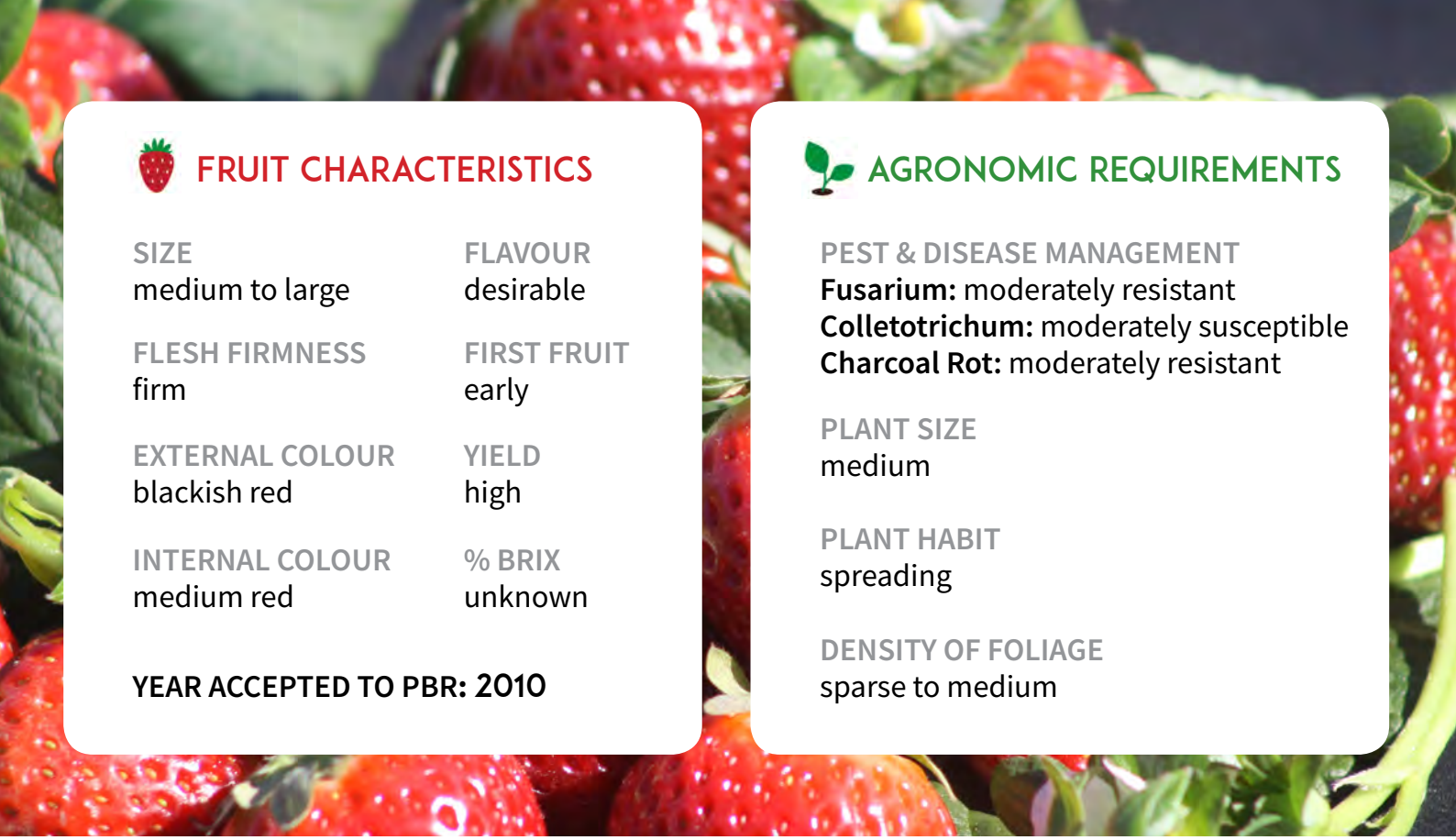
SUNCOAST DELIGHT

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
medium to large

FLAVOUR
desirable

FLESH FIRMNESS
firm

FIRST FRUIT
early

EXTERNAL COLOUR
blackish red

YIELD
high

INTERNAL COLOUR
medium red

% BRIX
unknown

YEAR ACCEPTED TO PBR: 2010

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: moderately resistant
Colletotrichum: moderately susceptible
Charcoal Rot: moderately resistant

PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
sparse to medium

SUNCOAST DELIGHT

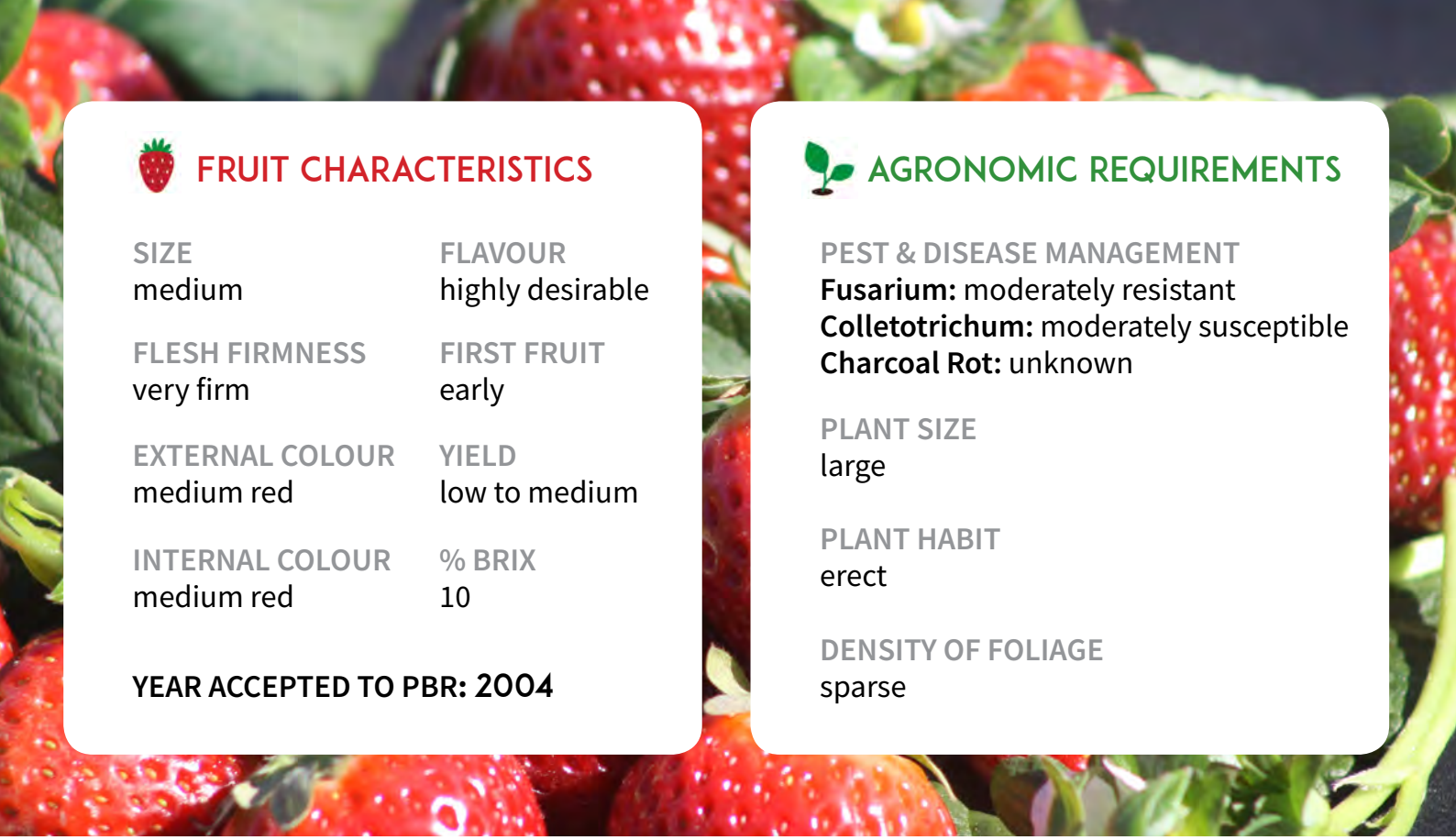
DPI RUBYGEM

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
medium

FLAVOUR
highly desirable

FLESH FIRMNESS
very firm

FIRST FRUIT
early

EXTERNAL COLOUR
medium red

YIELD
low to medium

INTERNAL COLOUR
medium red

% BRIX
10

YEAR ACCEPTED TO PBR: 2004

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: moderately resistant
Colletotrichum: moderately susceptible
Charcoal Rot: unknown

