Final Report

Fund Impact Assessment 2020/21 for cherry, vegetables and small tropicals: Evaluation of VG16068

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Delivery partner:

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Project code:

MT21013

Project:

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

Disclaimer:

Funding statement:

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

Publishing details:

Published and distributed by: Hort Innovation

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Contents

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 *VG16068 Optimising cover cropping for the Australian vegetable industry*. The project was funded by Hort Innovation over the period July 2017 to July 2020.

Methodology

The investment was first analysed qualitatively within a logical framework that included activities and outputs, outcomes, and impacts. Actual and/or 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).

Results/key findings

VG16068 increased vegetable grower and advisor awareness, knowledge, skills and resources relating to cover cropping. As a result, VG16068 supported an increased level of adoption of cover cropping practices than would otherwise have occurred. The impacts valued were:

- [Economic] Increased adoption of cover cropping research outputs supporting farm productivity and profitability through increased gross yields, or reduced input costs, or both. For example, through a reduced risk of soil disease, pest or weed outbreaks and mitigation of adverse weather events (e.g. topsoil runoff) for vegetable growers, reducing management costs.

Not all of the identified impacts could be valued in the assessment, particularly where there was a lack of credible data. These additional economic, social and environmental impacts have the potential to provide additional industry impact above what has been identified.

Investment criteria

Total funding from all sources for the project was $4.2 million (2022 equivalent value). The investment produced estimated total expected benefits of $39.52 million (2022 equivalent value). This gave a net present value of $35.32 million, an estimated benefit-cost ratio of 9.39 to 1, an internal rate of return of 36% and a modified internal rate of return of 12%.

Conclusions

The results reflect the outcome of improved industry knowledge and engagement, driving the adoption of specific cover cropping practices for four vegetable crops where data was available. These represented approximately 33% of the vegetable production value where the cover cropping research may also be relevant, highlighting the potential for significant upside impact.

In addition to the quantified benefits, adoption of cover cropping practices on intensive vegetable farming operations provide many other social and environmental impacts for vegetable growers and the wider community which were not quantified due to data limitations. For example, project activities through VG16068 collaborated with other complimentary RD&E initiatives on soil health, integrated crop protection and weed management supporting a greater level of researcher and grower engagement. Consultation also revealed a range of environmental impacts have been supported, reduced risks of soil erosion, and reduced reliance on chemical nutrition inputs (e.g. Nitrogen) and associated risk of environmental runoff through nutrient recycling.

Sensitivity testing was also undertaken to account for uncertainty in some of the variables and resulted in a BCR range of 4.51 to 14.21. The results were particularly sensitive to three variables: the extent to which the results from the modelled vegetable crops are multiplied to other relevant vegetable crops; the share of relevant vegetable growers that adopt the cover cropping practices and the extent to which the counterfactual would have lead to comparable results and the attribution of the realised outcomes from VG16068 compared to other complimentary projects.

Keywords

Impact assessment, cost-benefit analysis, vegetable, cover cropping, yield, production, capsicum, cucumber, leek, pumpkin

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.

Project *VG16068 Optimising cover cropping for the Australian vegetable industry* was randomly selected as one of the 9 investments in the 2020-21 sample for the Vegetable Fund. This report presents the analysis and findings of the project 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

Soil health is an important factor impacting vegetable productivity. Soil health is influenced by a range of factors including soil biology, tillage, nutrition, cover cropping, crop rotation and weather. The vegetable industry has recognised how initiatives to support soil health can deliver productivity gains for growers, having invested across several complimentary areas of research with integrated extension resources through the Soil Wealth and Integrated Crop Protection programs (VG13076, VG13078, VG16078) since 2014.

Research through these programs identified a knowledge gap relating to the understanding of the performance of cover cropping within Australian conditions to support soil health. While cover cropping is a well known practice that can improve soil microbial activity through the input of organic matter, boosting biological activity and production potential, limited applied research with relevance for Australian conditions was available for vegetable growers. Project VG16068 was delivered to support the industry with updated information and resources on how to manage cover crops to fit with current intensive vegetable practices to support soil health and productivity.

The overall objectives of VG16068 were:

- Deliver "Australianised" information on cover crops specific to the vegetable industry covering cover crop selection, establishment, management, and termination, and on the management of soil-borne diseases and weeds.
- Generate new information on the use of cover crops to manage soil structure, soil microbial communities, specific beneficial microbes, and soil-borne diseases under Australian conditions.
- Develop knowledge and capacity to promote the continual improvement of cover crop use in the Australian vegetable industry.

Alignment with the Vegetable Strategic Investment Plan 2017-2021

The vegetable levy investments are guided by a Strategic Investment Plan (SIP). The Vegetable SIP 2017-21 (under which VG15071 was delivered) identified "Improved farm productivity" as a priority outcome (Outcome 3) for Australia's vegetable industry. This outcome was supported by several strategies including "Soil and water: Improve the use and management of soil and water, which are critical inputs of commercial vegetable production".

