Hort Innovation

Final Report

Fund Impact Assessment 2020/21 for cherry, vegetables and small tropicals: Evaluation of CY12010

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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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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 *CY12010 Comparing the performance of new cherry rootstocks soon to be available to industry*. The project was funded by Hort Innovation over the period October 2012 to June 2017.

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.

Results and discussion

The delivery of project CY12010 provided new knowledge for cherry growers regarding the performance of four new dwarfing rootstocks, including recommendations for their use in orchard bench grafting. The project identified how the performance traits of dwarfing rootstock differed to existing industry standard rootstock with potential implications for orchard management, performance and productivity. New knowledge around the influence of cherry replant disorder on tree performance was also generated despite this not being featured in the original scope for the project. As the success of orchard bench grafting across the trial sites was found to be below existing industry standards, it was recommended that the industry contain the poor graft take to the nursery and instead invest in planting new orchards with established nursery trees to ensure even and productive orchard development.

The impact assessment quantified the reduction in risk faced by growers as a result of having improved upfront knowledge of the likely bench graft success rate. The results found that this risk reduction generated an industry benefit of $1.02 million compared to the RD&E cost of $0.43 million (2022 equivalent values), with a BCR of 2.38:1.

While the results showed an initial negative benefit to growers (reflecting the additional cost of two year nursery stock relative to orchard bench grafting) this was replaced by a longer term benefit due to the avoidance of replanting costs associated with the lower graft take rate.

Sensitivity testing showed that the total impact (BCR) varied from 0.6:1 to 4.2:1, and was particularly sensitive to changes in the following variables:

- Adoption. The counterfactual adoption was calculated through the CSIRO ADOPT framework (Kuehne et al 2017) by accounting for the high upfront cost and high risk of using bench grafting with new and untested rootstocks, and the impacts on future profitability as a result of having to replant failed orchard grafts. Despite the potential for reduced upfront establishment costs with orchard bench grafting relative to purchasing established nursery trees, the higher risk associated with the untested rootstock limited the estimated adoption to 3% over 12 years. When the potential for lower future profitability (from replanting and lost time and productivity) is also considered, the adoption drops to 1% over 12 years. This reflects the potential for the experiences and feedback from early adopters reducing a wider uptake-up of the rootstocks in orchard bench grafting. Across the tested range of 0.5% adoption (14 ha) to 3.5% adoption (99 ha) the BCR ranged from 0.6:1 to 4.2:1.
- Counterfactual attribution. The project was estimated to have a moderate (50%) potential for funding without matching funds through Hort (then HAL) given that it was funded through matched voluntary contributions (VC) primarily from a commercial nursery. Across the tested range of 25% attribution to 75% attribution the BCR ranged from 1.2:1 to 3.6:1.
- Graft take. CY12010 identified graft take for the new rootstocks to be between 17.5% and 54.0%, when compared to the industry standard of around 80% this generated the change in risk faced by growers as a result of undertaking orchard bench grafting with the new rootstock. Across the tested range of 17.5% graft take to 54% graft take the BCR ranged from 1.2:1 to 3.5:1.

This impact assessment also identified potential social impacts reflecting the development of research capacity for the cherry industry regarding dwarfing rootstock performance. While further research would be required, this capacity also extends to the unintended learning around the influence of cherry replant disorder and the potential influence this could have for ongoing orchard performance.

Keywords

Impact assessment, cost-benefit analysis, cherry, rootstock, dwarfing, bench graft, cherry plant disorder

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 *CY12010 Comparing the performance of new cherry rootstocks soon to be available to industry* was randomly selected as one of the 3 investments in the 2020-21 sample for the Cherry Fund. This report presents the analysis and findings of the project impact assessment.