PLANT SIZE
large

PLANT HABIT
erect

DENSITY OF FOLIAGE
sparse

DPI RUBYGEM

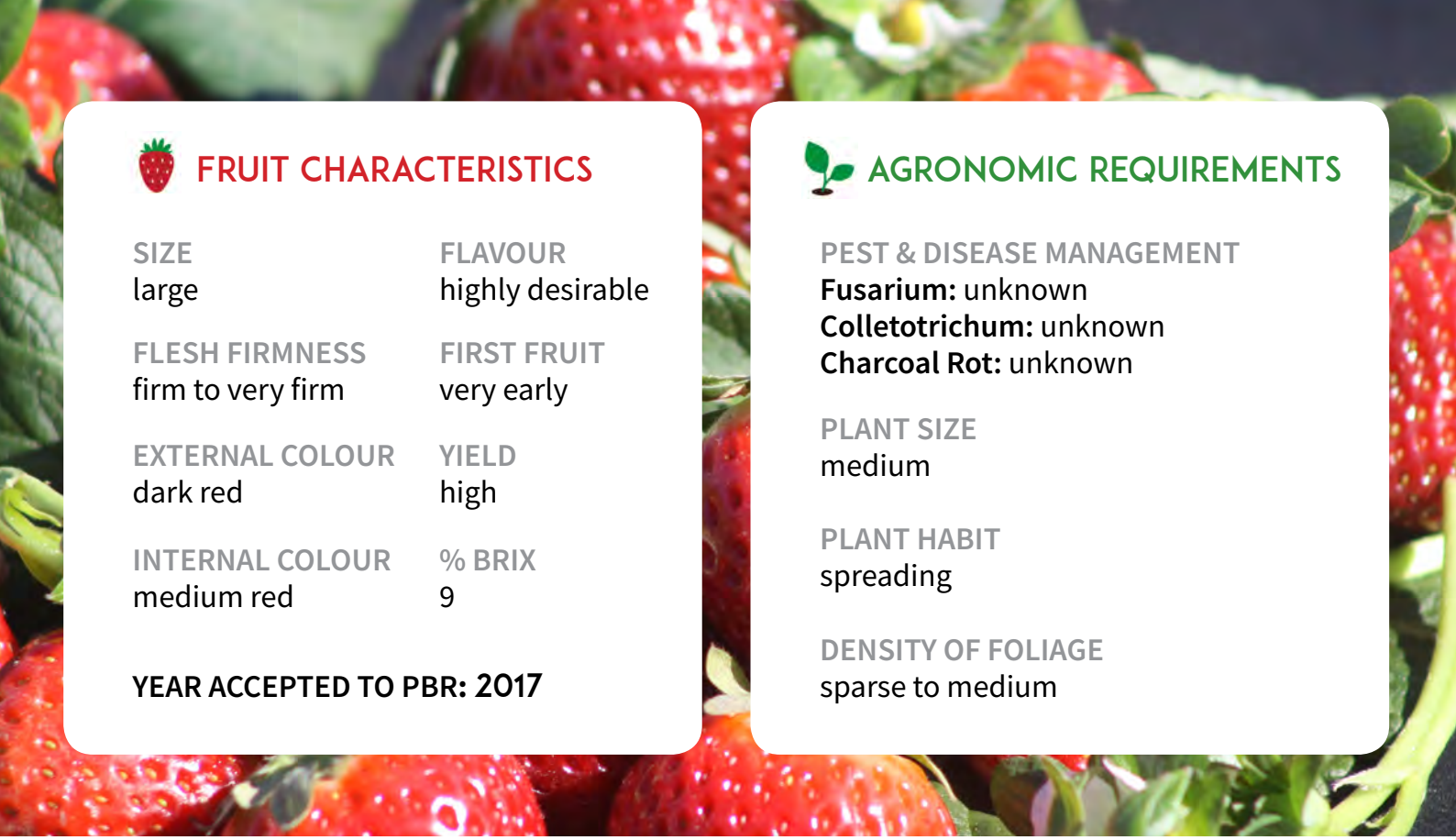
SCARLET ROSE ASBP

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
large

FLAVOUR
highly desirable

FLESH FIRMNESS
firm to very firm

FIRST FRUIT
very early

EXTERNAL COLOUR
dark red

YIELD
high

INTERNAL COLOUR
medium red

% BRIX
9

YEAR ACCEPTED TO PBR: 2017

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: unknown
Colletotrichum: unknown
Charcoal Rot: unknown

PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
sparse to medium

SCARLET ROSE ASBP

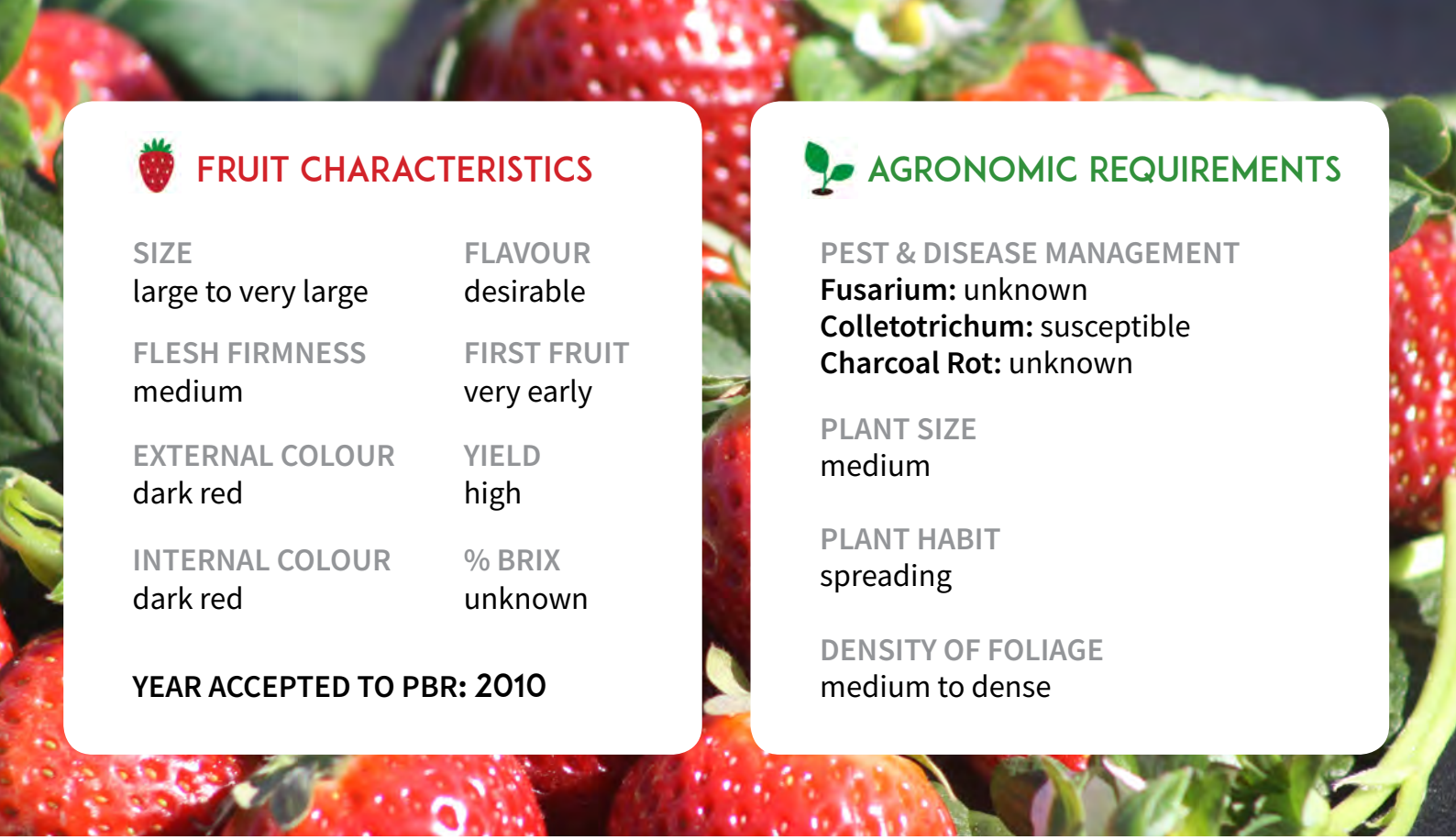
AUSSIEGEM

Hort Innovation
Strategic levy investment

STRAWBERRY FUND

STRAWBERRY INNOVATION

Queensland Government



FRUIT CHARACTERISTICS

SIZE
large to very large

FLAVOUR
desirable

FLESH FIRMNESS
medium

FIRST FRUIT
very early

EXTERNAL COLOUR
dark red

YIELD
high

INTERNAL COLOUR
dark red

% BRIX
unknown

YEAR ACCEPTED TO PBR: 2010

AGRONOMIC REQUIREMENTS

PEST & DISEASE MANAGEMENT
Fusarium: unknown
Colletotrichum: susceptible
Charcoal Rot: unknown