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 VG15071 project outcomes and related impacts will contribute to RD&E Priority 3 and 4; and to Science and Research Priority 1 and 2.

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

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

Table 2. Project details

Project code	VG16068
Title	Optimising cover cropping for the Australian vegetable industry
Research organization	Applied Horticultural Research
Project leader	Dr Kelvin Montague
Funding period	July 2017 to July 2020

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	**Research activities** • Initiate and maintain 14 field trials across New South Wales, Queensland, Victoria, South Australia and Western Australia to test the influence of a range of cover crops on: ○ Biofumigant growth ○ Glucosinolate production ○ Soil-borne disease ○ Strip tillage ○ Weed management ○ Mycorrhizae ○ Soil structure ○ Root knot nematodes ○ Microbial communities. • Sample 57 vegetable crops for mycorrhizae association on cover crops and vegetable crops. Root samples were taken to determine mycorrhizae colonisation levels and soil samples taken to determine mycorrhizae inoculum levels. **Extension** • Deliver new information, knowledge and tools to vegetable industry stakeholders across a range of formats including: ○ Cover Crop Coaching Clinics ○ Field walks ○ Webinars

	○ Podcasts ○ Presentations at industry forums ○ Factsheets, articles and guides. **Partnerships** • Alignment of research and extension activities with complimentary RD&E, including: ○ Sharing research sites with project VG15070 A Strategic Approach to Weed Management for the Australian Vegetable Industry. ○ Contributing cover crop expertise to demonstration sites maintained by VG16078 Soil Wealth and Integrated Crop Protection Soil Wealth demonstration sites and sharing learnings regarding the integration of strip tillage and cover crops. ○ Expanded the range of biofumigants and soil-borne diseases supporting Queensland Government Resilient Rivers project through the Bundaberg trial site. ○ Expanded the length and scope of the long-term field trial at Forthside, supporting progress towards DPIPWE AgriVision 2050.
Outputs	• 11 industry events (farm walks, workshops, field days). • 2 Cover Crop Coaching Clinics (New South Wales and Queensland) – 58 growers attended. • 7 articles: ○ Cover Crop Coaching Clinic Bundaberg March 2019. ○ Winter cover crops' effects on weeds: Results from TAS and WA trials. ○ Deon Gibson Covered in Glory - Grower Success Stories – Real results from the vegetable R&D levy. ○ Opening the doors to a sustainable farming future. ○ Cover cropping pioneer aiming to educate others. ○ Should you be making hay from your cover crop? ○ Forthside open day focusses on crop and soil health for greater productivity. • 20 fact sheets, including 15 fact sheets detailing the current commercially available biofumigant cover crops. • 6 guides: ○ Guide to Brassica Biofumigant Cover Crops. ○ Summary guide of 52 warm and cool season cover crops. ○ Cover Crop Agronomy. ○ Cover Crop and Soil-borne disease. ○ Cover Crops and Herbicides. ○ Cover Crop Termination. • 4 research reports: ○ Effect of cover crops on soil biological communities. ○ Cover crops to manage mycorrhizae for vegetable crops. ○ Long-term impacts of cover crops. ○ In vitro studies to determine the biofumigant effectiveness of Brassica cover crops on mortality of soil microorganisms. • Six webinars: ○ Biofumigation Cover Crops PART 1: What variety and when? ○ Biofumigation Cover Crops PART 2 Pest & diseases & impact on soil-borne diseases. ○ Using cover crops to manage mycorrhizal fungi in vegetable crops. ○ Cover crops and soil biology in vegetable soils. ○ East Gippsland Vegetable Innovation Days - Cover Crops and Strip Tillage live webinar panel session. ○ Cover crop trial discussion: East Gippsland Vegetable Innovation Days. • 5 podcasts: ○ Basics of cover crops. ○ Link between cover crops and soil health: An outline of the cover crop project. ○ Integrated Weed Management: Using cover crops and strip till. ○ Cover crop trials at Cowra NSW, with Marc Hinderager. ○ Benefits of cover crops and strip-till for pumpkin production: Interview with Michael Camenzuli from Bathurst. • 5 videos:

