Hort Innovation

Final Report

Fund Impact Assessment 2020/21 for cherry, vegetables and small tropicals: Evaluation of PR13007

Project leader:

George Revell

Delivery partner:

Ag Econ

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MT21013

Project:

Fund Impact Assessment 2020/21 for cherry, vegetables and small tropicals (MT21013)

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Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

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Executive summary

What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in *PR13007 Australian Sweet Persimmon Industry Development Project- Phase 4*. The project was funded by Hort Innovation over the period June 2014 to May 2017.

Methodology

The investment was first analysed qualitatively within a logical framework that included activities and outputs, outcomes, and impacts. Actual and potential impacts then were categorised into a triple bottom line framework. Principal impacts identified were then considered for valuation in monetary terms (quantitative assessment). Past and future cash flows were expressed in 2021-22 dollar terms and were discounted to the year 2021-22 using a real (inflation-adjusted), risk free, pre-tax discount rate of 5% to estimate the investment criteria and a 5% reinvestment rate to estimate the modified internal rate of return (MIRR).

Key findings

PR13007 conducted research, development and extension (RD&E) into a range of issues and opportunities facing the Australian persimmon industry including pest and disease management, variety and rootstock evaluation, removing astringency, and improved cool storage. A range of potential economic, social and environmental impacts were identified; however, not all could be valued, particularly where there was a lack of data or a high level of uncertainty. These additional economic, social and environmental impacts have the potential to provide further industry impact above those that have been valued.

The impacts valued were:

Mealybug pest management. Increased adoption of higher efficacy mealybug management in line with IPM, consisting of a Samurai® (clothianidin) soil drench at flowering, resulting in a reduction in operational costs (labour and chemical costs) associated with the previous practice of 6-8 largely ineffective contact chemical sprays, combined with hand removal of mealybugs and cleaning of fruit. This RD&E accounted for 43% of total nominal benefits, but 52% of total discounted (PV) benefits given the earlier benefit timeline. The mealybug RD&E built on previous Hort Funded RD&E. As such, PR13007 was assessed to generate impact (reduced cost through a reduced need for low efficacy contact pesticides followed by hand cleaning) through improved awareness and knowledge of best practice resulting in a change in the existing industry adoption curve.

Clearwing Moth (CWM) pest management. Increased adoption of higher efficacy CWM mating disruption pheromones, supporting reduced operational costs (labour costs) associated with the previous practice of high pressure sprays to physically remove CWM from the trees. This RD&E accounted for 7% of total nominal benefits, and 8% of total discounted (PV) benefits given the earlier benefit timeline. The CWM R&D built previous Hort Funded RD&E. As such, PR13007 was assessed to generate impact (reduced cost through a reduction in physical removal of CWM) through improved awareness and knowledge of best practice resulting in a change in the existing industry adoption curve.

New varieties—Rojo Brillante. Ongoing maintenance of new high performing varieties (such as Rojo), supporting their commercial availability in Australia, and increased knowledge of physical traits and characteristics relative to existing varieties, in turn generating increased productivity on Australian persimmon orchards. This RD&E accounted for the majority of undiscounted benefits (50%), but this reduced to 40% of total discounted (PV) benefits given the longer adoption timeline and the subsequent time required to reach full production (6 years). Adoption of Rojo was assessed to generate increased productivity (yield per unit of inputs).

Investment criteria

Total funding from all sources for the project was $1.17 million (2021-22 equivalent value). The investment produced estimated total expected benefits of $1.59 million (2021-22 equivalent value). This gave a net present value of $0.43 million, an estimated benefit-cost ratio (BCR) of 1.36 to 1, an internal rate of return of 7% and a modified internal rate of return of 6%. Sensitivity analysis showed that changes in the underlying variables resulted in a BCR range between 0.73:1 to 1.84:1, with the results particularly sensitive to changes in the discount rate given the long timeframe for adoption (planting) and production from new persimmon varieties.

Keywords

Impact assessment, cost-benefit analysis, persimmon, industry development, pest and disease, mealybug, clearwing moth, cool-storage, variety, Rojo Brillante, rootstock, astringency, postharvest

Introduction

Evaluating the impacts of levy investments is important to demonstrate to levy payers, Government and other industry stakeholders the economic, social and environmental outcomes of investment for industry, as well as being an important step to inform the ongoing investment agenda.

The importance of ex-post evaluation was recognised through the Horticulture Innovation Australia Limited (Hort Innovation) independent review of performance completed in 2017, and was incorporated into the Organisational Evaluation Framework.

Reflecting its commitment to continuous improvement in the delivery of levy funded research, development and extension (RD&E), Hort Innovation required a series of impact assessments to be carried out annually on a representative sample of investments across a cohort of Funds in its RD&E portfolio. The assessments were required to meet the following Hort Innovation evaluation reporting requirements:

- Reporting against the Hort Innovation's Strategic Plan and the Evaluation Framework associated with Hort Innovation's Statutory Funding Agreement with the Commonwealth Government.
- Reporting against strategic priorities set out in the Strategic Investment Plan for each Hort Innovation industry fund.
- Annual Reporting to Hort Innovation stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

As part of its commitment to meeting these reporting requirements, Ag Econ was commissioned to deliver the *Fund Impact assessment 2020/21: Cherry, Sweetpotato, Vegetables, Small Tropicals (MT21013)*. This program consisted of a once-off impact assessment series of randomly selected Hort Innovation RD&E investments (projects) within each of the nominated Funds.

Project *PR13007 Australian Sweet Persimmon Industry Development Project- Phase 4* was randomly selected as one of the 3 investments in the 2020-21 sample for the cluster of Small Tropicals Funds. This report presents the analysis and findings of the project impact assessment.

General method

Hort Innovation's small tropical levy funds include lychee, papaya, passionfruit, persimmon, and pineapple. The 2020-21 population for the small tropicals was defined as an RD&E investment where a final deliverable had been submitted in the five year period from 1 July 2016 to 30 June 2021. This generated an initial population of 140 Hort Innovation small tropical investments, worth an estimated $27.1 million (nominal Hort Innovation investment). Projects in the Frontiers Fund, those of less than $80,000 Hort Innovation investment, multi industry projects where levy funds were less than 50% of total Hort Innovation investment, enabler projects that didn't directly support a small tropicals 2017-2021 Strategic Investment Plan (SIP) outcome, and projects that have had a previous impact assessment completed were removed from the sample. A total of 7 projects with a combined value of $1.93 million satisfied these criteria and formed the eligible population. The 7 eligible projects were then stratified using:

- A consolidated set of small tropical 2017-2021 SIP outcomes
  - Supply/productivity
  - Demand
  - Capacity/comms/extension
  - Business insights (data).
- Three project value ranges
  - $80,000 to $160,000
  - $160,000 to $280,000
  - Above $280,000.

A random sample of 3 projects (one each for lychee, persimmon, and pineapple) was selected worth a total of $0.94 million (nominal Hort Innovation investment), equal to 47% of the eligible small tropicals RD&E population (in nominal terms).

The impact assessment followed general evaluation guidelines that are now well entrenched within the Australian primary industry research sector including Research and Development Corporations, Cooperative Research Centres, State

Departments of Agriculture, and some universities. The approach included both qualitative and quantitative descriptions that are in accord with the impact assessment guidelines of the CRRDC (CRRDC, 2018).

The evaluation process involved reviewing project contracts, milestones, and other documents; interviewing stakeholders including Hort Innovation staff, project delivery partners, growers and other industry stakeholders where appropriate (see *Acknowledgements*); and collating additional industry and economic data where necessary. Through this process, the project activities, outputs, outcomes, and impacts were identified and briefly described; and the principal economic, environmental, and social impacts were summarised in a triple bottom line framework.

Some, but not all, of the impacts identified were valued in monetary terms. Where impact valuation was exercised, the impact assessment uses cost-benefit analysis as its principal tool. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, a high degree of uncertainty surrounding the potential impact, or the likely low relative significance of the impact compared to those that were valued. The impacts valued are therefore deemed to represent the principal benefits delivered by the project. However, as not all impacts were valued, the investment criteria reported for individual investments potentially represent an underestimate of the performance of that investment.

