Industry-specific impact assessment program: avocado

Impact assessment report for project *Mechanisms of cultivar- and race-based disease resistance in avocado* (AV09024)

Impact analyst:

Tracy Henderson

Delivery partner:

AgEconPlus and Agtrans Research

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Level 7
141 Walker Street
North Sydney NSW 2060

Telephone: (02) 8295 2300

www.horticulture.com.au

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What the report is about

This report presents the results of an impact assessment of a Horticulture Innovation Australia Limited (Hort Innovation) investment in *AV09024: Mechanisms of cultivar- and race-based disease resistance in avocado.* The project was funded by Hort Innovation over the period August 2010 to May 2016.

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 in this avocado scholarship project has resulted in increased knowledge and understanding of the biology and ecology of Phytophthora root rot in avocado trees as well as improved research capability. This research project did not contribute directly to any tangible outcomes or benefits for the Australian avocado industry. The project confirmed root regenerative ability does not appear to be an important mechanism of tolerance/resistance to Phytophthora root rot and hence the industry avoided further future research investment along these lines.

Investment Criteria

Total funding from all sources for the project was $0.40 million (present value terms) with the Hort innovation investment in the project totalling $0.21 million (present value terms). Project funding was provided by Hort Innovation, the University of Queensland and the Department of Employment, Economic Development & Innovation. None of the impacts/potential impacts identified were valued in monetary terms, thus the full set of investment criteria were not estimated or reported as part of this impact assessment.

Conclusions

No project impacts were valued, however the project was successful in that the project objectives were achieved, with research capability being advanced and a PhD being awarded to the scholarship candidate by the University of Queensland.

Keywords

Impact assessment, cost-benefit analysis, AV09024, avocado, Phytophthora root rot, resistance mechanisms, *Persea Americana*, *Phytophthora cinnamomi*, plant disease, root development, scholarship.

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 *AV09024: Mechanisms of cultivar- and race-based disease resistance in avocado* 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 descript ions 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

Background

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 (Hort Innovation, 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

Phytophthora root rot caused by *Phytophthora cinnamomi* is a serious problem in avocado trees resulting in low productivity and small, poor quality fruit. Avocado root rot is the most important disease of this fruit crop world wide, and if left untreated, Phytophthora root rot will eventually kill affected trees. Rootstocks with high levels of resistance to Phytophthora root rot are not available in avocado, yet differences in tolerance to the disease have been observed among commonly used rootstock varieties (Drenth, 2016.)

Project AV09024 sought to investigate the mechanisms of cultivar- and race-based disease resistance of avocado rootstocks to Phytophthora root rot. The project was a PhD Scholarship Project conducted through The University of Queensland and utilising facilities at Maroochy Research Station and elsewhere.

AV09024 was consistent with the objectives of the Australian Avocado Strategic Investment Plan 2017-21. The project supports Outcome 4 "By 2021, productivity (marketable yield per hectare) has improved by 15 per cent on average, without increased production costs per kilogram". In particular AV09024 aligns with the Outcome 4 Strategy of "Review and prioritise the main constraints (for example irregular bearing, pest and disease, rootstock selection, nutrition, irrigation management) to increasing farm productivity and address those with the greatest national impact".

This project built on prior and parallel research investments including:

- AV0700 Improving yield and quality in avocado through disease management (2007-10)
- AV10001 Improving yield and quality in avocado through disease management Phase 2 (2010-15)

To address the complex constraint to avocado production and to build capacity and knowledge a PhD scholarship project was identified as being appropriate to address the issue; hence Project AV09024 was funded.

Project Details

Summary

Project Code: AV09024

Title: *Mechanisms of cultivar- and race-based disease resistance in avocado*

Research Organisation: The University of Queensland

Principal Investigator: Andre Drenth

Period of Funding: August 2010 to May 2016

Objectives

The objective of this PhD scholarship project was to improve understanding of the mechanisms underlying tolerance and resistance to the Phytophthora root rot caused by *Phytophthora cinnamomi* in avocado trees and identify less susceptible rootstock varieties.

Logical Framework

Table 2 provides a description of AV09024 in a logical framework.

