Hort Innovation

Final Report

Fund Impact Assessment 2020/21 for cherry, vegetables and small tropicals: Evaluation of VG15034 and VG15035

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Delivery partner:

Ag Econ

Project code:

MT21013

Project:

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

Disclaimer:

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What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in *Facilitating Adoption of IPM through a Participatory Approach with Local Advisors and Industry (VG15034, VG15035, and VG15036)*. The project was funded by Hort Innovation over the period February 2016 to February 2019.

Methodology

The investments were 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

The VG15034 investment cluster which ran from 2016 to early 2019, sought to demonstrate that it is possible to achieve rapid and widespread adoption of IPM through a participatory approach with vegetable advisors and growers. With a focus on South Australia, and covering a wide range of vegetables including field production of lettuce, brassicas, cucumbers, tomatoes, zucchini, beetroot, carrots, radishes, sweeds and turnips, celery, and leek, as well as hydroponic Asian greens, lettuce and herbs in protected cropping, the investments delivered a three year training program of theory workshops, practical field days, and ongoing technical support. By demonstrating successful IPM to local advisors and training them to give sound IPM advice, this project aimed to remove barriers to IPM uptake and make IPM the mainstream method of controlling pests.

In discussion with stakeholders, the investments were quantified as having improved industry knowledge, skills, and confidence to adopt IPM in South Australian field produced brassicas (broccoli, cabbage, cauliflower, and brussels sprouts) and lettuce. While there was likely some additional benefit in other crops, this was considered to be relatively minor due to the lower pest pressure or the already high uptake of IPM in those crops. For brassicas and field lettuce, the project supported growers to reduce overall pest management costs, with pest control being equal to or better than conventional pest management.

Total funding from all sources for the project was $0.72 million (2021-22 equivalent value). The investment produced estimated total expected benefits of $1.52 million (2021-22 equivalent value). This gave a net present value of $0.81 million, an estimated benefit-cost ratio (BCR) of 2.13 to 1, an internal rate of return of 42% and a modified internal rate of return of 11%.

As IPM incorporates a shift from cheaper, non-selective pesticides applied frequently (often in a routine fashion), to more expensive, selective insecticides applied only when required, the results were particularly sensitive to changes in the relative costs of conventional versus IPM insecticides, and relative frequency of conventional versus IPM insecticide sprays. Reasonable changes in these variables gave an impact (BCR) range of between 0.00:1 (no impact) to 8.87:1.

A lack of underlying data meant that there were additional economic, social and environmental outcomes of IPM (such as the reduced risk of insecticide resistance) identified but not quantified which have the potential to provide additional impact.

Keywords

Impact assessment, cost-benefit analysis, vegetable, pest and disease, IPM, broccoli, cabbage, cauliflower, lettuce

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 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.

The project *VG15034 Facilitating Adoption of IPM through a Participatory Approach with Local Advisors and Industry* was randomly selected as one of the nine investments in the 2020-21 sample for the Vegetable Fund, this project was clustered with related projects VG15035 (Coordination component) and VG15036 (Evaluation component). This report presents the analysis and findings of the VG15034 cluster impact assessment.

General method

The 2020-21 population for the Vegetable Fund 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 315 Hort Innovation investments, worth an estimated $88.7 million (nominal Hort Innovation investment). Projects in the Frontiers Fund, those of less than $80,000 Hort Innovation investment, multi industry projects where the Vegetable Fund was less than 50% of total Hort Innovation investment, enabler projects that don't directly support a 2017-2021 Vegetable Strategic Investment Plan (SIP) Outcome, and projects that have had a previous impact assessment completed were removed from the sample. A total of 90 projects with a combined value of $54.8 million satisfied these criteria and formed the eligible population. The eligible population was then stratified according to the 2017-2021 Vegetable SIP outcomes, and four project value clusters based on the distribution of project value within the population ($80,000-$265,000; $265,000-$440,000; $440,000-$695,000; $695,000-$8,680,000). A random sample of 9 projects was selected worth a total of $5.86 million (nominal Hort Innovation investment), equal to 10.7% of the eligible 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 impacts were valued, the impact assessment used 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. As not all impacts were valued, the investment criteria reported potentially represents an underestimate of the performance of that investment.