Background and rationale

Industry background

The Australian persimmon industry included approximately 80 growing businesses in 2022 (Hort Innovation 2022a). The persimmon industry recorded a five year average production of 2,635 tonnes (to year ending June 2021) increasing by an average 3% per year (Hort Innovation 2022b). The industry recorded a nominal production value of $11 million in 2020-21 which has increased at an average 1% per year. In 2020-21, Queensland accounted for 35% of production, Victoria 25%, New South Wales (NSW) 20% and South Australia 15%. Production had been steadily declining in Queensland, while increasing in Victoria and Southern Australia. Over the five years to 2020-21, approximately 94% of production went to the domestic fresh market, and 6% to the domestic market, with Australian production accounting for an average 83% of domestic supply (Hort Innovation 2022b).

Persimmon growers pay levies to the Department of Agriculture, Fisheries and Forestry (DAFF), who is responsible for the collection, administration and disbursement of levies and charges on behalf of Australian agricultural industries. Levy is payable on persimmons that are produced in Australia and either sold by the producer or used by the producer in the production of other goods. Hort Innovation manages the persimmon levy funds which are collected for both R&D and marketing purposes.

Rationale

After extensive consultation with the Persimmons Australia Inc. management committee, a set of RD&E priorities was established to improve productivity within the industry.

Developing effective practices for the management of mealybug. Mealybug is seen as a major pest for the persimmon industry (Bignall, 2017a). The honeydew excreted by mealybugs leads to the development of sooty mould, which detracts from the appearance of fruit and often leads to a downgrade in fruit quality in the market. Heavy infestations can affect the plant by reducing vigour and causing leaf and shoot deformation. The Australian industry had relied on a few contact insecticides for control of mealybug, namely petroleum and paraffinic oils, methidathion (Suprathion® no longer available as of 2021) and buprofezin (Applaud®) (QDAF, 2017b). Frequent use of broad spectrum insecticides such as methidathion is disruptive to naturally occurring predators and parasitoids, and may exacerbate the pest problem. Effective mealybug control, as part of an integrated pest management programme (IPM), requires selective insecticides with minimal impact on natural enemies. Clothianidin (Samurai®) had previously (Hort Innovation funded projects QDAF, 2012 and 2014) been identified as being an effective systemic control of mealybug in persimmon, that could be used in line with IPM as it has low mortality rates on predators and parasatoids. A minor use permit for use of clothianidin for mealybug control in persimmon was issued in 2013 APVMA, 2022). The industry identified the need for further research to confirm best practice of clothianidin and other control options, particularly with regards to optimal timing.

Developing effective practices for the management of clearwing moth. Clearwing moth (CWM) is a key pest in persimmon production that was extremely hard to control particularly in Queensland (QLD), with a potentially related species (“borer moth”) causing significant damage in South Australia (QDAF 2017c). CWM (including borer moths) create large lesions or holes in the tree bark leading to a loss of some parts of the tree, and thereby causing yield loss (QDAF 2022). Fuyu and Izu varieties are particularly susceptible (Stakeholder pers comm, see *Acknowledgements*). Inefficiencies in contact chemical once the pest is protected within the tree mean that chemical sprays often also require the pest to be physically removed. Physical removing options included scraping clean the infested areas and sealing the wounds with plastic paint or a tree sealer, or cleaning each tree with high pressure sprays (QDAF 2017c), both of which incur a large labour cost (Bignell 2014). Mating-disruption pheromone twist ties had been previously identified as being potentially effective for CWM control as early as 2005 (QDAF, 2005). A permit for the mating disruptors originally issued in 2012 was due for renewal in 2017 (APVMA 2022), and was expected to require supporting trial data. Trials prior to PR13007 had also proved inconclusive in their results due to high winds disrupting the pheromones, with industry looking to improve their understanding of best practice recommendations through more robust trials and data.

Evaluating new persimmon varieties. The Australian industry predominantly grows non-astringent persimmon types, and is entirely dependent on international breeding programs for new varieties to satisfy changing consumer preferences. New varieties offer the potential to extend the fruit supply season and provide fruit quality features sought by consumers. Cuttings of the most widely grown persimmon variety in Spain “Rojo Brillante” had been imported to Australia prior to 2011 through previous Hort Innovation funded research (Stakeholder pers comm). While Rojo is an astringent variety, it can be treated to remove astringency and therefore meet the demand for non-astringent persimmons as had been primarily targeted by Australian growers. The industry recognized the need to continue to import new varieties, and evaluate recently imported varieties such as Rojo.

Evaluating rootstocks. When trees are grafted onto seedling propagated rootstocks this creates a high degree of variability in orchards. To better understand vegetatively propagated rootstocks rather than seedling rootstocks, a shift to vegetatively propagated rootstocks focuses on continuing advances in precision farming, creating uniformity of trees in persimmon orchards, increasing productivity and enabling the next stage of growth and development in the Australian persimmon industry.

Looking at removing astringency. The Australian industry does not practice deastringency on the small volume of astringent persimmon produced. Late and early ripening as well as new astringent varieties present the opportunity to extend the supply season of the Australian persimmon industry, minimise supply fluctuations and decrease dependency on foreign markets pre- and post-harvest season.

Looking at improved cool-storage practices to extend the storage life of persimmons. Common practice in the Australian industry had been short duration postharvest storage (2 weeks) at relatively high temperature (15^{o}C). This leads to limited capacity to modulated oversupply during peaks in the harvest season, as well as limiting the ability to deliver high quality fruit into export markets.

Alignment with the Persimmon Strategic Investment Plan 2017-2021

The persimmon levy investments are guided by a Strategic Investment Plan (SIP). With a broad focus on management strategies to improved productivity, PR13007 was closely aligned with Outcome 2 of the Persimmon SIP 2017-2021 (Hort Innovation 2017): *Increased industry production and improved productivity to meet increasing domestic and international demand*.

Alignment with national priorities

The Australian Government’s National RD&E priorities (2015a) and Science and Research Priorities (2015b) are reproduced in Table 1. The PR13007 project outcomes and related impacts will contribute to RD&E Priority 4, and to Science and Research Priority 1.

Table 1. National Agricultural Innovation Priorities and Science and Research Priorities

Australian Government	
National RD&E Priorities (2015a)	**Science and Research Priorities (2015b)**
1. Advanced technology 2. Biosecurity 3. Soil, water and managing natural resources 4. Adoption of R&D.	1. Food 2. Soil and Water 3. Transport 4. Cybersecurity 5. Energy and Resources 6. Manufacturing 7. Environmental Change 8. Health.

Project details

Summary

Table 2. Project details

Project code	PR13007
Title	Australian Sweet Persimmon Industry Development Project- Phase 4
Research organization	The department of Agriculture and Fisheries, QLD (QDAF)
Project leader	David Oag
Funding period	June 2014 to May 2017

Logical framework

A logical framework is shown in Table 3 to highlight the connection between the project activities, outputs, outcomes, and impact.

Table 3. Project logical framework

Activities	• **Developing effective practices for the management of mealybug.** ○ Evaluation of surveillance/monitoring techniques including delta traps with citrous mealybug pheromone lures, visual inspection and adhesive bands to examine for the presence of mealybugs. ○ Building on research undertaken in preceding projects (PR12000), field studies were carried out over the course of two seasons to assess the efficacy and effectiveness of IPM compatible pesticides including foliar sprays—Movento® (spirotetramat) or Transform® (sulfoxaflor) —and systemic chemicals Samurai® (clothianidin). • **Developing effective practices for the management of clearwing moth** ○ A mating disruption pheromone trial was established in an orchard at Woombye, with weekly monitored pheromone twist ties (at a density of 1200 per hectare) installed in September 2014 and February 2015. • **Evaluating new persimmon varieties developed overseas** ○ Ongoing maintenance of existing variety trials, including the promising Spanish variety "Rojo Brillante". ○ Ongoing assessments of international breeding programmes looking for variants that would be suitable for the Australian industry. Trees of six varieties were added to the orchard at Maroochy Research Facility for variety evaluation including three non-astringent ('Isahay', 'Sunami', 'Kazusa') and three astringent ('Otanenashi', 'Tone Wase', 'Yoho') grafted to rootstock 'Kaki sun'. • **Evaluating rootstocks** ○ Activities to develop a reliable technique for the clonal propagation of persimmon rootstock were undertaken as a result of a partnership with a North Queensland nursery on two plants each of five seedling rootstock selections. • **Looking at removing astringency** ○ Conduct a pilot trial to gain experience with CO_2 deastringency, as part of evaluating the potential suitability of 'Rojo Brillante' for the Australian persimmon industry. • **Looking at improved cool-storage practices to extend the storage life of persimmons** ○ A study of advanced cool storage techniques for fruit grown in temperate Australia was conducted in 2015, with fruit sourced from three orchards (30 trays each) in the Shepparton region. • **Communication and extension activities** ○ Conduct annual industry workshops in major growing regions. ○ Contribute to separately funded industry communication programs such as *Persimmon Press*. ○ Attend and present findings at the *ISHS VI International Symposium on Persimmon*. Throughout the symposium, conversations and relationships were established with