	○ Cover crop spotlight on Buckwheat. ○ Cover crop spotlight on Sunn hemp. ○ Cover crops and strip tillage. ○ Cover crops and erosion. ○ Biofumigation: A cover crop option for the Australian vegetable industry.
Outcomes	• Increased knowledge of the performance of cover crops in vegetable production underpinned by robust Australian research on the benefits and agronomy. • Vegetable growers and advisers using new regional-specific cover-crop information and coaching to restore or maintain healthy soil for profitable and sustainable vegetable growing.
Impacts	• [Economic] Increased adoption of cover cropping research outputs supporting farm productivity and profitability through increased gross yields, or reduced input costs, or both. For example, through a reduced risk of soil disease, pest or weed outbreaks and mitigation of adverse weather events (e.g. topsoil runoff) for vegetable growers, reducing management costs. • [Social] Increased capacity and understanding of cover cropping principles by vegetable growers supporting greater levels of industry cohesion, engagement and sentiment. • [Social] Engagement with complimentary research programs supporting increased research capacity and goodwill. • [Social] Increased contribution to regional community wellbeing from more profitable vegetable growers. • [Environmental] Reduced risks of soil erosion, reducing impacts on the surrounding environment. • [Environmental] Reduced reliance on chemical nutrition inputs (e.g. Nitrogen) and associated risk of environmental runoff through nutrient recycling. • [Environmental] Increased biodiversity through enhanced soil microbial activity. • [Social, Environmental] Increased growing and environmental amenity through improving in-field growing and harvesting conditions.

Project costs

Nominal investment

Table 4. Project nominal investment

Year end 30 June	Hort Innovation ($)	Other in-kind ($)	Total ($)
2018	304,218	523,682	827,900
2019	456,327	785,522	1,241,849
2020	152,109	261,841	413,950
2021	228,159	392,753	620,912
Total	1,140,813	1,963,798	3,104,611

In-kind costs

Where in kind costs have been provided as a single whole-of-project figure, these have been apportioned based on the Hort Innovation annual costs to reflect the underlying investment delivery.

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 16.1% for the VG16068 funding period (2018-2021). This figure was then applied to the nominal Hort Innovation investment shown in Table 4.

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

Communication and extension were activities conducted within the project, so the project expenditure is assumed to be inclusive of extension costs.

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:

- [Economic] Increased adoption of cover cropping research outputs supporting farm productivity and profitability through increased gross yields, or reduced input costs, or both. For example, through a reduced risk of soil disease, pest or weed outbreaks and mitigation of adverse weather events (e.g. topsoil runoff) for vegetable growers, reducing management costs.

The impacts were valued by applying an estimated increase gross yield and reduction in input costs informed through performance of select crops trialled through the project where data was available (pumpkin, capsicum, cucumber, leek) for adopting growers. An impact multiplier was applied to reflect the impacts gained from the specific vegetable lines would also likely be achieved for growers adopting cover cropping practices for other vegetable lines including curcubits, brassicas, corn and salad vegetables.

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:

- [Social] Increased capacity and understanding of cover cropping principles by vegetable growers supporting greater levels of industry cohesion, engagement and sentiment.
- [Social] Engagement with complimentary research programs supporting increased research capacity and goodwill.
- [Social] Increased contribution to regional community wellbeing from more profitable vegetable growers.
- [Environmental] Reduced risks of soil erosion, reducing impacts on the surrounding environment.
- [Environmental] Reduced reliance on chemical nutrition inputs (e.g. Nitrogen) and associated risk of environmental runoff through nutrient recycling.
- [Environmental] Increased biodiversity through enhanced soil microbial activity.
- [Social, Environmental] Increased growing and environmental amenity through improving in-field growing and harvesting conditions.

Public versus private impacts

The impacts identified from the investment are predominantly private impacts accruing to vegetable growers and supply chain participants. However, some public benefits have also been produced in the form of capacity, spill-overs to regional communities from enhanced grower income and contributions to improved environmental outcomes from cover cropping.

Distribution of private impacts

This analysis quantified private benefits accruing to vegetable growers. Additional spillover private impacts would be generated in the wider economy. Increased post harvest input costs from increased production would result in increased spillover changes in income for businesses providing those goods and services. However, private impacts will also be offset somewhat through the reduced demand for other inputs (e.g. labour and fertilizer) from cover cropping. The total private impacts will be further redistributed between growers, processor/packers, wholesalers, exporters, and retailers depending on both short- and long-term supply and demand elasticities.

Impacts on other Australian industries

The project activities were explicit to the Australian levy-paying vegetable industry. However, there may be some additional impact generated from cover cropping for complimentary industries through a mixed farming system approach where land (and soil) is rotated for different production purposes. Industries could include other vegetables such as potatoes and onion, as well as broadacre cropping and livestock grazing.

Impacts overseas

There is limited overseas impact through this investment as the cover cropping research findings were explicit for Australian conditions.