Table 2: Logical Framework for Project AV09024

Activities and Outputs	• The PhD research scholarship to achieve the objective of this project was advertised nationally in late 2010, and readvertised in early 2011, with no suitable candidates identified through this process. A suitable applicant (Ms Merran Neilsen) was subsequently identified and commenced October 2011. • A number of physiological characteristics of avocado trees were investigated to see if they provided protection against the *Phytophthora* root rot pathogen. • Activites were conducted to determine if resistance to *Phythophthora* root rot in avocado rootstock is due to the availability of some rootstock to simply regenerate more roots more quickly thereby countering the effect of pathogen attack. - An experimental root evaluation system was developed. - Root regeneration processes of avocado seedling varieties were investigated. - Feeder root growth for different rootstock varieties in the field were identified. - Disease lesion extension and *Phytophthora cinnamomi* growth in root tips were determined. • Glasshouse root growth studies found no relationship between inherent root growth and susceptibility to the disease among nine seedling varieties. No correlation was found between susceptibility and stored starch, tree health, yield or tree growth parameters in field trials at two sites. Root regenerative ability was also not a factor. Source: https://www.horticulture.com.au/growers/help-your-business-

	grow/research-reports-publications-fact-sheets-and-more/av09024/ • The study did not provide clear advances in the understanding of mechanisms underlying field resistance in avocado rootstocks to Phytophthora root rot; however recommendations were made for future research to further investigate the mechanisms underlying field resistance in avocado rootstocks to Phytophthora root rot, and this occurred through subsequent projects including AV16007 (Andre Drenth, pers. comm., 2019). • The PhD confirmation was completed in April 2013, and the PhD awarded by The University of Queensland in 2016. The PhD was titled "*Evaluation of Phytophthora Root Rot Resistance in Avocado"*. • A 21-page final report for project AV09024 titled "*Mechanisms of cultivar- and race-based disease resistance in avocado"* was submitted to HIA in full and published in 2016 (Source: https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/av09024/). • Research outputs were presented and/or published at: - 2013-2014 Conference Proceedings for the Australasian Plant Pathology Conference, - New Zealand and Australian Avocado Growers' Conferences, and - International Horticultural Congress.
Outcomes	• The PhD student was awarded a PhD from the University of Queensland and went on to work as a Research Assistant at the Queensland Department of Agriculture and Fisheries and subsequently as a Technical Officer for the Northern Territory Department of Primary Industries and Fisheries (Andre Drenth, pers. comm., 2019). • Outputs of this research were useful in informing follow on research activities including AV16007 *Improving avocado orchard productivity through disease management* (2017-2021) (Andre Drenth, pers. comm., 2019).
Impacts	• Increased knowledge: the avocado research sector gained an improved understanding of phytophthora and its relationship to avocado rootstock resistance. • The project confirmed root regenerative ability does not appear to be an important mechanism of tolerance/resistance to Phytophthora root rot and hence the industry avoided further future research investment along these lines. The implication of this is that there are as yet no shortcuts in breeding and selection for Phytophthora resistant rootstocks to get around time consuming glasshouse and field screening studies. • Research capacity in understanding the physiological mechanisms and the tolerance and resistance of plant rootstock to disease was built as a result of this PhD project.

Project Investment

Nominal Investment

Table 3 shows the annual investment (cash and in-kind) in project AV09024 by Hort Innovation. Other investors in this project included The University of Queensland and Department of Employment, Economic Development & Innovation.

Table 3: Annual Investment in the Project AV09024 (nominal $)

Year ended 30 June	Hort Innovation ($)	Other ($)	Total ($)
2011	35,000	38,857	73,857
2012	35,000	38,857	73,857
2013	35,000	38,857	73,857
2017	17,500	19,429	36,929
Totals	122,500	136,000	258,500

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 (3-year average) reported in the Hort Innovation's Statement of Cash Flows (Hort Innovation Annual Report, various years). This multiplier was then applied to the nominal investment by Hort Innovation shown in Table 3.

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 Gross Domestic Product deflator index. There were no additional costs associated with project extension. Results were communicated to other researchers as part of the 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 AV09024

Economic	• The project confirmed root regenerative ability does not appear to be an important mechanism of tolerance/resistance to Phytophthora root rot and hence the industry avoided further future research investment along these lines.
Environmental	• Nil.
Social	• Increased knowledge. The avocado research sector gained an improved understanding of phytophthora and avocado rootstock resistance. • Increased capacity in avocado and plant disease research as a result of a PhD awarded to the scholarship candidate.

Public versus Private Impacts

The social and economic impacts identified in this evaluation are minor and predominantly 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.

Distribution of Private Impacts

Future potential private impacts from this project are uncertain and likely to be minor. Any private economic benefits are anticipated to be captured by individual avocado growers as a result of future research to develop improved disease management of Phytophthora root rot in avocados.

Impacts on Other Australian Industries

It is unlikely any other Australian industries may benefit from the AV09024 investment.

Impacts Overseas

No significant overseas impacts of AV09024 investment were identified, but as avocados are affected world-wide by the Phytophthora root rot pathogen, the project findings may have contributed to avoided further future research investment overseas.

