Industry-specific impact assessment program: apple and pear

Impact assessment report for project *An analysis of fruitspotting bug activity in avocado crops from fruit-set to harvest* (AV11021)

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Contents

Tables

Figures

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 *AV11021 An analysis of fruitspotting bug activity in avocado crops from fruit-set to harvest.* Hort Innovation funded this PhD scholarship project over the period January 2011 to July 2015.

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 2017/18 dollar terms and were discounted to the year 2018/19 using a 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

The investment has contributed improved knowledge of the ecology and behaviour of the banana spotting bug in avocado crops. This PhD scholarship project has contributed to improved understanding by researchers of the banana-spotting bug and control options. The main positive impact of AV11021 was social – with improved knowledge and improved research capacity in avocado pest research delivered by the project.

Investment Criteria

Total funding from all sources for the project was $0.20 million (present value terms). All project funding was provided by Hort Innovation. No impacts/potential impacts were valued, thus the full set of investment criteria were not estimated or reported as part of this impact assessment.

Conclusions

Project AV11021 was a PhD scholarship project that was successful in achieving the project objectives. Knowledge was produced and research capability was advanced with a PhD awarded to the scholarship candidate by the University of Queensland.

Keywords

Impact assessment, cost-benefit analysis, AV11021, *Amblypelta lutescens lutescens*, avocado, banana-spotting bug, behaviour, ecology, host plants, integrated pest management, pheromone trap.

Introduction

All research and development (R&D) and marketing levy investments undertaken by Horticulture Innovation Australia Limited (Hort Innovation) are guided and aligned to specific investment outcomes, defined through a Strategic Investment Plan (SIP). The SIP guides investment of the levy to achieve each industry's vision. The current industry SIPs apply for the financial years 2016/17 – 2020/21.

In accordance with the Organisational Evaluation Framework, Hort innovation has the obligation to evaluate the performance of its investment undertaken on behalf of industry.

This impact assessment program addresses this requirement through conducting a series of industry-specific ex-post independent impact assessments of the apple & pear (AP), avocado (AV), mushroom (MU) and table grape (TG) RD&E investment funds.

Twenty-seven RD&E investments (projects) were selected through a stratified, random sampling process. The industry samples were as follows:

- Nine AP projects were chosen worth $15.46 million (nominal Hort Innovation investment) from an overall population of 19 projects worth an estimated $33.31 million,
- Seven AV projects worth $1.91 million (nominal Hort Innovation investment) from an overall population of 27 projects worth approximately $9.97 million,
- Five MU projects worth $1.75 million (nominal Hort Innovation investment) from a total population of 20 projects worth $7.94 million, and
- Six TG projects worth $2.84 million (nominal Hort Innovation investment) from an overall population of 11 projects worth $5.0 million.

The project population for each industry included projects where a final deliverable had been submitted in the five-year period from 1 July 2013 to 30 June 2018.

The projects for each industry sample were chosen such that the investments represented (1) at least 10% of the total Hort Innovation RD&E investment expenditure for each industry, and (2) the SIP outcomes (proportionally) for each industry.

Project *AV11021*: *An analysis of fruitspotting bug activity in avocado crops from fruit-set to harvest* was randomly selected as one of the 22 unique MT18009 investments and was analysed in this report.

General Method

The impact assessment follows 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 includes both qualitative and quantitative descriptions that are in accord with the impact assessment guidelines of the CRRDC (CRRDC, 2018).

The evaluation process involved identifying and briefly describing project objectives, activities and outputs, outcomes, and impacts. The principal economic, environmental and social impacts were then summarised in a triple bottom line framework.

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

Background & Rationale

Avocado industry

The Australian avocado industry is one of Australia's 'growth' horticultural industries as illustrated in Table 1 below.

