Horticulture Impact Assessment Program:

Appendix 9: Innovating new virus diagnostics and planting bed management in the Australian sweetpotato industry (VG13004 Impact Assessment)

Impact analyst

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Delivery partner:

AgEconPlus and Agtrans Research

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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 *VG13004: Innovating new virus diagnostics and planting bed management in the Australian sweetpotato industry.* The project was funded by Hort Innovation over the period February 2014 to March 2018.

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 is likely to contribute to retention of high average yields and lower production costs in the Australian Sweetpotato Industry. Retention of high average yields will result from sustained virus control, and in the longer term, safe importation of superior genetic material. Lower production costs will be linked to lower cost planting material and fewer purchased inputs for the control of insect virus vectors. There will be a reduced risk of adverse environmental outcomes associated with chemical use and the industry will benefit from additional grower, extension and research capacity. Additional capacity has been developed in planting bed management and virus diagnostics.

Investment Criteria

Total funding from all sources for the project was $2.77 million (present value terms) with Hort Innovation investment in the project totalling $1.44 million. The investment produced estimated total expected benefits of $9.70 million (present value terms). This gave a net present value of $6.93 million, an estimated benefit-cost ratio of 3.5 to 1, an internal rate of return of 58% and a MIRR of 9%.

Conclusions

While several economic and social impacts identified were not valued, the impacts were considered indirect, uncertain and/or minor compared with the impact valued. Nevertheless, combined with conservative assumptions for the impacts valued, investment criteria as provided by the valuation may be underestimates of the actual performance of the investment.

Keywords

Impact assessment, cost-benefit analysis, VG13004, sweetpotato, pathogen tested, virus diagnosis, planting bed management

Introduction

Horticulture Innovation Australia Limited (Hort Innovation) required a series of impact assessments to be carried out annually on a number of investments in the Hort Innovation research, development and extension (RD&E) portfolio. The assessments were required to meet the following Hort Innovation evaluation reporting requirements:

- Reporting against the Hort Innovation's current 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 (SIP) for each Hort Innovation industry fund.
- Annual Reporting to Hort Innovation stakeholders.
- Reporting to the Council of Rural Research and Development Corporations (CRRDC).

The first series of impact assessments included 15 randomly selected Hort Innovation RD&E investments (projects) worth a total of approximately $9.31 million (nominal Hort Innovation investment). The investments were selected from an overall population of 85 Hort Innovation investments worth an estimated $50.38 million (nominal Hort Innovation investment) where a final deliverable had been submitted in the 2017/18 financial year.

The 15 investments were selected through a stratified, random sampling process such that investments chosen represented at least 10% of the total Hort Innovation RD&E investment in the overall population (in nominal terms) and was representative of the Hort Innovation investment across six, pre-defined project size classes.

Project *VG13004: Innovating new virus diagnostics and planting bed management in the Australian Sweetpotato industry* was selected as one of the 15 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

Background

The Australian Sweetpotato Industry has undergone significant growth and productivity improvement over the last decade and now has the highest commercial yield in the world. Its farm gate value was estimated at $60 million in 2009/10; in 2017/18 production was 97,222 tonnes valued at $73.8 million. The Australian industry is dominated by gold varieties (Bellevue, Beauregard and Orleans) and fresh Australian grown sweetpotatoes are available all year round (Hort Innovation, 2018).

Sweetpotatoes are predominantly grown in Queensland (QLD) with smaller areas of production in northern New South Wales (NSW) and Western Australia. Major production areas include the Atherton Tablelands, Bundaberg and the Lockyer Valley in QLD. Sweetpotato is forecast to be the third most important vegetable grown in QLD behind tomatoes and capsicums by the early 2020s. Sweetpotato is the only vegetable category whose Australian retail sales are increasing.

All fresh market Sweetpotatoes sold in Australia are grown in Australia. A small amount of product is processed, and 922 tonnes were exported fresh in 2017/18. All sweetpotato imports are currently in processed form (e.g. chips) (Nick Macleod, Director Vegetables and Deciduous Fruit RD&E, DAF, written communication). Most sweetpotato imports are sourced from China (Hort Innovation, 2018).

