Industry-specific impact assessment program: Banana

Impact assessment report for project *National banana bunchy top virus program – Phase 3 - QLD* (BA15006)

Impact analyst:

Talia Hardaker

Delivery partner:

AgEconPlus and Agtrans Research

Project code:

MT19012

Date:

18 December 2020

Funding statement:

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

Publishing details:

Published and distributed by: Hort Innovation

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 project BA15006 titled *"National banana bunchy top virus program – Phase 3 - QLD".* The project was funded by Hort Innovation over the period May 2016 to June 2019.

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 2019/20 dollar terms and were discounted to the year 2019/20 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

Investment in BA15006 continued surveillance and management of BBTV in southern QLD over the period 2015/16 to 2018/19 that is likely to have minimised potential losses from banana bunchy top disease in affected regions. The project also was likely to have contributed to reducing the risk of banana bunchy top virus (BBTV) spreading to non-affected areas and thus to the continued exclusion of BBTV from the majority of Australian commercial banana plantations and avoided BBTV production losses.

Investment Criteria

Total funding from all sources for the project was $0.66 million (present value terms). The investment produced estimated total expected benefits of $2.22 million (present value terms). This produced an estimated net present value of $1.57 million, a benefit-cost ratio of 3.38 to 1, an internal rate of return (IRR) of 15.62% and a modified IRR of 9.78% over 30-years at a discount rate of 5% and 5% reinvestment rate.

Conclusions

Two environmental and social impacts also were identified but not valued as part of the current assessment. Thus, given the impacts not valued, combined with conservative assumptions made for the principal economic impact valued, it is reasonable to conclude that the investment criteria reported may be an underestimate of the actual performance of the BA15006 investment.

Keywords

Impact assessment, cost-benefit analysis, BA15006, banana, banana bunchy top virus, BBTV

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 almond (AL), banana (BA), citrus (CT) and onion (VN) research, development and extension (RD&E) investment funds.

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

- Nine AL projects were chosen worth $5.84 million (nominal Hort Innovation investment) from an overall population of 21 projects worth an estimated $10.78 million,
- Eight BA projects worth $3.02 million (nominal Hort Innovation investment) from an overall population of 24 projects worth approximately $16.72 million,
- Eight CT projects worth $5.40 million (nominal Hort Innovation investment) from a total population of 35 projects worth $15.78 million, and
- Four VN projects worth $2.40 million (nominal Hort Innovation investment) from an overall population of 8 projects worth $3.89 million.

The project population for each industry included projects where a final deliverable had been submitted in the five-year period from 1 July 2014 to 30 June 2019. 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. Four projects had been randomly selected as part of a related Hort Innovation project (MT18011) and were included in the samples for the AL industry (AL14006 and AL16004) and the CT industry (CT15006 and CT15013). This left 25 unique projects randomly selected for evaluation under MT19012.

Project BA15006*: National banana bunchy top virus program – Phase 3 – QLD* was randomly selected as one of the 25 unique MT19012 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 (RDCs), Cooperative Research Centres (CRCs), 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 actual and/or potential 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 used cost-benefit analysis as its principal tool. The decision not to value certain impacts was due either to a shortage of necessary evidence/data, a high degree of uncertainty surrounding the potential impact, or the likely low relative significance of the impact compared to those that were valued. 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.

