Providing Economic Support to Project Game Changer

Mackay Whitsunday 2016

Final Report

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Final Report: Providing Economic Support to Project Game Changer Mackay Whitsunday 2016

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Glossary of Key Terms

CCS	Commercial Cane Sugar
PRS	Percentage Recoverable Sugar
HYZ	High Yield Zone
MYZ	Medium Yield Zone
LYZ	Low Yield Zone
VR system	Variable Rate system
BYP	Block Yield Potential
DYP	District Yield Potential
DIN	Dissolved Inorganic Nitrogen
NUE	Nitrogen Use Efficiency

Introduction

The Reef Catchments Sugarcane Innovations Program integrates several funding streams to explore innovative, aspirational practices to reduce nutrient and pesticide losses from Mackay Whitsunday sugarcane farms. The program is funded through a number of projects including: Project Catalyst, a pioneering partnership funded by the Coca-Cola Foundation through the World Wide Fund for Nature (WWF); the Australian Government Reef Programme Game Changer project; and the Australian Government Reef Programme through Reef Water Quality grants that allow earlier adoption of practice changes to ultimately improve water quality outcomes. These projects are delivered in partnership with the Department of Agriculture and Fisheries, Farmacist, Mackay Area Productivity Services (MAPS), Plane Creek Productivity Services (PCPSL) and Sugar Services Proserpine Limited (SSPL).

A particular focus of the program is to foster the rapid uptake of innovative management practices and technologies that improve the quality of water leaving farms to alleviate the potential for adverse effects on the resilience of the Great Barrier Reef. It provides an opportunity for sugar cane growers to work closely with technical specialists to examine game changing management practices that may enhance productivity and profitability, whilst improving environmental outcomes. The farm-based research trials undertaken as part of the program highlight the associated costs and benefits of adoption, as well as practical improvements to management practices. They generate evidence-based research data and advance knowledge about the implications from adopting innovative practices. Moreover, the engagement process facilitates the diffusion of information to other growers, by enabling participating farmers to learn and disseminate their experiences to other farmers, which serves as a catalyst to a sustainable farming future.

The Game Changer project has three major components. Firstly, grower involvement and active participation in the trial ensures an understanding of the implications for their farming systems and businesses. Secondly, the involvement of the respective agronomist in providing technical advice on setting up the trial ensures that the relevant facets of the trial are correctly accounted for and scientific rigor exists. Finally, the economic support is required to analyse and understand the economic viability of the trialled technologies, and likelihood of industry adoption.

Achieving industry adoption of new management practices requires an understanding of the benefits and risks for the grower for such a change. The ability for the grower to step through the components of their business (i.e. practices associated with each crop stage) allows them to analyse where adjustments can be made and greater productivity and efficiency gains achieved. The economic support to the Game Changer project seeks to help growers understand the economic implications of technologies being trialled on sugarcane farms in the Mackay Whitsunday Natural Resource Management (NRM) region.

This report comprises the final economic analysis to be undertaken for the Game Changer project in the Mackay Whitsunday NRM region.

Aims and objectives

The economic component of the Game Changer project aims to assess the viability of specific advanced management plans utilising precision agricultural technologies and expert agronomy for a number of farmers in the Mackay Whitsunday region. The focus is on site specific management of nutrients and herbicides by matching inputs to the requirements of different zones within paddocks, or based on District Yield Potential (DYP), Block Yield Potential (BYP) or differing soil types. These plans will be validated through on-ground trials investigating practicality, economic outcome and water quality impacts.

The specific objectives are:

- Understanding the economic implications of changing management practices through assessing the marginal changes in the production system;
- Assessing the economic viability of industry adoption of innovative technologies;
- Understanding the private and public trade-offs of the changes in management and consider an efficient policy mix; and
- Analyse where opportunities exist for productivity or efficiency gains.

Project management

Of the trials initially put forward for the project, most have progressed well, and information pertaining to the farming systems and businesses of the growers associated with these trials has been captured. All the growers, once engaged, were visited by DAF economists to complete an initial economic assessment of the farming operations, and there has been a level of enthusiasm displayed by most growers throughout this process. The growers have recognised the importance of economic analyses, and have taken the opportunity to understand their business operations from this perspective.

Initial economic assessments have been conducted for the 30 growers involved at the beginning of the project. Trial designs were received for 25 trials, and either complete or partial results were available for 21 of these trials. In cases where incomplete data was received by the department, the missing data points have been populated with assumed values developed through discussion with the relevant project agronomist. The status of the PCPSL trials is presently unknown, and this was mainly due to the departure of their agronomist at a late stage in the Game Changer project. Despite visits and engagement with the growers, results for the PCPSL trials have not been received, and we have presented an analysis in this report using the initial interviews and trial designs for those growers. All up an analysis of some form has been undertaken in this report for 28 block trials, on 26 sugarcane farms, in the Mackay Whitsunday region.

Finally, it is worth noting that the 2016 season has been a very dry period for the Mackay Whitsunday region (Bureau of Meteorology 2016). At the time of writing, below average rainfall has occurred in Mackay, Proserpine, Koumala and Sarina for this period. Along with yellow canopy syndrome, and in some cases cane grub damage, this unseasonably dry weather will have affected the trial results for the Game Changer project.

Methods

The Farm Economic Analysis Tool (FEAT) software program developed by the Queensland Department of Agriculture and Fisheries (DAF) was used to determine the gross margins of each treatment scenario. The gross margin in each treatment was calculated based on the revenue obtained from each system and then subtracting the variable costs involved in growing the cane. The change in gross margin between each treatment was analysed. To focus the analysis on the specific changes in question, a number of variables have been standardised so that the results are not influenced by changes in input prices. This economic analysis used a net sugar price of $440/tonne and all fertiliser and chemical prices are current for the Mackay Whitsunday as of July, 2015. All labour was costed at $30 per hour for casual labour including all associated costs. Population of the FEAT spreadsheets required detailed information of cane yields, percentage recoverable sugar (PRS) or commercial cane sugar (CCS), land preparation, fertiliser, weed control, insect control, fallow operations and machinery to determine the variable costs of growing sugarcane. To complete the individual grower FEAT analyses, information has been obtained from the grower or project agronomist in relation to farm historical management practices for a variety of machinery, implements, soil type and irrigation. Irrigation in this model has been held constant throughout the analysis. This is due to the variation in irrigation systems and environmental conditions which face each different farm.