Sweetpotato is a major crop throughout the Asia-Pacific, Africa and the Americas (e.g. Peru and the United States). A number of countries have exportable surpluses and are expected to apply to export fresh sweetpotatoes to Australia. The Australian industry will need to import genetic material and must be certain that it is not also importing sweetpotato viruses.

Rationale

Sweetpotatoes are grown vegetatively and viruses in planting material are a major factor limiting worldwide sweetpotato yield and the production of easy peeling crops (viruses constrict and distort tuber shape). A range of viruses are known to infect sweetpotato, from a number of different virus families, including the aphid transmitted potyvirus Sweetpotato Feather Mottle Virus (SPFMV) and the whitefly transmitted begomovirus Sweetpotato Leaf Curl Virus (SPLCV). Both these viruses are present in Australia.

A major Australian RD&E outcome since the 1990s has been the development and use of the Pathogen Tested (PT) Scheme for supplying virus free planting material. The provision of disease-free planting material is a key driver of Australia's Sweetpotato Industry. PT has been so successful in eliminating viruses from planting material that it has been adopted by 100% of Australian growers.

However, viruses constantly evolve and there is a risk that the current PT system will break down. The risk of breakdown is exacerbated by the presence in Australia of additional virus vectors and the risk of transmission of new viruses through fresh sweetpotato imports. Some 22 known sweetpotato viruses are not present in Australia and are capable of being imported through supply of product from countries with sweetpotato export capacity. Consequently, there is a need to know the virus status of other countries and for Australia to have the ability to diagnose viruses rapidly and accurately. Currently the detection of sweetpotato viruses relies on a combination of biological assays using indicator hosts, antibody-based ELISA (enzyme-linked immunosorbent assays) and PCR-based (polymerase chain reaction) molecular assays.

In addition, to produce PT planting material, PT roots are planted into designated planting beds to produce high quality cuttings, which are grown out, cut by hand and transferred to commercial sweetpotato fields. Efficiency in this process ensures planting stock is available, is virus free and produced at the lowest cost. Significant planting bed losses have been experienced by the sweetpotato industry and issues with constant supply of planting material poses challenges to the industry. It is essential that best practice techniques for planting bed management are known and adopted.

Project Details

Summary

Project Code: VG13004

Title: *Innovating new virus diagnostics and planting bed management in the Australian Sweetpotato industry*

Research Organisation: Department of Agriculture and Fisheries, Queensland

Principal Investigator: Craig Henderson

Period of Funding: February 2014 to March 2018

Objectives

The project's key objectives were:

1. Improve virus diagnostic techniques and maintain the integrity of the PT System.
2. Ensure that best practice planting bed management systems are in place to produce ample high quality low cost planting material.

Logical Framework

The focus of VG13004 was to develop improved virus diagnostic and planting bed management approaches for the Australian Sweetpotato Industry. Table 1 provides a detailed description of the project in a logical framework.

Table 1: Logical Framework for Project VG13004

Activities and Outputs	• Survey the literature to identify world sweetpotato virus status and new sweetpotato virus diagnostic techniques including travel to Louisiana State University to work with world leading sweetpotato virologists. • Work with growers to determine which viruses are impacting Australian production. • Research relationships between growing bed management and crop productivity. • Develop, evaluate and implement new virus diagnostic techniques (e.g. herbaceous indexing, NCM-ELISA and qPCR) suitable for endemic and exotic sweetpotato viruses. • Investigate the causes of plant bed losses and develop strategies to minimise the risk of these events (e.g. creation of anaerobic conditions, fungus damage). • Complete agronomic experiments to determine which variables are responsible for planting bed performance (e.g. depth and arrangement of PT roots). • Describe the practices that impact on the ability of the planting bed to generate physiologically hardened, yet rapid-growth capable sweetpotato cuttings, which can in turn provide high numbers of marketable sweetpotato roots per cutting. • Describe how to determine the balance between sequential cutting of existing planting beds, and when to switch to a new planting bed. • Outline the desirable equipment and land resource attributes that can best deliver optimal planting bed conditions e.g. row covers, irrigation, soil condition, nutrient status and PT root planting arrangements. • As a result of the research the productivity of planting beds increased 20%. The gain was attributable to the construction of higher, well drained beds, only covering beds with 3cm to 5cm of soil, irrigating sparingly early and keeping soil temperatures between 17^{o}C and 26^{o}C in spring by careful use of plastic covers. • The dominant issue was premature plant bed breakdown, particularly with the new, nematode-resistant cultivar Bellevue. The project investigated physiological and pathogenic causes of breakdown and developed guidelines to reduce risk. • Outputs included virus surveys, virus diagnostic tools, factsheets (grower virus management and planting bed field guides) and web page information (placed on both the Australian Sweetpotato Grower (ASPG) Inc. and Hort Innovation websites).