Background and rationale

Industry background

The national vegetable levy is payable on all vegetable crops excluding potatoes, onions, mushrooms, sweetpotatoes, asparagus, garlic, ginger, herbs (except fresh shallots and parsley) and tomatoes. The levy is payable on vegetables that are produced in Australia and either sold by the producer or used by the producer in the production of other goods. Producers pay levies to the Department of Agriculture, Fisheries and Forestry (DAFF), which is responsible for the collection, administration and disbursement of levies and charges on behalf of Australian agricultural industries. Hort Innovation manages the vegetable levy funds which are directed to R&D investments.

The Australian levy paying vegetable industry has approximately 1,700 growers across Australia (Hort Innovation 2022a), with a 5-year average (to 2020-21) production value of $2.5 billion, growing at a trend 6.19% and a volume trend of 1.77% per annum (Hort Innovation 2022b). The majority of leviable vegetables are supplied to the domestic market, with approximately 10% exported at a total value of $170 million in 2020-21 growing at an average 1.19% per annum from 2016-17. Leviable vegetables are grown across Australia, however Queensland accounts for the highest share (32%), followed by Victoria (24%), Western Australia (16%), New South Wales (8%), South Australia (9%) and Tasmania (8%) in 2020-21.

Rationale

Integrated Pest Management (IPM) is an approach that combines all available methods of controlling pests, rather than just relying on a single management tool such as insecticides. IPM was seen as an important focus area for the industry due to a number of converging factors. This included access to chemicals becoming more limited, resistance to chemical controls becoming increasingly likely from high levels of chemical use, and markets increasingly seeking chemical-free produce as consumer concerns about the health and environmental impacts of chemicals grew.

While indoor vegetable production had seen increased adoption of IPM due to higher incidence of resistance, for outdoor production IPM was seen as more complicated and risky. It was identified that in order to increase confidence and adoption in IPM growers needed access to experienced advisors; however, IPM advice and services were not readily available to the industry. As a result, prior to the project IPM was not seen as a mainstream control option by Australian vegetable growers and was not widely practiced.

South Australia (SA) was identified as a model to demonstrate that it is possible to achieve rapid and widespread adoption of IPM through a participatory approach with local advisors and industry. By demonstrating successful IPM to local advisors and training them to give sound IPM advice, this project aimed to remove barriers to IPM uptake and make IPM the mainstream method of controlling pests in the SA vegetable industry.

Alignment with the Vegetable Strategic Investment Plan 2017-2021

The vegetable levy investments are guided by a Strategic Investment Plan (SIP). With a focus on pest management to improved productivity, the VG15034 cluster was closely aligned with Outcome 3: *Improved farm productivity*, Strategy 3.4 *Pests and diseases*.

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 VG15034 cluster outcomes and related impacts contributed to RD&E Priorities 2&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	VG15034	VG15035	VG15056
Title	Facilitating Adoption of IPM through a Participatory Approach with Local Advisors and Industry (Training Component)	Facilitating Adoption of IPM Through a Participatory Approach with Local Advisors and Industry (Coordination Component)	Facilitating Adoption of IPM Through a Participatory Approach with Local Advisors and Industry (Evaluation Component)
Research organization	IPM Technologies	AUSVEG SA	Clear Horizon Consulting
Project leader	Dr Paul Horne	Jordon Brooke-Barnett	Dr Jill Campbell
Funding period	Jan 2016 to Jan 2019	Feb 2016 to Jan 2019	Feb 2016 to Feb 2019

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	AUSVEG SA and IPM Technologies collaborated in the development and delivery of the combined IPM project, with AUSVEG providing a coordination and engagement support role, and IPM technologies focussing on technical delivery. Key areas of responsibility for the individual projects were: • Plan and deliver a three year training program (theory workshop and practical field days), including identifying and engaging commercial partners (chemical resellers and advisors) to participate in the training. • Establish and support IPM demonstration sites. While focussing primarily on field lettuce and brassica, the demonstration sites included a wide range vegetables including field production of lettuce, brassicas, cucumbers, tomatoes, zucchini, beetroot, carrots, radishes, sweeds and turnips, celery, and leek, as well as hydroponic Asian greens, lettuce and herbs in protected cropping. • Provide regular IPM support to participating advisors • Conduct additional communication and extension activities, including developing information materials, such as fact sheets, that chemical service providers may supply to interested growers.
Outputs	• 52 IPM training workshops and field days. • 30 IPM demonstration sites. • IPM support. • Extension and communications material including IPM case studies and videos.