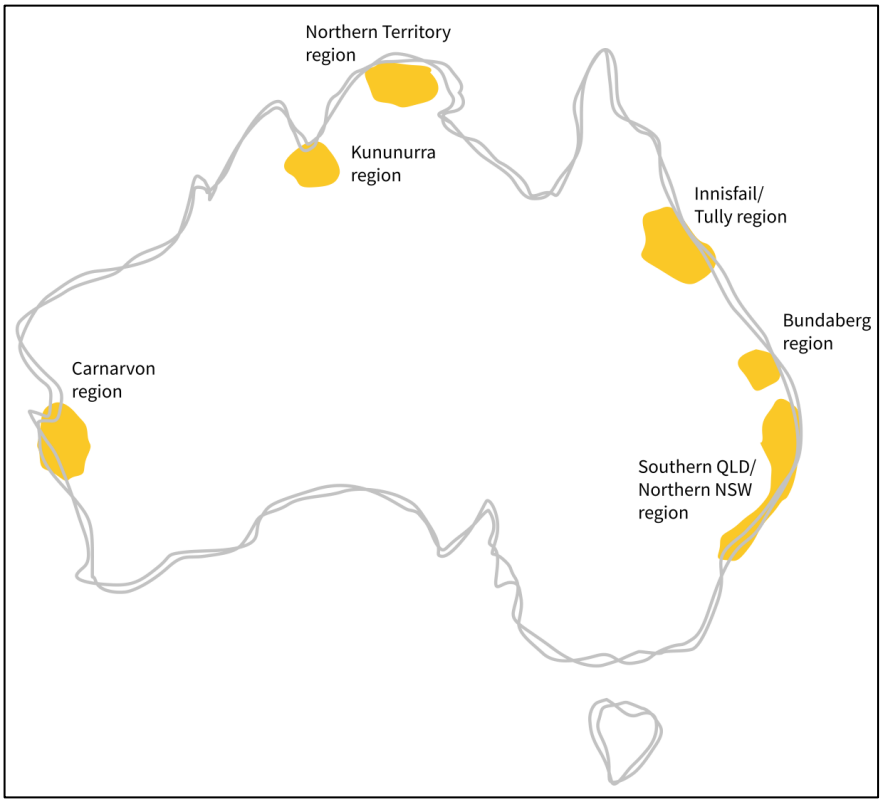
Background & Rationale

Background

The Australian Banana Industry

Bananas have been grown in Australia since the 1880s. Today, bananas are grown in subtropical and tropical regions including in Queensland (Qld), northern New South Wales (NSW), the Northern Territory (NT) and Western Australia (WA) (Hort Innovation, 2020). On average, Qld accounts for approximately 90% of the total area of bananas grown and over 95% of total Australian production (10-year average[1]). Figure 1 shows Australia's banana growing regions and Table 1 provides a summary of the data for production of bananas for both Australia and Qld.

Figure 1: Australia's Banana Growing Regions



Source: https://australianbananas.com.au/Pages/all-about-bananas/the-banana-story

[1] Based on area data from the Australian Bureau of Statistics (ABS), series 7121.0 *Agricultural Commodities, Australia* 2009/10 to 2018/19 and production data from the Australian Banana Growers' Council (ABGC)

Table 1: Production Statistics for the Australian and Qld Banana Industry (year ended 30 June 2010 to 2019)

Australia											
Year ended 30 June	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**10yr Avg.**
Total area (ha)	12,497	13,296	15,484	15,348	12,879	11,788	16,612	14,021	12,477	11,902	13,630
Area (bearing age) (ha)	11,543	11,196	13,496	14,218	12,085	10,936	15,610	13,274	11,551	10,962	12,487
Production[(a)] (t)	309,505	330,980	202,423	339,922	370,176	370,989	395,878	413,660	388,265	371,915	349,371
Yield (t/ha)	26.8	29.6	15.0	23.9	30.6	33.9	25.4	31.2	33.6	33.9	28.0
Gross value ($m)	488.1	316.0	466.8	490.7	341.3	455.0	409.0	538.5	487.6	490.9	448.4
QLD											
Year ended 30 June	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**10yr Avg.**
Total area (ha)	10,869	11,480	13,576	13,886	11,356	10,101	15,794	13,182	11,502	10,829	12,258
Area (bearing age) (ha)	10,083	9,727	11,810	12,986	10,726	9,446	14,933	12,597	10,693	10,030	11,303
Production[(b)] (t)	270,358	287,553	177,135	310,468	328,548	320,442	378,709	392,562	359,425	340,294	316,549
Yield (t/ha)	26.8	29.6	15.0	23.9	30.6	33.9	25.4	31.2	33.6	33.9	28.0
Gross value ($m)	448.3	283.1	415.4	456.5	322.8	440.8	401.2	525.8	472.0	468.3	423.4

Source: ABS Series 7121.0 *Agricultural Commodities, Australia* (2009/10 to 2018/19) and ABS Series 7503.0 *Value of Agricultural Commodities Produced, Australia* (2009/10 to 2018/19)

(a) Production data from the ABGC based on compulsory levies.