	• Extension included on-farm field walks and workshops, regular updates of the ASPG newsletter and Good Fruit and Vegetable articles. Scientific journal articles were published and conference presentations were given. More than 85% of Australian sweetpotato growers attended project on-farm walks and workshops. • The project also resulted in collaborative relationships between sweetpotato researchers at several Australian universities, neighbouring Pacific countries and key scientists from Louisiana State University.
Outcomes	• Improved virus detection methods incorporated into industry PT Scheme. • Australian sweetpotato planting material remains virus free. • Yield is maintained with virus free planting material. • Improved genetics can be imported without introducing viruses. • Improved planting beds lower the cost of virus free planting material and improve the certainty of its supply. • Growers save cost on planting material (the final report estimates a 20% saving by 2020), input requirements (saving on chemicals for control of insect virus vectors) and there is a reduced risk of adverse environmental events. • Sweetpotatoes produced sustainably in line with consumer expectations. • Australian industry, extension and research capacity has been further developed.
Impacts	• Economic – avoided yield loss with maintenance of virus control through the PT Scheme and longer term through the safe importation of superior genetic material. • Economic – production cost savings due to lower cost planting material and reduced input requirements (chemicals for control of insect virus vectors). • Environmental - reduced adverse environmental risks from the use of insect vector control chemicals. • Capacity – industry, extension and research skills developed, especially in relation to planting bed management and virus diagnostics. • Social - increased income in regional Australia associated with a more profitable and sustainable sweetpotato industry (spill-over benefit).

Project Investment

Nominal Investment

Table 2 shows the annual investment (cash and in-kind) in project VG13004 by Hort Innovation and others. 'Other' investors were the Department of Agriculture and Fisheries (DAF) QLD and the ASPG Inc.

Table 2: Annual Investment in the Project VG13004 (nominal $)

Year ended 30 June	Hort Innovation ($)	Other ($)	Total ($)
2014	80,639	100,188	180,827
2015	210,022	248,710	458,732
2016	264,485	251,013	515,498
2017	247,265	266,392	513,657
2018	321,269	180,035	501,304
Totals	1,123,680	1,046,338	2,170,018

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 2.

For the DAF and ASPG Inc. investment (other), it was assumed that program management and administration costs were already included in the nominal amounts 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. 'Extension' costs were included in budget totals – the project was completed in partnership with ASPG Inc.

Impacts

Table 3 provides a summary of the principal types of impacts delivered by the project. Impacts have been categorised into economic, environmental and social impacts.

Table 3: Triple Bottom Line Categories of Principal Impacts from Project VG13004

Economic	• Avoided yield loss with maintenance of virus control through the PT Scheme and longer term through the safe importation of superior genetic material. • Production cost savings as a result of lower cost planting material (i.e. material is more reliably and cost effectively produced in improved planting beds) and reduced input requirements (i.e. fewer chemicals required for the control of virus vectors such as aphids and whitefly).
Environmental	• With improved Sweetpotato virus control, fewer chemicals will be needed for the control of insect virus vectors. This reduced usage means fewer chemicals on farm and a reduced potential for chemicals in the district environment, with potential positive impacts on biodiversity and water quality.
Social	• Increased industry, extension and research capacity in Australia, especially in relation to planting bed management and virus diagnostics. • Increased regional income in Australia as a result of stronger, more profitable sweetpotato growing communities (spill-over impact).