General method

The 2020-21 population for the Cherry 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 61 Hort Innovation investments, worth an estimated $3.9 million (nominal Hort Innovation investment). Projects in the Frontiers Fund, those of less than $80,000 Hort Innovation investment, multi industry projects where the Cherry Fund was less than 50% of total Hort Innovation investment, enabler projects that didn't directly support a 2017-2021 Cherry Strategic Investment Plan (SIP) Outcomes, and projects that have had a previous impact assessment completed were removed from the sample. A total of 7 projects with a combined value of $2.44 million satisfied these criteria and formed the eligible population. The eligible population was then stratified according to the 2017-2021 Cherry SIP outcomes and three project value clusters ($80,000-$180,000; $180,000-$280,000; $280,000-$850,000), based on the distribution of projects by value within the eligible population. A random sample of 3 projects was selected worth a total of $1.35 million (nominal Hort Innovation investment), equal to 55% 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 relevant 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.

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 for individual investments potentially represent an underestimate of the performance of that investment.

Background and rationale

Industry background

The Australian cherry industry included approximately 346 growing businesses in 2020-21 (Hort Innovation 2022a). The cherry industry recorded a five year average production of 16,321 tonnes (to year ending June 2021) increasing by a trend average 11% per year, although annual volumes have varied through these years due to seasonal weather impacts (Hort Innovation 2022). The industry recorded a nominal production value of $231 million in 2020-21 which had increased at a trend average 16% per year from 2016-17 (Hort Innovation 2022b). In 2020-21, New South Wales, Victoria and Tasmania accounted for approximately 81% of cherry production. Approximately 62% of production went to the domestic fresh market, 30% to exports, and 8% to processing (Hort Innovation 2022b).

Cherry growers 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. Levy is payable on cherries that are produced in Australia and either sold by the producer or used by the producer in the production of other goods. Hort Innovation manages the cherry levy funds which are collected for both R&D and marketing purposes.

Rationale

The development of temperate fruit tree crops had shifted to a focus on higher density orchards supported by dwarfing varieties, supporting continued advances in productivity through positive influences over light penetration and pest resistance. Higher density plantings with compact trees enable more efficient labour practices such as pruning and picking as reliance on machinery and ladders for support are minimized, and reliance on other inputs such as netting may be reduced.

CY12010 was commissioned to support the Australian cherry industry understand the performance of dwarfing rootstocks to influence advances in productivity. The overall objective of the project was to investigate the impact of several dwarfing rootstocks on productivity, and to investigate the use of bench grafted trees in orchard establishment to reduce the costs of planting to enable rapid expansion and uptake of new rootstocks for the industry. Three trial sites were established across major cherry growing districts (Derwent Valley, Tasmania; Cobram, Victoria; and Young, NSW) using the industry standard rootstocks Mazzard F1/F12 and Stallion (Colt) and comparing them to new dwarfing rootstocks GiSelA5 (A5), GiSelA6 (A6), Krymsk5 (K5) and Krymsk6 (K6), all grafted with Belise and Simcoe cherry varieties. The rootstock's performance was to be tested over three seasons (2014/15, 2015/16 and 2016/17).

Alignment with the Cherry Strategic Investment Plan 2017-2021

The cherry levy investments are guided by a Strategic Investment Plan (SIP). CY12010 aligned with Cherry SIP 2017-21 (under which final delivery of CY21010 occured) Outcome 3 "Reduce costs at every level of the supply chain to improve global competitiveness", and specifically the supporting strategy "Facilitate industry adoption of improved cultivars and rootstocks".

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 CY12010 project outcomes and related impacts will contribute to RD&E Priority 4, and to Science and Research Priority 1.

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

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

Project details

Summary

Table 2. Project details

Project code	CY12010
Title	Comparing the performance of new cherry rootstocks soon to be available to industry
Research organization	Scientific Horticulture
Project leader	Gordon Brown
Funding period	October 2012 to June 2017

Logical framework

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

Table 3. Project logical framework

Activities	• Obtain 30 rootstocks each (all but K6) from supplying nurseries (winter 2011) and graft to Belise and Simcoe varieties (winter 2012). • Dig trees from nursery site in winter 2014 and establish orchard trials at three trial sites in Tasmania, Victoria and NSW – 'two year old nursery trees'. • Bench graft newly propagated rootstocks and plant out at the trial sites to provide a complete set of rootstocks for comparison against two year old nursery trees and industry standard rootstocks. • Collect data after two years of growth at trial sites including tree survival, canopy volume and trunk cross sectional area above the graft union (data collection for third season was not possible due to poor fruit set conditions during the spring of 2016). • Analyse performance differences using T-test and analysis of variance statistical methods where possible. • Document and report findings of rootstock performance.