PLANT SIZE
medium

PLANT HABIT
spreading

DENSITY OF FOLIAGE
medium to dense

AUSSIEGEM

Appendix 8: Strawberry innovation website news articles

- Tassie strawberry growers unite to stamp out pests – 2 June 2016
- The Sweetest Job campaign starts with a bang in Queensland – 7 June 2016
- Denmark project pairs drones and ladybirds – 7 June 2016
- Strawberry season comes to an end in Victoria – 21 June 2016
- Pinata Farms launces substrate strawberries – 21 June 2016
- Rain damage affects the Queensland crop – 23 June 2016
- Latest developments on Charcoal Rot – 24 June 2016
- Strawberry world market overview – 28 June 2016
- What's better than a strawberry? A chocolate dipped strawberry! – 5 July 2016
- New robotic picking wheel design patented – 13 July 2016
- Cold-stored runners to extend season for strawberry growers – 28 July 2016
- Shedding light on Strawberry Little Leaf Disease in Victoria – 2 August 2016
- Warmer weather slows strawberry production in Queensland – 5 August 2016
- New leaf wetness model to validate Strawberry Advisory System in US – August 9 2016
- Grower interest in R&D highlighted – August 11 2016
- Gene technologies may contribute to control of angular leaf spot (ALS) – August 15 2016
- California Agriculture journal – special edition on methyl bromide – August 17 2016
- Genetic ancestry of cultivated strawberries revealed – August 26 2016
- Locals employed for the Sweetest Job – 8 September 2016
- First pick of substrate strawberries at Pinata Farms – 13 September 2016
- Aerial attack on two-spotted mites – 20 September 2016
- Australian Made Campaign welcomes research that shows consumers want 'Australian made' – 28 September 2016
- Continued interest in robot harvesting – 3 October 2016
- US industry trialling mechanical strawberry planter – 11 October 2016
- Australian Horticulture Statistics Handbook 2014/15 – 14 October 2016
- Resources for greenhouse strawberry production – 19 October 2016
- Researchers and industry unite in pollination campaign – 21 October 2016
- Japanese White Strawberries – 27 October 2016
- Tunnels extending production window of Albion in the states – 28 October 2016
- California strawberries celebrate access to China – 2 November 2016
- Commercial strawberry genome breakthrough – 2 November 2016
- Discovery set to make food shelf life longer – 4 November 2016
- Hort Innovation MoU with leading Dutch institution for Masterclass in Horticultural Business – 4 November 2016
- Bacchus Marsh Strawberry season celebrations – 11 November 2016
- Improving the competitiveness and quality of European berry crops – 11 November 2016
- Highlighting strawberry health benefits in November – 15 November 2016
- Challenge set to find solution to agricultural plastic waste – 15 November 2016
- Looking to technology for Soil Health management – 15 November 2016
- New varieties pushing growth in US Strawberry industry – 17 November 2016
- Applications now open for Masterclass in Horticultural business – 18 November 2016
- Horsepower mounting for "real-world" robotic strawberry harvester – 16 December 2016
- Precision Agriculture improving American strawberry production – 9 January 2017
- Yarra Valley strawberry season: it's better late than never – 11 January 2017
- Australian researchers develop eco-friendly nanotechnology pesticide spray – 12 January 2017
- Driscoll's marketing to emotions; eating berries makes you happy! – 17 January 2017
- "Pick your own" tourism has helped offset late Victorian season woes – 18 January 2017
- Spanish producer sees sales growth of 15% thanks to packaging – 30 January 2017
- Benefits of breeding: Scientists say larger strawberries offer 20 per cent saving on labour – 30 January 2017
- New strawberry production system allows room for up to 200,000 plants per hectare – 3 February 2017

- Biodegradable plastic mulches in organic production – 13 February 13 2017
- New app checks fruit and vegetables for chemical residues – 13 February 2017
- New packaging for Strawberries on-the-go (US) – 14 February 2017
- Timing of IPM in hydroponic berry production – 16 February 2017
- Old greenhouses seeing new days with Strawberries, Poland – 17 February 2017
- Wild strawberry exhibits resistance to Spotted-wing Drosophila – 20 February, 2017
- Hand-picked specialty crops 'ripe' for precision agriculture techniques – 3 March, 2017
- Berries and leafy veg: top heart health foods – 8 March, 2017
- Grant for research into immunizing honey bees against varroa mite – 10 March, 2017
- Smartphone app to foresee strawberry production – 15 March, 2017
- Strawberries to be put on the map in Wagga Wagga, NSW – 27 March, 2017
- New blends of media growing for horticulture – 4 April, 2017
- Growth in organic strawberries – California – 7 April, 2017
- Insights into strawberry production in Spain – 18 April, 2017
- Study shows strawberry extract inhibits spread of breast cancer cells in mice – 20 April, 2017
- Tomato potato psyllid: Wester Australian strawberry industry says losses could top $80 million – 28 April, 2017
- Tomato potato psyllid: Fruit exports from Western Australia to resume after emergency meeting – 11 May, 2017
- Labour savings with new strawberry container – 24 May, 2017
- Potential soil pathogen inoculum sources for strawberries – 26 May, 2017
- Philippines: Demand for tissue-cultured strawberries rises – 29 May, 2017
- Cost of labour driving Australia's move towards more protected cropping – 30 May, 2017
- Increase in seasonal workers in Tasmania – 6 June, 2017
- New technology to help reduce strawberry waste – 26 June, 2017
- Frozen berries scare prompts industry to urge "eat local" – 27 June, 2017
- Positive influence of biochar and chitin additives in strawberry – 30 June, 2017
- Robotic Strawberry Picker Ramping up for Rollout in US – 12 July, 2017
- Shared lessons on the challenges of 'difficult' greenhouse strawberry production – 12 July, 2017
- Farmers turn to hydroponics, aquaponics, greenhouses to meet growing demand for food using less resources – 14 July, 2017
- Australian growers to compete with frozen strawberry imports – 15 July, 2017
- New varieties from the breeding program hit the market – 22 July, 2017
- Red Rhapsody hits supermarket shelves – 24 July, 2017
- Sterile Insect Technology to aid in control of QFF – 1 August, 2017
- BerryWorld joint venture with Pinata Farms – 21 August, 2017
- Shared lessons from berry production under a retractable roof – 21 August, 2017
- Future of Robot Pickers in the Strawberry Industry – 24 August, 2017
- Nanocoating antimicrobial spray extends shelf life of produce – 24 August, 2017
- Atracticidal sphere lures spotted wing drosophila – 24 August, 2017
- Weather and price affect Qld production – 25 August, 2017
- Tomato Potato Psyllid Inevitable on East Coast? – 30 August, 2017
- Soil-borne disease control in organic strawberries – 1 September, 2017
- New funded research announced in the US – 1 September, 2017
- Shared lessons from Pinata Farms' substrate trial – 4 September, 2017
- Transition to management plan – tomato potato psyllid in Australia – 18 September, 2017
- Good timing for new varieties amid strawberry glut – 22 September 2017
- Strawberry Workforce Shortage – 24 September 2017
- New high folate strawberry a sweet find – 26 September 2017
- Steaming system for strawberry cultivation in row – 27 September 2017
- Phytophthora treatment in Danish strawberries – 27 September 2017
- Korea gets greenlight to ship berries to Australia – 23 October 2017
- NFF observes labour pains in industry – 23 October 2017
- Tech focused Queensland strawberry growers gathering – 23 October 2017
- US – Breeding seed propagated strawberry varieties for organic production – 24 October 2017