Public versus Private Impacts

The majority of impacts identified in this evaluation are sweetpotato industry related and therefore are considered private benefits. Public benefits have also been delivered including two types of social benefit. Social benefits delivered by the research included increased capacity (research, extension and industry) as well as additional regional incomes resulting from the increased profitability of sweetpotato production.

Distribution of Private Impacts

The impacts on the sweetpotato industry from investment in this project will be shared along the supply chain with growers, packers, transporters, wholesalers and retailers all sharing impacts produced by the project. The share of benefits captured by each link in the supply chain will depend on the interplay of both short- and long-term supply and demand elasticities for sweet potato and its closest substitutes.

Impacts on Other Australian Industries

Impacts on industries other than the sweetpotato industry and its associated sectors may include potential gains in other industries via any future spill-overs from the increases in research and extension capacity.

Impacts Overseas

Sweetpotatoes are an important crop in developed and developing countries worldwide. Additional virus and planting bed management knowledge will be relevant to the worldwide industry. For example, PNG makes use of a PT Scheme based on the Australian model. The Solomon Islands is working toward the uptake of a PT Scheme.

Match with National and Industry Priorities

The Australian Government's Science and Research Priorities and Rural RD&E priorities are reproduced in Table 4. The project findings and related impacts will contribute primarily to Rural RD&E Priorities 1, 2 and 4, and to Science and Research Priority 1.

Table 4: 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 Sweetpotato Strategic Investment Plan 2017-2021

The strategic outcomes and strategies for the sweetpotato industry are outlined in the Vegetable Strategic Investment Plan 2017-2021[1] (Hort Innovation, 2016). Project VG13004 addressed Outcome 2, Strategy 2.4.

Valuation of Impacts

Impacts Valued

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions, particularly when some uncertainty was involved. Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria.

Two key impacts of the project were valued. One was the avoided loss of sweetpotato yield due to failure of the PT Scheme. The other was production cost savings due to lower cost planting material. These two impacts were deemed to be the principal impacts of the project.

Impacts Not Valued

Not all of the impacts identified in Table 3 could be valued in the assessment. The environmental and social impacts were hard to value due to lack of evidence/data, difficulty in quantifying the causal relationship and pathway between VG13004 and the impact and the complexity of assigning monetary values to the impact. Also, potential economic impacts including less risk of importing genetic material with viruses and cost savings associated with reduced chemical requirements were not valued due to insufficient data and uncertainty regarding the pathways to impact.

The economic impacts identified but not valued were:

- Reduced risk of importing genetic material with viruses.
- Cost savings with reduced inputs (chemicals for control of insect vectors).

The environmental impact identified but not valued was:

- Reduced adverse environmental risks from the use of insect vector control chemicals.

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

The social impacts identified but not valued were:

- Industry, extension and research capacity developed, especially in relation to planting bed management and virus diagnostics.
- Increased regional income as a result of stronger, more profitable sweetpotato growing communities (spill-over impact).

Valuation of Impact 1: Avoided Yield Loss with PT Scheme Failure

The VG13004 investment produced new knowledge on sweetpotato viruses and effective virus diagnostics. This information was incorporated into the PT Scheme. As a result, the PT Scheme is more effective and there is less chance of growers receiving virus infected planting material. All Australian sweetpotato growers source their planting material through the PT Scheme. With an improved PT Scheme in place, average industry sweetpotato yield (111.2t/ha) will remain unaffected by virus. Prior to the PT Scheme introduction in the 1990s sweetpotato yield was a modest 28.8t/ha.

Attribution

VG13004 builds on a suite of DAF, Hort Innovation and ACIAR projects that have contributed to an increase in average sweetpotato yield (see Agtrans Research, 2017). For this reason, a small attribution factor has been applied to the share of potential yield loss attributed to VG13004.

Counterfactual

In the absence of VG13004, breakdown of the supply of virus free planting material from the PT Scheme would have occurred in the short to medium term and the need for an alternative virus and virus diagnostic project would have become apparent. Three years after the commencement of VG13004 an alternative project addressing sweetpotato viruses and effective virus diagnostics would have been funded.