<table>
<tr><td>Outcomes</td><td>

By the end of Year 2 it was estimated that the majority of private-sector advisors that give pest management recommendations to vegetable growers in South Australia had undertaken both theory and practical training. As a result, IPM was promoted in South Australia by all key pest management advisors servicing vegetable growers. Outcomes for participating advisors included:
Agronomists and other advisors

Participants have increased awareness of and skills in monitoring, identification and incorporating naturally occurring beneficial insects and mites into pest management, and are better able to make informed decisions about insecticide use and product selection within an IPM program. Prior to the project, 63% of surveyed advisors said they already provided IPM advice to growers, however they rated their confidence in providing advice their knowledge of beneficials, insect lifecycles and IPM techniques; and their confidence in making IPM decisions as being moderate. The remaining 37% of advisors had not yet provided IPM advice before the project, and rated their knowledge and confidence as low.
100 % of surveyed advisors stated that they had increased knowledge of IPM techniques on a wide range of (particularly field grown) vegetables.
100 % of surveyed advisors stated that they had increased confidence in making IPM decisions and giving IPM advice as a result of the training program.

Growers

Assisted by agronomists and other advisors, growers have increased acceptance of, confidence in, and adoption of IPM as a key component in vegetable growing for a wide range of (particularly field grown) vegetables. Adoption was greatest in brassicas and head lettuce (stakeholder pers comm). At the conclusion of the project, the delivery partners estimated that IPM adoption was estimated to have increased dramatically in the target vegetables, including from less than 20% to 70% for field brassica, and 20% to 80% for field head lettuce
Reduced reliance on chemicals for managing key insect pests in vegetable production, with ongoing insecticide use focusing on selective insecticide rather than broad-spectrum insecticide.

</td></tr>
<tr><td>Impacts</td><td>
As a result of increased knowledge, skills, and confidence to adopt IPM, the following potential impacts are identified:

Reduced insecticide inputs supporting:

[Economic] Lower pest management costs with pest control equal to or better than conventional pest management. However, in some cases, a higher number of cheaper broad spectrum insecticide sprays may be offset by fewer but more expensive selective insecticide sprays, as well as increased scouting requirements.
[Economic] Reduce longer term risk relating to chemical reliance, including risks of pest resistance and risks of de-registrations.
[Environmental] Reduced environmental impact from crop pest management, including a reduced impact on beneficial insects and other non-target species from lower use of non-selective insecticides, as well as a reduction in the vegetable industry’s environmental toxicity level (ETL) from lower overall insecticide use.
[Social-economic] Increased social licence from reduced chemical usage supporting an image of “clean and green” thereby improving the industry’s policy operational environment.

Improved yield supporting

[Economic] Higher farm productivity and farm profit.

Improved quality supporting:

[Economic] Greater consumer appeal and demand from sustained or improved vegetable quality (visual, taste) as well as from a more “clean and green” image, and thereby supporting higher prices for growers.
[Environmental] Increased quality of vegetable produce supporting reduced food waste at the farm level.

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Project costs

Nominal investment

Table 4. Project nominal investment

Year end 30 June	Hort Innovation ($)	Total ($)
2016	122,503	122,503
2017	98,174	98,174
2018	98,174	98,174
2019	100,114	100,114
Total	**418,965**	**418,965**

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 16.2% for the VG15034 cluster funding period (2016-2019). This figure was then applied to the nominal Hort Innovation investment shown in Table 4.