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)
Impact start	2022	Analyst assumption. Field trials were conducted through the project with cover cropping guides and resources finalised at project conclusion (2020-21).
Annual production (t) pumpkin	118,074 (±2%)	Australian Horticulture Statistics Handbook, 5 year average 2017-2021 (Hort Innovation 2022b). Production adjusted for outdoor volume.
Annual production (t) capsicum (outdoor)	38,021 (±5%)	
Annual production (t) cucumber (outdoor)	45,935 (±3%)	
Annual production (t) leek	10,243 (±12%)	
Time to max adoption	6 years	ADOPT model output (see Appendix A)
Max adoption (% of industry annual production	40% (-52%, +32%)	ADOPT framework (Appendix A) showed a likely industry adoption of 50%, however this result was sensitive to whether a small profit advantage occurs (50%) or not (24%). Consultation with researcher confirmed that a higher adoption of two-thirds (66%) of growers potentially adopting cover cropping practices could occur. Based on this, max adoption was tested at 66%, minimum adoption of 24%, and midpoint (base) of 45%. Additionally, it was assumed that 20% of eligible growers were already using cover cropping, so the final rate of adoption was scaled by a factor of 0.8.
Baseline industry yield (t/ha) pumpkin	31.3 (±42%)	Combined average yield ABS Ag Commodities (2013-14 & 2015-16 to 2020-21), DPI gross margin (NSW DPI 2013), DPI growing guide (NSW DPI 2005) and soil wealth estimate.
Baseline industry yield (t/ha) capsicum	25.7 (±23%)	Combined average yield ABS Ag Commodities (2013-14 & 2015-16 to 2020-21), DPI gross margin (NSW DPI 2013), project estimate and WA growing guide (DPIRD 2016).
Baseline industry yield	24.2 (±36%)	Combined average yield ABS Ag Commodities (2013-14, 2020-

(t/ha) cucumber		21), DAF gross margin (QLD DAF 2018).
Baseline industry yield (t/ha) leek	19.3 (±37%)	Combined average yield ABS Ag Commodities (2013-14), Oplanić *et al.* (2009) and Spackman (2016).
Yield increase % capsicum	7% (±29%)	Project trial reported 9% yield increase, assumed as upper limit. A midpoint of 7% and lower estimate of 5% are assumed.
Yield increase % cucumber	15% (±33%)	Grower case study reported yield doubling following cover crop and strip tillage. Consultation confirmed that this represents high point. Adjusted base yield increase of 15% is assumed, tested at a low of 10% and high of 20% increase.
Additional gross margin capsicum (% applied to additional yield)	68%	Additional yield has been assumed to be an increase in plant productivity from soil improvements, which would incur extra harvest and post harvest yield based costs (i.e labour, cooling, packing, bin hire, levies). These costs are assumed at 32% of additional income for capsicum (NSW DPI 2013), therefore 68% of additional income is applied as a benefit.
Additional gross margin cucumber (% applied to additional yield)	60%	Additional yield has been assumed to be an increase in plant productivity from soil improvements, which would incur extra harvest and post harvest yield based costs (i.e labour, cooling, packing, bin hire, levies). These costs are assumed at 40% of additional income for cucumber (QLD DAF 2018), therefore 60% of additional income is applied as a benefit.
Cost reduction ($/ha) pumpkin	$916	Labour cost reduction of $626/ha, scaled using average yield following project trial estimate of $1000/ha in labour savings with a 50t/ha yield through cleaner pumpkins, plus reduced nitrogen input (see below note).
Cost reduction ($/ha) capsicum	$290	Soil Wealth calculation assuming a cover crop can add 160-200kg of N/ha. Value estimated using an average 5-year price of urea ($812/t, or $1.76/kg for N).
Cost reduction ($/ha) cucumber	$290	
Cost reduction ($/ha) leek	$454.65	Consultation indicated that fertilizer inputs have halved. Assumes a broad spectrum fertilizer (Nitrophoska) of 350kg/ha is applied at $2.598/kg. No additional nitrogen input savings are assumed.
Nitrogen savings scale factor	0.33 (-70%, +50%)	Not all cover crops have nitrogen fixing properties. An adjustment factor of 0.33 has been applied assuming 1 in 3 cover crops planted will fix nitrogen as per Cover Cropping Guide.
Cost of adoption ($/ha)	$193.50 (-37%, +64%)	Additional seed and planting (tractor fuel) costs are required to adopt cover cropping. Tested at the lower (Tillage radish™) and upper Caliente 199™ level of seed costs. 5 year average real farm adjusted fuel price of $1.15/L was used (Ag Econ estimate using Australian Institute of Petroleum data) to support field preparation, taking 1.5 hr/ha, assuming tractor uses 15L/hr.
Impact multiplier (application to other crops)	2.05 (±51%)	Project data was only available for four crops (pumpkin, capsicum, cucumber, leek), although was funded and extended to other vegetable crops. An upper bound of 3.1 x impacts was considered as the available crops represented 33% of total in scope vegetables (brassicas, cucurbits, sweetcorn, carrots, lettuce). A conservative lower bound of 1 x impacts quantifies the impacts to the four data crops only.
Outcome attribution	60%	Cover cropping is used with other soil management practices, such that the 60% of the realised outcome (increased yields,