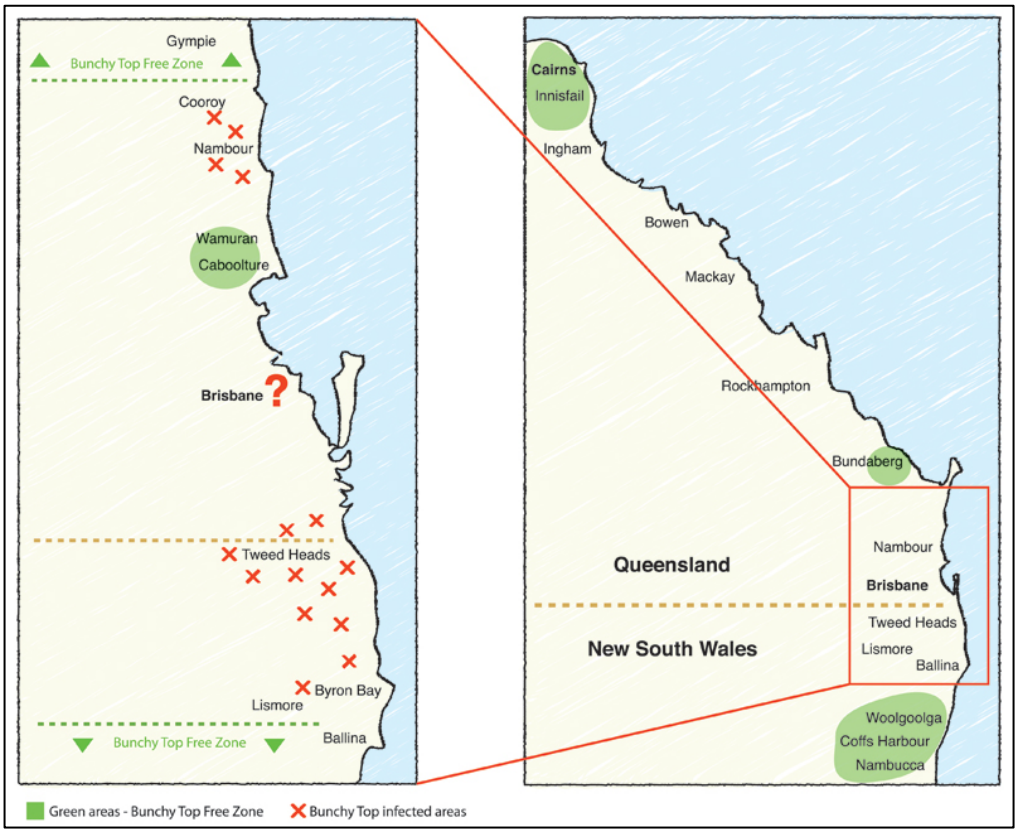
(b) Derived from ABS area (bearing age plants) and the Australian average yield for each year.

Banana Bunchy Top Virus

Bunchy top disease, caused by banana bunchy top virus (BBTV), is one of the most devastating viral diseases of bananas worldwide. The disease is characterised by the 'bunched' appearance of newly emerging leaves and dot-dash flecking of banana plant leaves and petioles (Plant Health Australia, n.d.). BBTV is widespread and exists in Asia, Africa and Oceania. The virus is known to be spread by the banana aphid, *Pentalonia nigronervosa,* and through infected planting material. Plants that are infected when young rarely produce a fruit bunch. When diseased suckers are planted they become severly stunted and do not produce fruit. Plants infected at a later growth stage may produce a distorted bunch (Jackson, 2017).

In Australia, BBTV was first found in the Tweed River area near the border of New South Wales (NSW) and Queensland (QLD) in 1913. Currently, the disease remains restricted to a small area of south-east QLD and northern NSW (Queensland Government, 2019). Figure 2 shows the current distribution of banana bunchy top in Australia. Banana bunchy top inspections are carried out both within the BBTV zone and in commercial plantations in Bundaberg and south of the BBTV zone. A geographic boundary of Cooloola National Park separates Noosa and Gympie, and is an impedance to the aphid-borne northward spread of BBTV (Kathy Crew, pers. comm., 2020).

Figure 2: Distribution of Banana Bunchy Top in Australia



Source: https://www.promusa.org/blogpost263-Australia-s-Hundred-Years-War-on-bunchy-top

The severity of banana bunchy top was illustrated in Australia in the 1920s when approximately 90 per cent of the QLD and NSW banana crops were destroyed. This devastation of the industry prompted State government initiatives to contain BBTV through eradication of infected plants and controls on the movement of planting material from affected areas, which led to a gradual recovery of the banana industry (Cook, et al., 2012).

Rationale

The Banana bunchy top virus now is a regulated pest in Australia and containment strategies are in place in both QLD and NSW to prevent the disease from spreading. Cook et al. (2012) estimated that excluding BBTV from commercial banana plantations in Australia would avoid annual losses of between $15.9 and $27.0 million for the banana industry.

From 2009/10 Hort Innovation commenced the first phase (Phase 1) of a ten year program known as the National Banana Bunchy Top Virus Management Project (Project BA08020). The investment represented

a new, science-based strategy (including new surveillance, data recording and extra financial resources) aimed at containing and potentially eradicating BBTV from Australia. Phase 1 ran from 2009/10 to 2011/12 and Phase 2 from 2012/13 to 2014/15 (Project BA12006).

Project BA15006: *National banana bunchy top virus program – QLD – Phase 3* was funded to continue the work of the BBTV management project in QLD from 2015/16 to 2018/19 (a sister project, BA15007, was funded for BBTV in NSW for the same period).