	exporters and producers as well as international researcher organisations such as the Japanese Ministry of Agriculture Forestry and Fisheries (MAFF).
Outputs	• Industry resources: ○ Updated Postharvest Manual 2017. ○ Revised IPDM manual 2017. ○ Mealybug paper, *Monitoring and control strategies for mealybug of persimmon in Australia*, presented at the *VI International Symposium on Persimmon* • Industry extension ○ Farm visits enhancing relationships between growers and researchers linked to the project. ○ Industry workshops 2014, 2015 ○ 2016 Australian Persimmon Industry Conference consisting of an oral presentation and accompanying paper. ○ 6th International Symposium on Persimmon, 2016 consisting of two oral presentations and one paper in the symposium proceedings. ○ 2017 Australian Persimmon Industry Conference and Field Day consisting of three oral presentations and accompanying articles for the event proceedings. ○ 2017 *Persimmon Press* articles (x2). ○ Diagnostic services for pests and diseases were delivered to growers on demand during the project term.
Outcomes	• **Mealybug management** ○ Increased understanding of mealybug seasonal activity in different persimmon growing regions in Australia guiding improved timing of pest management options. ○ Increased awareness and understanding of how to integrate systemic insecticides controls and monitoring practices into an annual IPM programme for control of mealybug, and the effectiveness of the products. ○ Industry had sufficient trial data to justify seeking Samurai® label registration for use in the persimmon industry (registered 2022, available under permit since 2017), providing industry with additional resources for control of mealybug pests in line with IPM practices with a focus on systemic (soft) insecticides. • **Developing effective practices for the management of CWM** ○ Increased industry knowledge of industry best practice for the management of CWM, with updated findings that mating-disruption pheromones significantly reduced pest numbers and damage in pest pressure areas (south east Queensland). The original permit issued in 2012 expired in 2017. A new permit for mating disruptors was granted in 2020 (APVMA, 2022) to a new supplier, with the application partly informed by QDAF research (2014 and 2017b) (inSense pers comm). • **Evaluating new persimmon varieties developed overseas** ○ The Australian industry has expanded varietal trial resources at Maroochy Research facility, with the maintenance of existing varieties (such as Rojo), and addition of six new varieties. ○ Discussions with the Japanese MAFF persimmon breeder at the *VI International Symposium on Persimmon* ascertained a new willingness of MAFF to commercialize Japanese-bred varieties and established a professional relationship for future negotiations. • **Evaluating rootstocks** ○ Increased awareness on the importance of vegetative propagation (asexual) of rootstocks to ensure uniformity of trees and thus improve orchard productivity, transitioning away from the use of seedling rootstocks. ○ Knowledge of tissue culture, single bud cuttings and old woody shoots (layering) warranting a thorough study to develop a reliable technique for vegetative propagation of persimmon rootstocks in Australia. • **Looking at removing astringency** ○ Increased knowledge on the removal of astringency using CO_2, including from new astringent persimmon cultivar Rojo Brillante. With Rojo testing higher than both unidentified astringent varieties and the industry standard non-astringent variety 'Fuyu' for flavour, sweetness, texture, and firmness. This reaffirmed the ongoing evaluation and potential suitability of 'Rojo Brillante' to the Australian persimmon industry, and highlighted the opportunity for CO_2 deastringency to be applied to existing astringent varieties grown in

	Australia; however, the research noted further and larger scale CO_2 deastringency trials were needed to develop industry protocols.
	• **Looking at improved cool-storage practices to extend the storage life of persimmons**
	  ○ Increased knowledge of the potential to extend the storage period of fruit from a temperate environment, including:
	    ▪ SmartFreshSM (1-MCP) can extend the postharvest storage period of 'Fuyu' fruit to two to eight weeks.
	    ▪ Modified environment bags did not extend the post-harvest storage period past the existing two weeks.
	• **General**
	  ○ As a result of attending the *VI International Symposium on Persimmon*, the Australian industry has greater connectivity and collaboration potential with international researchers and organisations such as the Japanese MAFF.

Impacts	• **Mealybug and CWM management**
	  ○ Increased adoption of higher efficacy mealybug and CWM management in line with IPM. Resulting in:
	    ▪ [Economic] Improved pest management productivity (efficacy (quality) or cost or both)
	    ▪ [Economic] Reduced risk of pesticide resistance associated with high chemical usage.
	    ▪ [Socio-economic] Reduced risk of human exposure to insecticides directly during application or through residues.
	    ▪ [Environmental] Reduced off-target impact on beneficial insects and reduced industry environmental toxicity load.
	• **Rootstocks and varieties**
	  ○ Ongoing maintenance of new high performing varieties (such as Rojo) supporting.
	    ▪ [Economic] Increased productivity on Australian persimmon orchards.
	    ▪ [Economic] The extension of the Australian persimmon season, supporting industry expansion.
	    ▪ [Economic] Industry expansion and market growth as a result of improved fruit quality and varieties sought by customers, supporting increased demand and price support.
	  ○ Increased industry capacity, to develop clonal / vegetative propagation from contacts with Japanese breeders using vegetative propagation for dwarfing rootstocks. Supporting:
	    ▪ [Economic] Uniform orchard growth with improvement in input and operational consistency and efficiencies.
	    ▪ [Economic] Increases in productivity and yield.
	• **Removing astringency**
	  ○ [Economic] Increased industry capacity to transform astringent fruit (such as Rojo) into a non-astringent product has the potential to allow the industry to maintain flexibility in targeting different segments in domestic and overseas markets. The research noted further and larger scale CO_2 deastringency trials were needed to develop industry protocols.
	• **Improved cool-storage practices to extend the storage life of persimmons**
	  ○ Improved knowledge and capabilities with regards to storage practices (specifically the use of SmartFreshSM) enabling Australian growers to:
	    ▪ [Economic] Modulate supply and extend the supply season beyond the harvest period, potentially supporting import replacement and export development.
	• **General**
	  ○ [Social] Increased contribution to regional community wellbeing from more profitable persimmon growers as a result of adoption of new levy research outputs.
	  ○ [Social] Increased sustainability of quality and affordable persimmon supply, supporting increased consumption of persimmons with associated health and wellbeing benefits.

Project costs

Nominal investment

Table 4. Project nominal investment

Year end 30 June	Hort Innovation ($)	QDAF ($)	Total ($)
2014	55,157	71,235	126,392
2015	17,542	22,655	40,197
2016	107,823	139,253	247,076
2017	97,311	125,677	222,988
Total	277,833	358,820	636,653

*Other funds from QDAF are provided in the contract as a lump sum, so have been apportioned yearly based on Hort Innovation cash costs.

Program management costs

R&D costs should also include the administrative and overhead costs associated with managing and supporting the project. The Hort Innovation overhead and administrative costs were calculated for each project funding year based on the data presented in the *Statement of Comprehensive Income* in the *Hort Innovation Annual Report* for the relevant year. Where the overhead and administrative costs were equal to the total expenses, less the research and development and marketing expenses. The overhead and administrative costs were then calculated as a proportion of combined project expenses (RD&E and marketing), averaging 15.8% for the PR13007 funding period (2014-2017). This figure was then applied to the nominal Hort Innovation investment shown in Table 4. Note that annual reports for 2014 and 2015 financial years were not available online at the time of reporting, so an average of the 2016-2021 financial years of 15.9% was assumed to apply for these years.