- The impact of colored plastic films on strawberry cultivation – 27 October 2017
- Treating strawberry plant pathogens with UV-C Irradiation – 27 October 2017
- New technology hopes to grow strawberries year round – 27 October 2017
- Korean strawberries to make entry into Australian market – 31 October 2017
- Outfoxing food decay: antimicrobial borne by feral foxes found to slow food decay – 31 October 2017
- Shaping consumer response through food label colouring – 2 November 2017
- Warm weather kicks off Tasmanian berry season – 3 November 2017
- Food Safety Supercharger lands in Australia – 14 November 2017
- Victoria: Tomato potato psyllid surveillance ramps up for spring – 16 November 2017
- "Sweet" Queensland strawberries hit Indonesian shops – 16 November 2017
- SPAIN: Strawberries perform on coconut fibre – 16 November 2017
- Best Practice Strawberry Farming showcased at Strawberry Springs – 16 November 2017
- Silvan grower transitions to hydroponics – 21 November 2017
- Strawberries – the new magic fruit? – 21 November 2017
- Strawberry-picking bot is quick, nimble, and ready to replace humans – 24 November 2017
- Taste 'N See go soil-less – 24 November 2017
- California strawberry production breaks record reaching 197.3M crates – 27 November 2017
- Overcrowded' strawberry industry slams SA government for funding new farm – 27 November 2017
- Taking a punnet on the next generation of raspberry, blackberry and blueberry industry leaders – 1 December 2017
- Tech tool saving strawberry growers from being in the red – 4 December 2017
- Strawberry farmer wages war on waste – 6 December 2017
- Research uncovers new weed control options for US strawberry growers – 6 December 2017
- Beating strawberry mildew with garlic – 7 December 2017
- Berry breeding at speed – 7 December 2017
- Backpacker tax not a deterrent – 8 December 2017
- Fund for future strawberry industry leaders – 15 December 2017
- App to check taste and nutrients of produce – 15 December 2017
- Impacts of research into organic strawberry production – 18 December 2017
- Turning strawberries into gin – 18 December 2017
- Seasonal marketing (USA) – 20 December 2017
- Shared lessons – greater biosecurity harmonization will help protect nursery industry – 2 January 2018
- On farm innovation – compostable containers and 'slashed' potting media – 2 January 2018
- Japanese strawberries set eyes on the Australian market – 3 January 2018
- Multi-coloured Japanese strawberries to commence production in China – 5 January 2018
- Seed propagated strawberry varieties for organic production – 5 January 2018
- Fewer seasonal workers observed following "Backpacker Tax" – 16 January 2018
- Growth in agricultural robotics – 17 January 2018
- Health benefits and motivators for berry consumption – 18 January 2018
- Export opportunities on the horizon for WA despite TPP outbreak – 19 January 2018
- Robotics race – 25 January 2018
- Tasmanian biosecurity team supported by QFF experts – 25 January 2018
- Fruit fly detection in Tasmania – 26 January 2018
- Seasonal worker shortages – 30 January 2018
- Turners Beach Berry Patch caught up within Fruit Fly control zone – 30 January 2018
- Traders face compliance notices under new Hort Code – 2 February 2018
- Technology to extend strawberry shelf life by 40% - 9 February 2018
- Isolating the strawberry gene to increase strawberry production – 9 February 2018
- Qld Fruit Fly control in Queensland – 9 February 2018
- Improved retractable roof technology for berry growers – 9 February 2018
- Berry Pickers struggle to find accommodation – 12 February 2018
- National Farmers Federation Launching New Horticulture Council – 13 February 2018
- BerryQuest International 2018 – 15 February 2018
- DROPSA present latest findings – 16 February 2018
- Researchers find gene that may increase strawberry production – 16 February 2018