Project Details

Summary

Project Code: BA15006

Title: *National banana bunchy top virus program – QLD – Phase 3*

Research Organisation: Lagom Agriculture Pty Ltd

Principal Investigator: Barry Sullivan

Period of Funding: May 2016 to June 2019

Objectives

The overall goal of the national banana bunchy top virus program (NBBTVP) has been to achieve staged eradication of the virus in zones so that limited resources can be concentrated for maximum effect. The specific control objectives of BA15006 were to:

1. Protect areas outside of the BBTV zone that are currently free – especially the Bundaberg production area. This will be achieved through:
   (a) Exclusion activities to prevent entry of BBTV, and
   (b) Support for early detection and rapid and effective response.
2. Minimise the impact of the disease in the bunchy top zone in northern NSW and southern QLD. This will be achieved as follows:
   (a) Maintain freedom in subzones currently free of BBTV (Wamuran Growing Zone, WGZ),
   (b) Local eradication in subzones where it is feasible – beginning with Border Growing Zone (BGZ), then transitioning to Sunshine Coast Growing Zone (SCGZ),
   (c) Suppression and containment in subzones where eradication is not currently feasible, and
   (d) Focus on commercial eradication on farms and in buffer zones around them, with lower priority given to urban/peri-urban areas.

Logical Framework

Table 2 briefly describes the activities, outputs, outcomes, and actual and potential impacts of project BA15006 in a logical framework.

Table 2: Logical Framework for Project BA15006

Activities	• The project commenced in May 2016 following a project restructure from the previous, original BBTV Phase 3 project BA14011. • Part of the restructure separated one national project into two state projects (BA15006 – QLD and BA15007 - NSW). • Barry Sullivan was appointed as the project manager for BA15006 and a casual inspector also was appointed (a third inspector also assisted the project when necessary). • The known BBTV zone in south-east QLD includes an area from the QLD border north to Tinbeerwah (near Cooroy). In this area there were 35 banana farms across 19 different locations. • All 35 farms were regularly inspected by the project team. Additional farms as far north as Bundaberg also were inspected.

	• A total of approximately 62 farms covering approximately 450 ha were inspected during the Phase 3 project. • Commercial farms are placed into various categories determined by their known BBTV status: (i) Category A farms – No BBTV recorded (ii) Category B farms – No BBTV recorded for 2 years or more (iii) Category C farms – No more than one BBTV recorded in the past 12 months (iv) Category D farms – More than 1 but less than 10 BBTV cases recorded in the past 12 months (v) Category E farms – More than 10 BBTV cases recorded in the past 12 months • These categories determined the frequency of inspections that occurred. • Category D and E farms were inspected monthly. • Category C farms aimed to be inspected at 3-monthly intervals, but often were inspected more frequently. • Category A and B farms were inspected usually only once per annum, but sometimes more frequently as needed/permitted. • Overall, due to the limited project funds available, the category D and E farms received the most attention. • Inspections were carried out by the project inspectors (usually 1 or 2 people) who walked the rows within the banana plantations, inspecting all plants to detect bunchy top infections. • When BBTV was detected, the plants were marked with pink tape and their position was recorded by GPS (Global Positioning System). • The affected plants then were treated using both a herbicide and an insecticide directly injected into the stem of the plant. • The infected plants were also oversprayed with a paraffin oil to contain the infectious aphids (possibly winged) that may have been present. • If one stem in a clump of banana plants displayed symptoms, the whole clump was deemed to be infected and was destroyed. • The plants usually died within 3 to 4 weeks and were then no longer infectious (the virus does not survive in the soil). • All inspection work was based on best practice techniques based on available current scientific information. • All chemicals used to carry out the destruction of infected plants were listed on an APVMA[2] minor use permit and were based on scientific efficacy testing. • In some cases, growers requested that samples be confirmed by laboratory diagnosis. • These samples were tested at the EcoScience Precinct in Brisbane. • Scientists carried out a visual inspection of the samples followed by a molecular test (if required). • The documented findings were then passed back to the growers. • No samples identified as infected by the inspectors were disputed by the laboratory. • Backyard inspections, based on buffer zones around existing commercial banana farms, were carried out from time to time as time permitted. • Such inspections were targeted at 1 to 2 km buffer zones adjacent to commercial banana farms plus the occasional ad hoc notification inspections and targeted known potential BBTV infected areas through local knowledge • Extensive backyard inspections occurred within the northern area of the BBTV zone and initial infections found were destroyed, and subsequent follow-up inspections occurred throughout the life of the project. • Some extension activities also were carried out during the project including presentations to garden clubs.