		reduced costs) is due directly through VG16068.
Attribution period	Full attribution 10 years	A full attribution period of 10 years was estimated, followed by a compounded decline of 10% per year for the remaining 20 year analysis period. This reflects the likely need for further research to provide updated knowledge and resources concerning targeted cover cropping practices, reducing the relevance of VG16068 findings over time.
R&D counterfactual	60%	Cover cropping is already a known practice, however knowledge and uptake would have been suppressed without VG16068 as existing material was not directly related to Australian conditions. As such, it was assumed that 60% of the benefits would not have occurred without Hort Innovation funding of this project.

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 (2020-21) 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. The present value of benefits (PVB) attributable to the Hort Innovation investment, shown in Table 7, has been estimated by multiplying the total PVB by the Hort Innovation proportion of real investment (40%).

Table 6. Impact metrics for the total investment in project VG16068

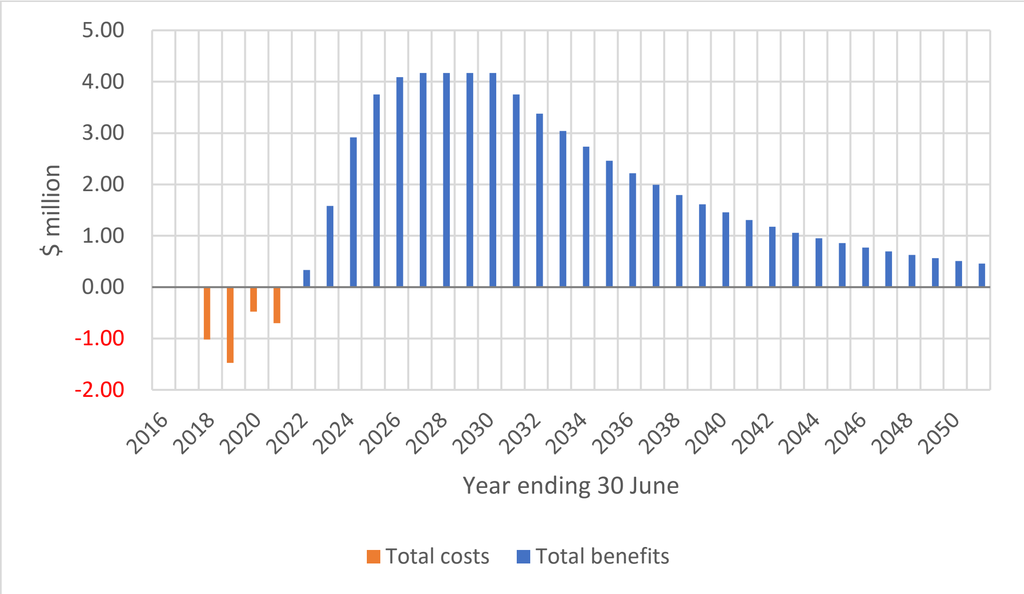
Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	4.21	4.21	4.21	4.21	4.21	4.21	4.21
PVB ($m)	0.33	14.36	27.75	34.43	37.53	38.96	39.52
NPV ($m)	-3.87	10.15	23.54	30.23	33.32	34.75	35.32
BCR	0.08	3.41	6.60	8.18	8.92	9.26	9.39
IRR	Negative	25%	35%	36%	36%	36%	36%
MIRR	Negative	19%	21%	18%	15%	14%	12%

Table 7. Impact metrics for the Hort Innovation investment in project VG16068

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	1.70	1.70	1.70	1.70	1.70	1.70	1.70
PVB ($m)	0.13	5.79	11.19	13.88	15.13	15.71	15.93
NPV ($m)	-1.56	4.09	9.49	12.19	13.43	14.01	14.24
BCR	0.08	3.41	6.60	8.18	8.92	9.26	9.39
IRR	Negative	25%	35%	36%	36%	36%	36%
MIRR	Negative	19%	21%	18%	15%	14%	12%

Figure 1 shows the annual undiscounted benefit and cost cash flows for the total investment of VG16068. 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