Table 1 Avocado Industry Performance 2014-2018

Year ended June	Production (tonnes)	Gross Value of Production (m$)	Farmgate value (m$)	Export value (m$)
2014	48,715	313	297	5.6
2015	57,595	356	331	6.4
2016	66,716	438	412	9.2
2017	65,992	398	374	12.5
2018	77,032	557	543	11.6
Average	63,210	412	391	9.1

Source: Facts at a Glance for the Australian avocado industry-2017/18 (Avocados Australia, 2018).

While avocados are grown in all Australian States and the Northern Territory, production is dominated by Queensland followed by Western Australia; together these two states produced 87% of avocados in 2017/18. Due to the broad range of climatic conditions and locations where avocados are grown, they are produced nearly all year round. Two varieties of avocados dominate the industry: Hass (78%) and Shepard (19%) (Avocados Australia, 2018).

Australian consumption of avocados has increased in line with the production increase. Based on new plantings, production of Australian avocados is expected to increase significantly in the next few years. Avocado exports are minimal at 2.3% of production in 2017/18, but growth in exports is expected in the future if the third desired outcome in the SIP is achieved (10% of production exported - see below).

The marketing and research and development activities of the avocado industry are guided by the industry's Strategic Investment Plan (SIP). The activities are funded by levies payable on avocados produced in Australia; the marketing and R&D levy funds are managed by Hort Innovation.

The previous avocado Industry Strategic Plan expired in 2015 and placed emphasis on development of the domestic market, increased production for year round supply, and the maintenance of demand and price via marketing programs and supply of consistent quality avocados.

The current SIP has been driven by levy payers and addresses the Australian avocado industry's needs from 2017 to 2021. Strategies and priorities in the Plan have been driven by a set of four desired outcomes (Avocados Australia, 2017).

1. By 2021, increase domestic demand for Australian avocados has increased by at least 20%.
2. By 2021, over 90 per cent of avocados received by consumers will meet or exceed their expectations of quality.
3. By 2021, over 10 per cent of production will be exported to markets where customers have a willingness and capacity to pay a premium for Australian avocados.
4. By 2021, productivity (marketable yield per hectare) has improved by 15 per cent on average, without increased production costs per kilogram.

Rationale

Banana-spotting bug (*Amblypelta lutescens lutescens*) is a type of fruitspotting bug and a serious pest to avocado and other tree fruit, nut and vine crops throughout coastal and sub-coastal areas of tropical and subtropical Australia. The pest stings the avocado fruit at all stages of development from fruitset until picking. Symptoms include fruit shedding if fruit is stung when small, fruit distortion and dimpling, and woody 'stones' where stung (Queensland Department of Agriculture and Fisheries, 2019.) These factors negatively influence avocado quality and yield. Avocados are potentially the most affected crop by banana-spotting bugs, as bugs will attack newly set to harvestable fruit over a five to six month period.

AV11021 was developed to improve understanding of the ecology and behaviour of banana-spotting bug in avocado crops and to investigate the potential of using pheromone traps to improve pest management. With the recent deregistration of endosulfan, growers are no longer able to use this chemical to control banana-spotting bug in avocado orchards (Source: project proposal). Alternative cost-effective control techniques for banana-spotting bug are required by the avocado industry.

AV11021 built upon prior Australian avocado research conducted in the late 1990s and early 2000s that provided information on how bug damage develops through an avocado crop, the importance of hotspots, edge effects and proximity to nearby scrub in relation to the damage caused. The Australian Centre for International Agricultural Research also funded related research to improve understanding and minimise losses to avocado crops from banana-spotting bug (Ian Newton, pers. comm., 2019). Hort Innovation project MT10049 *A multi-target approach to fruitspotting bug* (2011-2016) was conducted in parallel to this AV11021 project. The aim of MT10049 was to investigate more strategic, long-term and sustainable management approaches to fruitspotting bugs (including banana-spotting bug) that affect a large range of fruit and nut crops in Australia (https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/mt10049/).