[2] Australian Pesticides and Veterinary Medicines Authority: https://apvma.gov.au/

	• Articles relating to the project were included in the ABGC Banana Magazine and a bunchy top information brochure was developed and used for communication purposes for the duration of the project.
Outputs	• In total, the project team conducted 314 farm inspections and 773 backyard inspections during the project. • 478 farm infections and 228 backyard infections were detected over the course of the inspections. • During the previous Phase 2 project the BBTV incidence was present on 10 farms. Only one new farm presented with BBTV during the Phase 3 project, bringing the total to 11. • BBTV data were continuously added to a commercial banana farms database. Data included the number of plants and leaves displaying symptoms and their location. • A number of extension and communication materials were produced to help improve awareness of BBTV and limit the spread of the virus.
Outcomes	• Project BA15006 (and sister project BA15007) represented the end of the initial 10 year BBTV management investment. A new Phase 4 project has been funded (BA18000[3]) to continue to protect uninfested areas, limit and remove infestations from farms (and protect them from reinfestation) and to reduce the range of the disease. • Despite a number of impediments that occurred during the life of the project and some budget cuts, the project successfully contributed to continued containment of BBTV in south-east QLD, protecting BBTV-free banana areas particularly in eastern Australia (Barry Sullivan, pers. comm., 2020). • The project also has increased awareness of BBTV in QLD both within the banana industry and the broader community and has increased the confidence of banana growers in the BBTV management program. • Also, the continuous maintenance of the commercial farms database and the constant updating of the BBTV detection data provided a valuable epidemiological resource. • Sharing of these data with researchers from the University of Cambridge, the Department of Agriculture and Fisheries QLD and the University of Queensland has enabled the development of epidemiological models that have already been used to assess the efficacy of current and proposed control strategies. • The models also have the potential to devise pre-emptive containment and control strategies for potential incursion into currently BBTV-free regions such as north QLD.
Impacts	• Maintained or increased productivity/ profitability for Australian banana producers through avoided potential production losses for some banana growers through the project's contribution to continued exclusion of BBTV from commercial banana farms in northern QLD and central-southern NSW, the NT and WA through ongoing surveillance and containment. • Containment of BBTV on infested farms and private backyards thus minimising spread and associated production losses in QLD BBTV zones. • Potentially, some contribution to negative environmental outcomes through increased use of agricultural chemicals used to destroy infected banana plants and hence BBTV • Potentially, some contribution to maintained or enhanced regional community wellbeing through spillover benefits from maintained/increased commercial banana producer incomes.

[3] For further information see: https://www.horticulture.com.au/growers/help-your-business-grow/research-reports-publications-fact-sheets-and-more/ba18000/

Project Investment

Nominal Investment

Table 3 shows the annual investment (cash and in-kind) in project BA15006 by Hort Innovation. Hort Innovation provided 100% of the project funding.

Table 3: Annual Investment in the Project BA15006 (nominal $)

Year ended 30 June	Hort Innovation ($)	Other ($)	Total ($)
2016	58,570	0	58,570
2017	146,718	0	146,718
2018	135,964	0	135,964
2019	138,683	0	138,683
Totals	479,935	0	479,935

Source: derived from BA15006 Project Agreement and Variation documents supplied by Hort Innovation 2020

Program Management Costs

For the Hort Innovation investment the cost of managing and administrating 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 were expressed in 2019/20 dollar terms using the Gross Domestic Product deflator index (ABS, 2020). No additional costs associated with project extension were incorporated as the project included a high level of industry interaction and included a number of extension and communication activities.

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 BA15006

Economic	• Maintained or increased productivity/ profitability for Australian banana producers through avoided potential production losses for some banana growers through the project's contribution to continued exclusion of BBTV from commercial banana farms in northern QLD and central-southern NSW, the NT and WA through ongoing surveillance and containment. • Containment of BBTV on infested farms and private backyards thus minimising spread and associated production losses in QLD BBTV zones.
Environmental	• Potentially, some contribution to negative environmental outcomes through increased use of agricultural chemicals used to destroy infected banana plants and hence BBTV.
Social	• Potentially, some contribution to maintained or enhanced regional community wellbeing through spillover benefits from maintained/increased commercial banana producer incomes.

Public versus Private Impacts

The impacts identified in this evaluation are private in nature. Private benefits are likely to be realised by banana producers in BBTV-free areas (northern QLD, central/southern NSW, NT and WA) and by growers who have reduced/minimised their incidence of BBTV in BBTV zones.

Some minor public benefits may occur and include maintained or enhanced regional community wellbeing.

Distribution of Private Impacts

The impacts on the Australian banana industry from investment in project BA15006 will primarily be captured by banana growers in QLD and NSW, and to some extent, the NT and WA. However, medium- to long-term benefits are likely to be shared along banana supply chains (including Australian banana consumers) according to relevant short- and long-term supply and demand elasticities.

Impacts on Other Australian Industries

No direct or significant impacts to other Australian industries were identified.

Impacts Overseas

No direct impacts to overseas parties were identified. However, control strategies identified and/or improved upon in Australia may be shared through international industry and researcher networks and may create positive impacts for overseas banana industries managing BBTV.