Real Investment costs

For purposes of the investment analysis, the investment costs of all parties were expressed in 2021-22 dollar terms using the Implicit Price Deflator for Gross Domestic Product (ABS, 2022).

Extension costs

Research was extended to growers and other stakeholders through the project (annual workshops) and also through the separately funded industry communication program. Based on the Persimmon Fund Annual Report (Hort Innovation 2022c), industry communications accounts for approximately 28% of total RD&E spending. This was reduced to half (14%) given the additional communication and extension work completed within PR13007.

Project impacts

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria.

Impacts valued

The following impacts were quantified.

Mealybug pest management. Increased adoption of higher efficacy mealybug management in line with IPM, consisting of a Samurai® (clothianidin) soil drench at flowering, resulting in:

- Reduced operational costs (labour and chemical costs).

CWM pest management. Increased adoption of higher efficacy CWM mating disruption pheromones, supporting:

- Reduced operational costs (labour costs relating to high pressure spray treatment)

New varieties. Ongoing maintenance of new high performing varieties (such as Rojo) supporting.

- Increased productivity on Australian persimmon orchards.

Valuation method

Mealybug pest management. Prior to the project, the Australian persimmon industry relied on a few contact insecticides for control of mealybug, namely petroleum and paraffinic oils, methidathion (Suprathion®) and buprofezin (Applaud®) (QDAF 2017b). As mealybug typically hide in the protected calyx of the persimmon, the efficacy of contact pesticides is reduced, necessitating 6-8 applications per season (growers pers comm). A permit for use of a systemic pesticide (Samurai® active ingredient clothianidin) was issued in 2013 (APVMA, 2022) based on previous research including by QDAF (2012 and 2014). The counterfactual assumed a shift from contact pesticides to systemic pesticide under permit was underway from 2013, maintaining the same efficacy (fruit quality) at a lower pest management cost. In discussion with stakeholders, the analysis further assumed that the PR13007 research into best practice increased confidence in the new product, supporting a more rapid industry adoption, and to a lesser extent, providing support for a permit renewal in 2018. This was quantified using stakeholder feedback and available data to inform inputs into CSIRO ADOPT analysis (Kuehne et al 2017). Data on pesticide application rates was sourced from product labels and discussions with grower and researcher stakeholders, and cost data was sourced from industry retailers.

CWM pest management. Prior to the project, persimmon growers used contact chemicals (Noon, 2019) as well as a high pressure sprays to physically remove CWM from the trees, spraying each tree for 5-20 minutes per tree every 1-2 years (researcher and grower consultation). Mating disruptor pheromones had been commercially available under APVMA permit since 2012 with a renewal due 2020 (APVMA 2022). Previous research (including QDAF 2014) highlighted the potential of the mating disruptors to reduce the damage caused by CWM in persimmon orchards and negate the need for contact chemicals and high pressure sprays. However, high winds in the trials proved inconclusive, thereby limiting grower confidence to adopt the disruptors and highlighting the need for further research. The permit for mating disruptors was renewed in 2020 (APVMA, 2022) which was partly informed by QDAF research (2014 and 2017) (inSense pers comm). The PR13007 research into the CWM mating disruptor efficacy and best practice, and (to a lesser extent) the support to gaining the product permit in 2020, was assumed to generate increased confidence in the new product, supporting a more rapid industry adoption. This was quantified using stakeholder feedback and available data to inform inputs into CSIRO ADOPT analysis (Kuehne et al 2017). Application details of one disrupter applied per tree, once to twice per year were taken from the product permit (APVMA 2022) and stakeholder consultation, with the 2022 cost of the mating disrupter identified as $2.5 each and application time (labour) being negligible (stakeholder consultation).

New Variety—Rojo Brillante. Industry adoption was assumed to have started in 2020 based on stakeholder consultation. Using stakeholder feedback and available data, an industry adoption curve was developed using CSIRO ADOPT analysis (Kuehne et al 2017) with the assumption that Rojo was used to replace existing varieties rather than as part of industry expansion. Trials of Rojo show improved yield of 29% over traditional Australian varieties. The yield benefit of the new variety was priced using the Hort Stats Handbook 5 year average farmgate price (Hort Innovation 2022b), less additional production costs (QDAF 2005) including yield based costs including harvesting, grading, and packaging.

Impacts not valued

The following potential impacts were unable to be quantified due to a lack of data to confidently attribute impact.

Mealybug pest management.

- Reduced risk of pesticide resistance associated with high chemical usage.
- Reduced risk of human exposure to insecticides directly during application or through residues.
- Reduction off-target impact on beneficial insects and reduced industry environmental toxicity load.

Rootstocks and varieties.

- Ongoing maintenance of new high performing varieties supporting.
  - The extension of the Australian persimmon season, supporting industry expansion.
  - Industry expansion and market growth as a result of improved fruit quality and varieties sought by customers, supporting increased demand and price support.
- Increased industry capacity, to develop clonal / vegetative propagation from contacts with Japanese breeders using vegetative propagation for dwarfing rootstocks. Supporting:
  - Uniform orchard growth with improvement in input and operational consistency and efficiencies.
  - Increases in productivity and yield.

Removing astringency

- Increased industry capacity to transform astringent fruit (such as Rojo) into a non-astringent product has the potential to allow the industry to maintain flexibility in targeting different segments in domestic and overseas markets. The research noted further and larger scale CO_2 deastringency trials were needed to develop industry protocols.

Improved cool-storage practices to extend the storage life of persimmons

- Improved knowledge and capabilities with regards to storage practices (specifically the use of SmartFreshSM) enabling Australian growers to:
  - Modulate supply and extend the supply season beyond the harvest period, potentially supporting import replacement (e.g. New Zealand produce) and export development.

Public versus private impacts

The potential impacts identified from the investment are predominantly private impacts accruing to persimmon growers and supply chain participants. However, some public benefits have also been produced in the form of capacity built and spill-overs to regional communities from potential enhancements to grower profitability and industry capability as well as improved environmental outcomes.

Distribution of private impacts

The analysis quantified direct benefits accruing to persimmon growers. Additional flow-on (spillover) impacts would be generated in the wider economy. These include:

- Production-induced effects, which reflect the flow-on changes to the supply chain (upstream and downstream) that result from farm level changes in inputs (chemicals, labour, packaging, transport, marketing) associated with practice change.
- Consumption induced effects, which reflect the flow-on changes generated through the payments of wages and salaries to households and the subsequent expenditure of those incomes of purchasing household goods and services.

Furthermore, the true impact would also be influenced by the price effect, which reflects changes in prices (of inputs and outputs) as a result in changes in supply and demand of those inputs and outputs. RD&E that focusses on increased productivity would support increased industry supply (in the short or long term subject to capacity constraints), and thereby put downward pressure on prices, effectively shifting some of the benefit from producers to consumers. The extent to which this would occur would depend on the slope of the short and long term supply and demand curves. Given the relatively niche domestic market for persimmons, and the low level of exports, there would likely be a reduced capacity for the market to absorb increased supply without a decrease in prices.

Impacts on other Australian industries

The project impacts primarily focussed on the persimmon industry, but have the potential to inform related tree crop industries, or industries with similar pest pressures. One example identified in discussions with stakeholders was that trials with vegetative propagation of persimmons informed ongoing work to vegetatively propagate custard apples.

Impacts overseas

The impacts primarily focussed on Australian persimmon production; however, international collaboration achieved as part of the project (such as through VI International Symposium on Persimmon) have the potential to inform RD&E and impact in overseas persimmon production.

Data and assumptions

A summary of the key assumptions made in the assessment is provided in Table 5.

