Project AutoWeed Economic Case Studies (1-3)

Reducing herbicide usage on sugarcane farms in reef catchment areas using precise robotic weed control.

JCU

Great Barrier Reef Foundation

AUTOWEED

sra Sugar Research Australia

Queensland Government

This publication has been compiled by Edward Vaggelas & Caleb Connolly of Regional Economic Development, Department of Primary Industries

The Department of Primary Industries proudly acknowledges all First Nations peoples (Aboriginal peoples and Torres Strait Islanders) and the Traditional Owners and Custodians of the country on which we live and work. We acknowledge their continuing connection to land, waters and culture and commit to ongoing reconciliation. We pay our respect to their Elders past, present and emerging.

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Introduction

This publication is the combination of three economic case studies produced by DPI economists for the project “Reducing herbicide usage on sugarcane farms in reef catchment areas using precise robotic weed control”, otherwise known as Project AutoWeed. These three case studies evaluate the differences in spraying product costs (herbicides and adjuvants) between Project plots that received a conventional, blanket, herbicide spray (control) and plots that were sprayed using AutoWeed technology (AW). Each trial was replicated (unrandomised) with at least two control plots and two AW plots.

Key findings across the studies

Project results indicate that the use of AutoWeed technology can lead to reductions in applied spray products (herbicide and wetter). This has been found in the studies by comparing the average costs of AW plots to the average costs of conventional plots at each trial site. Across each of the five trials considered in this publication, AW spraying was associated with reductions in volume of spray products applied and in product costs ranging from 8.4% to 60.5% (36.3% on average across the 5 sites), relative to conventional blanket spraying (Figure 1).

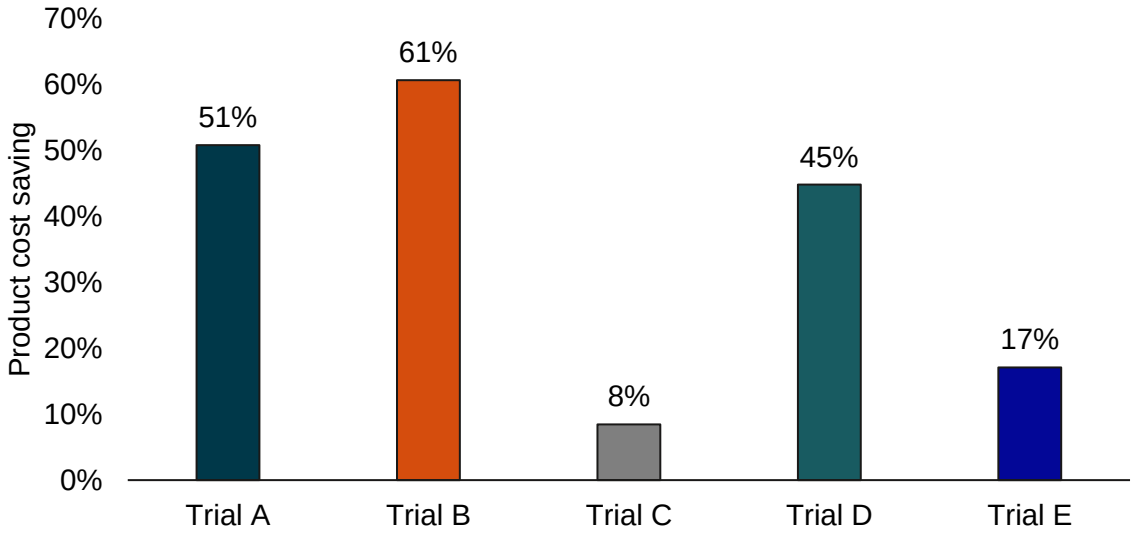

Figure 1 Average of AutoWeed plot product cost savings, compared to blanket spray plots, for each trial

Note: Due to the layout of each site (e.g. unrandomised and, in some cases, limited replicates) a statistical comparison was not completed. Any savings reported are simple averages (and are not attributed to treatment differences at a statistically significant level of confidence).