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 2, and to some extent Priority 4, 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 6. Resources 7. Advanced Manufacturing 8. Environmental Change 9. Health

Sources: (Commonwealth of Australia, 2015) and (Australian Government, 2015)

Alignment with the Banana Strategic Investment Plan 2017-2021

The strategic outcomes and strategies of the banana industry are outlined the Banana Strategic Investment Plan 2017-2021[4] (2017). Project BA15006 primarily addressed Outcome 2 through Strategy 2.1 (Continue to drive adoption of best management practice for on-farm biosecurity to ensure biosecurity risks are minimised) and, in part, to Outcome 1 through Strategy 1.3 (Continue research to improve pest and disease management and biosecurity).

[4] 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

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.

The one primary economic impact was valued. This impact was associated with maintained or increased productivity/ profitability for Australian banana producers driven by:

(a) Avoided potential production losses for some banana growers through the project's contribution to continued exclusion of BBTV from commercial banana farms in northern QLD and central-southern NSW, the NT and WA (that is, a reduced risk of the spread of BBTV).
(b) Containment of BBTV on infested farms thus minimising spread and associated production losses in BBTV zones.

Impacts Not Valued

Not all of the impacts identified in Table 4 could be valued in the assessment. In particular, environmental and social impacts were hard to value due to a lack of evidence/data on which to base credible assumptions, difficulty in quantifying the causal relationship and the pathway between BA15006 and the impact and/or the complexity of assigning magnitudes and monetary values to the impact.

The environmental impact identified but not valued was:

- Potentially, some contribution to negative environmental outcomes through increased use of agricultural chemicals used to destroy BBTV infected plants.

The social impacts identified but not valued was:

- Potentially, some contribution to maintained or enhanced regional community wellbeing through spillover benefits from maintained/increased commercial banana producer incomes.

Valuation of Impact 1: Increased productivity/profitability for Australian banana producers through avoided production losses associated with BBTV

Investment in BA15006 has contributed to continued surveillance and management of BBTV in southern QLD and that is likely to have minimised potential losses from banana bunchy top disease in affected regions. Further, the project has contributed to reducing the risk of BBTV spreading to non-affected areas and thus to the continued exclusion of BBTV from the majority of Australian commercial banana plantations.

A stratified diffusion spread model was used by Cook et al. (2012) to simulate the potential benefits of exclusion of BBTV from commercial banana plantations over time relative to a nil/zero management situation where no surveillance or containment activities took place. The study estimated that excluding BBTV from commercial banana plantations in Australia would avoid annual losses of between $15.9 and $27.0 million for the banana industry.

Specific assumptions for the valuation of Impact 1 are described in Table 6.

Attribution

A number of investments both past and current contribute to ongoing management and containment of BBTV in Australia and ongoing RD&E investment continues to deliver outputs intended to improve control of BBTV and minimise or eradicate banana bunchy top disease. For example, other NBBTVP investments such as project BA08020, projects BA12006, BA15007 (the BA15006 sister project in NSW) and BA17001.

Project BA15006 contributed directly to surveillance and containment of BBTV in southern QLD. To acknowledge the contributions of BBTV RD&E investment that also contribute to the impact valued, an attribution factor of 20% was applied to the estimated benefits.

Counterfactual

In recent years, co-funding for the NBBTVP has declined and projects now are increasingly funded by the broader industry in far north QLD and matched by Hort Innovation in an effort to protect them (Barry Sullivan, pers. comm., 2020). As a significant and known industry issue, it was assumed that, in the absence of investment in BA15006, some investment associated with management of BBTV would have taken place (e.g. through state department and industry RD&E investments such as DAF QLD and ABGC). However, it is likely that the level of investment would have been significantly less, and the resulting RD&E would have less efficient and/or effective (particularly if focused within a particular state boundary). Thus, it was assumed that 70% of the estimated net benefits were driven specifically by the BA15006 investment.

Summary of Assumptions

A summary of the key assumptions made for valuation of the impacts is shown in Table 6.

Table 6: Summary of Assumptions

Variable	Assumption	Source/Comment
Impacts 1: Reduced risk of spread of BBTV		
WITHOUT investment		
Avoided total annual losses for the Australian banana industry through exclusion of BBTV from commercial banana plantations	$15.9 million	Cook et al. (2012)
Estimated value of annual losses avoided through exclusion of BBTV from commercial banana plantations given BBTV has not been eradicated in southern QLD and northern NSW and that there would likely be some effort/ investment by industry and/or government in BBTV control in the future should BBTV spread.	$10.0 million	Conservative analyst estimated based on a lower estimated of $15.9 million p.a. against a case of zero BBTV management in Cook et al. (2012) and that fact that over 90% of Australian banana production is in QLD
Time for a BBTV incursion to reach maximum spread and impact	15 years (i.e. avoided annual losses increase to a maximum of $8 million p.a. over 15 years)	Based on the period between the first detection of BBTV in Australia in 1913 and identification of BBTV and implementation of BBTV management strategies in 1927 (Vezina, 2013)
Risk of a further BBTV incursion and subsequent spread to other regions	15% each year	Analyst assumption
WITH investment		
Reduction in the risk of further incursion and spread of BBTV	5% (that is, the risk is reduced to 10% each year)	Analyst assumption after consultation with John Thomas (project leader)
First year of impact	2015/16	First year of surveillance and containment activities under BA15006
Last year of impact	2018/19	Based on maximum impact of the project during the BA15006 investment period 2015/16 to 2018/19 – assumes that key driver of the project's impact was the surveillance and containment