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 AV09024 addressed primarily Outcome 4 (Strategy 4.5)

Valuation of Impacts

Impacts Valued

This investment in AV09024 did not produce any direct and/or significant impacts, so no quantitative evaluation processes were applied. The project confirmed root regenerative ability does not appear to be an important mechanism of tolerance/resistance to Phytophthora root rot and hence the industry avoided further future research investment along these lines.

Impacts Not Valued

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

Results

All past costs were discounted to 2018/19 using a discount rate of 5%.

To ensure consistency with other Hort Innovation project analyses and reporting, the PVC was reported for the length of the investment and for different time periods up to 30 years from the last year of investment (2016/17) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

Tables 6 and 7 show the investment criteria estimated for different periods of benefit for the total investment and the Hort Innovation investment respectively. As no impacts were valued, the investment criteria were limited to the Present Value of Investment Costs (PVC).

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

Table 6: Investment Criteria for Total Investment in Project AV09024

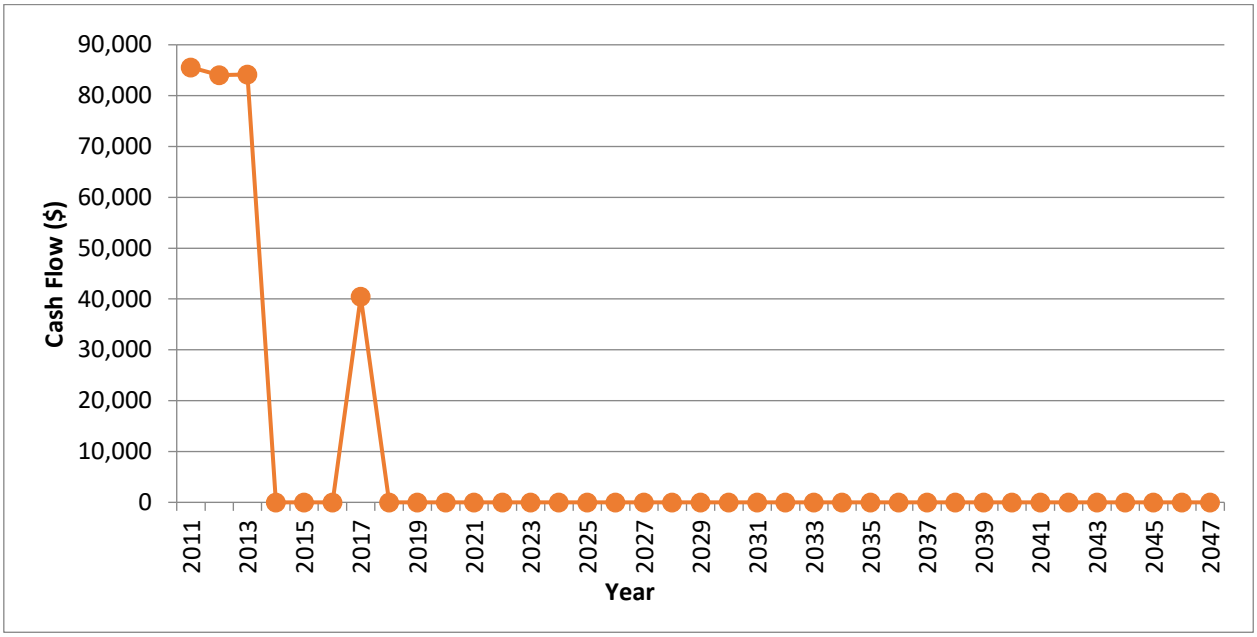
Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Costs ($m)	0.40	0.40	0.40	0.40	0.40	0.40	0.40

Table 7: Investment Criteria for Hort Innovation Investment in Project AV09024

Investment Criteria	Years after Last Year of Investment						
	0	5	10	15	20	25	30
Present Value of Costs ($m)	0.21	0.21	0.21	0.21	0.21	0.21	0.21

The annual undiscounted benefit and cost cash flows for the total investment for the duration of AV09024 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 has resulted in improved research capability in the area of avocado disease management. The project confirmed root regenerative ability does not appear to be an important mechanism of tolerance/resistance to Phytophthora root rot and hence the industry avoided further future research investment along these lines. The implication of this is that there are as yet no shortcuts in breeding and selection for Phytophthora resistant rootstocks to get around time consuming glasshouse and field screening studies. Total funding for AV09024 totalled $0.40m (present value terms). The Hort Innovation investment costs were $0.21m (present value terms). While research capability was built as a result of this project, the investment did not result in any significant and/or direct 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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Andre Drenth, University of Queensland

Abbreviations

AP	Apple and Pear
AV	Avocado
CRRDC	Council of Research and Development Corporations
DAWR	Department of Agriculture and Water Resources (Australian Government)
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