About the AutoWeed technology

Trial results for efficacy (weed kill rates) contained in this publication and the following sections entitled "About the AutoWeed technology", "Trial spray application mapping" and "Improving the technology" are based on information provided by AutoWeed.

The AutoWeed units are designed to fit onto an existing spray rig. In most project trials AutoWeed units were fitted to Sugar Research Australia's (SRA) own 4-row spray boom. AutoWeed uses artificially intelligent (AI) 'scanners' to detect and classify individual weeds and ignore sugarcane. Once a weed is detected the system applies a targeted spot spray as the sprayer passes by.

The technology is known as green-on-green spot spraying, meaning it can detect green weeds in a green planted crop. The AutoWeed software and spray system has been used in trials at a speed of 8 km/h. The system detects weeds and instructs a solenoid to spray within 60 milliseconds (0.06s), to ensure that the herbicide is applied onto detected weeds, only spraying areas of a paddock that contain weeds.

For example, if only 60% of a paddock has weeds present, then the aim of the AutoWeed technology is to only operate for 60% of the time (with a 40% reduction in applied spray product, compared to a blanket spray). As of mid-2024, the technology only exists in prototype form, and is not commercially available.

Image 1 AutoWeed experimental dual-tank herbicide spray rig at a Field Day demonstration in the Burdekin region and displays of example trial spray application maps

Spray application mapping

The AutoWeed team note that an additional benefit of the AW technology is its ability to produce spray application maps after each use. Figure 2 provides a snippet of the spray application map from Trial D showing the locations where the AutoWeed units activated during the trial. Red sections of the spray map show where herbicide was applied. These spray maps can provide useful insights into the weed density and distribution of a paddock with the potential to provide accurate spray application records for farming enterprises.

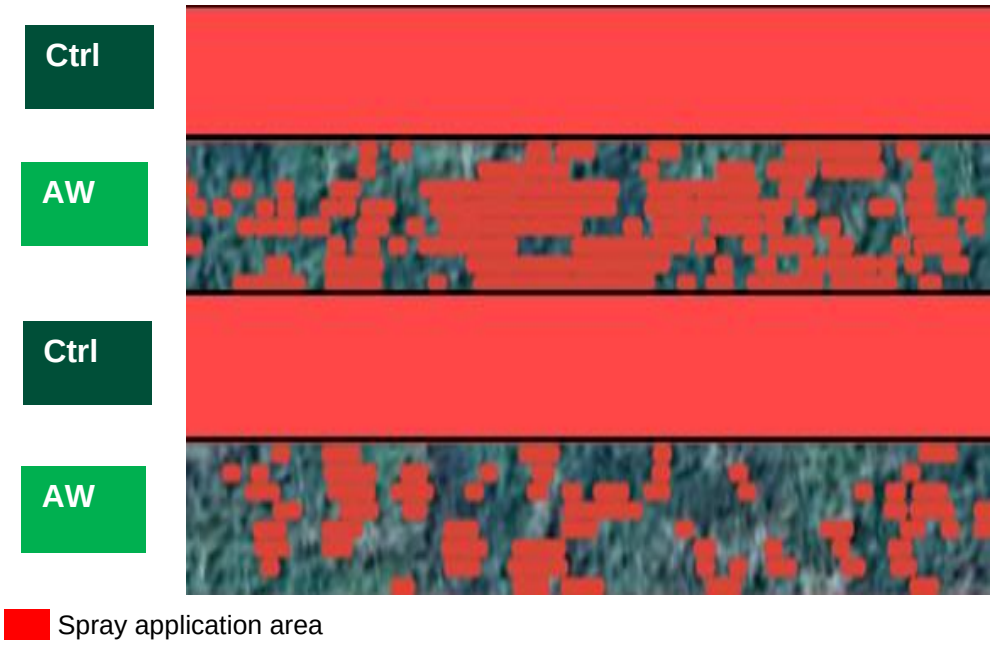

Figure 2 Trial D spray application map

Improving the tech

The AutoWeed team note that continuous refinement and updates are being made to the technology to improve detection performance, adapt the system to new crop/weed scenarios and refine the user interface for future farmers. As with any new technology, the Project team has faced and overcome technical challenges in the early stages of development.