- Year round control of fruit fly – 19 February 2018
- Improving biosecurity at harvest time – 19 February 2018
- User friendly language with simple tools for growers to use – 22 February 2018
- Creating value from second grade produce – 22 February 2018
- Stopping spotted wing drosophila in protected cropping – 22 February 2018
- 2017 Annual Horticulture Review - 22 February 2018
- Sentinel beehives provide defence against varroa mite invasion – 26 February 2018
- Australian ag to take action on gender diversity – 26 February 2018
- USA: Growth in organic berry market – 26 February 2018
- Organic versus conventional strawberries – 26 February 2018
- Fruit fly in Tasmania – 26 February 2018
- Biosecurity risk – brown marmorated stink bug – 27 February 2018
- One year on – TPP quarantine restrictions still hinder WA strawberry growers – 1 March 2018
- Potassium/Calcium ratio affects on soil-less strawberry quality and colour – 2 March 2018
- The growing importance of packaging – 2 March 2018
- … and the winner is! Taste 'N See- 2017 Horticulture Farmer of the Year – 2 March 2018
- Latest weapon in the fight against Queensland fruit flies – 7 March 2018
- Burlington Berries – "Pay people properly and treat them well" – 7 March 2018
- Global: Agriculture robotics ease the farm labour crunch – 16 March 2018
- Global: Heavy rainfall in California highlights benefits of protected cropping – 19 March 2018
- Netherlands: Strawberry cultivation has to become more sustainable – 20 March 2018
- Big interest in picking robots – but are they good? – 21 March 2018
- Global Berry Congress Highlights – 22 March 2018
- Strawberries without plastic waste? – 23 March 2018
- UK: Why are hoverflies so useful to strawberry growers – 23 March 2018
- Seasonal occurrence of pests and beneficials in tunnel berries – 28 March 2018
- Popularity of greenhouse strawberries – 1 April 2018
- Strawberry powder helping tackle the 'War on Waste' – 2 April 2018
- Quality a main driver for Australia's horticultural exports – 2 April 2018
- Horticulture Produce Agreement deadline – 2 April 2018
- Berries Australia's most valuable horticulture commodity – 5 April 2018
- Agriculture's labour shortfall confirmed – 9 April 2018
- Alternative soil fumigant approved – 16 April 2018
- Smart agriculture creation in South Korea – 19 April 2018
- New hydroponic strawberry glasshouse planned for Latrobe Valley – 19 April 2018
- Latrobe Valley in the running for $37 million hydroponic strawberry glasshouse – 20 April 2018
- Manipulating genetic inheritance of spotted-wing drosophila – 23 April 2018
- Certhon Innovation Centre berry trials – 26 April 2018
- Autonomous strawberry harvester – 27 April 2018
- Pacific workers filling Australian labour shortfall – 4 May 2018
- Tasmania: Fruit fly eradication 'top priority' – 11 May 2018
- Growers express concern over potential imports – 21 May 2018
- USA: Looking for the next big biotech traits – disease-resistant GMO strawberries – 21 May 2018
- "No fruit waste" policy – value addition enterprise sees strawberries transformed into cider – 23 May 2018
- Tasmanian government hopes to eradicate fruit fly by Spring – 25 May 2018
- Australian farmers turning to the Seasonal Workers Programme for labour – 28 May 2018
- Can robotic strawberry pickers replace humans? – 28 May 2018
- Queensland grower hopes to export strawberries to Hong Kong and Indonesia – 30 May 2018
- New website for Queensland fruit fly management – 5 June 2018
- GoodBerry working on climate-proof berry production – 8 June 2018
- Soil steaming used to control pests, weeds and diseases – 12 June 2018
- Rockwool used to increase strawberry yield – 13 June 2018
- Queensland strawberry delegates return from market research adventure – 15 June 2018
- Relief as colder weather reduces threat of Queensland fruit fly – 19 June 2018
- Bumper crops expected for growers in South East Queensland – 22 June 2018