The Game Changer trials have been tailored to the farming operations of individual growers and are presented in this report under the following general themes:

- Varied rate of nutrient application
  - Compare different nitrogen application rates on older ratoon cane
  - Lower nitrogen rates on paddocks with a low block yield potential
  - Compare production and profitability of a Six Easy Steps nitrogen rate with a lower nitrogen rate on late harvest ratoons
  - Variable rate application of nutrient based on zone yield potential
  - Determine if block yield potential to calculate nitrogen rates has an effect on yield
- Use of enhanced efficiency urea
- Rate of ameliorant application
  - Changing ameliorant application to improve nitrogen use efficiency
  - Efficacy of buried or surface (banded) mill mud application
- Pesticide trials
  - Comparison and efficiency of knockdown and residual herbicides on in-crop weeds
  - Shielded sprayer versus conventional boom for weed control
  - Assessment of variable rate application of Balance (isoxaflutole) herbicides

Mackay Whitsunday Case Studies

Varied rate of nutrient application

Compare different nitrogen application rates on older ratoon cane

The current industry practice is to apply nutrients at the same rate on first and subsequent ratoons, often determined using the Sugar Research Australia's (SRA) Six Easy Steps approach. Generally, older sugarcane does not yield as high as younger sugarcane and therefore the practice of fertilising old ratoons for the yield potential of the first ratoon is uneconomical and has the potential to create increased nutrient runoff. This group of trials aims to reduce nitrogen applied to old ratoon sugarcane.

David Erba – Sarina – Farmacist

David is interested in increasing his profitability by matching nutrient rates on older ratoons with the life stage and realistic yield potential of this cane. He aims to use mill mud, a by-product of the milling process, as a source of nitrogen, phosphorus (P), potassium (K) and sulfur (S). The effect of mill mud application as a partial fertiliser for the final ratoon crop before ploughing out sugarcane is not well understood. The rationale is that the mill mud will provide some nitrogen to the current crop, and also deliver carry over phosphorus that will remain in the soil and be sufficient for planting the next crop.

David has two different products he is comparing and two different nitrogen application rates on the trial site (shown in Figure 1). The products he is comparing are mill mud plus a top-up of MKY160 liquid fertiliser, and a straight application of MKY160P. For each of these products, he is comparing his normal nitrogen application of 150 kg/ha against a 25% lower rate of 110 kg/ha (see Table 1).

Figure 1: Erba's Age of Ratoon trial paddock

Table 1: David Erba reduced nitrogen on old ratoons

No	Description
T1	Mud at 50t/ha 2m^3 of MKY160/ha Total Nitrogen= 110kg N/ha Total Fertiliser Cost/ha =$562.66
T2	Mud at 50t/ha 3.2m^{3}of MKY160 Total Nitrogen =150kg N/ha Total Fertiliser Cost/ha = $685.86
T3	MKY160P at 3.2m^3/ha Total Nitrogen =110kg N/ha Total Fertiliser Cost/ha = $329.86
T4 - Control	MKY160P at 4.4m^3/ha Total Nitrogen = 150kg N/ha Total Fertiliser Cost/ha = $453.55

Results

The economic analysis for this trial is shown below in Table 2. The results show that T1 gives the highest gross margin of all the four treatments. The treatment T1 also had the highest Nitrogen Use Efficiency (NUE) of all four treatments in the trial. For treatment T1, mill mud was combined with liquid fertiliser to give a total nitrogen application of 110 units, and this treatment had the same yield and nearly the same PRS as the next most nitrogen efficient treatment T2.

According to an ANOVA test conducted on these trial results, however, there was no statistically significant difference in the yields (p value of 0.09) and PRS (p value of 0.12) recorded in this trial at the 95% confidence level. If these production data are drawn from the same statistical population, as the ANOVA test would suggest, then the lower grow costs for the treatment T3 will mean that this practice will represent the greatest improvement in farm profitability over the long run. Having said this, at the 90% confidence level the same ANOVA test would indicate a statistical difference in yield somewhere among the four treatments, and at the 80% confidence level it would indicate a significant difference in both yield and PRS. This means that an improvement in yield and sugar as a result of the mill mud treatment T1 cannot be completely ruled out, even though it falls within confidence bounds for the standard ANOVA test.

Depending on the location of the trial strips, it also should be recognised that soil and topographic variation in the trial block can contribute to yield differences between the treatment groups. While it seems as though some potential does exist for David's mill mud application in T1, more trials and testing will be needed in order to confidently establish the practice for David's farm. At any rate, though, the analysis in this section has identified the two low nitrogen treatments of David's trial (i.e. T1 and T3) as the primary candidates for his optimum practice; and doing so we have demonstrated the economic benefits from reducing nitrogen application to meet the nutrient requirements of old ratoon sugarcane.

Table 2: David Erba trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	73	14.93	10.90	19	9
T2	73	15.08	11.00	40	4
T3	67	14.35	9.62	-21	4
T4 – Control	71	13.93	9.89	0	0

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 3 examines the sensitivity of gross margins between treatments. The row divisions show a seasonal fluctuation resulting in a 10% increase or decrease in yield, and the right-most columns show variation in the price of sugar (in $50 increments). The table shows that the treatment T1 is more profitable than T2, T3 and T4 in all cases; however it should be noted that our ANOVA analysis did not reveal a statistically significant difference in yield or PRS at the 95% confidence level.