Valuation of Impact 2: Lower cost planting material

Planting bed efficiencies identified in VG13004 have been shown to reduce the cost of planting material sold to sweetpotato growers by 20% and that sweetpotato runners grown using the more efficient system will be available from 2019/20 (VG13004 final report).

Attribution

No other projects have contributed to the 20% gain in sweetpotato planting bed efficiencies identified in VG13004.

Counterfactual

DAF is the only researcher working on the efficiency of sweetpotato planting beds. In the absence of the project, it is unlikely that another research organisation would have sought a project in this area.

Summary of Assumptions

A summary of the key assumptions made for valuation of the impacts is shown in Table 5.

Table 5: Summary of Assumptions

Variable	Assumption	Source/Comment
Impact 1: Avoided Yield Loss with PT Scheme Failure		
WITH Investment in Project VG13004		
Average sweetpotato yield with effective PT Scheme.	111.2t/ha	6,175 cartons/ha (2,500 cartons/acre) with 18kg of sweetpotato in each carton. (Michael Hughes, Farming Systems Officer, DAF, pers. comm.). Estimate revised to current level after Agtrans Research (2017) was extensively reviewed within DAF.
Average sweetpotato yield prior to the PT Scheme.	28.8t/ha	Average sweetpotato yield was 28.8t/ha prior to introduction of PT testing in the 1990s (Michael Hughes, Farming Systems Officer, DAF, pers. comm.).
Upper limit loss in sweetpotato yield with failure of the PT Scheme.	82.4t/ha	111.2t/ha less 28.8t/ha.
Attribution of impacts to VG13004.	10%	Consultant estimate after considering other projects which have contributed to Australian sweetpotato yield gain since the 1990s e.g. investments in improved agronomy.
Value of lost yield.	$400/t	Derived from DAF sweetpotato gross margin updated 2018 (DAF, 2018) and based on a farm price of $756/t adjusted to $400/t after considering additional harvesting, packing and transport costs.
Area of sweetpotato grown in Australia.	900 ha	Sweetpotato production of approximately 100,000 tonnes with an average industry yield of 111.2t/ha.
Year of first impact.	2018/19	One year after Project VG13004 completion.
WITHOUT Investment in Project VG13004		
Investment in alternative project to maintain the integrity of the PT Scheme.	2016/17	Three years after commencement of VG13004 and when breakdown of PT Scheme starts to become apparent.
Year of first impact of alternative project.	2020/21	Four years after commencement of alternative project to maintain integrity of the PT Scheme (same duration as VG13004).
Level of impact.	See 'with investment' assumptions above	
Impact 2: lower cost planting material		
Cost of sweetpotato planting material	$448/ha	Sourced from DAF sweetpotato gross margin updated 2018 (DAF, 2018)
Planting material cost saving with new planting bed management systems in place	20%	VG13004 final report
Year of first impact.	2019/20	VG13004 final report.

Results

All costs and benefits were discounted to 2018/19 using a 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 (2017/18) 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. The present value of benefits (PVB) attributable to Hort Innovation investment only, shown in Table 7, has been estimated by multiplying the total PVB by the Hort Innovation proportion of real investment (55.4%).

Table 6: Investment Criteria for Total Investment in Project VG13004

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0	8.77	9.06	9.28	9.46	9.59	9.70
Present Value of Costs ($m)	2.77	2.77	2.77	2.77	2.77	2.77	2.77
Net Present Value ($m)	-2.77	6.00	6.28	6.51	6.68	6.82	6.60
Benefit-Cost Ratio	0	3.16	3.27	3.35	3.41	3.46	3.50
Internal Rate of Return (%)	negative	57.5	57.7	57.7	57.7	57.7	57.7
MIRR (%)	negative	26.0	16.3	12.8	11.0	9.9	9.1

Table 7: Investment Criteria for Hort Innovation Investment in Project VG13004

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0	4.86	5.02	5.19	5.24	5.32	5.38
Present Value of Costs ($m)	1.53	1.53	1.53	1.53	1.53	1.53	1.53
Net Present Value ($m)	-1.53	3.33	3.49	3.62	3.71	3.79	3.85
Benefit-Cost Ratio	0	3.18	3.29	3.37	3.43	3.48	3.52
Internal Rate of Return (%)	Negative	59.1	59.3	59.3	59.3	59.3	59.3
MIRR (%)	Negative	26.2	16.4	12.9	11.1	9.9	9.2

The annual undiscounted benefit and cost cash flows for the total investment for the duration of VG13004 investment plus 30 years from the last year of investment are shown in Figure 1.