Real Investment costs

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

Extension costs

The VG15034 cluster was largely focused on extension, delivering theory workshop and practical field days as well as communications through AUSVEG SA. As such, no additional extension costs were included in the analysis.

Project impact valuation

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions, particularly when there was a level of uncertainty 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.

Increased knowledge, skills, and confidence to adopt IPM, reduced insecticide inputs, in turn supporting:

- [Economic] Lower pest management costs with pest control equal to or better than conventional pest management.

Valuation method

Drawing on project reporting and stakeholder consultation, with- and without-investment IPM adoption curves were established using the CSIRO ADOPT methodology (Kuehne et al 2017). The generated adoption curves were applied to South Australian field production hectares for brassicas (broccoli, cabbage, cauliflower, and brussels sprouts) and lettuce, which were the primary focus crops of the research and those with the largest change in IPM adoption (stakeholder pers comm). The benefits of IPM adoption were then quantified as a combined change in the frequency of insecticide applications (decrease), the average cost of insecticides (increase), and the frequency of crop inspection/scouting (increase).

Impacts not valued

Not all of the impacts identified in Table 3 could be valued in the assessment, particularly where there was a lack of data making it difficult to quantify the causal relationship and impact pathway. Other impacts identified but not valued were:

- Reduced insecticide inputs supporting:
  - [Economic] Reduce longer term risk relating to chemical reliance, including risks of pest resistance and risks of de-registrations.
  - [Environmental] Reduced environmental impact from crop pest management, including a reduced impact on beneficial insects and other non-target species from lower use of non-selective insecticides, as well as a reduction in the vegetable industry's environmental toxicity level (ETL) from lower overall insecticide use.
  - [Social-economic] Increased social licence from reduced chemical usage supporting an image of "clean and green" thereby improving the industry's policy operational environment.
- Improved yield supporting
  - [Economic] Higher farm productivity and farm profit.
- Improved quality supporting:
  - [Economic] Greater consumer appeal and demand from sustained or improved vegetable quality (visual, taste) as well as from a more "clean and green" image, and thereby supporting higher prices for growers.
  - [Environmental] Increased quality of vegetable produce supporting reduced food waste at the farm level.

Public versus private impacts

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

Distribution of private impacts

The identified potential private impacts of the VG15034 cluster would include direct and flow-on (spillover) impacts. Spillover impacts would 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 (such as labour, machinery, and insecticides) associated with pest management practice change.
- Consumption induced effects, which reflect the flow-on changes generated through changes in payments of wages and salaries to employees along the supply chain and the subsequent expenditure of those incomes in purchasing household goods and services.

Furthermore, the true impact would also be influenced by the equilibrium (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. The price effect, essentially shifts benefits along the supply chain and between 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.

Impacts on other Australian industries

The project impacts primarily focussed on the vegetable industry, but have the potential to inform related tree crop industries, or industries with similar pest pressures.

Impacts overseas

The impacts primarily focussed on Australian vegetable production and would be limited in their direct application in international production given compounding differences in pest pressures, climate, and production systems.