This PhD project (AV11021) was developed to fill a specific gap in knowledge regarding the presence of the different life stages of banana-spotting bug and their significance to the epidemiology of damage in avocado crops, the contribution to damage escalation of immigration versus breeding within the crop, and the role pheromone traps can play in determining changes in bug activity.

To progress understanding of the ecology and behaviour of the banana-spotting bug in avocado crops and improve understanding of the potential of using pheromone traps in improving pest management, the PhD project was developed and funded by Hort Innovation.

Project Details

Summary

Project Code: AV11021

Title: *An analysis of fruitspotting bug activity in avocado crops from fruit-set to harvest*

Research Organisation: The University of Queensland

Principal Investigator: Harry Fay, Private Consultant (previously DAF, Queensland)

Period of Funding: January 2011 to July 2015

Objectives

The overall objective of AV11021 was to improve understanding of the ecology and behaviour of the banana-spotting bug *Amblypelta lutescens lutescens* in relation to avocado crops and investigate the potential of using pheromone traps to improve pest management.

Logical Framework

Table 2 provides a description of AV11021. The description is provided in a logical framework structure.

Table 2: Logical Framework for Project AV11021

Activities and Outputs	Four main activities were completed: • Development, survival and fecundity of banana-spotting bug on distinct phonological stages of different crop host plants. • Sampling efficiency and bias of pheromone traps capturing banana-spotting bug. • Population monitoring and spatial distributions of banana-spotting bug in avocado traps. • Potential applications of pheromone traps for Integrated Pest Management of banana-spotting bug. The main output of this project was new knowledge regarding the biology and ecology of the banana-spotting bug in avocado orchards. Specific outputs included: • Avocado was found to be a poor host for banana-spotting bug. • After hatching from the egg, banana-spotting bug were observed feeding; survival rates were found to be affected by the quality of food provided. • In avocado crops in far North Queensland, banana-spotting bug densities were found to be high from October through to June but lower from July to September. Furthermore, population densities were not correlated with the presence of fruit on trees. It was found that high densities of the pest can remain in the avocado orchards after harvest. • Spatial analysis of banana-spotting bug distributions in avocado crops found that population densities are high in areas close to lime crops, suggesting lime crops generate source populations that then invade avocado crops. • When pheromone traps were placed in avocado trees, the density of banana-spotting bugs caught in traps was found to be positively correlated with fruit damage in the tree. Pheromone traps were found to be successful in concentrating banana-spotting bug populations in trees, thus providing a specific target for reduced input insecticide control strategies. The following recommendations for pest management were made in the AV11021 Final Report: • Distribute pheromone traps on avocado orchards as a monitoring tool to identify areas with high population densities and to monitor changes in population densities over time. • Begin monitoring for banana-spotting bug in October and continue monitoring until the avocado crop has been harvested. • Apply insecticides to areas/trees where high numbers of banana-spotting bugs are captured in pheromone traps and when population densities begin to increase. • Focus monitoring and insecticide applications in areas that are adjacent to other crops favourable for banana-spotting bug development including citrus (including lime), mango and papaya. • Monitor banana-spotting bug populations in other horticultural crops near avocado crops and apply insecticides to these crops when numbers reach high levels to reduce movement of the bugs into the avocado crop. The following recommendations for future research were made in the AV11021 Final Report: • Examine the suitability of different species of native vegetation that grow in the environ of avocado orchards for banana-spotting bug nymph survival and development to adults. • Examine movement patterns of adults between horticultural crops and between native vegetation to avocado crops. Examine distances that individual adults move within determined time frames. • Establish economic thresholds for avocado crops based on pheromone trap catches so that insecticides can be applied prudently.