Variability of results

Any reduction in spray volume achieved by using AutoWeed technology, depends largely on paddock weed density. The magnitude of any cost saving (per hectare) is dependent on the reduction in applied spray product and the cost of the spray products used. These factors contribute to variability in cost savings, as seen in the following case studies.

Case Study 1 (CS1)

Project trials A and B were investigated in Case Study 1. Trial A was conducted in a mung bean fallow crop, and Trial B in a plant cane crop (Table 1). AutoWeed units were fitted to an existing spray rig and each trial was sprayed using a 4 row flat boom with a PowerFarm Landini 110HC tractor. There were two replicates (unrandomised) of the control plots and AW plots at each site.

Table 1 Key trial information

	Trial A: Mung Beans in Fallow	Trial B: Plant Cane
Target Weed/s	Grass weeds	Nutgrass
Density of weeds	Low density	Low density (very patchy)
Herbicide (& adjuvant)	Verdict ® 520 (& Activator®)	Sempra® 750 (& Deluge™)
Herbicide rate / ha	0.15 L / ha	0.13kg / ha
Soil type	Sandy loams	Sandy loams
Total trial area	3.6 hectares	2.8 hectares

Key findings of CS1

- Trial A saw a 50.8% reduction in product application, a cost saving of $5.69 per ha.
- Trial B saw a 60.6% reduction in product application, a cost saving of $37.20 per ha.
- Compared to traditional blanket spraying, each AutoWeed plot had decreased weed kill rates, including a 5.8% decrease for AW plot 1 / 2 in Trial B. Please refer to the sections of this publication entitled “improving the tech” and “what else can be considered?”

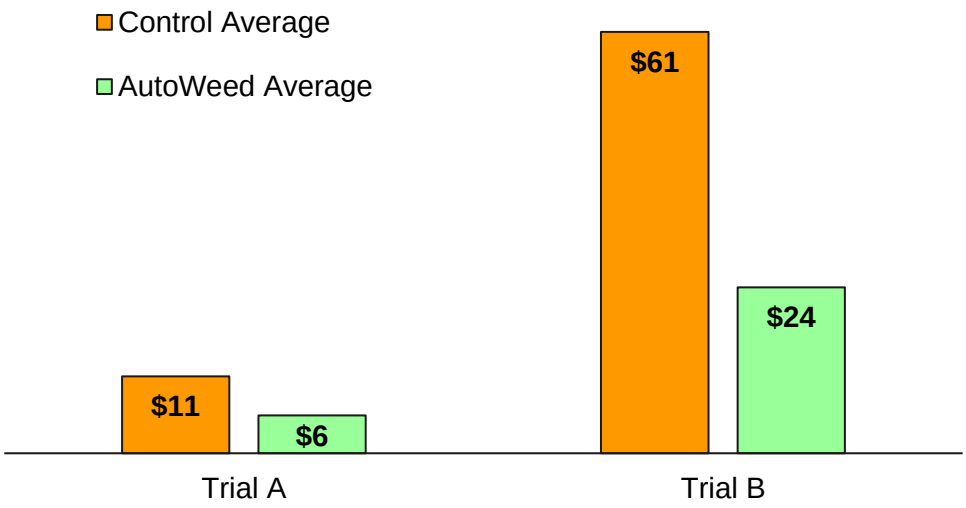

Figure 3 Trial product costs per hectare

Overview of CS1 results

Table 2 Overview of trial results

	Trial A^ Mung Beans in fallow		Trial B^ Plant cane	
	Control	**Spot spray**	**Control**	**Spot spray**
Area of plot sprayed Range of values	**100%**	**49.2%** 43.7% - 54.7%	**100%**	**39.5%** 28.6% - 50.1%
Decrease of % sprayed	**50.8%**		**60.5%**	
Product cost / ha^^ Range of values	**$11.2 / ha**	**$5.5 / ha** $4.9 - $6.1	**$61.0 / ha**	**$24.2 / ha** $17.6 - $30.8
Product cost saving	**$5.7 / ha (50.8%)**		**$37.2 / ha (60.5%)**	
Average efficacy^^^ Range of values	**99.2%** 99.6% - 98.8%	**96.0%** 95.6% - 96.4%	**100%** 100% - 100%	**95.8%** 94.1% - 97.5%
Loss in spray efficacy	**-3.2%**		**-4.2%**	