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)
Impacts start	2016	First theory workshop and practical field days delivered
Outcome attribution	75 (±50%)	While the projects drew on existing IPM research, the improved agronomist and grower knowledge, skills, and confidence to adopt can largely be attributed to the work conducted through these projects.
R&D counterfactual	75 (±50%)	The projects supported the establishment of commercial IPM services through local agronomists, indicating that there would be some commercial incentive to develop these services without industry levy investment. However, the persistently low IPM adoption (at an advisor and grower level) indicates that there were significant barriers to this change occurring, which may have prevented or delayed any commercial (or other) investment in this area.
Attribution period (years)	5 (±40%)	Stakeholder consultation highlighting there is a need for ongoing education and training within industry to ensure knowledge and skills are updated with new products, pests, and crop varieties. This ongoing investment would dilute the impact of the original training over time. In the event that skills are not kept up to date, the total and attributable benefit would similarly atrophy. A declining attribution of 10% (range 5% to 15%) was applied.
IPM in brassica		
SA field production (ha)	635 (±35%)	5 year average and standard deviation of South Australian production area of broccoli (23%), cabbage (17%), cauliflower (36%), and brussels sprouts (24%) (ABS 2018-2022). With an estimated 100% field production (stakeholder consultation).
Without project IPM adoption (% of production)	14 (±100%)	Stakeholder consultation. See ADOPT methodology in Appendix A.
With project IPM adoption (% of production)	Max 60% (±17%) after 5 years	Stakeholder consultation. See ADOPT methodology in Appendix A.
Weeks of production	52	Stakeholder consultation
Insecticide application (machinery) cost ($/application/ha)	11	QDAF (2017-2021)
Conventional spray applications per week	2 (±25%)	Insecticide sprays vary between summer and winter plantings, and depending on seasonal conditions and pest pressure. Two or more insecticides applied 1-2 times a week may be required in peak pest periods (Stakeholder consultation). Assumed yearly average of 2 x insecticides applied per week, with range 1.5 to 2.5.
Conventional chemical cost ($/application/ha)	40 (±44%)	Insecticide (Group 1,3, & 4) applied in industry gross margins through QDAF (2017-2021), QDAF (2018), NSW DPI (2009-2013) and identified in stakeholder consultation. Applying most recent product prices from the same sources as well as Ag Econ (2022), at recommended rates per ha per application.
Conventional scout cost ($/ha/year)	10	Conventional pest management included limited inspecting, just managing by spray schedule and gut feel, reacting to damage (Stakeholder consultation). Assumed 0.25 hours/ha at

		$40/hr
IPM sprays per week	0.75 (±33%)	One selective insecticide every 2 weeks (Stakeholder consultation)
IPM chemical cost ($/application)	89.5 (±48%)	Key IPM insecticide (Group 11 & 28) recommended and used through VG15034, prices sourced from industry gross margins (QDAF 2017-2021, QDAF 2018, NSW DPI, 2009-2013, Ag Econ 2022), with recommended label rates per ha per application.
IPM scout cost ($/ha/year)	171	With IPM, scouting is conducted weekly, for example 1 hour per week covering around 30 acres (12.14 ha) (Stakeholder consultation), giving approximately 4.3 h/ha/yr at $40/h
IPM in field lettuce		
SA production (ha)	294 (±14%)	5 year average and standard deviation of South Australian production area of field lettuce (ABS 2018-2022).
Without project IPM adoption (% of production)	14 (±100%)	Stakeholder consultation. See ADOPT methodology in Appendix A.
With project IPM adoption (% of production)	Max 70% (±14%)	Stakeholder consultation. See ADOPT methodology in Appendix A.
Insecticide application (machinery) cost ($/application/ha)	11	QDAF (2017-2021)
Weeks of production	52	Stakeholder consultation
Conventional spray applications per week	1.25 (±20%)	Insecticide sprays vary between summer and winter plantings, and depending on seasonal conditions and pest pressure. A yearly average of 1.25 insecticide spray per week is estimated from Stakeholder consultation, with an assumed to range 0.75 to 1.25 sprays per week.
Conventional chemical cost ($/application/ha)	40 (±44%)	Insecticide (Group 1,3, & 4) applied in industry gross margins (QDAF 2017-2021, QDAF 2018, NSW DPI, 2009-2013) and confirmed with stakeholders. Applying most recent product prices from the same sources, as well as Ag Econ (2022), at recommended label rates per ha per application.
Conventional scout cost ($/ha/season)	10	With conventional pest management there is limited inspection, just managing by spray schedule and gut feel, reacting to damage (Stakeholder consultation). Assume 0.25 hours/ha at $40/hr
IPM sprays per week	0.3 (±50%)	Insecticide use varies between summer and winter, and depends on seasonal conditions and pest pressure. VG15034 trials showed sprays in lettuce down from a routine weekly spray to 1 in 20 weeks. A more conservative yearly average of 1 spray in 3 weeks was used, tested at 1 in 2 and 1 in 6.
IPM chemical cost ($/application)	89.5 (±48%)	Key IPM insecticide (Group 11 & 28) recommended and used through VG15034, prices sourced from industry gross margins (QDAF 2017-2021, QDAF 2018, NSW DPI, 2009-2013, Ag Econ 2022), with recommended label rates per ha per application.
IPM scout cost ($/ha/year)	171	With IPM, scouting is conducted weekly, for example 1 hour per week covering around 30 acres (12.14 ha) (Stakeholder consultation), giving approximately 4.3 h/ha/yr at $40/h