Table 5. Summary of assumptions for impact valuation

Variable	Assumption	Source / comment
Discount rate	5% (± 50%)	CRRDC Guidelines (2018)
National production (t)	2771 (±5%)	Production between 2017 and 2021 ranged from 2500t and 2839t (Hort Innovation 2022b). In anticipation of increased productive area (Hort Innovation 2022a), the 5 year maximum was used, plus and minus the 5y standard deviation (Hort Innovation 2022b).
Trees per hectare	1000	Stakeholder consultation.
Industry yield (t/ha)	25 (±18%)	Yield data from Noon (2019), with fruit sizes ranging 155-330g per fruit (average 240g) (QDAF 2017c)
Mealybug pest management		
Contact pesticide cost ($/application)	$2625 (±50%)	6-8 applications with example contact pesticide cost (Buprofezin $73/kg @ 600mL/ha) (Ag Econ 2022 and APVMA 2022), plus $83/ha application cost (machinery and labour)

		(NSW DPI 2018), and hand cleaning of 20%-40% of total fruit for 4-8 seconds per fruit at $30/hr labour (assumption based on QDAF 2017c and stakeholder consultation).
Systemic pesticide management cost ($/application)	$1128	1 application of Samurai® @ $209/kg (Nutrien pers comm), 5g/tree (APVMA 2022), plus $83/ha application cost (NSW DPI 2018).
Counterfactual adoption of new systemic insecticide	Start 2013 Max 34% by 2021	Samurai® permit available in 2013. See Appendix A for adoption curve methodology.
Change in adoption with PR13007	Start 2017 Max 93% (±10%) by 2021	PR13007 Samurai® research completed and extended 2016. See Appendix A for adoption curve methodology.
Outcome attribution (change in adoption)	80% (±20%) to 2023, declining to 28% by 2047	While the product was available from previous research into systemic pesticides including QDAF 2012 and QDAF 2014, PR13007 provided additional data and extension material to support greater awareness, knowledge, and confidence in the recommended practice, thus giving a high level of attribution to the quantified shift in adoption. Attribution was assumed to decline after 10 years by a compound 5% per year given the need to update management methods with new varieties, products and production systems.
R&D counterfactual	80% (±12.5%)	As a small industry it is likely that there would be limited interest to engage in persimmon RD&E without the support of Hort Innovation levy funding.
CWM pest management		
Industry CWM presence % of national production	15%	High levels of infestations in QLD (32% affected) and SA (15%) with limited damage in other states (QDAF 2017c). Damage rates applied to QLD (35% of national) and SA (15%) production (Hort Innovation 2022b).
High pressure spay cost ($/ha)	$4,688 (±20%)	5 to 20 minutes of high pressure spray per tree, once every 1-2 years, $30/hour labour (stakeholder consultation)
Pheromone mating disruptor cost ($/ha)	$3,750 (±5%)	Prices were $0.65 /disruptor in 2005 (adjusted to 2022 equivalent using ABS 2022), increasing to $2.5 /disruptor by 2022 potentially due to a change in manufacturer and COVID trade disruptions (stakeholder consultation). $2.5 /disrupter taken as the upper level, with $2.25 as mid, and $2.0 as lower.
Counterfactual adoption of disruptor	Start 2012 Max 15% by 2021	Mating disruptor permit available in 2012 (APVMA 2022). See Appendix A for adoption curve methodology.
Change in adoption with PR13007	Start 2017 Max 86% (±10%) by 2022	PR13007 research on disruptors completed and extended 2016. See Appendix A for adoption curve methodology.
Outcome attribution (change in adoption)	80% (±20%)	While the product was available from previous research into pheromone mating disruptors, including QDAF 2014, PR13007 provided additional data and extension material to support greater awareness, knowledge, and confidence in the recommended practice, thus giving a high level of attribution to the quantified shift in adoption. Attribution was assumed to decline after 10 years by a compound 5% per year given the need to update management methods with new varieties, products and production systems.
R&D counterfactual	80% (±12.5%)	As a small industry it is likely that there would be limited interest to engage in persimmon R&D without the support of Hort Innovation levy funding.
New variety — Rojo Brillante		
Rojo yield benefit (% above existing varieties	29%	Rojo yields 45 tonnes per hectare compared to Jiro and Fuyu varieties that yield 30-35 tonnes per hectare. Yield gain taken

t/ha)		as 45/30=29%. Applied to industry average 25 (±18%) (Noon 2019). With marketable yield of 97.5% (QDAF 2017a, Grade Standards figure 1).
Price ($/kg)	$4.60 (±11%)	Hort Stats Handbook farmgate price (Hort Innovation 2022b) adjusted to 2022 equivalent values (ABS 2022), 5 year average and standard deviation.
Production timeline (years from planting)	First yield 3 years Max yield 6 years Replace 30 years	QDAF (2005)
Gross Margin on additional yield	40% (±25%)	Standard gross margin of 30% (QDAF 2005) taken as the minimum GM on additional yield on the assumption that some costs (pesticides, fertilizer, water, pruning) will be less affected by varietal changes, with the primary change in farm costs coming from yield based costs (harvest, grading, packaging).
Adoption of new varieties	Start 2020 Max 34% (±79%) by 2031	Early adoption was underway by 2022 including through propagation of Rojo maintained in PR13007 (stakeholder pers comm). See Appendix A for adoption curve methodology.
Outcome attribution (availability and knowledge of new variety)	20% (±50%)	Rojo was imported prior to 2011 but only one fruiting tree was confirmed as Rojo. This was maintained through PR13007 and propagated for distribution to growers. Ongoing evaluation was undertaken by Hort Innovation funded project *PR17000 National persimmon varietal evaluation program 2018-2023* including the importation of further Rojo rootstock. Assuming a 14 year period of import and evaluation (2010-2023), with values adjusted for CPI (ABS 2022), the four years of PR13007 account for 30% of total costs, which was taken as the upper given limited material and additional later imports. Midpoint of 20%, lower of 10%.
R&D counterfactual	80% (±12.5%)	As a small industry it is likely that there would be limited interest to engage in persimmon R&D without the support of Hort Innovation levy funding.

Results

All costs and benefits were discounted to 2021-22 using a real discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base analysis used the best available estimates for each variable, notwithstanding a level of uncertainty for many of the estimates. All analyses ran for the length of the project investment period plus 30 years from the last year of investment (2026-17) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment criteria

Table 6 shows the impact metrics estimated for different periods of benefit for the total investment.

Table 6. Impact metrics for the total investment in project PR13007

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	1.17	1.17	1.17	1.17	1.17	1.17	1.17
PVB ($m)	0.01	0.33	0.62	0.93	1.22	1.44	1.59
NPV ($m)	-1.16	-0.84	-0.55	-0.24	0.05	0.27	0.43
BCR	0.01	0.28	0.53	0.80	1.05	1.23	1.36
IRR	Negative	Negative	Negative	2%	5%	7%	7%
MIRR	Negative	Negative	0%	4%	5%	6%	6%

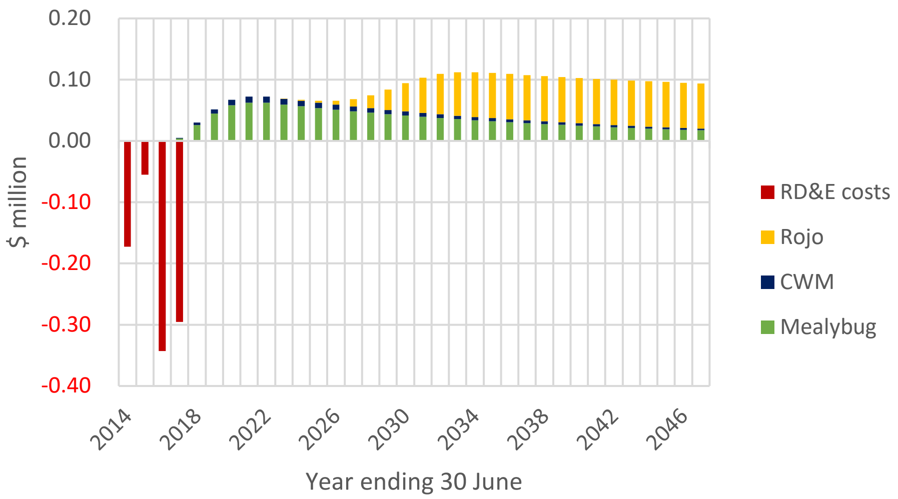
Table 7 shows the impact metrics estimated for different periods of benefit for the Hort Innovation investment. The benefits attributable to Hort Innovation were based on a 50% funding share (present values including admin costs).