Table 3: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	9%	9%	9%
	T2	0%	2%	4%
	T3	8%	6%	4%
	T4	0%	0%	0%
0	T1	9%	9%	9%
	T2	2%	4%	5%
	T3	6%	4%	3%
	T4	0%	0%	0%
+10%	T1	9%	10%	10%
	T2	3%	5%	6%
	T3	5%	4%	3%
	T4	0%	0%	0%

Malcolm Langdon – Sarina – Plane Creek Productivity Services

Malcolm's trial has aimed to reduce nitrogen on fourth or older ratooning canes. Malcolm usually uses a liquid fertiliser contractor to apply nutrients to his ratooning sugarcane, and his trial looked at two different fertiliser rates in comparison to Malcolm's normal practice of 170kg N/ha. The first treatment was an application at 114kg N/ha, based on a BYP of 81 tonnes of cane per hectare. The BYP was determined based on historical yield data, as well as spatial data and apparent Electrical Conductivity (ECa) mapping. The second treatment was an application of 150kg N/ha, based on the DYP. A full description of Malcolm's trial is shown below in Table 4. By better matching fertiliser to the crop potential, Malcolm is aiming to see economic benefits due to savings in the fertiliser cost.

Table 4: Malcolm Langdon reduced nitrogen rates on older ratoons

No	Description
T1	LO N Planter at 3.8m³ Urea at 160kg/ha Total Nitrogen = 114kg N/ha Total Fertiliser Cost/ha = $468.36/ha
T2	LO N Planter at 3.8m³ Urea at 240kg/ha Total Nitrogen = 150kg N/ha Total Fertiliser Cost/ha = $522.04/ha
T3 - Control	LO N Planter at 3.8m³ Urea at 285kg/ha Total Nitrogen = 170kg N/ha Total Fertiliser Cost/ha $552.24

Results

Economic data and trial information were recorded and analysed prior to harvest. Malcolm indicated that the dry period caused this trial to struggle during the season, but he mentioned there was no visual difference in the trial block. As harvest data has not received for Malcolm's trial, we have undertaken a cost minimisation analysis based on the grow costs for the different treatments in his trial, and this is presented below in Table 5. On this basis, the results show that both T1 and T2 are economically better than the control treatment T3. T1 had 6% decrease in costs compared to the control, and T2 had a 2% decrease in costs. If there was no difference in yields and PRS between the three treatments, Malcolm should have confidence that his productivity will not suffer due to fertilising paddocks based on BYP or DYP.

Table 5: Malcolm Langdon estimated trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	-	-	-	-6	-
T2	-	-	-	-2	-
T3 - Control	-	-	-	0	-

Adam Keilbach – Sarina- Farmacist

Traditionally Adam applies 161kg N/ha to his ageing sugarcane ratoon crops. As part of the Game Changer trial Adam will investigate if lowering nitrogen rates to 120kg/ha and 140kg/ha respectively, will have any effect on cane yields and sugar quality. A satellite image of the trial paddock on Adam's farm is shown below in Figure 2. A treatment description for the different fertiliser rates used in this trial is shown in Table 6.

Figure 2: Keilbach Age of Ratoons trial

Table 6: Adam Keilbach treatment details

No	Description
T1	MKY 190P at 3.1m³/ha Total Nitrogen =119kg N/ha Total Fertiliser Cost/ha = $389.48/ha
T2	MKY 190P at 3.6m³/ha Total Nitrogen =138kg N/ha Total Fertiliser Cost/ha = $452.30/ha
T3 - Control	MKY190P 4.2m³/ha Total Nitrogen =161kg N/ha Total Fertiliser Cost/ha $527.69

Results

The results of the economic analysis for this trial are shown in Table 7. Overall the grow costs decreased by 8 and 15 percent for T1 and T2, respectively, in comparison with Adam's normal practice in T3. The highest gross margin was observed for treatment T1, where the cost savings due to reduced fertiliser rates outweighed the slight reduction in overall tonnes of sugar per hectare. An ANOVA analysis did not reveal a statistically significant difference in yield (p-value of 0.61) or PRS (p-value of 0.52) between the treatments in Adam's trial (at the 95% confidence level). Given this is the case, the reduction in input costs for treatment T1 is likely to be Adam's most cost effective management practice over the long run.

Table 7: Adam Keilbach age of ratoons results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	64	17.71	11.33	-15	7
T2	65	17.27	11.23	-8	0
T3 - Control	65	17.54	11.40	0	0

Sensitivity Analysis

Table 8 presents a sensitivity analysis of the percentage change in gross margin for each of T1 and T2, in comparison to the control treatment T3. The row divisions show a 10% increase and decrease in yield; and the right-most columns present sugar price variation in $50 increments. The table shows that treatment T1 is more profitable than both T2 and the T3 control treatment in all cases.

Table 8: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	11%	8%	7%
	T2	2%	1%	0%
	T3	0%	0%	0%
0%	T1	9%	7%	6%
	T2	1%	0%	0%
	T3	0%	0%	0%
10%	T1	8%	6%	5%
	T2	0%	0%	0%
	T3	0%	0%	0%

Gary Considine – Bloomsbury- Farmacist

Gary's usual rate of fertiliser application is 758 kg/ha of CK160S, which equates to a nitrogen application rate of 212 kg N/ha. By reducing the fertiliser application rate on old ratoon cane by 116kg/ha, decreasing nitrogen application by 32kg/ha, Gary hopes to generate a saving in fertiliser costs while maintaining yield. Table 9 shows Gary's fertiliser application rates for the two treatments.

Table 9: Gary Considine comparing differing nitrogen rates on ageing ratoons

No	Description
T1 - Control	CK 160S at 758 kg/ha Total Nitrogen = 212kg N/ha Total Fertiliser Cost/ha = $591.24
T2	CK 160S at 642 kg/ha Total Nitrogen = 180kg N/ha Total Fertiliser Cost/ha = $500.76

Figure 3: Considine trial location

Results

The results of the economic analysis for this trial are shown below in Table 10. The grow costs for T2 were 7% lower than T1, and this was the main driver of a 3% increase in gross margin for this treatment. An ANOVA analysis revealed no statistically significant difference in yield (p value of 0.76) or CCS (p value of 0.25) between the two treatments (at the 95% confidence level); and given this result, some confidence can be gained to reduce nitrogen rates on older ratoons.

Table 10: Gary Considine age of ratoon nitrogen rate trial results

.No	t/ha	CCS	ts/ha	% Change Grow Cost	% Change GM/ha
T1 – Control	78.07	15.53	12.11	0	0
T2	77.34	15.48	11.97	-7	3

Sensitivity Analysis

Table 11 presents a sensitivity analysis of gross margin changes between the two treatments. The row divisions in this table indicate a 10% increase or decrease in yield; while the right-most columns show variation in the price of sugar (in $50 increments). The results in this table show that T1 is more profitable than T2 in all scenarios. More trials should be conducted to improve the rigour of these results. Replication will enable more robust economic findings to be made.