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 (2018-19) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment criteria

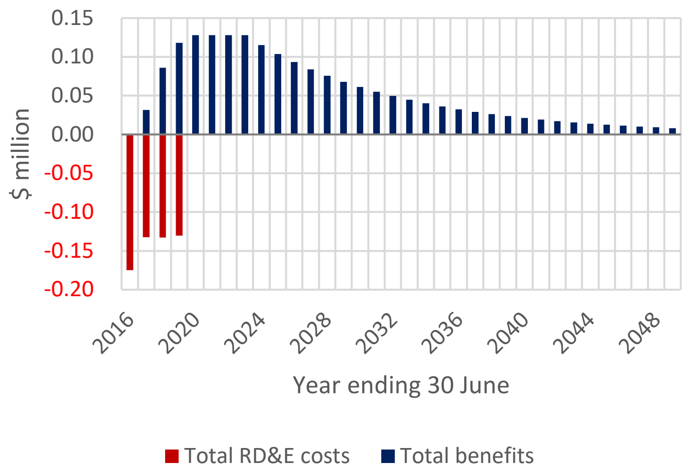
Table 6 shows the impact metrics estimated for different periods of benefit for the total investment. Hort Innovation was the only funding organisation for this project.

Table 6. Impact metrics for the total investment in the VG15034 cluster

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	0.72	0.72	0.72	0.72	0.72	0.72	0.72
PVB ($m)	0.28	0.91	1.25	1.40	1.47	1.51	1.52
NPV ($m)	-0.43	0.19	0.53	0.69	0.76	0.79	0.81
BCR	0.39	1.27	1.74	1.96	2.06	2.11	2.13
IRR	Negative	38%	42%	42%	42%	42%	42%
MIRR	Negative	24%	20%	16%	14%	12%	11%

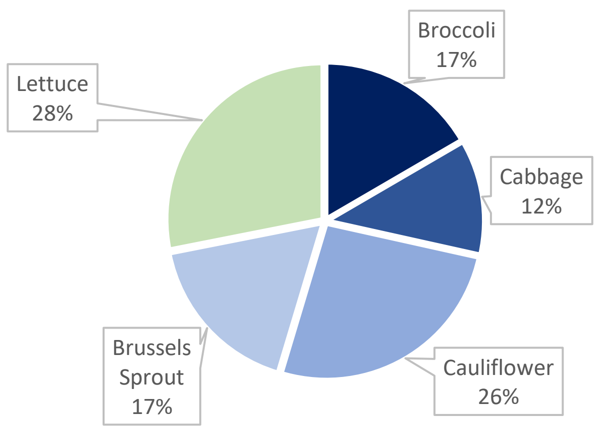
Figure 1 shows the annual undiscounted benefit and cost cash flows for the total investment of the VG15034 cluster. Cash flows are shown for the duration of the investment plus 30 years from the last year of investment.