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 presents the results for those variables that experienced the highest sensitivity on the final impact. 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	2.5%	5.0%	7.5%
	BCR range	12.48	9.39	7.25
Attribution decline compound rate (%)	Variable range	5%	10%	15%
	BCR range	11.12	9.39	8.34
Max adoption through VG16068 (%)	Variable range	19%	40%	53%
	BCR range	4.51	9.39	12.40
N cover crop share (%)	Variable range	10%	33%	50%
	BCR range	9.07	9.39	9.62
Impact multiplier (application to other crops)	Variable range	1.00	2.05	3.10
	BCR range	4.58	9.39	14.21
Adoption cost ($/ha)	Variable range	$122.5	$193.5	$317.5
	BCR range	9.82	9.39	8.69
Yield increase capsicum (%)	Variable range	5%	7%	9%
	BCR range	8.57	9.39	10.22
Yield increase cucumber (%)	Variable range	10%	15%	20%
	BCR range	7.65	9.39	11.13
Tonnes/ha pumpkin	Variable range	18.21	31.30	44.39
	BCR range	10.38	9.39	8.99
Realised income capsicum (%)	Variable range	55%	68%	82%
	BCR range	8.82	9.39	9.97
Realised income cucumber (%)	Variable range	48%	60%	72%
	BCR range	8.35	9.39	10.44
Attribution / counterfactual factor (%)	Variable range	50%	60%	90%
	BCR range	7.83	9.39	14.09

Conclusions

The analysis showed that the quantified benefits were greater than the investment costs for VG16068, with a BCR 9.39:1. The results reflect the outcome of improved industry knowledge and engagement, driving the adoption of specific cover cropping practices by select levy-paying vegetable growers for supporting increases to crop yield and reducing input costs. The quantified benefits were assessed for four vegetable crops where data was available, representing approximately 33% of the remaining vegetable production value that were also assessed as being covered by the cover cropping practices covered in the research.

Extension is a key step in the impact pathway of R&D and can make the difference between a rapid or slow industry adoption and impact. VG16068 was supported by comprehensive extension and communication initiatives and was an important factor in driving the industry benefits realised through the investment. The cover cropping initiatives were also supported by, and integrated into, the complimentary R&D Soil Wealth and Integrated Crop Protection, and Weed Management programs. The cover cropping specific impacts estimated through the impact assessment has been scaled by an attribution factor to reflect this dynamic.

To account for the variability in the underlying data, sensitivity testing was conducted across a range of variables, that showed a BCR ranging from 4.51 to 14.21. The results were most sensitive to the tested ranges of five inputs:

- Impact multiplier. Available data on the impacts of cover cropping was limited to four vegetable crops, however it is noted that the cover cropping principles could be applied across a wider range of brassica and curcubit vegetables, plus carrots, sweetcorn and lettuce. To reflect the scope for the additional impact, an impact multiplier was applied, that was sensitivity tested at 1 (no impact valued outside the four vegetables modelled), 2.05 (base case), and 3.1 (all vegetable lines realising impact).
- Maximum adoption level. Prior to VG16068, there was existing awareness of cover cropping principles, however available evidence of cover cropping strategies and techniques was not available to reflect Australian conditions. The extent to which vegetable growers would be positioned to adopt cover cropping practices was tested through CSIRO's ADOPT tool, which found that maximum adoption levels of between 24% and 50% would be likely achieved after 6 years from project conclusion. Discussions with the research suggested that a peak adoption level of 66% could be possible depending on crop type and location.
- Counterfactual / attribution factor. The extent to which VG16068 would have been delivered without Hort Innovation investment was captured to reflect that there was existing knowledge of cover cropping practices and that some agronomists may have been advising around cover cropping practices. However the extent of change possible through VG16068 would not have been possible, due to the comprehensive study and representation of cover cropping for Australian conditions. The attribution of the results was also impacted by extensive interaction of cover cropping practices amongst broader soil wealth, integrated crop protection and weed management practices.
- Yield increase. Potential yield improvements for capsicum and cucumber crops realised from cover cropping practices are likely to be influenced by a various factors including existing management practices, weather and underlying soil health. The extent to which cover cropping will influence yield changes is a significant determinant of the impact that would be realised for industry.
- Additional industry income. When marketable yield increases (as a result of cover cropping practices implemented from VG16068), not all additional income can be attributed as an industry benefit. Firstly, yield based post-harvest costs (such as packaging, cooling, labour and levies) need to be removed. Using the gross margins for capsicum and cucumber (crops assessed to have a yield increase through cover cropping) as a guide, these costs were respectfully calculated as 32% and 40% of additional income (68% and 60% of additional income is applied as a benefit). While not included in the industry benefit calculated as part of this analysis, these costs would result in corresponding spillover increases in income for upstream and downstream businesses providing those goods and services.

A lack of underlying data meant that there were economic and social outcomes identified but not quantified which had the potential to provide additional impact to the vegetable industry. As such, the quantified impacts represent a conservative estimate of the total potential impact that would be realized through cover cropping across the levy-paying vegetable industry.

The analysis quantified private benefits accruing to vegetable growers. Additional spillover impacts would be generated in the wider economy. Adoption of cover cropping practices have associated changes in production management costs such as reduced chemical use, and increased plating costs for cover crops. At the same time, improved yield results in increased post-harvest costs such as packaging, transport, and marketing. Changes in these costs would result in corresponding spillover changes in income businesses providing those goods and services which would generate additional impact above that quantified in this analysis.