Outputs	• Demonstration sites across three growing locations to enable comparison of the performance of the different rootstocks.
	• Two articles explaining the different performance of the rootstocks drafted for the cherry industry magazine.
	• Comparative data and information documented on the early orchard tree growth of new cherry rootstocks in three Australian cherry growing districts.
	• Documented issues with orchard establishment when bench grafts of dwarfing rootstocks:
	  ○ Orchard establishment was recorded at below the industry standard.
	• Documented susceptibility to cherry replant disorder across the trial sites and rootstocks:
	  ○ Industry standard F12/1 was found to be extremely susceptible to cherry replant disorder.

Outcomes	• Knowledge of rootstock graft take.
	  ○ Graft tak and hence tree propagation on the new dwarfing rootstocks was far more difficult than the industry standards. This meant that the use of bench grafted trees for orchard establishment was not recommended as successful grafting can be expected to be below 50% resulting in significant regrafting costs over several seasons, uneven orchard development and delayed return on investment. It was recommend that it would be better to contain the poor graft take to the nursery and to invest in planting new orchards with established nursery trees to ensure even and productive orchard development.Knowledge of rootstock performance across trial sites including:
	  ○ Canopy size. Gi5 and Gi6 reduced canopy size by 60% and 75% compared to F1/12.
	  ○ Tree size. Orchards established from bench grafted trees were 20% smaller than traditional nursery trees after two seasons of growth with a potential negative impact on the size of the first crop.
	  ○ Planting density. Gi5 and Gi6 density should be planted with 70% and 30% more trees compared to F1/12. Planting densities to be adjusted for virgin or replant soils.

	○ Vigour. K5 was noted as the most vigorous of the dwarfing rootstocks studied. When planted into virgin soil the K5 had a slight dwarfing character and K6 had a mild dwarfing character in line with the published information for these rootstocks. ○ Variability in trial site performance occurred, which may have been influenced by replant disorder. • Knowledge of industry standard rootstock Stallion (Colt) and new dwarfing rootstocks in replanting situations. These rootstocks may be relatively more resistant to replant disorder compared with F12/1.
Impacts	• [Economic] Improved grower and nursery knowledge of the performance of dwarfing rootstocks using bench graft, contributing to more informed selection, budgeting, orchard establishment and management that supports production efficiencies. • [Social and economic] Improved cherry rootstock research and industry capacity will underpin future initiatives to support ongoing development of industry productivity, profitability and resilience.

Project costs

Nominal investment

Table 4. Project nominal investment

Year end 30 June	Hort Innovation managed investment* ($)	Total ($)
2013	41,251	41,251
2014	39,012	39,012
2015	42,588	42,588
2016	40,338	40,338
2017	55,701	55,701
Total	218,890	218,890

*Investment consisted of voluntary funds (VC) sourced from Oak Enterprises and Scientific Horticulture that was managed by Hort Innovation (then HAL).

Program management costs

R&D costs should also include the administrative and overhead costs associated with managing and supporting the project. The Hort Innovation overhead and administrative costs were calculated for each project funding year based on the data presented in the *Statement of Comprehensive Income* in the *Hort Innovation Annual Report* for the relevant year. Where the overhead and administrative costs were equal to the total expenses, less the research and development and marketing expenses. The overhead and administrative costs were then calculated as a proportion of combined project expenses (RD&E and marketing), averaging 15.8% for the CY12010 funding period (2013-2017). This figure was then applied to the nominal Hort Innovation investment shown in Table 4. Note that annual reports for the 2013, 2014 and 2015 financial years were not available online at the time of reporting, so an average of the 2016-2021 financial years of 15.9% was assumed to apply for these years.

Real Investment costs

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

Extension costs

There were no additional costs associated with CY12010 for project extension. Results were communicated through researchers as part of the project.

Project valuation

Analysis was 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

- [Economic] Improved grower and nursery knowledge of the performance of dwarfing rootstocks using bench graft, contributing to more informed selection, budgeting, orchard establishment and management that supports production efficiencies.