		activities of the project manager and associated inspectors
Risk Factors and Other Variables		
Probability of output	100%	Analyst assumption, based on successful completion of BA15006
Probability of outcome	80%	Analyst assumption – refers to the probability that the BBTV model will be used to improve ongoing management and containment of BBTV
Probability of impact	80%	Analyst assumption, allows for exogenous factors that may affect realisation of impact
Attribution of benefits to investment in BA15006	20%	See 'valuation of impact 1' above
Counterfactual	70%	See 'valuation of impact 1' above

Results

All costs and benefits were discounted to 2019/20 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 (2018/19) as per the CRRDC Impact Assessment Guidelines (CRRDC, 2018).

Investment Criteria

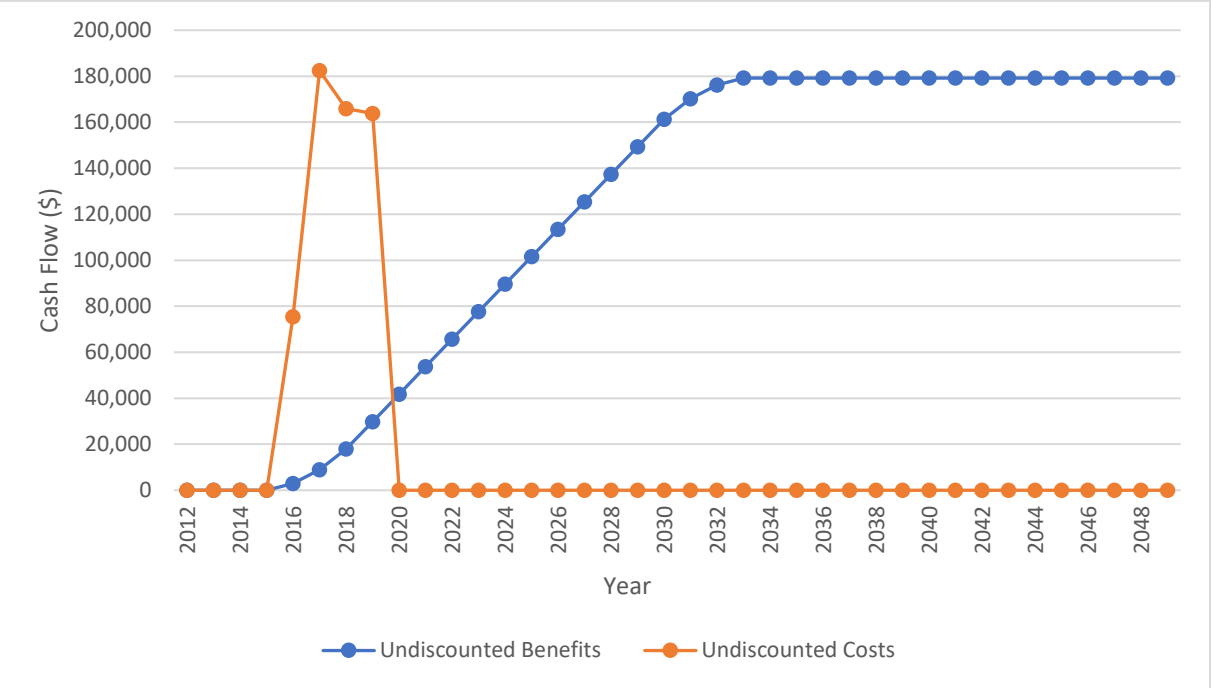
Table 7 shows the investment criteria estimated for different periods of benefit for the total investment. Hort Innovation provided 100% of project funding.

Table 7: Investment Criteria for Total Investment in Project BA15006

Investment Criteria	**Years after Last Year of Investment**						
	0	**5**	**10**	**15**	**20**	**25**	**30**
Present Value of Benefits ($m)	0.07	0.36	0.80	1.28	1.68	1.98	2.22
Present Value of Costs ($m)	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Net Present Value ($m)	-0.59	-0.30	0.14	0.63	1.02	1.32	1.57
Benefit-Cost Ratio	0.10	0.55	1.22	1.95	2.55	3.01	3.38
Internal Rate of Return (%)	negative	negative	8.09	13.11	14.74	15.36	15.62
MIRR (%)	negative	negative	7.56	10.55	10.67	10.26	9.78

The annual undiscounted benefit and cost cash flows for the total investment for the duration of BA15006 investment plus 30 years from the last year of investment are shown in Figure 3.