	The following journal articles were published as a result of AV11021: • Two journal articles were published in *The Journal of Economic Entomology* in 2016 and 2019 (Lindsay & Furlong, 2016; Lindsay et. al., 2019). A PhD Thesis was awarded in 2017 as a result of AV11021: Lindsay, K. R. Ecology and behaviour of *Amblypelta lutescens lutescens* (Hemiptera: Coreidae) in avocado orchards. PhD thesis. The University of Queensland, St Lucia, Brisbane.
Outcomes	• Improved understanding of the epidemiology of damage by *A. lutescens* in avocados. • Verification of the effectiveness of pheromones for monitoring bug activity providing greater confidence in the technology. Commercial product development: • Utilising the knowledge produced in follow on research projects (including AV11021), Organic Crop Protectants developed and commercially released the *banana-spotting bug Lure & Trap* pheromone in 2017 (http://ocp.com.au/wp-content/uploads/2014/07/OCP430_BSB-trap-instructions_V4.pdf and https://www.goodfruitandvegetables.com.au/story/4901771/banana-spotting-bug-trap-finally-released/#). Initial experimental uptake of the commercially available *banana-spotting bug Lure & Trap* system by a small number of avocado growers in Queensland has occurred with mixed results (Jason Vella, pers. comm., July 2019; Leonie Wittenberg, pers. comm., July 2019; Ian Newton, pers. comm., August 2019). A small number of growers and crop scouts currently use the *Lure and Trap* system in a small number of hot spot areas on each farm to monitor the incidence of banana spotting bug in avocado orchard crops with mixed results. The pest density data together with other information may help inform some grower/crop scout decisions regarding the timing of chemical control to reduce banana-spotting bug damage (Jason Vella, pers. comm., July 2019; Leonie Wittenberg, pers. comm., July 2019). Widespread uptake of the pheromone system is currently limited by the reliability and cost of the system, the time required to effectively implement the system, and the scale of benefits to growers as a result of implementing the system (Leonie Wittenberg, pers. comm., July 2019).
Impacts	• This project contributed new knowledge regarding the ecology and behaviour of the banana-spotting bug *Amblypelta lutescens lutescens* in avocado crops, and the potential of using pheromone traps to improve pest management. • This project delivered increased capacity in avocado and pest research as a result of a PhD awarded to the scholarship candidate. • This project may in the future contribute to potential economic gains to avocado growers as a result of improved fruit quality and a reduction in avocado yield losses due to this project's contribution to improved monitoring and control of banana-spotting bug in avocado crops. • This project made a small contribution to the commercial development of the *banana-spotting bug Lure & Trap* system. The product is currently used by a small number of avocado growers in hot spot areas. Broader adoption is limited by the costs of the system, the time required to effectively implement the system and the scale of resultant benefits to growers.

Project Investment

Nominal Investment

Table 3 shows the annual investment (cash and in-kind) in project AV11021 by Hort Innovation. There were no 'other' investors in this research project.

Table 3: Annual Investment in the Project AV11021 (nominal $)

Year ended 30 June	Hort Innovation ($)	Other ($)	Total ($)
2012	35,000	0	35,000
2013	35,000	0	35,000
2014	35,000	0	35,000
2015	0	0	0
2016	17,500	0	17,500
Totals	122,500	0	122,500

Program Management Costs

For the Hort Innovation investment the cost of managing the Hort Innovation funding was added to the Hort Innovation contribution for the project via a management cost multiplier (1.162). This multiplier was estimated based on the share of 'payments to suppliers and employees in total Hort Innovation expenditure reported in the Hort Innovation's Statement of Cash Flows (Hort Innovation Annual Report, various years, 3 year average). This multiplier was then applied to the nominal investment by Hort Innovation shown in Table 2.

Real Investment and Extension Costs

For the purposes of the investment analysis, investment costs of all parties were expressed in 2017/18 dollar terms using the GDP deflator index. There were no additional costs associated with project extension as results were communicated to other researchers via published journal articles the PhD thesis, and other means as part of this project.

Impacts

Table 4 provides a summary of the principal types of impacts delivered by the project. Impacts have been categorised into economic, environmental and social impacts.