Table 11: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	7%	5%	3%
0	T1	0%	0%	0%
	T2	5%	3%	2%
+10%	T1	0%	0%	0%
	T2	4%	3%	2%

Lower nitrogen rates on paddocks with a low block yield potential

There is a strong argument for applying lower amounts of nutrients where blocks consistently yield below DYP due to soil limitations and inherent properties of the farmland. These trials focus on increasing the understanding of in-block variation of soils and techniques for nutrient application that accord with BYP rather than DYP.

David Ellwood – Walkerston- Farmacist

David is interested in matching nitrogen rates to the soil types found on his farm. On David's farm, ECa and spatial mapping, together with historic yield data, have illustrated variation in yield across different soil types. The data have indicated that, over time, some of David's blocks are produce well below DYP. Better matching nitrogen rates to the actual yield potential of those blocks, would result in greater NUE and improve the quality of farm water run-off. David's normal nutrient application rate of 145kg N/ha, and in this trial David compares his normal practice to a low rate of 120kg N/ha and a high rate of 170kg N/ha (see Table 12 below). By reducing nitrogen application on blocks that yield below average harvests, David hopes to generate cost savings and also contribute to better water quality outcomes for the Great Barrier Reef (GBR).

Table 12: David Ellwood matching nitrogen rates to specific soil type and location

No	Description
T1	Liquid 50/50 at 4.0m³/ha 10kg/ha Easy N plus 25kg/ha Super Phosphate Total Nitrogen = 120kg N/ha Total Fertiliser Cost/ha $400.02
T2 - Control	Liquid 50/50 at 4.0m³/ha 35kg/ha Easy N plus 25kg/ha Super Phosphate Total Nitrogen = 145kg N/ha Total Fertiliser Cost/ha $430.27
T3	Liquid 50/50 at 4.0m³/ha 60kg/ha Easy N 25kg/ha Super Phosphate Total Nitrogen = 170kg N/ha Total Fertiliser Cost/ha $460.52

Figure 4: Ellwood trial location

Results

The results of the economic analysis for this trial are shown below in Table 13. Because the trial PRS results were not received, to conduct our analysis we have assumed a uniform PRS of 15% for each treatment*. Of the treatments, T1 had the highest NUE out of all the treatments and had a gross margin improvement of 4% over the control (T2); T3 had a 5% gross margin improvement when compared to the control, and this was mainly due to an additional three tonnes of yield gained in this treatment. Our ANOVA analysis has indicated that there has been no statistically significant difference in the yields between the three treatments (p value of 0.67) at a 95% confidence level, suggesting that in the long run the lowest cost treatment T1 may be economically optimal.

Table 13: David Ellwood trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	69	15*	10.35	-4	4
T2 - Control	68	15*	10.20	0	0
T3	71	15*	10.65	4	5

* PRS figures were not provided to the department for this trial, and the figures entered in this table are based on information provided by David Ellwood in relation to his average farm production.

Sensitivity Analysis

Table 14 presents a sensitivity analysis of the proportionate change in gross margin between the control treatment T1 and the alternate treatments T2 and T3 in this trial. The row divisions in this table correspond to a 10% increase or decrease in yield, and the right-most column divisions show variation in the price of sugar in $50 increments. For all the scenarios in this table, T1 and T3 are more profitable than the control T2.

Table 14: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t) 390	440	490
-10%	T1	6%	5%	4%
	T2	0%	0%	0%
	T3	5%	5%	5%
0%	T1	5%	4%	4%
	T2	0%	0%	0%
	T3	5%	5%	5%
10%	T1	4%	4%	3%
	T2	0%	0%	0%
	T3	5%	5%	5%

Tony Hinschen – Proserpine – Sugar Services Proserpine Limited

Tony is investigating a reduced nitrogen application rate on old ratoon cane. He is trialling a low rate of 120kg N/ha and high rate of ~160kg N/ha, and aims to match nutrient application with the soil test coming off his paddock. Tony is using a custom blend fertiliser, and in the high rate treatment is combining this custom product with urea (applied at 95kg/ha). The aim of the trial is to compare the productivity and profitability of reducing nitrogen application on old ratoon cane. The trial design is summarised below in Table 15, and an image of Tony's block is shown in Figure 5.

Table 15: Tony Hinschen reduced fertiliser on older ratoons

No	Description
T1	Custom Blend at 680kg/ha Total Nitrogen = 120kg N/ha Total Fertiliser cost/ha = $427.24
T2 - Control	Custom Blend at 680kg/ha plus Urea 95kg/ha Total Nitrogen = 163kg N/ha Total Fertiliser Cost/ha = $475.68

Figure 5: Tony Hinschen's trial block

Results

The economic analysis for this trial is shown below in Table 16. The trial result indicate a 4% higher yield and 1% higher CCS for Tony's regular practice in T2, however an ANOVA analysis did not find these differences were statistically significant at the 95% confidence level (i.e. a p value of 0.20 for yield and 0.18 for CCS). Despite the reduced nitrogen treatment in T1 having a 6% reduction in grow costs, the lower yield and CCS observed for this treatment lead to a 6% reduction in gross margin per hectare on the trial block. However, further trials and economic analysis will be required to understand this long-term impact of reducing nitrogen application on Tony's block. To further add to this, dry weather conditions and yellow canopy syndrome both affected the trial results for season just gone.

Table 16: Tony Hinschen project trial results

No	t/ha	CCS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	66.16	15.59	10.31	-6	-6
T2 - Control	68.80	15.77	10.84	0	0

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 17 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% change in yield and the right-most columns show variation in the sugar price (in $50 increments). The table shows that the control T2 was more profitable than the reduced nitrogen treatment T1 in all scenarios.