CY12010 provided knowledge that could be used to guide growers' decisions regarding the risk of orchard establishment or development through the bench grafting of new dwarfing rootstocks.

The counterfactual (without CY12010 scenario) was quantified by first estimating the industry area that would have employed orchard bench grafting using the new dwarfing rootstocks. This was estimated using the ADOPT framework (Kuehne et al 2017), considering the high risk associated with undertaking orchard bench grafting with an untested rootstock. For this adoption area, the low-cost but high-risk of on-farm bench grafting with the new dwarfing rootstocks (with a higher likelihood of the need to replant due to low graft take), was compared to the higher-cost but lower-risk of planting with established two year old nursery trees in the first instance. Attribution factors were then applied to reflect the extent to which the outcome (orchard planting risk reduction) can be attributed to CY12010, and also the likelihood that this research would have been undertaken without VC matching through Hort Innovation (then HAL).

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.

Given the absence of data on longer-term rootstock performance the valuation of the avoided orchard risk was limited to an estimate of the avoided replanting losses associated with the low grafting rate. Further data on orchard performance across orchard development and maturity would support a more informed assessment of the implications of adopting the new rootstocks.

Other impacts identified but not valued were:

- [Social and economic] Improved cherry rootstock research and industry capacity will underpin future initiatives to support ongoing development of industry productivity, profitability and resilience.

Public versus private impacts

The potential impacts identified from the investment are predominantly private impacts accruing to cherry growers and supply chain participants. However, some public benefits have also been produced in the form of RD&E capacity built.

Distribution of private impacts

The identified potential private impacts of CY12010 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 (e.g. rootstocks, graft material, labour) associated with practice change.
- Consumption induced effects, which reflect the flow-on changes generated through the payments of wages and salaries to households and the subsequent expenditure of those incomes of purchasing household goods and services.

Furthermore, the true impact would also be influenced by the 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 were explicit to the Australian cherry industry.

Impacts overseas

As the rootstocks were trialled across a range of local Australian growing regions, limited overseas impact from this project is expected.

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	2016-17	Recommendations were finalised at project conclusion
Total industry area (ha)	2,845	Cherry Grower Association (2020)
Plant costs with orchard bench graft ($/ha)	$13,000	CY12010 Final Report
Plant costs with two year old nursery trees ($/ha)	$38,000	CY12010 Final Report
Mature orchard gross margin ($/ha)	$79,511	Based off Irrigated cherry gross margin budgets (NSW DPI, UNK) showing 40% gross margin on mature orchards, combined with an average price of $12.67/kg (Hort Stats Handbook 2 year average 2021 and 2022) with prices tested at the 2018 low price of $10.75/kg (CPI adjusted to 2022) and a 2020 high price of $13.03/kg (Hort Innovation 2022b).
Adoption	2% (± 75%) reached over12 years	CSIRO adopt modelling showed a maximum adoption of 1% to 3% over 12 years depending on the perception of changes to orchard profitability (with replanting). This was tested at 0.51% and 3.49% reflecting the potential variation with rounding (see Appendix A).
New rootstock graft take	36% (± 51%)	CY12010 Final Report
Benchmark rootstock graft take	80%	CY12010 Final Report
Outcome attribution	100% (-25%)	Knowledge of these rootstocks is only attributable to project CY12010
R&D counterfactual	50% (25%, 75%))	The project was funded through matched voluntary contributions (VC) primarily from a commercial nursery, indicating a moderate potential for funding without matching funds through Hort (then HAL).

Results

All costs 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 (2016-17) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment criteria