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 brassica (blue) and lettuce crops ($ million PV, 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%	8%
	BCR range	2.57	2.13	1.81
SA production (combined ha)	Variable range	680	947	1,213
	BCR range	1.52	2.13	2.74
Previous adoption (% SA production)	Variable range	0.00	0.14	0.27
	BCR range	2.79	2.13	1.48
New adoption brassica (%)	Variable range	0.5	0.6	0.7
	BCR range	1.79	2.13	2.47
New adoption lettuce (%)	Variable range	0.6	0.7	0.8
	BCR range	2.02	2.13	2.24
Conventional insecticide cost ($/insecticide application)	Variable range	22.4	40.3	58.2
	BCR range	0.00	2.13	8.87
IPM insecticide cost ($/insecticide application)	Variable range	47.0	89.5	132.0
	BCR range	7.99	2.13	0.00
Conventional sprays brassica (av. annual insecticides per week)	Variable range	1.50	2.00	2.50
	BCR range	0.60	2.13	5.10
IPM sprays brassica (av. annual insecticides per week)	Variable range	0.50	0.75	1.00
	BCR range	5.43	2.13	0.60
Conventional sprays lettuce (av. annual insecticides per week)	Variable range	0.75	1.00	1.25
	BCR range	1.53	2.13	2.95
IPM sprays lettuce (av. annual insecticides per week)	Variable range	0.17	0.33	0.50
	BCR range	3.34	2.13	1.53
Scouting cost ($/hr)	Variable range	30.0	40.0	50.0
	BCR range	2.31	2.13	1.95
Outcome attribution increased adoption of IPM (%)	Variable range	50%	75%	100%
	BCR range	1.42	2.13	2.84
Attribution period (years)	Variable range	3.00	5.00	7.00
	BCR range	1.89	2.13	2.35
Attribution decline (% compound)	Variable range	0.05	0.10	0.15
	BCR range	2.62	2.13	1.85
R&D counterfactual (%)	Variable range	50%	75%	100%
	BCR range	1.42	2.13	2.84

Conclusions

The analysis showed that the quantified benefits were greater than the investment costs for the investment cluster VG15034, VG15035 and VG15036, with a BCR 2.13:1. The results reflect the benefits of improved industry knowledge, skills, and confidence to adopt IPM in South Australian field production of brassica (broccoli, cabbage, cauliflower, and brussels sprouts) and lettuce, with the potential to reduce overall pest management costs. A lack of underlying data meant that there were additional economic, social and environmental outcomes identified but not quantified which have the potential to provide additional impact.

The quantified impact was tested for sensitivity to changes in the underlying data and assumptions, resulting in an impact (BCR) range of between 0.00:1 (no impact) to 8.87:1. Of note, the variables were tested individually, and did not account for cumulative effects of multiple variable changes. As IPM incorporates a shift from cheaper, non-selective pesticides applied frequently (often in a routine fashion), to more expensive, selective insecticides applied only when required, the results were particularly sensitive to changes in:

- Relative costs of conventional versus IPM insecticides. The price range used in the analysis were drawn from typical conventional non-selective insecticides (Groups 1, 3 and 4) and IPM compatible selective insecticides (Groups 11 and 28). The sensitivity testing showed that the relative price of conventional and IPM insecticides had the highest impact on the results, with the potential to mitigate any savings from reduced spray frequency (BCR 0.0:1), or generate a high impact of up to 8.87:1.
- Relative frequency of conventional versus IPM insecticide sprays. The frequency of sprays were drawn from the project trials and reporting, as well as additional consultation with the project researcher and growers and agronomists involved in the trials. The results were more sensitive to the relative change in brassica insecticide application (BCR range of 0.60:1 to 5.43:1) compared to lettuce (BCR of 1.53:1 to 3.34:1) due to both the higher intensity of conventional pesticide use in brassicas as well as the larger combined crop area.

This analysis quantified direct private benefits accruing to vegetable growers. Additional flow-on (spillover) private impacts would be generated in the wider economy. Changes in farm inputs from increased production and exports 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, supply chain partners and consumers depending on both short- and long-term supply and demand elasticities.

A lack of underlying data meant that there were also social and environmental outcomes identified but not quantified which had the potential to provide additional impact above that quantified in this analysis.

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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