Table 17: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	-6%	-6%	-5%
	T2	0%	0%	0%
0	T1	-6%	-6%	-5%
	T2	0%	0%	0%
+10%	T1	-6%	-6%	-6%
	T2	0%	0%	0%

Ron Telford – Proserpine - Sugar Services Proserpine Limited

Ron is investigating lowering nitrogen rates on old ratoon cane using his custom blend fertiliser product. Using the soil tests coming off his paddock, Ron aims to better match his fertiliser application with the nutrient requirement of the crop. He compared a low nutrient application rate of 110kg N/ha to a high application rate of 160kg N/ha, as shown below in Table 18 and Table 19.

Table 18: Ron Telford custom blend fertiliser nutrient analysis

No	Description
T1	Custom Blend – N:18.9; P:3.4; K:20.6; S:3.4
T2 - Control	Custom Blend – N:23.9; P:3.0; K:17.9; S:1.5

Table 19: Ron Telford reducing nitrogen rates on older ratoons

No	Description
T1	Custom Blend at 580kg/ha Total Nitrogen = 110kg N/ha Total Cost/ha = $504.40
T2 - Control	Custom Blend at 660kg/ha Total Nitrogen = 160kg N/ha Total Cost/ha = $558.52

Figure 6: Ron Telford's trial block

Results

The results of the economic analysis for this trial are shown below in Table 20. The table shows that the grow costs in T1 were 6% lower than T2, and the gross margin were 4% higher, indicating economic advantages from the reduced nitrogen application. However, the trial year was unseasonably dry, and there was high yellow canopy syndrome pressure, so that the results reported here may not reflect a 'normal' growing season for the Telford farm.

According to our ANOVA analysis there was no statistically significant difference in either yield (p-value of 0.79) or PRS (p-value of 0.79) between the two treatments in this trial (at a 95% confidence level). It is therefore likely that the yield and PRS differences between treatments are a result of statistical variation, so that the cost savings in T1 (i.e. the lower nitrogen rate) will make it the most economical treatment.

Table 20: Ron Telford project trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	61.97	14.97	9.28	-6	4
T2 - Control	62.57	14.89	9.29	0	0

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 21 examines the sensitivity of the change in farm gross margins between treatments. The left column shows a 10% change in yield and the right-most columns show sugar price variation in $50 increments. The table shows that T1 was more profitable than T2 in all scenarios.

Table 21: Change in gross margin in response to a change in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	6%	5%	4%
	T2	0%	0%	0%
0	T1	5%	4%	3%
	T2	0%	0%	0%
+10%	T1	4%	3%	3%
	T2	0%	0%	0%

George Sammut – Sarina –Plane Creek Productivity Services

George Sammut was interested in reducing his nitrogen budget to accommodate for a legume crop. Due to unforeseen circumstances with machinery and weather, George was unable to plant his legume crop and has therefore withdrawn from the project for this year. The economics team met with George and worked through the economic position of his farm. George was extremely enthusiastic about being part of the project and very open to discussions about ways to improve the profitability of his farm.

Compare production and profitability of a Six Easy Steps nitrogen rate with a lower nitrogen rate on late harvest ratoons

Borg – Mackay – Mackay rea Productivity Services

The Borg family are investigating the profitability and productivity of changing from the Six Easy Steps nitrogen rate to a reduced rate on late harvested ratoons on their family farm in North Eton, Queensland. Harvesting the sugarcane late in the growing season, i.e. in December, will limit the growing time for the next crop to eight or nine months, compared to 12 months for sugarcane harvested in September. A description of the treatments in the Borg family trial is presented below in Table 22. By reducing nitrogen rates from 173kg N/ha to 131kg N/ha, the Borg family hope that productivity will not be hindered and gross margins will be improved through a saving in grow costs. Reducing nitrogen rates will also minimise the potential for environmental losses. The fertilisers used in this trial (i.e. LOS+P and MKY160P) have been applied by a contractor using a 7 row tractor applicator with a precision rate controller. A satellite image of the Borgs' trial block is shown in Figure 7 below.

Table 22: Treatment and fertiliser key parameters

No	Description
T1 - Control	LOS+P at 3.7m³/ha Total Nitrogen = 173kg N/ha Total Cost/ha = $535.21
T2	MKY 160P at 3.7m³/ha Total Nitrogen = 131kg N/ha Total Cost/ha = $447.33

Figure 7: Trial paddock on Borg's farm North Mackay

Results

Trial results for the Borg's property are shown in Table 23. The change in gross margin between the two treatments was 1%, i.e. the lower nitrogen rate had small positive effect on farm profitability. The sugarcane yields between the two treatments were much the same, i.e. 71 t/ha for T1 and 70 t/ha for

T2, indicating that reducing the nitrogen rate on late harvested ratoons had a negligible impact on productivity. Furthermore, an ANOVA analysis also indicated that there was no significant difference in yield (p value of 0.52) or PRS (p value of 0.65) between the two treatments, at a 95% confidence level. Given this result, and observing the 15% reduction in grow costs for treatment T2, it seems likely that reducing nitrogen application on late cut ratoons will be a cost effective practice for the Borg farm, in the long run.

Table 23: Paul Borg trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1 - Control	71.39	14.65	10.46	0	0
T2	70.14	14.48	10.16	-15	1

Sensitivity Analysis

Table 24 presents a sensitivity analysis of the proportionate change in gross margin between T1 and T2. The row divisions show a 10% increase and decrease in the trial yields; and the right-most columns present a range of sugar prices (in $50 increments). According to the table, treatment T2 is at least as profitable as T1 in all scenarios. The results show only a small improvement in gross margin between these two treatments, but also reflect the relative size of the yield and PRS results between treatments T1 and T2. Since there was no statistically significance difference in these results, the yield and PRS are likely to be the same for the two treatments in the long run. On this basis, the long run improvement in gross margin from late harvested ratoons, as a result of reducing nitrogen application, may be between 4% and 5% regardless of seasonal factors or the price of sugar (based on the FEAT files we have completed for this trial).

Table 24: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	2%	1%	1%
0	T1	0%	0%	0%
	T2	1%	1%	0%
+10%	T1	0%	0%	0%
	T2	1%	0%	0%

Variable rate application of nutrient based on zone yield potential

The adoption of precision agriculture techniques, specifically variable rate (VR) nutrient application, is seen by many as a viable mechanism to reduce levels of Dissolved Inorganic Nitrogen (DIN) in the Great Barrier Reef. Targeted trials undertaken as part of Project Catalyst have shown some potential to improve NUE, without compromising yields, by varying nutrient application rates in paddocks. A number of growers in the Game Changer project are investigating VR nutrient application on their properties. These growers have traditionally applied nutrients at a uniform rate across their paddocks.