Table 7. Impact metrics for the Hort Innovation investment in project PR13007

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	0.59	0.59	0.59	0.59	0.59	0.59	0.59
PVB ($m)	0.00	0.16	0.31	0.47	0.61	0.72	0.80
NPV ($m)	-0.58	-0.42	-0.28	-0.12	0.03	0.13	0.21
BCR	0.01	0.28	0.53	0.80	1.05	1.23	1.36
IRR	Negative	Negative	Negative	2%	5%	7%	7%
MIRR	Negative	Negative	0%	4%	5%	6%	6%

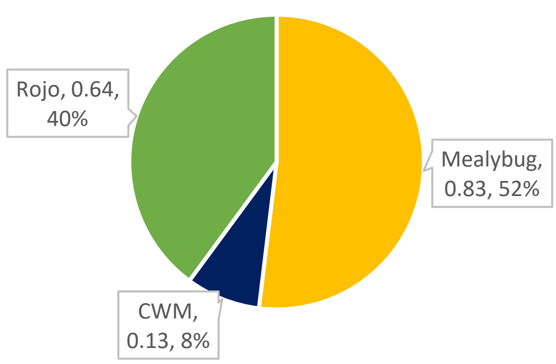
Figure 1 shows the annual undiscounted benefit and cost cash flows for the total investment of PR13007. Cash flows are shown for the duration of the investment plus 30 years from the last year of investment.

Figure 1. Annual cash flow of undiscounted total benefits and total investment costs



The breakdown of discounted (present value) benefits by R&D area are shown in figure 2. The delay until the new variety benefits, due to the longer adoption timeline (see appendix A) and the subsequent time required to reach production, mean that these benefits have been more heavily discounted than the other R&D areas.

Figure 2. Share of benefits across investment areas ($ million, and % share of total PV benefits)



Sensitivity analysis

A sensitivity analysis was carried out on key variables identified in the analysis where a data range was identified, or there was a level of uncertainty around the data (Table 8). Data ranges and sources are described in Table 5.

Table 8. Sensitivity of impact (total investment BCR) to changes in key underlying variables

Variable		Low	Baseline	High
Discount rate (%)	Variable range	3%	5%	10%
	BCR range	1.84	1.36	0.73
Persimmon production (t)	Variable range	2,632	2,771	2,910
	BCR range	1.31	1.36	1.42
Yield (t/ha)	Variable range	20	25	30
	BCR range	1.36	1.36	1.36
Mealybug management				
Previous chem applications (#)	Variable range	6	7	8
	BCR range	1.30	1.36	1.42
Hand cleaning time/fruit (sec/fruit)	Variable range	0.0008	0.0014	0.0019
	BCR range	1.04	1.36	1.69
Hand cleaning (% of fruit)	Variable range	30%	40%	50%
	BCR range	1.16	1.36	1.57
Change in Samurai® adoption (appendix A)	Variable range	Low	Mid	High
	BCR range	1.19	1.36	1.44
Samurai outcome attribution (adoption change)	Variable range	60%	80%	100%
	BCR range	1.19	1.36	1.54
Samurai R&D Counterfactual	Variable range	70%	80%	90%
	BCR range	1.28	1.36	1.45
Clearwing Moth management				
HPS time per tree (hours)	Variable range	0.08	0.21	0.33
	BCR range	1.25	1.36	1.60
HPS applications per year	Variable range	0.50	0.75	1.00
	BCR range	1.25	1.36	1.50
Mating disruptor cost ($/unit)	Variable range	2.00	$2.25	2.50
	BCR range	1.40	1.36	1.33
Mating disruptor applications per year	Variable range	1	1.50	2
	BCR range	1.46	1.36	1.27
Change in mating disruptor adoption (appendix A)	Variable range	Low	Mid	High
	BCR range	1.34	1.36	1.39
Disruptor outcome attribution (adoption change)	Variable range	60%	80%	100%
	BCR range	1.34	1.36	1.39
Disruptor R&D Counterfactual	Variable range	70%	80%	90%
	BCR range	1.35	1.36	1.38
New variety — Rojo Brillante				
Fruit average price ($/kg)	Variable range	4	4.60	5.10
	BCR range	1.31	1.36	1.42
Average GM on additional yield (% of revenue)	Variable range	30%	40%	50%
	BCR range	1.23	1.36	1.50
Rojo adoption curve (Appendix A)	Variable range	Low	Mid	High
	BCR range	0.96	1.36	1.77
Rojo outcome attribution (availability and knowledge)	Variable range	10%	20%	30%
	BCR range	1.09	1.36	1.64
Rojo R&D Counterfactual	Variable range	70%	80%	90%
	BCR range	1.30	1.36	1.43

Conclusions

The analysis showed that the quantified benefits were greater than the investment costs for PR13007, with a BCR 1.36:1. The results reflect the benefits of three areas of RD&E; mealybug pest management, CWM pest management, and variety evaluation.

Mealybug pest management accounted for 43% of total nominal benefits, but 52% of total discounted (PV) benefits given the earlier benefit timeline. The recommendations of the mealybug pest management R&D built on work completed in previous Hort Funded RD&E relating to systemic pesticides that were already commercially available. PR13007 was assessed to generate impact (reduced cost through a reduced need for low efficacy contact pesticides followed by hand cleaning) through improved awareness and knowledge of best practice resulting in a change in the existing industry adoption curve. Of note, the results only showed the benefits of the change in adoption attributable to PR13007, not the total benefits of improved mealybug management. In addition, the results reflect only the farm level productivity benefits (reduced cost). The results for this area of research were particularly sensitive to changes in the counterfactual extent of hand-cleaning (percent of fruit and time) required to remove the mealybugs and mealybug honeydew.

CWM pest management accounted for 7% of total nominal benefits, and 8% of total discounted (PV) benefits given the earlier benefit timeline. The recommendations of the CWM pest management R&D built on work completed in previous Hort Funded RD&E relating to pheromone mating disrupters that were already commercially available. PR13007 was assessed to generate impact (reduced cost through a reduction in physical removal of CWM) through improved awareness and knowledge of best practice resulting in a change in the existing industry adoption curve. Of note, the results only showed the benefits of the change in adoption attributable to PR13007, not the total benefits of improved CWM management. While not tested for sensitivity, the relative size of this impact was largely affected by the smaller proportion (15%) of industry impacted by CWM, with high pressure damage restricted to QLD and SA, and also varying between varieties. Across the tested variables, the results for this area of research were most sensitive to changes in the counterfactual intensity (labour time and frequency) of physically removing the CWM from the trees; however, these had limited influence on the overall impact given the lower contribution of this research area.

New variety—Rojo Brillante accounted for the majority of undiscounted benefits (50%), but this reduced to 40% of total discounted (PV) benefits given the longer adoption timeline (see Appendix A) and the subsequent time required to reach production. PR13007 was part of a 14 year RD&E process (ongoing to 2023) to make Rojo available to Australian knowledge, and given them the insights necessary for adoption and production. Based on an estimated cost share, 10%-30% of the total varietal benefit (higher yield relative to existing varieties) was assessed to be attributable to PR13007. As such, the results only reflect a small proportion of the total benefit of the 14 year RD&E program. The results for this area of research were particularly sensitive to changes in the variety adoption curve which was tested at a relatively wide range (between 7% adoption and 60% adoption) given uncertainties relating to the performance of the variety relative to established and other new varieties. In addition, this research area was also heavily influenced by the discount rate (given the long timeframe to impact) and the level of attribution (10% to 30%).

Across the total impact, the analysis showed an impact (BCR) ranging from a low value of 0.73:1 to a high of 1.84:1. Of note, the variables were tested individually, and did not account for cumulative effects of multiple variable changes.

A lack of underlying data meant that there were economic, social and environmental outcomes identified but not quantified which had the potential to provide additional impact to the persimmon industry.

This analysis quantified direct private benefits accruing to persimmon growers. Additional flow-on (spillover) private impacts would be generated in the wider economy. Changes in farm inputs relating to pest management would result in corresponding spillover changes in income for businesses providing those goods and services. The total private impacts would be further redistributed between growers, wholesalers, exporters, and retailers depending on both short- and long-term supply and demand elasticities. Incorporating these additional impact effects (flow-on and price) requires more complex modelling such as input-output (for flow-on effects) and equilibrium modelling (for flow-on and price effects); however, the use of these will be limited by available time and data making their application to industries more difficult.