*^All results displayed in **bold** are averages. Reductions/changes referred to throughout the table are the changes for the AW treatment relative to the control.*
^^ Product costs exclude GST and include herbicide(s) and adjuvant(s) and are based on historic pricing (averaged over multiple years, if available).
^^^ Efficacy refers to the kill rate of weeds in trial plots (losses presented in absolute terms).

The impacts of changes in product costs on savings

The potential impact on product cost savings of a hypothetical 20% increase or decrease in product costs is shown in Table 3.

Table 3 Sensitivity of AutoWeed plot cost savings to changes in product costs

	Trial A: Mung Beans in Fallow	Trial B: Plant Cane
20% decrease in product costs	**$5**/ha saving	**$30**/ha saving
Product costs held constant	**$6**/ha saving	**$37**/ha saving
20% increase in product costs	**$7**/ha saving	**$45**/ha saving
Trial herbicide product Trial adjuvant	Verdict® 520 Activator®	Sempra® 750 Deluge™
Average AutoWeed plot product cost savings	51% (with low weed density)	61% (very patchy weed density)

The rate of herbicide units (L or kg) applied per ha is 150mL/ha in Trial A and 130g/ha in Trial B. The per unit cost of Verdict® 520 used is $47 / L and the cost of Sempra® 750 used is $450 / kg. Any percent (%) change in product cost has a more noticeable impact on cost savings in Trial B involving Sempra® 750. The cost savings for Trial B are also influenced by the very patchy weed density in that trial.

Case Study 2 (CS2)

Project trial B and, an additional trial, C were investigated in Case Study 2. As mentioned in CS1, trial B was conducted in a plant cane crop. Trial C was conducted in a ratoon cane crop (Table 4). AutoWeed units were fitted to an existing spray rig, and Trial B was sprayed using a 4 row flat boom (over top) with a PowerFarm Landini 110HC tractor. Trial C was performed utlising the same tractor, but with an Irvin leg spraying system (4 rows at a time). There were two replicates (unrandomised) of the control plots and AW plots at each site.

Table 4 Key trial information

	Trial B: Plant cane	Trial C: Ratoon cane
Target weed/s	Nutgrass	Nutgrass
Density of weeds	Low density (very patchy)	Very high density
Herbicide (& adjuvant)	Sempra® 750 (with Deluge™)	Krismat® WG (with Agral®)
Herbicide rate / ha	0.13kg / ha	2kg / ha
Soil type	Sandy loams	Clay loams
Total trial area	2.8 hectares	4.4 hectares

Key findings of CS2

- Trial B saw a 60.6% reduction in product application, a cost saving of $37.20 per ha.
- Trial C saw an 8.4% reduction in product application, a cost saving of $7.74 per ha.
- Compared to traditional blanket spraying, AutoWeed spot sprays resulted in decreases in weed kill rates. Please refer to the sections of this publication entitled “improving the tech” and “what else can be considered?”