The CRRDC Guidelines focusses on first round impacts, which calculates shifts in the supply and demand curves with no price effect. When considering these second-round price effects, RD&E that focusses on increased productivity (increased yield and decreased input costs) would support increased industry supply, 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 supply and demand curves. Given the low level of exports in the vegetable industry, there is a reduced capacity for the market to absorb increased supply without a decrease in prices.

Acknowledgements

Ag Econ would like to acknowledge the input from the following:

Sarah Cumpston, Hort Innovation; Byron de Kock, Hort Innovation; Kelvin Montague, Applied Horticultural Research; Darren Schreurs, Peter Schreurs & Sons; Jake Ryan, Three Ryans; Deon Gibson, Premium Fresh Tasmania.

References

Applied Horticultural Research (2021). *Optimising cover cropping for the Australian vegetable industry*. Final report, funded by Hort Innovation using the vegetable research and development levy and contributions from the Australian Government. https://www.horticulture.com.au/contentassets/8a91e39172144734baa6bff01f878d49/vg16068---final-report-complete.pdf. Accessed November 2022.

Australian Bureau of Statistics (ABS) (2015). Agricultural Commodities, Australia. *Agricultural Commodities, Australia, state/territory and SA4 - 2013-14*. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/7121.02013-14?OpenDocument. Accessed November 2022.

Australian Bureau of Statistics (ABS) (2022). Agricultural Commodities, Australia. *Agricultural commodities, Australia and state/territory and ASGS regions - 2020-21*. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/industry/agriculture/agricultural-commodities-australia/latest-release#data-download

Australian Bureau of Statistics (ABS) (2022). 5206.0 – *Australian National Accounts: National Income, Expenditure and Product, Dec 2021*. Table 5. Expenditure on Gross Domestic Product (GDP), Implicit price deflators. Retrieved from Australian Bureau of Statistics: https://www.abs.gov.au/statistics/economy/national-accounts/australian-national-accounts-national-income-expenditure-and-product/latest-release#data-download

Commonwealth of Australia (2015a). *Agricultural Competitiveness White Paper*. Retrieved from https://www.awe.gov.au/agriculture-land/farm-food-drought/agriculture-white-paper. Accessed July 2022.

Commonwealth of Australia (2015b). *Strategic Science and Research Priorities*. Canberra: Commonwealth of Australia. Retrieved from https://www.industry.gov.au/data-and-publications/science-and-research-priorities#:~:text=Australia%20depends%20on%20science%20and,and%20improve%20national%20well%2Dbeing. Accessed July 2022.

Council of Rural Research and Development Corporations (CRRDC) (2018). *Cross-RDC Impact Assessment Program: Guidelines*. Canberra: Council of Rural Research and Development Corporations. Retrieved from http://www.ruralrdc.com.au/wp-content/uploads/2018/08/201804_RDC-IA-Guidelines-V.2.pdf

Department of Primary Industries and Regional Development (2016). *Growing capsicums and chillies.* https://www.agric.wa.gov.au/capsicums-and-chillies/growing-capsicums-and-chillies. Accessed November 2022.

Hort Innovation (2017). *Vegetable Strategic Investment Plan 2017-2021*. Retrieved from https://www.horticulture.com.au/globalassets/hort-innovation/levy-fund-financial-and-management-documents/sip-pdfs-new/hortinnovation-sip-vegetable-2017-2021-web.pdf. Accessed November 2022.

Hort Innovation (2022a). *Vegetable Strategic Investment Plan 2022-2026*. Retrieved from https://www.horticulture.com.au/globalassets/hort-innovation/levy-fund-financial-and-management-documents/sip-2022-2026-pdfs/hort-innovation-sip-2022-26-vegetable-r3.pdf. Accessed June 2022.

Hort Innovation (2022b). *Horticulture Statistics Handbook 2012-13 to 2020-21*. Received from Hort Innovation pers comm. Data available https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/grower-resources/ha18002-assets/australian-horticulture-statistics-handbook/

Kuehne G, Llewellyn R, Pannell D, Wilkinson R, Dolling P, Ouzman J, Ewing M (2017). Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy, *Agricultural Systems* 156:115-125 https://doi.org/10.1016/j.agsy.2017.06.007

NSW Department of Primary Industries (2005). *Vegetable growing in the Central West.* Primefact 56. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/45926/Vegetable_growing_in_the_Central_West_-_Primefact_56-final.pdf. Accessed November 2022.

NSW Department of Primary Industries (2013). Horticulture gross margin budgets. https://archive.dpi.nsw.gov.au/content/agriculture/gross-margin-budgets/vegetable. Accessed November 2022.