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Glossary of economic terms

Cost-benefit analysis	A conceptual framework for the economic evaluation of projects and programs in the public sector. It differs from a financial appraisal or evaluation in that it considers all gains (benefits) and losses (costs), regardless of to whom they accrue.
Benefit-cost ratio	The ratio of the present value of investment benefits to the present value of investment costs.
Discounting	The process of relating the costs and benefits of an investment to a base year using a stated discount rate.
Internal rate of return	The discount rate at which an investment has a net present value of zero, i.e. where present value of benefits = present value of costs.
Modified internal rate of return	The internal rate of return of an investment that is modified so that the cash inflows from an investment are re-invested at the rate of the cost of capital (the re-investment rate).
Net present value	The discounted value of the benefits of an investment less the discounted value of the costs, i.e. present value of benefits - present value of costs.
Present value of benefits	The discounted value of benefits.
Present value of costs	The discounted value of investment costs.

Abbreviations

ADOPT The Commonwealth Scientific and Industrial Research Organisation's (CSIRO) Adoption & Diffusion Outcome Prediction Tool (Kuehne et al 2017)

CRRDC Council of Rural Research and Development Corporations

DAFF Department of Agriculture, Fisheries and Forestry (Australian Government)

GDP Gross Domestic Product

GVP Gross Value of Production

IRR Internal Rate of Return

MIRR Modified Internal Rate of Return

PVB Present Value of Benefits

PVC Present Value of Costs

RD&E Research, Development and Extension

SIP Strategic Investment Plan

Appendix A. Adoption and diffusion using the ADOPT framework

Appendix A includes the data inputs for the ADOPT model (Kuehne et al 2017) used in this analysis. The results were tested for sensitivity of the adoption rate and level by adjusting answers relating to the key adoption and diffusion parameters of each impact area.

Mealybug pest management

A permit for use of a systemic pesticide (Samurai® active ingredient clothianidin) was issued in 2013 (APVMA, 2022). Drawing on discussions with stakeholders and available data the counterfactual assumed a shift from contact pesticides to systemic pesticide was underway from 2013 (Figure 3). The analysis further assumed that from 2017 (following research into Samurai® completed and extended from 2016) PR13007 supported increased awareness (Q12) and improved industry skills relating to best practice (Q13) resulting in improved efficacy, which itself supported improved results relating to profit (Q16) and the environment (Qs19-20), and a reduced perception of risk associated with the new practice (Q21).

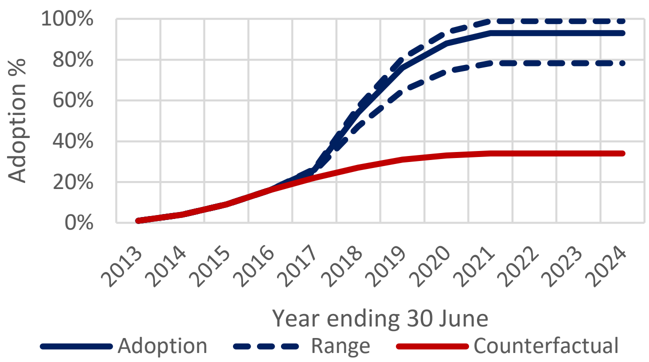

Figure 3. Change in adoption and diffusion curve for the use of Samurai® in mealybug pest management.

ADOPT inputs for mealybug pest management

1. What proportion of farms have maximising profit as a strong motivation?

A majority all have maximising profit as a strong motivation

2. What proportion of farms has protecting the natural environment as a strong motivation?

About half have protection of the environment as a strong motivation

3. What proportion of farms has risk minimisation as a strong motivation?

About half have risk minimisation as a strong motivation

4. On what proportion of farms is there a major enterprise that could benefit from the technology?

Almost all of the target farms have a major enterprise that could benefit

5. What proportion of farms have a long-term (greater than 10 years) management horizon for their farm?

About half have a long-term management horizon

6. What proportion of farms are under conditions of severe short-term financial constraints?

A minority currently have a severe short-term financial constraint

7. How easily can the innovation be trialled on a limited basis before a decision is made to adopt it on a larger scale?

Very easily trialable

8. Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used?

Slightly difficult to evaluate effects of use due to complexity

9. To what extent would the innovation be observable to farmers who are yet to adopt it when it is used in their district?

Not observable at all

10. What proportion of growers use paid advisors capable of providing advice relevant to the innovation?

A minority use paid advisors

11. What proportion of growers participate in groups that enable discussion relevant to the innovation?

About half of growers participate in relevant discussion groups from previous RD&E.

A majority of growers participate in relevant discussion groups (through PR13007 extension).

12. What proportion of growers/advisors will need to develop substantial new skills and knowledge to use the innovation?

About half will need to develop substantial new skills and knowledge from previous RD&E.

A minority will need to develop substantial new skills and knowledge (through PR13007 extension).

13. What proportion of growers would be aware of the use of trialling of this innovation in their district?

About half would be aware of the use of trialling of this innovation from previous RD&E.

A majority would be aware of the use of trialling of this innovation (through PR13007 extension).

14. What is the size of the up-front cost of the investment relative to the potential annual benefit from using the innovation?

No initial upfront cost

15. To what extent is the adoption of the innovation able to be reversed?

Very easily reversed

16. To what extent is the use of the innovation likely to affect the profitability of the farm business in the years that it is used?

Small profit advantage (without PR13007) due to a lower understanding of best practice supporting some ongoing use of contact pesticides.

Moderate profit advantage (with PR13007) due to an improved understanding of best practice supporting minimal use of contact pesticides.

17 To what extent is the use of the innovation likely to have additional effects on the future profitability of the farm business?

Small profit advantage in the future (relating to reduced risk of pest resistance from high chemicals use)

18 How long after the innovation is first adopted would it take for effects on future profitability to be realised?

3-5 years

19. To what extent would the use of the innovation have net environmental benefits or costs?

Small environmental gain (without PR13007) due to a lower understanding of best practice supporting some ongoing use of contact pesticides with negative off-target effects such as on other insects.

Moderate environmental advantage (with PR13007) due to an improved understanding of best practice supporting minimal use of contact pesticides.

20. How long after the innovation is first adopted would it take for the expected environmental benefits or costs to be realised?

Immediately

21. To what extent would the use of the innovation affect the net exposure of the farm business to risk?

Small increase in perceived risk without PR13007 due to a lower understanding of best practice and efficacy

Small reduction in perceived risk with PR13007 due to an improved understanding of and confidence in best practice and efficacy

22. To what extent would the use of the innovation affect the ease and convenience of the management of the farm in the years that it is used?

No change

CWM pest management

The primary areas of CWM damage (and therefore adoption) were identified as being QLD (32% of production damaged) and SA (15% of production damaged) (QDAF 2017c). Applying this to average production for QLD (35% of national) and SA (15% of national) (Hort Innovation 2022a) gave a maximum possible adoption of 15% of national production. Mating disruptor pheromones had been commercially available under APVMA permit since 2012 with a renewal due 2020

(APVMA 2022). Drawing on discussions with stakeholders and available data the counterfactual assumed a shift from physical removal of CWM to mating disruptors was underway from 2012 (Figure 4). The analysis further assumed that from 2017 (following PR13007 research into the mating disruptors completed and extended from 2016) PR13007 supported increased awareness (Q11 & Q13) and improved industry skills relating to best practice (Q12) resulting in improved efficacy, which itself supported improved results relating to profit (Q16) and convenience (Q22), and a reduced perception of risk associated with the new practice (Q21).

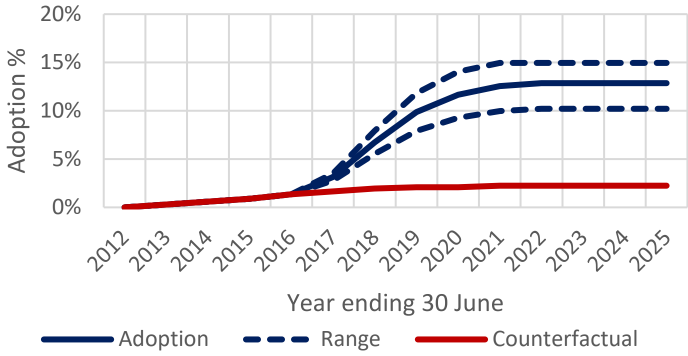

Figure 4. Change in adoption and diffusion curve for the use of CWM mating disruptors.