Where variable yield zones occur, however, there is the potential to reduce nitrogen rates in areas that consistently perform below the block's yield potential. A typical three-zone VR system divides the farmland into a High Yield Zone (HYZ), Medium Yield Zone (MYZ) and Low Yield Zone (LYZ), and specifies nutrient application with in each of these zones. Depending on the level of variability in the land, a two zone system may be implemented that specifies nutrient application in only a HYZ and a LYZ. The Game Changer trials look to vary the nutrients being applied to different zones within a block based on the yield history, remote sensing data and ECa mapping. By applying high and low rates of nutrients to corresponding yield zones, the overall level of nutrient application on the block may be reduced, and this offers both economic and environmental benefits (i.e. in terms of reduced input costs and possible improvements in water quality).

Steve Young- Homebush - Farmacist

Steve Young is investigating full VR fertiliser application according to zone yield potential on his 42ha farm in Homebush. Through extensive analysis of his soils, remote sensing of yield and historic yield records Steve Young has determined the he has three distinct yield zones on his farm (i.e. an HYZ, MYZ and LYZ). He is investigating varying the rate of fertiliser application to ratooning sugarcane on his farm within these three yield zones. A satellite image showing an overlay of the yield map of Steve's Homebush property is shown in Figure 8 below.

Steve's usual rate of nitrogen application for his sugarcane ratoons is 160kg/ha and applied uniformly across 32 ha of his farm, which comprises multiple blocks. In this trial, Steve will vary is application rate to correspond with a rate of 160kg N/ha in the HYZ, 140kg N/ha in the MYZ and 110kg N/ha in the LYZ. The trial design is summarised below in Table 26. As a result of varying this nitrogen application rate, Steve will also be varying the other nutrient components of the fertiliser applied to his crop. However, advice from the agronomist for this trial indicates that nitrogen is the limiting factor for sugarcane growth on Steve's property. He will have a significant saving per hectare in fertiliser costs and reduce the potential for excess nutrient to leave his farm.

Steve has gradually moved blocks of his Homebush farm to this granular VR system over the course of time as he has become increasingly confident in the system. In general, however, the switch to VR nutrient application can be accomplished in a much shorter period of time. According to discussion with the agronomist for this trial, once the yield map has been determined then the VR nutrient application can commence. In many cases growers will wait for one season in order to verify the yield maps for themselves at harvest time, but this is not a requisite for the adoption of the system.

Table 25: Steve Young site and trial description

No	Description
T1	Gargett Ratooner 425kg/ha – LYZ Gargett Ratooner 540kg/ha – MYZ Gargett Ratooner 625kg/ha - HYZ
T2 - Control	Gargett Ratooner 625kg/ha