Oplanić, M., Ban, D., Peršurić, A.S., & Žnidarčič, D. (2009). Profitability of leek (Allium porrum L.) in three production systems. *International journal of food, agriculture and environment*, 7:376-381.

QLD Department of Agriculture and Fisheries (2018). *Gross margin for cucumber – cartons – Southern Queensland*. https://www.publications.qld.gov.au/dataset/agbiz-tools-plants-vegetables/resource/7127602d-2576-423c-9b95-90124ca484c2?inner_span=True. Accessed November 2022.

Spackman, P (2016). *Discover the secrets to successfully growing leeks*. https://www.fwi.co.uk/arable/discover-secrets-successfully-growing-leeks. Accessed November 2022.

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

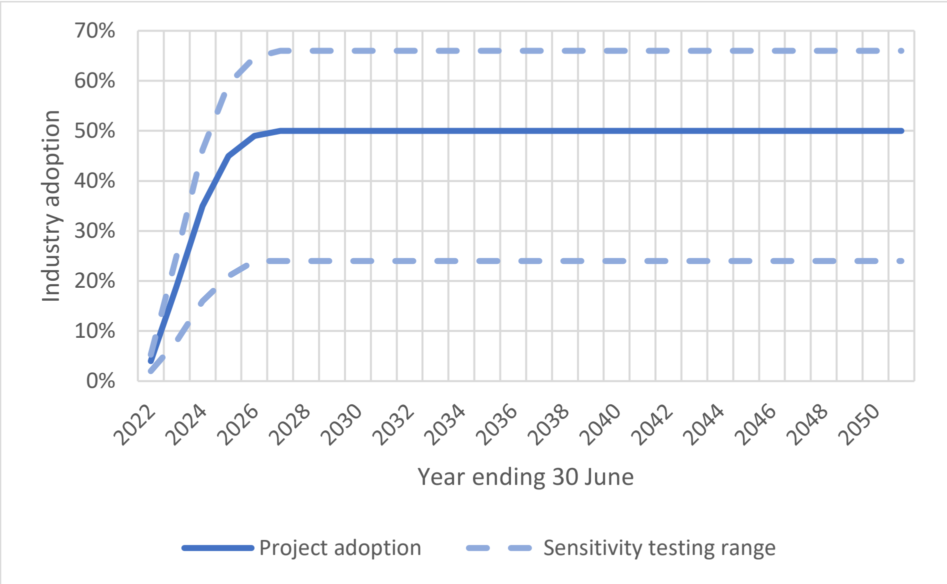
RD&E Research, Development and Extension

SIP Strategic Investment Plan

Appendix A. ADOPT questions and answers for VG16068 impact assessment

Appendix A includes the data inputs for the ADOPT model (Kuehne et al 2017) used in this analysis. Inputs were developed based project outputs and in consultation with project stakeholders. The baseline output from the adopt model identified that a maximum level of adoption of 50% would be possible within five years (2026-27). Consultation indicated that the rate of adoption could be as high as two-thirds (66%) of industry, based off localised experience, and this was taken as the upper level of industry adoption. The extent to which cover cropping is likely to affect the profitability of the vegetable grower in the years that it is used (question 16) was found to have a significant bearing on the level of adoption. The baseline model nominated that a “small profit advantage in the years that it is used” would be possible, however the variability in cover cropping application may not necessarily always provide a profit advantage. Where “no profit advantage or disadvantage in years that it is used” was nominated, the adoption level dropped to a maximum of 24% being reached after six years. This level was adopted as the lower-bound of adoption and illustrates the high level of adoption sensitivity. The overall adoption curve and sensitivity testing range can be seen in Figure 2.

Figure 2. Adoption and diffusion curve for VG16068



1. What proportion of farmers have maximising profit as a strong motivation?
A majority have maximising profit as a strong motivation

2. What proportion of farmers has protecting the natural environment as a strong motivation?
About half have protection of the environment as a strong motivation

3. What proportion of farmers has risk minimisation as a strong motivation?
About half have risk minimisation as a strong motivation

4. On what proportion of farmers 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 farmers 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 farmers 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?
Not at all 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 growers use paid advisors capable of providing advice relevant to the project?
About half use a relevant advisor without AP16007
A majority use a relevant advisor with AP16007

11. What proportion of growers participate in farmer-based groups that discuss farming?
About half are involved with a group that discusses farming without AP16007
A majority are involved with a group that discusses farming with AP16007

12. What proportion of growers will need to develop substantial new skills and knowledge to use the innovation?
Almost all will need new skills or knowledge without AP16007
A minority will need new skills or knowledge with AP16007

13. What proportion of growers would be aware of the use or trialling of the innovation in their district?
A minority are aware without AP16007
A majority are aware with AP16007

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 investment required

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 in years that it is used

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 or disadvantage 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?
Moderate environmental advantage

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 reduction in risk

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

Ends.