ADOPT inputs for CWM pest management

1. What proportion of farms have maximising profit as a strong motivation?

A majority all have maximising profit as a strong motivation

2. What proportion of farms has protecting the natural environment as a strong motivation?

About half have protection of the environment as a strong motivation

3. What proportion of farms has risk minimisation as a strong motivation?

About half have risk minimisation as a strong motivation

4. On what proportion of farms is there a major enterprise that could benefit from the technology?

Almost all of the target farms have a major enterprise that could benefit

5. What proportion of farms have a long-term (greater than 10 years) management horizon for their farm?

About half have a long-term management horizon

6. What proportion of farms are under conditions of severe short-term financial constraints?

A minority currently have a severe short-term financial constraint

7. How easily can the innovation be trialled on a limited basis before a decision is made to adopt it on a larger scale?

Very easily trialable

8. Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used?

Slightly difficult to evaluate effects of use due to complexity

9. To what extent would the innovation be observable to farmers who are yet to adopt it when it is used in their district?

Not observable at all

10. What proportion of growers use paid advisors capable of providing advice relevant to the innovation?

A minority use paid advisors

11. What proportion of growers participate in groups that enable discussion relevant to the innovation?

About half of growers participate in relevant discussion groups from previous RD&E.

A majority of growers participate in relevant discussion groups (through PR13007 extension).

12. What proportion of growers/advisors will need to develop substantial new skills and knowledge to use the innovation?

About half will need to develop substantial new skills and knowledge from previous RD&E.

A minority will need to develop substantial new skills and knowledge (through PR13007 extension).

13. What proportion of growers would be aware of the use of trialling of this innovation in their district?

About half would be aware of the use of trialling of this innovation from previous RD&E.

A majority would be aware of the use of trialling of this innovation (through PR13007 extension).

14. What is the size of the up-front cost of the investment relative to the potential annual benefit from using the innovation?

No initial upfront cost

15. To what extent is the adoption of the innovation able to be reversed?

Very easily reversed

16. To what extent is the use of the innovation likely to affect the profitability of the farm business in the years that it is used?

Small profit advantage without PR13007 due to a lower understanding of best practice supporting some ongoing use of physical removal measures.

Moderate profit advantage with PR13007 due to an improved understanding of best practice supporting minimal use of physical removal measures.

17 To what extent is the use of the innovation likely to have additional effects on the future profitability of the farm business?

No profit advantage in the future

18 How long after the innovation is first adopted would it take for effects on future profitability to be realised?

Not applicable

19. To what extent would the use of the innovation have net environmental benefits or costs?

No environmental benefits or costs

20. How long after the innovation is first adopted would it take for the expected environmental benefits or costs to be realised?

Not applicable

21. To what extent would the use of the innovation affect the net exposure of the farm business to risk?

Small increase in perceived risk without PR13007 due to a lower understanding of best practice and efficacy

Small reduction in perceived risk with PR13007 due to an improved understanding of and confidence in best practice and efficacy

22. To what extent would the use of the innovation affect the ease and convenience of the management of the farm in the years that it is used?

Small increase in ease and convenience without PR13007 due to a lower understanding of best practice supporting some ongoing use of physical removal measures.

Moderate increase in ease and convenience with PR13007 due to an improve understanding of best practice supporting minimal use of physical removal measures.

New variety—Rojo Brillante

Rojo was imported prior to 2011; however only one fruiting tree in the Maroochy Research Facility orchard was confirmed as Rojo. This was maintained through PR13007 and propagated for distribution to growers, with additional plant material imported, propagated, evaluated and made available through *PR17000 National persimmon varietal evaluation program 2018-2023*. Drawing on discussions with stakeholders and available data, industry adoption (commercial planting) of Rojo was assumed to have started in 2020 with limited adoption up to 2023 given a low availability of planting material (Figure 5). From 2024 adoption was assumed to increase, with a potential adoption range developed by adjusting the variables for the profitability of Rojo relative to existing varieties (Q16), as well as the extent to which there is a perceived risk exposure in planting a new and relatively unproven new variety (Q22).

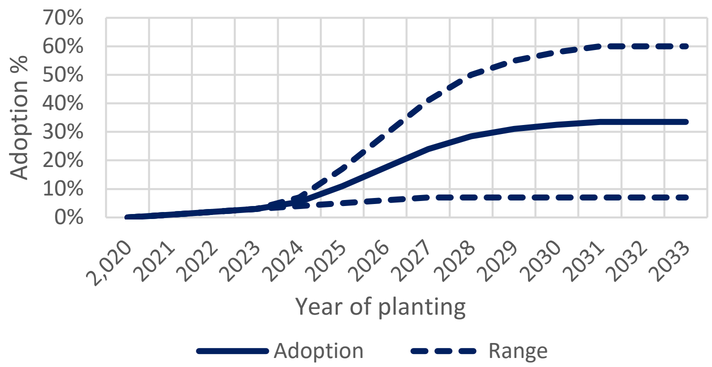

Figure 5. Change in adoption and diffusion curve for the new variety—Rojo Brillante.

ADOPT inputs for new variety—Rojo Brillante

1. What proportion of farms have maximising profit as a strong motivation?

A majority all have maximising profit as a strong motivation

2. What proportion of farms has protecting the natural environment as a strong motivation?

About half have protection of the environment as a strong motivation

3. What proportion of farms has risk minimisation as a strong motivation?

About half have risk minimisation as a strong motivation

4. On what proportion of farms is there a major enterprise that could benefit from the technology?

Almost all of the target farms have a major enterprise that could benefit

5. What proportion of farms have a long-term (greater than 10 years) management horizon for their farm?

About half have a long-term management horizon

6. What proportion of farms are under conditions of severe short-term financial constraints?

A minority currently have a severe short-term financial constraint

7. How easily can the innovation be trialled on a limited basis before a decision is made to adopt it on a larger scale?

Moderately triallable due to the long time period required for on-farm evaluation of tree crops

8. Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used?

Slightly difficult to evaluate effects of use due to complexity

9. To what extent would the innovation be observable to farmers who are yet to adopt it when it is used in their district?

Not observable at all

10. What proportion of growers use paid advisors capable of providing advice relevant to the innovation?

A minority use paid advisors

11. What proportion of growers participate in groups that enable discussion relevant to the innovation?

About half of growers participate in relevant discussion groups from previous RD&E.

12. What proportion of growers/advisors will need to develop substantial new skills and knowledge to use the innovation?

About half will need to develop substantial new skills and knowledge from previous RD&E.

13. What proportion of growers would be aware of the use of trialling of this innovation in their district?

About half would be aware of the use of trialling of this innovation from previous RD&E.

14. What is the size of the up-front cost of the investment relative to the potential annual benefit from using the innovation?

Minor upfront cost for the purchase of clonally propagated Rojo varieties relative to traditional seed propagated varieties.

15. To what extent is the adoption of the innovation able to be reversed?

Difficult to reverse due to the additional time and resources to remove and replant trees before their end of life

16. To what extent is the use of the innovation likely to affect the profitability of the farm business in the years that it is used?

Moderate to very large profit advantage from increased productivity.

17 To what extent is the use of the innovation likely to have additional effects on the future profitability of the farm business?

No profit advantage in the future

18 How long after the innovation is first adopted would it take for effects on future profitability to be realised?

Not applicable

19. To what extent would the use of the innovation have net environmental benefits or costs?

No environmental benefits or costs

20. How long after the innovation is first adopted would it take for the expected environmental benefits or costs to be realised?

Not applicable

21. To what extent would the use of the innovation affect the net exposure of the farm business to risk?

Nil to small increase in perceived risk in planting a new and relatively unproven new variety, and the long-term nature of the investment.

22. To what extent would the use of the innovation affect the ease and convenience of the management of the farm in the years that it is used?

No change.

Ends.