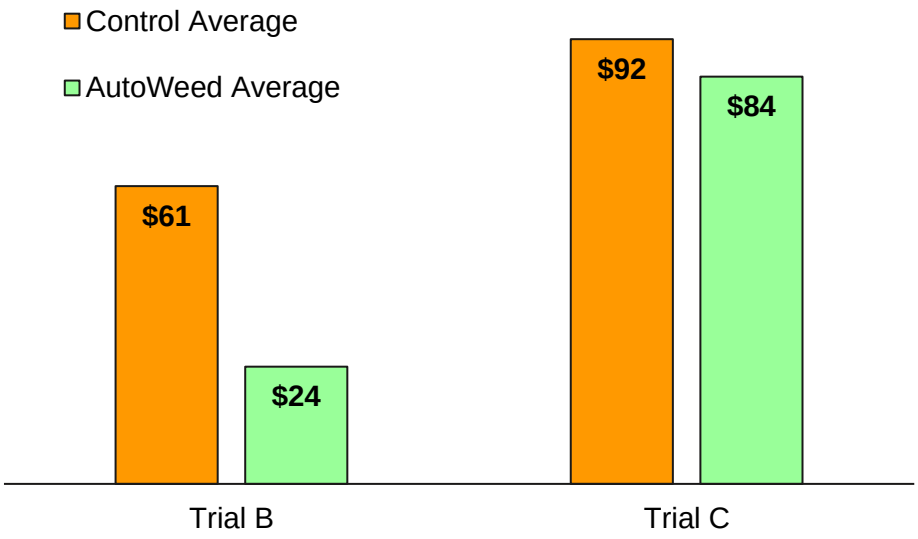

Figure 4 Trial product costs per hectare

Overview of CS2 results

Table 5 Overview of trial results

	Trial B^ Plant Cane		Trial C^ Ratoon Cane	
	Control	**Spot spray**	**Control**	**Spot spray**
Area of plot sprayed Range of values	**100%**	**39.4%** 28.6% - 50.1%	**100%**	**91.6%** 89.5% - 93.6%
Decrease of % sprayed	**60.5%**		**8.4%**	
Product cost / ha^^ Range of values	**$61.0 / ha**	**$24.2 / ha** $17.6 - $30.8	**$91.6 / ha**	**$83.9 / ha** $82.0 - $85.8
Product cost saving	**$37.2 / ha (60.6%)**		**$7.7 / ha (8.4%)**	
Average efficacy^^^ Range of values	**100%** 100% - 100%	**95.8%** 94.1% - 97.5%	**97.2%** 96.4% - 98.0%	**89.2%** 84.4% - 94.0%
Loss in spray efficacy	**-4.2%**		**-8.0%**	

^, ^^, ^^^ *Please refer to explanatory notes for Table 2 (Case Study 1).*

The impacts of changes in weed density on product cost savings

As noted previously in the section of this publication entitled “variability of results” the magnitude of any product cost saving from using AutoWeed depends on the weed density of a paddock (which impacts the amount of product applied) and the cost per unit (kg or L) of each product that is applied. Of course, if the paddock was 100% covered in weeds, no product cost saving would be expected, and if there were no weeds in the paddock, a full product cost saving would be expected. Trial C, on average, had only an 8.4% reduction in herbicide applied in AutoWeed plots (largely due to very high weed density), which resulted in a $8 per ha product cost saving. A sensitivity analysis (Figure 5) shows that, if trial C were to hypothetically have a 60.6% reduction in herbicide applied (as was the case for trial B due to low weed density) then there would have been a product cost saving of $56 per hectare.