Table 4: Triple Bottom Line Categories of Principal Impacts from Project AV11021

Economic	• This project may in the future make a minor contribution to potential economic gains by avocado growers as a result of improved fruit quality and a reduction in avocado yield losses due to this project's contribution to improved monitoring and control of banana-spotting bug in avocado crops. • This project made a small contribution to the commercial development of the *banana-spotting bug Lure & Trap* system. The product is currently used by a small number of avocado growers in hot spot areas with mixed results. Broader adoption is limited by the reliability of the system, the costs of the system, the time required to effectively implement the system and the scale of resultant benefits to growers.
Environmental	• Nil.
Social	• This project contributed new knowledge regarding the ecology and behaviour of the banana-spotting bug *Amblypelta lutescens lutescens* in avocado crops, and the potential of using pheromone traps to improve pest management. • The project delivered increased capacity in avocado and pest research as a result of a PhD awarded to the scholarship candidate.

Public versus Private Impacts

Impacts identified in this evaluation are minor and mostly public in nature. Public benefits are anticipated to be realised by the research sector as a result of improved research capability delivered by this PhD scholarship project. Small-scale private benefits may be attributed to project AV11021 in the future as a result of avocado growers achieving reduced avocado yield losses and additional profitable sales. However, these impacts are more likely to be attributable to the research and extension activities undertaken within the associated research project MT10049, not AV11021.

Distribution of Private Impacts

Future potential private impacts from this project are likely to be minor. Any private economic benefits are anticipated to be captured by individual avocado growers as a result of future utilisation of the knowledge produced by AV11021 together with other research investments.

Impacts on Other Australian Industries

Impacts on industries other than the Australian avocado industry may include potential gains in other horticultural cropping industries impacted by banana-spotting bug. Furthermore, additional impacts may be realised via any future spillovers from the increase in knowledge and research capacity resulting from this investment.

Impacts Overseas

Potential benefits may accrue to overseas avocado and horticultural producers as the banana-spotting bug also causes damage internationally and the knowledge produced by this project may be utilised by researchers in countries other than Australia.

Match with National Priorities

The Australian Government's Science and Research Priorities and Rural RD&E priorities are reproduced in Table 5. The project findings and related impacts will contribute to Rural RD&E Priority 1 and to Science and Research Priority 1.

Table 5: Australian Government Research Priorities

Australian Government	
Rural RD&E Priorities (est. 2015)	**Science and Research Priorities (est. 2015)**
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

Sources: (DAWR, 2015) and (OCS, 2015)

Alignment with the Avocado Strategic Investment Plan 2017-2021

The strategic outcomes and strategies of the avocado industry are outlined the Avocado Strategic Investment Plan 2017-2021[1] (Hort Innovation, 2017). Project AV11021 addressed both Outcome 2 (Strategy 2.3) and Outcome 4 (Strategy 4.2).

[1] For further information, see: https://www.horticulture.com.au/hort-innovation/funding-consultation-and-investing/investment-documents/strategic-investment-plans/

Valuation of Impacts

Impacts Valued

This investment in AV11021 did not produce any significant impacts, so no quantitative evaluation processes were applied. Any contribution by the project to improved monitoring and control of banana-spotting bug in avocado crops in the future was considered minor and uncertain, as was any contribution to the commercial development of the banana-spotting bug Lure & Trap system that currently has a minor uptake anyway due to cost and effort to implement. Furthermore, the pathways to these minor contributions were unclear.

Impacts Not Valued

The impact identified in Table 4 of increased capability in avocado pest research was not valued as this project has contributed only in a minor way to future anticipated avocado disease management impacts.

Results

Investment Criteria

As no impacts were valued, the investment criteria were limited to the Present Value of Investment Costs (PVC). All past costs were discounted to 2018/19 using a discount rate of 5%. Tables 6 and 7 show the PVCs for different periods of the total investment and the Hort Innovation investment respectively. As the funding for the project was only from Hort Innovation, the figures in the two tables are identical.