Figure 1: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs

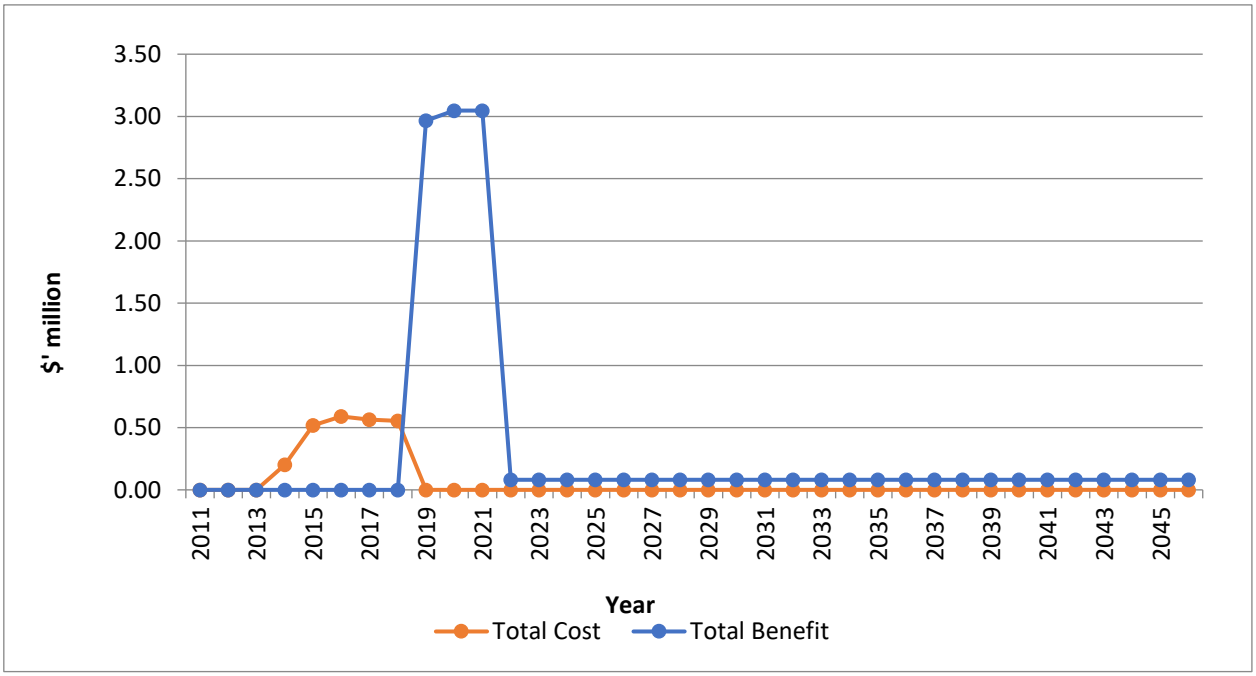

Table 8 shows the contribution of each impact to the total PVB.

Table 8: Contribution of Benefits

Impact	PVB ($M)	% of Total PBV
Impact 1: Avoided yield loss with PT Scheme failure	8.48	87.4%
Impact 2: Lower cost planting material	1.22	12.6%
Total	9.70	100.0%

Sensitivity Analyses

A sensitivity analysis was carried out on the discount rate. The analysis was performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values. Table 9 present the results. The results show a moderate sensitivity to the discount rate.

Table 9: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5%	10%
Present Value of Benefits ($m)	11.24	9.70	8.87
Present Value of Costs ($m)	2.43	2.77	3.16
Net Present Value ($m)	8.81	6.60	5.71
Benefit-cost ratio	4.63	3.50	2.81

A sensitivity analysis was then undertaken for the assumed loss in industry average yield. Even with a more modest assumed yield loss of 20.6t/ha the project produces a positive return on investment – Table 10.