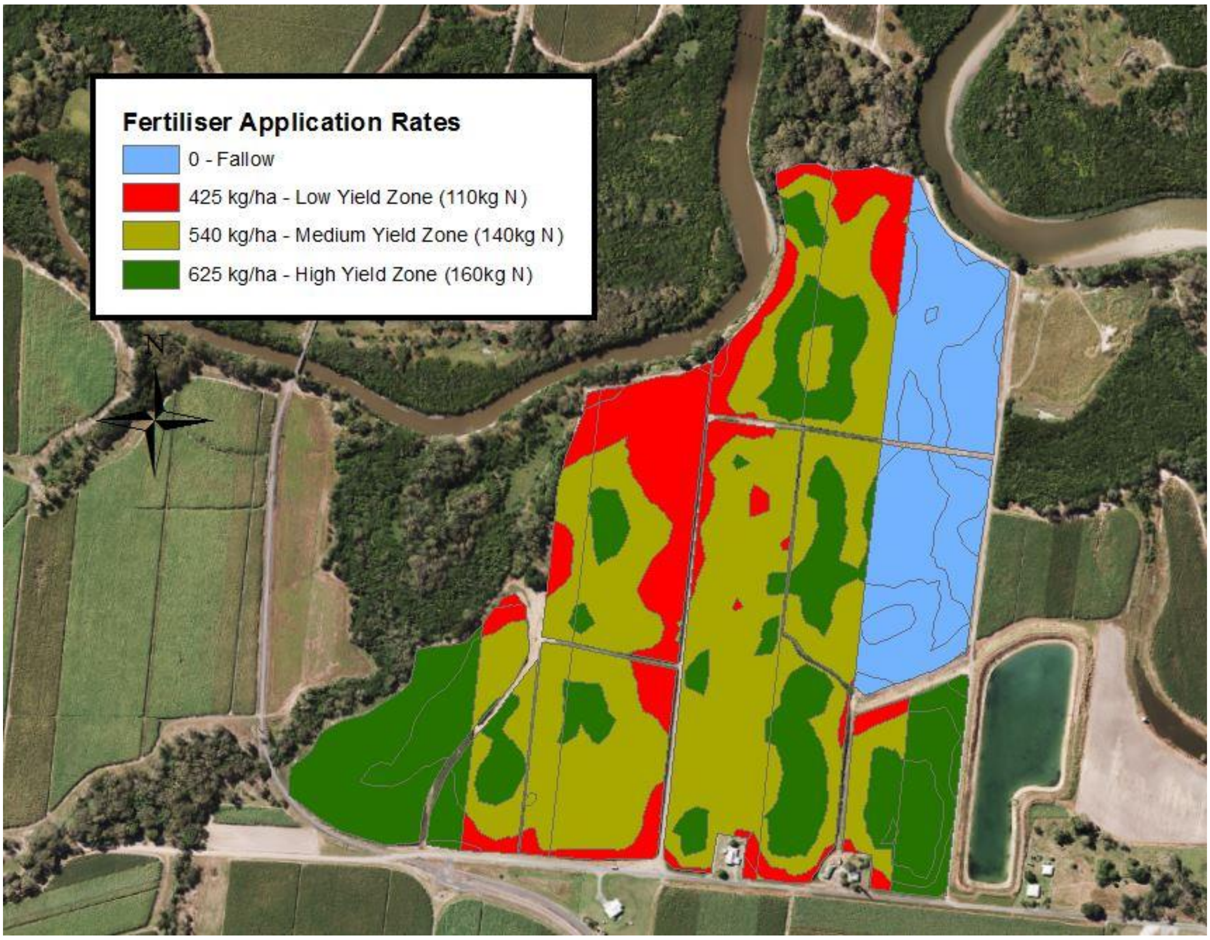

Figure 8: Satellite image and yield map of Steve Young's property in Homebush

Table 26: Steve Young full VR application trial of all macro nutrients

No	Description
T1	Gargett Ratooner at 425kg/ha (6 ha) Total Nitrogen=110kg N/ha Total Cost/ha = $302.60 Gargett Ratooner at 520kg/ha (20 ha) Total Nitrogen=140kg N/ha Total Cost/ha = $384.48 Gargett Ratooner at 625kg/ha (6 ha) Total Nitrogen=160kg N/ha Total Cost/ha = $445.00
T2 - Control	Gargett Ratooner at 625kg/ha (32 ha) Total Nitrogen = 160kg N/ha Total Cost/ha = $445.00

Results

The economic analysis for this trial is shown below in Table 27. Based on advice and data obtained from the project agronomist, the yield and PRS have not changed between Steve's historical practice and the VR system. Therefore holding yield, PRS and tonnes of sugar constant, an economic analysis is presented below in Table 27. This analysis shows that treatment T1, i.e. the VR system, has 7% lower grow costs than Steve's regular practice (T2-Control) and a 6% higher farm gross margin.

Table 27: Steve Young trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	70*	15*	10.5	-7	6
T2 - Control	70*	15*	10.5	0	0

* Yields and PRS are assumed, and have been based on discussions with the project agronomist.

Net Present Value of Investing in VR Nutrient Application

Taking into account the potential variation in yield and sugar price, Table 28 examines Net Present Value (NPV) of the marginal investment in the variable rate drive equipment required for the VR system, combined with the added agronomic advice over ten years. This analysis has been undertaken for a farm that already operates at a high level of management, i.e. utilising GPS guidance, and looks at the value added by the additional investment in VR technology under various scenarios for yield improvement and the price of sugar. The row divisions of Table 28 show a 10% increase or decrease in yield after a switch to the VR farming system; and the right-most columns show variation in the sugar price (in $50 increments). The results show the NPV of the investment in the VR system is negative for the cane yields at or below the pre-VR yield (i.e. 0% and -10% yield scenarios), regardless of the sugar price. With a 10% improvement in yield, the NPV increases to a positive level which ranges from $36,891 at 9% per annum real discount rate and a cane price of $390 per tonne, to $65,571 at a 5% real discount rate and a sugar price of $490 per tonne. Under the assumption of 7% real discount rate and no change in yield, Table 28 shows that the investment in the VR system is negative, and thus has not added value to the farming enterprise.

Table 28: Net Present Value of Investing in VR Nutrient Application

Yield	Discount rate %	Cane price ($/t)		
		390	440	490
-10%	5	-$76,149	-$85,437	-$94,725
	7	-$70,425	-$78,873	-$87,321
	9	-$65,457	-$73,176	-$80,895
0	5	-$14,577	-$14,577	-$14,577
	7	-$14,420	-$14,420	-$14,420
	9	-$14,283	-$14,283	-$14,283
+10%	5	$46,995	$56,283	$65,571
	7	$41,586	$50,034	$58,482
	9	$36,891	$44,610	$52,330

Net Present Value versus Farm Size

Figure 9 shows a break even analysis for the NPV of the VR system compared with the farm size in hectares. This analysis has been based on the change in farm gross margin on the trial property for this study, in the Mackay-Whitsunday sugar growing region.

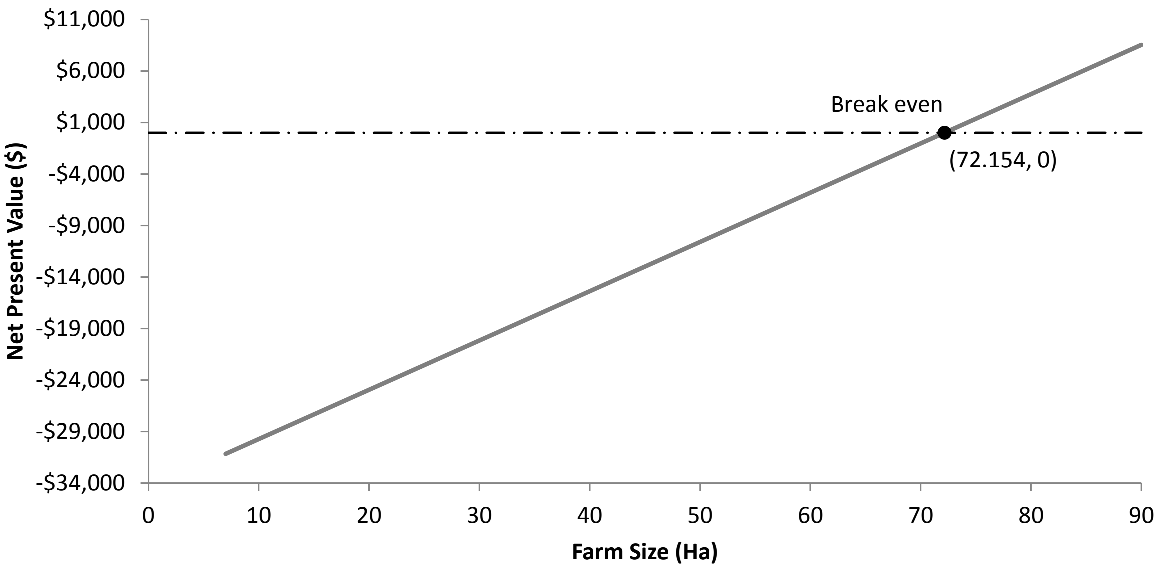

Figure 9: Break even analysis for the NPV of Steve Young's investment required to under his VR fertiliser system (given that he already operates under GPS guidance)

The results in Figure 9 show that the viability of the VR system (as implemented on Steve Young's property in Homebush) depends on the scale of the farming enterprise. The breakeven point, i.e. where the NPV is $0, is illustrated in the graph by the closed point at 72.154 ha. Due to the upfront costs of the VR system for advanced practice farmers, i.e. those already undertaking farming activities under GPS guidance, economies of scale exist for the VR system. Consequently, the system may lend itself to implementation by grower collectives or via a dedicated contracting service. Such contractors already exist for liquid fertilisers in the region (Damian Baxter of Wilmar BioEthanol AgServices, *per. comm.*).