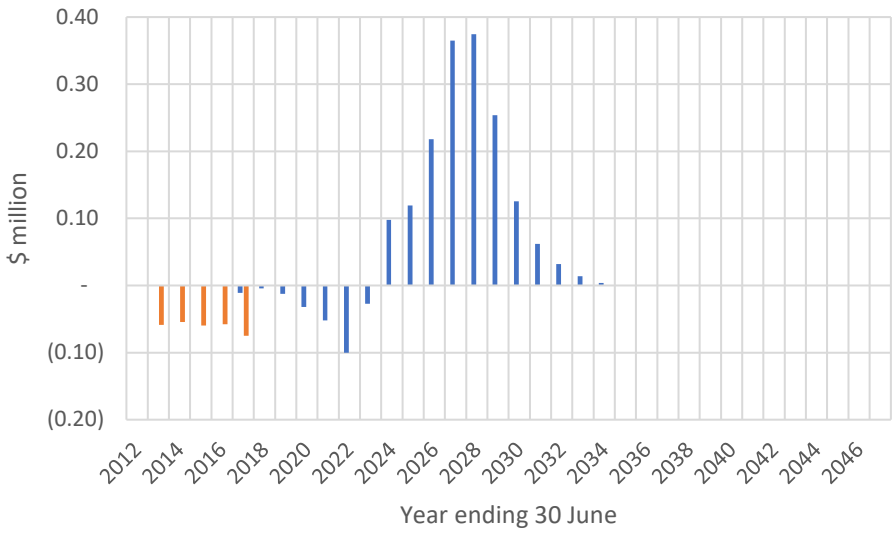
Table 6 shows the impact metrics estimated for different periods of benefit for the total investment. Hort Innovation was the only investor in CY12010.

Table 6. Impact metrics for the total investment in project CY12010

Impact metric	Years after last year of investment						
	0	5	10	15	20	25	30
PVC ($m)	-0.43	-0.43	-0.43	-0.43	-0.43	-0.43	-0.43
PVB ($m)	-0.01	-0.22	0.41	1.01	1.02	1.02	1.02
NPV ($m)	-0.44	-0.65	-0.02	0.58	0.59	0.59	0.59
BCR	-0.03	-0.52	0.95	2.36	2.38	2.38	2.38
IRR	Negative	Negative	5%	11%	12%	12%	12%
MIRR	Negative	Negative	5%	8%	8%	7%	7%

Figure 1 shows the annual undiscounted cash flows for the total investment of CY12010. 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 7 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 7. 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	3.3	2.4	1.7
Graft take for new rootstocks (% of planted)	Variable range	18%	36%	54%
	BCR range	3.5	2.4	1.2
Adoption max (% of industry area)	Variable range	0.5%	2.0%	3.5%
	BCR range	0.6	2.4	4.2
Cherry farmgate price ($/kg)	Variable range	10.75	12.67	13.03
	BCR range	2.00	2.4	2.5
Outcome attribution (%)	Variable range	75%	100%	100%
	BCR range	1.8	2.4	2.4
R&D counterfactual	Variable range	25%	50%	75%
	BCR range	1.2	2.4	3.6

Discussion and conclusions

The delivery of project CY12010 provided new knowledge for cherry growers regarding the performance of four new dwarfing rootstocks, including recommendations for their use in orchard bench grafting. The project identified how the performance traits of dwarfing rootstock differed to existing industry standard rootstock with potential implications for orchard management, performance and productivity. New knowledge around the influence of cherry replant disorder on tree performance was also generated despite this not being featured in the original scope for the project. As the success of orchard bench grafting across the trial sites was found to be below existing industry standards, it was recommended that the industry contain the poor graft take to the nursery and instead invest in planting new orchards with established nursery trees to ensure even and productive orchard development.

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This impact assessment also identified potential social impacts reflecting the development of research capacity for the cherry industry regarding dwarfing rootstock performance. While further research would be required, this capacity also extends to the unintended learning around the influence of cherry replant disorder and the potential influence this could have for ongoing orchard performance.

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References

Australian Bureau of Statistics (ABS) (2022). 5206.0 – *Australian National Accounts: National Income, Expenditure and Product, June 2022*. 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

Cherry Growers Australia (2020) *Australian cherry industry statistics*. Retrieved from Cherry Growers Australia: https://www.cherrygrowers.org.au/industry-statistics/#:~:text=At%20a%20glance%3A%201%20485%20cherry%20enterprises%202,2019%29%207%2030%2B%20Australian%20Cherry%20export%20market%20destinations. ble. Accessed May 2023.

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

Hort Innovation (2017). *Cherry 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-cherry-2017-2021.pdf. Accessed June 2022.