Table 10: Sensitivity to Loss of Sweetpotato Yield with PT Scheme Failure
(Total investment, 30 years)

Investment Criteria	Yield Loss with PT Scheme Failure		
	20.6t/ha	41.2t/ha	82.4t/ha
Present Value of Benefits ($m)	3.34	5.46	9.70
Present Value of Costs ($m)	2.77	2.77	2.77
Net Present Value ($m)	0.57	2.69	6.60
Benefit-cost ratio	1.21	1.97	3.50

A final sensitivity test examined the attribution of benefits from investment in VG13004 to prevention of PT Scheme failure. At a 5% assumed attribution investment criteria continue to show a favourable result – Table 11.

Table 11: Sensitivity to Attribution of Benefits from VG13004 to PT Scheme Failure
(Total investment, 30 years)

Investment Criteria	Attribution of Benefits to VG13004		
	5%	10%	20%
Present Value of Benefits ($m)	5.46	9.70	18.19
Present Value of Costs ($m)	2.77	2.77	2.77
Net Present Value ($m)	2.69	6.60	15.41
Benefit-cost ratio	1.97	3.50	6.56

Confidence Rating

The results produced are highly dependent on the assumptions made, some of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 12). The rating categories used are High, Medium and Low, where:

- High: denotes a good coverage of benefits or reasonable confidence in the assumptions made
- Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
- Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 12: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
Medium-high	High

Coverage of benefits was assessed as medium-high. The two most important benefits (avoided yield loss with PT Scheme failure and lower cost planting material) were quantified, other economic benefits – reduced risk of importing genetic material with viruses and cost savings with reduced inputs (chemicals for control of insect vectors), were not valued. Consequently, the investment criteria as provided by the valued benefits are likely to be underestimated to some degree.

Confidence in assumptions was rated as high. The approach used was similar to an independent impact assessment completed for DAF for investment in eleven sweetpotato projects in 2017 (Agtrans Research, 2017).

Conclusion

The investment in VG13004 is likely to contribute to retention of high average yields and lower production costs in the Australian sweetpotato industry. Retention of high average yields will result from sustained virus control, and in the longer term, safe importation of superior genetic material. Lower production costs will be linked to lower cost planting material and fewer purchased inputs for the control of insect virus vectors. There will be a reduced risk of adverse environmental outcomes associated with chemical use and the industry will benefit from additional grower, extension and research capacity. Additional capacity has been developed in planting bed management and virus diagnostics.

Total funding from all sources for the project was $2.77 million (present value terms) with Hort Innovation investment in the project totalling $1.53 million. The investment produced estimated total expected benefits of $9.70 million (present value terms). This gave a net present value of $6.93 million, an estimated benefit-cost ratio of 3.5 to 1, an internal rate of return of 57% and a modified internal rate of return of 9%.

While several economic, environmental and social impacts identified were not valued, the impacts were considered indirect, uncertain and/or minor compared with the impacts valued. Nevertheless, combined with conservative assumptions for the impacts valued, investment criteria as provided by the valuation may be underestimates of the actual performance of the investment.

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

ACIAR	Australian Centre for International Agricultural Research
ASPG	Australian Sweetpotato Growers Inc.
CRRDC	Council of Research and Development Corporations
DAF	Department of Agriculture and Fisheries, Queensland
DAWR	Department of Agriculture and Water Resources (Australian Government)
ELISA	Enzyme-Linked Immuno-Sorbent Assay
GDP	Gross Domestic Product
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
NSW	New South Wales
OCS	Office of Chief Scientist Queensland
PCR	Polymerase Chain Reaction
PNG	Papua New Guinea
PT	Pathogen Tested
PVB	Present Value of Benefits
QLD	Queensland
RD&E	Research, Development and Extension
SIP	Strategic Investment Plan
SPFMV	Sweetpotato Feather Mottle Virus
SPLCV	Sweetpotato Leaf Curl Virus