- Queensland strawberry grower finds solution to waste – 27 June 2018
- Berry bowls from wood pulp – 9 July 2018
- Biosecurity – Fruit Fly Update – 17 July 2018
- Global: Research into strawberry varieties adaptable to climate change – 19 July 2018
- Robots to help with field logistics in the UK – 19 July 2018
- Year round New Zealand strawberries now a possibility – 19 July 2018
- Queensland season – great quality and supply – 25 July 2018
- Recycled strawberry punnet packaging? – 27 July 2018
- Biosecurity legacy challenges – Tasmanian QFF incursion – 14 August 2018
- A focus on taste for north Queensland strawberry farm – 15 August 2018
- Urban farming in a jam over strawberry production – 20 August 2018
- Queensland: Market glut demands large fruit only – 23 August 2018
- A cupful of strawberries could help keep the doctor away – 23 August 2018
- Essex university experimenting with robotic strawberry pickers – 23 August 2018
- Worst glut in Australian history? – 31 August 2018
- Disease solution in greenhouses? – 31 August 2018
- Using air to increase shelf life of fruit – 31 August 2018
- War on strawberry waste – 7 September 2018
- Short-term visas for horticulture – 12 September 2018
- Sex chromosome changes in strawberries – 12 September 2018
- Compostable strawberry punnet – 13 September 2018
- Coconut substrate for strawberries – 13 September 2018
- Non-toxic pest control for horticulture – 17 September 2018
- Coir waste management for berries – 20 September 2018
- Strawberry Industry Crisis Update – 16 October 2018
- Europe: delaying strawberry decay – 1 November 2018
- Strawberry growers feature in campaign for Ag Visa – 1 November 2018
- Aussie hort growers set to reap benefits under new Trans-Pacific Partnership – 2 November 2018
- Applying AI in berry harvesting – 5 November 2018
- Appointment of strawberry industry recovery officer – 6 November 2018
- Robot hopes to solve challenges of under-cover pollination for berries – 7 November 2018
- Queensland research leads to new strawberry varieties – 8 November 2018
- Offering premium berries in convenience packaging – 9 November 2018
- Arrest of first saboteur in needles in strawberries incident – 12 November 2018
- Australia and NZ join forces on plant biosecurity research – 12 November 2018
- RASberry – Robotics and Automation Systems for berry production – 12 November 2018
- Robotic hands, sensitive enough to pick soft fruit – 23 November 2018
- Validation of anthocyanins for their anticarcinogenic, anti-inflammatory, antimicrobial and antioxidant properties – 6 December 2018
- LAMP test for Queensland Fruit Fly – 18 December 2018
- States and territories in deadlock over fruit fly agreement – 24 December 2018
- Airboom sprayer designed for strawberries – 9 January 2019
- USA: Researchers receive $2m to study organic management of Spotted Wing drosophila – 9 Jan 2019
- Tasmania's growers looking to restore full market access after regaining Pest Free Area status – 15 January 2019
- Berries Australia appoints new Executive Officer – 15 January 2019
- Strawberry genome jointly decoded by Israel's NRGene, Japan's Toyota – 21 January 2019
- Mitigating the adverse effects of drought stress on strawberries with Silicon – 23 January 2019
- Increasing demand for retractable roofs – 31 January 2019
- Strawberry tampering scandal impacts Perth plantings – 31 January 2019
- Predictive model for strawberry anthracnose – 31 January 2019
- Multilayered production system triples strawberry production – 31 January 2019
- Strawberry tampering scandal contributed to by poor regulation – 6 February 2019
- The benefits of natural vegetation on strawberry production – 6 February 2019
- Workplace compliance a top issue for Fair Farms workshop – 8 February 2019

- Australian pay more for locally grown frozen berries – 13 February 2019
- Value adding boost for Western Australia strawberry grower – 22 February 2019
- The future of the strawberry industry in the US – 22 February 2019
- Old-fashioned strawberry revival – 28 February 2019
- Increasing production with bacteria – 1 March 2019
- Export security changes – 4 March 2019
- Alpine strawberries a potential crop for Florida growers – 4 March 2019
- Sequenced strawberry genome – 4 March 2019
- A strawberry a day might keep the doctor away – 4 March 2019
- 2019 Farm Biosecurity of the Year award given to strawberry grower – 13 March 2019
- Bolivian strawberries hit by pathogens and a fungus – 18 March 2019
- High demand for white strawberries – 18 March 2019
- Growers shut the gate as a result of tampering crisis – 5 April 2019
- Perth strawberry growers count on the price rise due to shortage – 12 April 2019
- Perth growers keep an eye on strawberry prices – 15 April 2019
- Driscoll's Strawberry dilemma – 15 April 2019
- Combating powdery mildew with robots – 24 April 2019
- Varietal selection in organics market – 24 April 2019
- Sealed pack Ozone treatment kills moulds, yeast and human pathogens – 25 April 2019
- USA: cardboard strawberry clamshells – 2 May 2019
- Runner quality to determine market price – 3 May 2019
- Australian back bumblebee pollination of Tasmanian tomato crops – 3 May 2019
- UK: Recyclable, biodegradable and home compostable Sugarcane-based packaging – 3 May 2019
- Spain: special strawberry packaging for Mother's Day – 6 May 2019
- Overview of Australian strawberry market – 6 May 2019
- Strawberry supplies run short in supermarkets – 8 May 2019
- Common fruit flies in Australia developing resistance to insecticides – 10 May 2019
- Russia: 'Aeroponics' used to grow strawberries – 10 May 2019
- USA: Benefits of growing strawberries under low tunnels – 10 May 2019
- Specialty strawberry sprayer for table-top production – 16 May 2019
- Attacking thrips with Bugline – 22 May 2019
- Scottish strawberries all year round – 24 May 2019
- Practical solutions to combat fruit fly – 6 June 2019
- Protective cropping and precision ag tech – 7 June 2019
- Be sure to put berries in your basket – 13 June 2019
- Should we be moving away from plastic? – 19 June 2019.