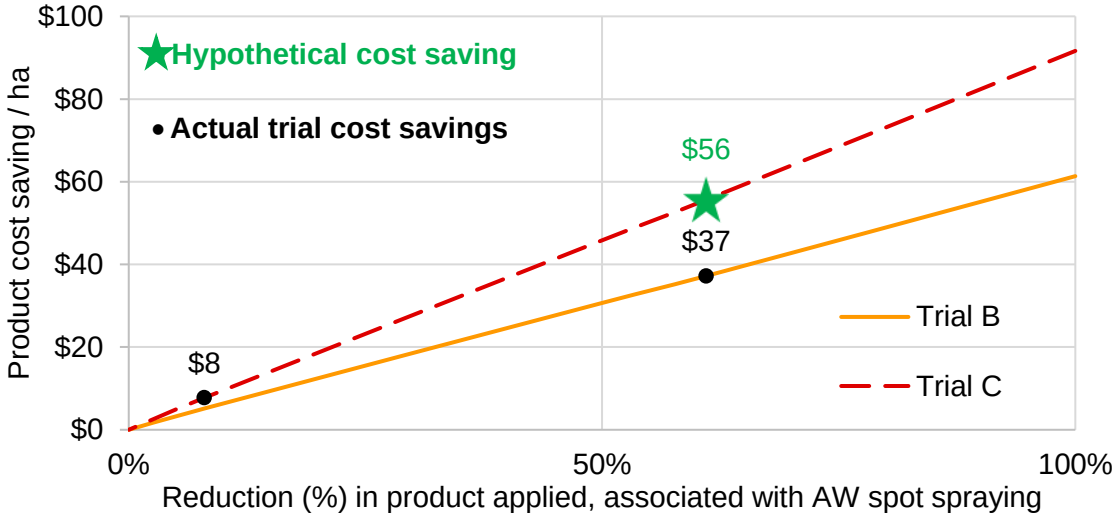

Figure 5 Sensitivity of product cost savings to changes in paddock weed density

For the sensitivity analysis (Figure 5) it is assumed that all other factors are held constant and that the AutoWeed units operate correctly and accurately (in the hypothetical scenario).

Potential operational cost savings

Depending on the weed density of a paddock being sprayed, the use of AutoWeed technology can result in a lower total amount of product applied per hectare. In certain circumstances this may lead to savings in machinery operation costs. For example, in one of the AutoWeed plots in Trial B, the amount of herbicide applied per hectare was halved, and this result was attributed to the very patchy (low) weed density. Such circumstances may reduce the number of times the spray tank would need to be refilled. An analysis of potential changes in machinery operation costs, indicated a saving of $6/ha if the spray tank was refilled once rather than twice (with an improved machinery work rate, due to less refilling time and more spraying time).[1]

Image 2 Tractor fitted with AutoWeed spraying units during a project trial.

[1] Assuming for the analysis: a labour cost of $40/hour, excluding fixed/capital costs, for a grower-performed operation; use of a four-row spray rig, as per the trial; and assuming that the tractor speed and costs factored in on an hourly basis (for fuel, oil, repairs, and maintenance) remained the same for the AutoWeed spot spray and the conventional blanket spray scenario. The estimated operational cost saving is case specific and dependent on various factors that may impact the ability to minimise spray tank refills and use less product.

Case study 3 (CS3)

The additional Project trials D and E were investigated in case study 3. The crop class for both trials was ratoon cane (Table 6). AutoWeed units were fitted to an existing spray rig and each trial was sprayed using a boom sprayer with Irvin legs covering 4 interrows, fitted to a PowerFarm Landini 110HC tractor. There were six replicates (unrandomised) of the control plots and five of the AW plots for each trial. Both trials occurred at a Sugar Research Australia (SRA) site in the Burdekin.

Table 6 Key trial information

	Trial D Ratoon Cane	Trial E Ratoon Cane		
Target weed/s	Nutgrass	Various weeds (other than Nutgrass)		
Density of weeds	Patchy (nutgrass)	High density (various weeds)		
Herbicide/s (& adjuvant)	Sempra® 750 (with Hasten™)	Ametrex® 800 WG	Kelpie® A-Zine Easy Flow 600sc (with Activator®)	Spraytop® 330
Herbicide rate / ha	0.13kg / ha	2.5kg / ha	5L / ha	1.2L / ha
Soil type	Sandy loams	Sandy loams		
Total trial area	2.0 hectares	1.8 hectares		

Key findings of CS3

- Trial D saw a 44.8% reduction in product application, a cost saving of $34.97 per ha.
- Trial E saw a 17.1% reduction in product application, a cost saving of $19.60 per ha.
- Compared to traditional blanket spraying, AutoWeed spot spraying was associated with minimal, or nil, differences in weed kill rates.