Hort Innovation (2022a). *Cherry 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-cherry-r.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 DPI (UNK) *Irrigated cherry gross margin budget*. Retrieved from NSW DPI: https://archive.dpi.nsw.gov.au/content/agriculture/gross-margin-budgets/vegetable. Accessed May 2023.

Scientific Horticulture (2017). *Comparing the performance of new cherry rootstocks soon to be available to industry (CY12010)*. Final report, funded by Hort Innovation using the cherry research and development levy and contributions from the Australian Government. Retrieved from https://www.horticulture.com.au/globalassets/laserfiche/assets/project-reports/cy12010/cy12010-final-report-2-824.pdf. Accessed October 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

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 to estimate the (without CY12010 scenario) use of the new rootstocks in orchard bench grafting. The adoption variable relating to future profits was used to generate an adoption range. There would likely be initial perceptions of the potential for no profit disadvantage in the event that orchard bench grafting is successful; however, this would shift to the realisation of a large profit disadvantage due to the increased risk of replanting. Changing this variables shifted the maximum adoption from 3% to 1%, which was expanded to 0.51% and 3.49% due to the potential for rounding effects, with an average figure of 2% used in the baseline.

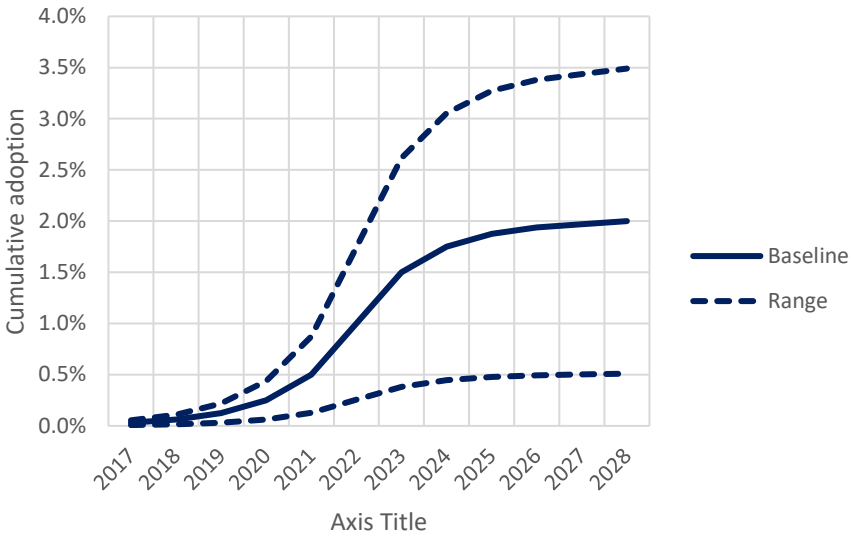

Figure 2. Estimated "without CY12010" adoption of the new rootstocks in orchard bench grafting

ADOPT inputs for mealybug pest management

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

A majority all have maximising profit as a strong motivation

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

About half have protection of the environment as a strong motivation

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

A majority have risk minimisation as a strong motivation

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

A majority of the target farms have a major enterprise that could benefit

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

About half have a long-term management horizon

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

A minority currently have a severe short-term financial constraint

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

Moderately trialable (due to the long term nature of the investment new rootstocks are inherently less trialable than shorter term investments such as new chemical products, or annual crops).

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

Slightly difficult to evaluate effects of use due to complexity

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

Not observable at all

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

Almost none used a relevant advisors due to the rootstocks being newly available and untested in Australia

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

About half of growers participate in relevant discussion groups that discuss rootstocks.

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

Almost none will need to develop substantial new skills and knowledge from previous RD&E.

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

There has been limited to no previous use and no previous trialling in Australia.

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

Moderate initial upfront cost for orchard establishment

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

Difficult to reverse due to the time and cost involved

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?

Large profit advantage for orchard bench grafting relative to the cost of purchasing established nursery trees.

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

Perceptions of the potential for no profit disadvantage in the event that orchard bench grafting is successful; however, this would shift to the realisation of a large profit disadvantage due to the increased risk of replanting.

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

Not applicable

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

No environmental consequences

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

Not applicable

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

Moderate increase in risk from the use of untested rootstocks in orchard bench grafting

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

No change in ease and convenience.

Ends.