Table 6: Investment Criteria for Total Investment in Project AV11021

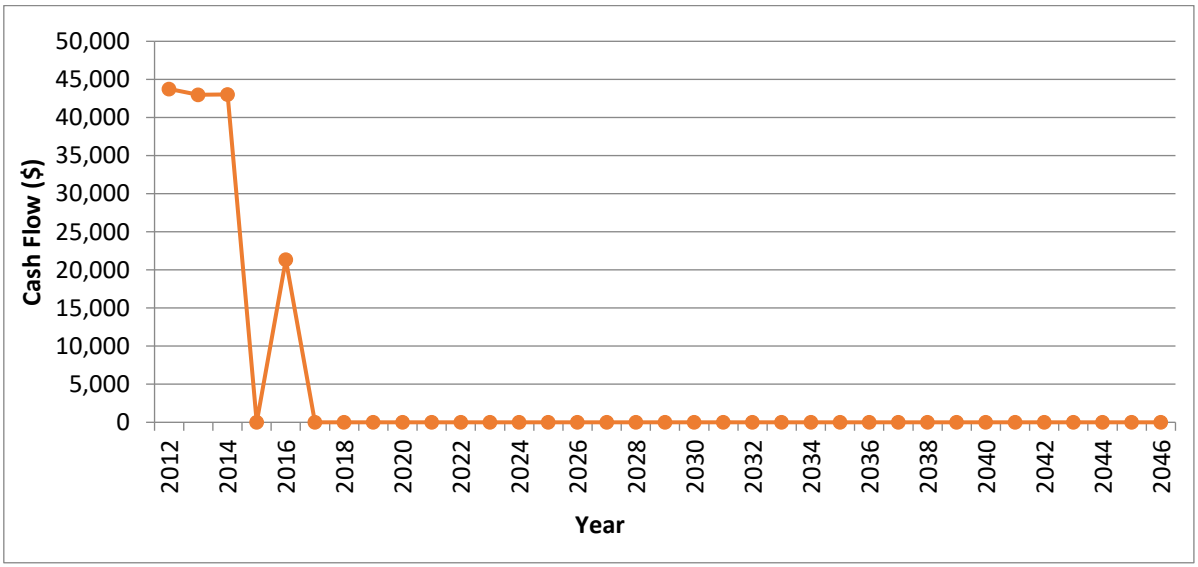
Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Costs ($m)	0.20	0.20	0.20	0.20	0.20	0.20	0.20

Table 7: Investment Criteria for Hort Innovation Investment in Project AV11021

Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Costs ($m)	0.20	0.20	0.20	0.20	0.20	0.20	0.20

The annual undiscounted cost cash flows for the total investment for the duration of AV11021 investment plus 30 years from the last year of investment are shown in Figure 1.

Figure 1: Annual Cash Flow of Undiscounted Total Investment Costs



Conclusion

The investment by Hort Innovation in PhD scholarship project AV11021 has resulted in improved research capacity in the area of avocado pest management. Total funding of AV11021 was $0.20 million (present value terms). While knowledge was delivered and research capability developed as a result of this investment, the project did not result in any significant impacts that could be valued.

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.
Investment criteria:	Measures of the economic worth of an investment such as Net Present Value, Benefit-Cost Ratio, and Internal Rate of Return.
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.

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Abbreviations

AP	Apple and Pear
AV	Avocado
CRRDC	Council of Research and Development Corporations
DAF	Department of Agriculture and Fisheries (Queensland Government)
DAWR	Department of Agriculture and Water Resources (Australian Government)
GDP	Gross Domestic Product
MIRR	Modified Internal Rate of Return
MU	Mushroom
OCS	Office of Chief Scientist Queensland
PVC	Present Value of Costs
R&D	Research and Development
RD&E	Research, Development and Extension
SIP	Strategic Investment Plan
TG	Table Grape