Figure 3: Annual Cash Flow of Undiscounted Total Benefits and Total Investment Costs



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 8 present the results. The results were moderately sensitive to the discount rate.

Table 8: Sensitivity to Discount Rate
(Total investment, 30 years)

Investment Criteria	**Discount rate**		
	0%	**5% (base)**	**10%**
Present Value of Benefits ($m)	4.57	2.22	1.29
Present Value of Costs ($m)	0.59	0.66	0.73
Net Present Value ($m)	3.98	1.57	0.56
Benefit-cost ratio	7.78	3.38	1.76

A sensitivity analysis was then undertaken for the reduction in the risk of further incursion and spread of BBTV attributable to BA15006 assumed for Impact 1. The results are presented in Table 9 and show a moderate to high sensitivity to the assumed reduction in risk. This was expected as the reduction is risk is the primary driver of the economic model. A break-even analysis indicated that, with all other assumptions held at their base values, the investment criteria remain positive (a benefit-cost ratio of 1:1) at an assumed risk reduction of 1.5%.

Table 9: Sensitivity to Assumed Reduction in Risk of Further BBTV Incursion and Spread
(Total investment, 30 years)

Investment Criteria	**Reduction in risk of BBTV incursion and spread**		
	0.5%	**5.0% (base)**	**10.0%**
Present Value of Benefits ($m)	0.22	2.22	4.45
Present Value of Costs ($m)	0.66	0.66	0.66
Net Present Value ($m)	-0.44	1.57	3.79
Benefit-cost ratio	0.34	3.38	6.76

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 10). 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 10: Confidence in Analysis of Project

Coverage of Benefits	Confidence in Assumptions
High	Medium

Coverage of benefits was assessed as High – the primary and most important economic impact was valued; however, two potential environmental and social impacts were not able to be valued within the current assessment. These impacts, however, were considered secondary potential benefits and were likely small relative to the primary impact valued.

Confidence in assumptions was rated as Medium. Data used in the analysis were drawn from published and/or credible sources such as Hort Innovation, published scientific journal articles and expert scientific opinion. However, a number of other key assumptions were necessarily analyst assumptions and were therefore somewhat uncertain.

Conclusion

Investment in BA15006 continued surveillance and management of BBTV in southern QLD over the period 20105/16 to 2018/19 that is likely to have minimised potential losses from banana bunchy top disease in affected regions. The project also was likely to have contributed to reducing the risk of BBTV spreading to non-affected areas and thus to the continued exclusion of BBTV from the majority of Australian commercial banana plantations and avoided BBTV production losses.

Total funding from all sources for the project was $0.66 million (present value terms). The investment produced estimated total expected benefits of $2.22 million (present value terms). This produced an estimated net present value of $1.57 million, a benefit-cost ratio of 3.38 to 1, an internal rate of return (IRR) of 15.62% and a modified IRR of 9.78% over 30-years at a discount rate of 5% and a 5% reinvestment rate.

Two environmental and social impacts also were identified but not valued as part of the current assessment. Thus, given the impacts not valued, combined with conservative assumptions made for the principal economic impact valued, it is reasonable to conclude that the investment criteria reported may be an underestimate of the actual performance of the BA15006 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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Acknowledgements

AgEconPlus and Agtrans Research would like to thank all the project and program personnel associated with Horticulture Innovation Australia Limited that were involved in the evaluation process. Their cooperation and feedback throughout the evaluation process contributed significantly to this report.

Specific acknowledgments:
Kathy Crew, Senior Plant Pathologist (Virology), Agri-Science Queensland, Department of Agriculture and Fisheries Queensland
John Thomas, Associate Professor and Principal Research Fellow, Centre for Horticulture Science, Queensland Alliance for Agriculture and Food Innovation
Brendan O'Keeffe, Analyst, Horticulture Innovation Australia Ltd

Abbreviations

ABGC	Australian Banana Growers' Council
ABS	Australian Bureau of Statistics
AL	Almond
APVMA	Australian Pesticides and Veterinary Medicines Authority
BA	Banana
BBTV	Banana Bunchy Top Virus
BGZ	Border Growing Zone
CRC	Cooperative Research Centre
CRRDC	Council of Rural Research and Development Corporations
CT	Citrus
GPS	Global Positioning System
Hort Innovation	Horticulture Innovation Australia Ltd
NBBTVP	National Banana Bunchy Top Virus Program
NSW	New South Wales
NT	Northern Territory
QLD	Queensland
R&D	Research and Development
RD&E	Research, Development and Extension
RDC	Research and Development Corporation
SCGZ	Sunshine Coast Growing Zone
SIP	Strategic Investment Plan
VN	Onion
WA	Western Australia
WGZ	Wamuran Growing Zone