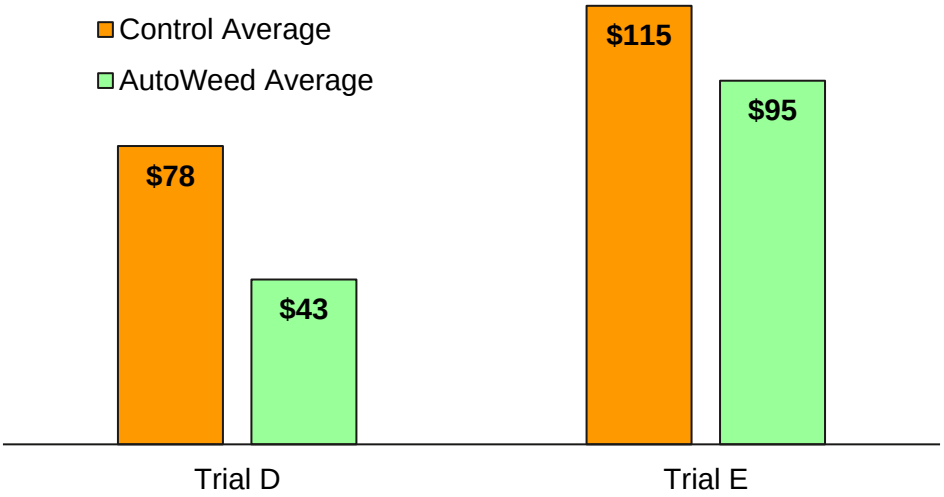

Figure 6 Trial product costs per hectare

Overview of CS3 results

Table 7 Overview of trial results

	Spray Trial D^ Ratoon cane		Spray Trial E^ Ratoon cane	
	Control	**Spot spray**	**Control**	**Spot spray**
Area of plot sprayed Range of values	**100%**	**55.2%** 41.0% - 82.0%	**100%**	**82.9%** 72.9% - 89.6 %
Decrease in % sprayed	**44.8%**		**17.1%**	
Product cost / ha^^ Range of values	**$78.0 / ha**	**$43.1 / ha** $32.0 - $64.0	**$114.7 / ha**	**$95.1 / ha** $83.6 - $102.8
Product cost saving	**$35.0 / ha (44.8%)**		**$19.6 / ha (17.1%)**	
Average efficacy^^^ Range of values	**100%** 100% - 100%	**100%** 100% - 100%	**99.8%** 99% - 100%	**99.0%** 96% - 100%
Loss in spray efficacy	**0.0%**		**-0.8%**	

^, ^^, ^^^ *Please refer to explanatory notes for Table 2 (Case Study 1).*

What else can be considered?

This publication is an output of the project '*Reducing herbicide usage on sugarcane farms in reef catchment areas using precise robotic weed control.*' The publication's scope is limited to evaluating differences in product costs. Future publications and/or trials could investigate/integrate additional matters, such as:

A. The impact of spot spraying on crop production results and water quality results;
B. Insights from agronomists and growers on the use of the AutoWeed tech;
C. Full investment analyses to factor in the capital costs of the AutoWeed tech; and
D. Additional trials with robust randomised designs, over various crop growth stages and crop classes.

Image 3 Tractor fitted with AutoWeed spraying units during a project trial.
Image used with permission. Copyright © 2023, AutoWeed. All rights reserved.

For further information on the costings reported, please contact DPI on 13 25 23. For queries on data provided to DPI by project partners (e.g. trial profiles, weed densities and efficacy rates) please contact Terry Granshaw, Sugar Research Australia, on 0457 650 181.

This publication has been produced by the Queensland Government's Department of Primary Industries (DPI) as an output of the project 'Reducing herbicide usage on sugarcane farms in reef catchment areas using precise robotic weed control.' DPI would like to kindly acknowledge the contributions of growers and contractors involved in this project.

The project is led by James Cook University (JCU) and funded by the Reef Trust Partnership between the Australian Government and the Great Barrier Reef Foundation (GBRF). Some data used in this study was collected by project collaborators including SRA and AutoWeed. Support is provided by DPI economists to the project through the Queensland Government's Queensland Reef Water Quality Program.

Each farming business is unique in its circumstances. Therefore, the parameters and assumptions used in each study only reflect the specific situations for each grower, paddock, trial and prevailing conditions. Consideration of individual circumstances must be made before applying case study findings to another situation.