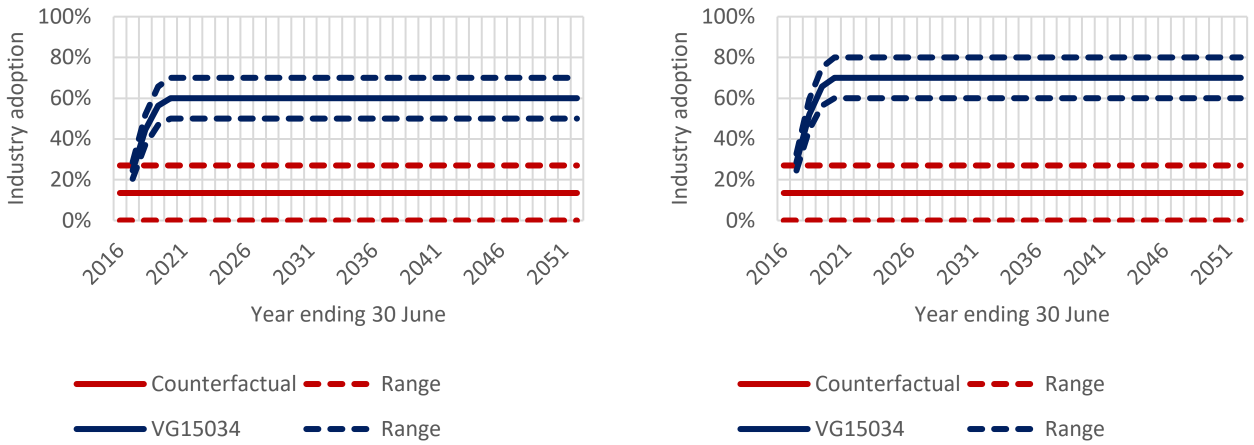
SIP Strategic Investment Plan

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 industry adoption and diffusion curve was developed by adjusting parameters relating to knowledge, skills, and risk perceptions. Questions relating to knowledge and skills were the provision of advice through paid advisors (Q10), participation in grower groups such as the workshops and field days provided through the project (Q11), the change in grower skills (Q12), and the change in awareness as a result of the trials and other extension activities (Q13). Changes in risk perception relating to IPM were incorporated by adjusting Q21. From this process two adoption curves were estimated.

- The ADOPT framework indicated a without-project (low knowledge, skills, and high risk perception) maximum adoption level of 27%, which compared to an estimated pre-project IPM adoption of 0% to 20% (stakeholder consultation), so a range of 0% to 27% was used with a midpoint baseline of 13.5%. Adoption was assumed to have already reached its peak due to barriers to practice change such as the high risk perception and low agronomist IPM skills and knowledge to counter these perceptions.
- The ADOPT framework indicated a without-project (high knowledge, skills, and high risk perception) maximum adoption level of 66% in 5 years, which compared to an estimated pre-project IPM adoption of 50% to 70% for brassica and 60% to 80% for lettuce (stakeholder consultation). The ADOPT curve maximum was adjusted to the stakeholder estimated range, keeping the rate of 5 years.

The adoption curves can be seen in figures 3 and 4. With the ADOPT framework inputs shown below.



Figures 3 and 4. Counterfactual and with-project adoption curves for brassica (left) and lettuce (right).

ADOPT inputs for IPM in vegetables (brassica and lettuce)

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

Almost 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 of paid advisors are capable of providing IPM advice

Almost all paid advisors are capable of providing IPM advice

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

Almost no growers participate in discussion groups that enable discussion of IPM without VG15034.

A majority of growers participate in discussion groups that enable discussion of IPM (through VG15034 extension).

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

About all growers and advisors need to develop substantial new skills and knowledge of IPM without VG15034.

A minority of need to develop substantial new skills and knowledge of IPM as a result of VG15034.

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

Almost none would be aware of the use of trialling of IPM in their district without VG15034.

Almost all would be aware of the use of trialling of IPM in their district as a result of VG15034.

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?

Potential for a small to moderate profit advantage of IPM relative to conventional pest management.

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?

Moderate environmental advantage of IPM due to a reduced impact on beneficial insects and other non-target species from lower use of non-selective insecticides, as well as a reduction in the vegetable industry's environmental toxicity level (ETL) from lower overall insecticide use.

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?

Moderate increase in perceived risk of IPM without VG15034 due to a greater reliance on beneficials with less grower control and the heightened importance of timely and accurate pest scouting, and available spray windows to ensure yield and quality are not impacted.

With VG15034 there remains a small increase in perceived risk of IPM relative to conventional management due to the same issues, but with improved knowledge of IPM efficacy and skills in beneficial management and scouting.

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 decrease in ease and convenience from the need to be more responsive to pest pressure rather than prescriptive with scheduled management.

Ends.