Adam Keilbach – Sarina- Farmacist

Adam Keilbach is investigating the use of VR fertiliser application on one block of his farm in Sarina. The adoption of precision agriculture techniques, specifically VR nutrient application, has the potential to reduce nutrient application which may decrease levels of DIN entering the Great Barrier Reef. Through analysis of his soils, remote sensing of yields and the use of historical data, Adam has identified three distinct yield zones in his block: an LYZ, MYZ and HYZ. He is investigating varying fertiliser application within the trial block according to nutrient regimes specified for each of the management zones. Adam's trial block and his management zone map are shown in Figure 10 and Figure 11 respectively. In relation to the management zone map in Figure 11, the LYZ is shown as the area coloured red; the MYZ as area coloured green; and the HYZ as area coloured blue.

The trial design for Adams' block is shown in Table 29. Adam's usual rate nitrogen application is 160kg N/ha and this trial will compared his normal practice with a varied application regime that applies: 160kg N /ha in the HYZ and 110 kg N/ha in the LYZ. While an MYZ was identified in the block, this zone covered only a small area of Adam's block (the green zone in Figure 11) and thus was not implemented in the VR system.

Figure 10: Keilbach's trial block

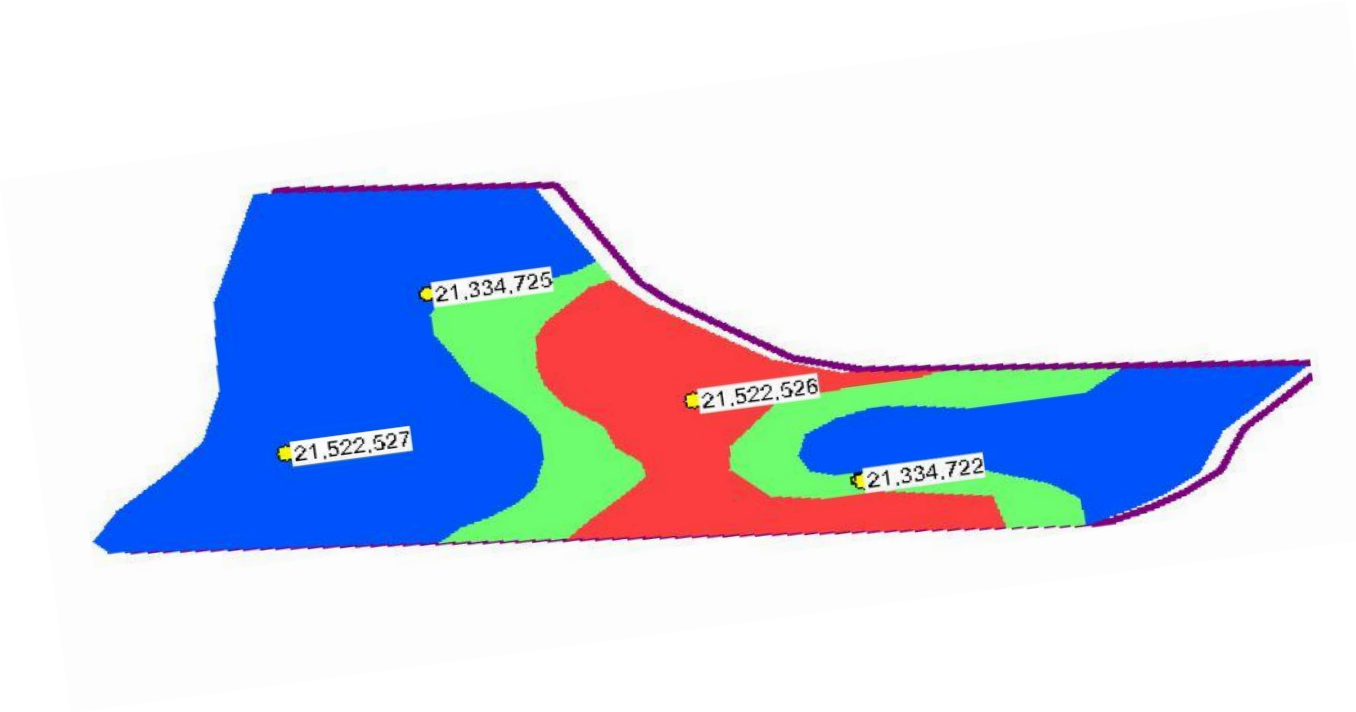

Figure 11: Management Zones for Keilbach's variable rate (VR) trial

Table 29: Adam Keilback comparing VR application of all nutrients to blocks with three yield zones

No	Description
T1	MKY190P at 2.9m^3 - LYZ MKY 190P at 4.3m^3 - HYZ Total Nitrogen = 110 units Total Nitrogen = 170 units Total cost/ha = $450.36
T2- Control	MKY190P at 4.2m^3 Total Nitrogen = 160 units Total cost/ha = $525.42

Results

The economic analysis for this trial is shown below in Table 30. In order to complete this analysis we have assumed that each of the HYZ and the LYZ occupied 50% of Adam's block, as this information was not available from the trial designs. Table 30 shows that there was no difference in either yield or PRS between T1 and T2. However, the reduced fertiliser application in T1 meant that grow costs were 8% lower in this treatment and translated into a 12% improvement in gross margin. Therefore the VR system improves the net revenue from farming under the assumptions used in this analysis. However, during the season Adam indicated that he could see no visual difference in the two treatments, and suggested that a combination of dry weather, cane grubs and yellow canopy syndrome may have led to poor crop performance. Thus, the differences in yield and PRS between T1 and T2 for this trial may not typify the VR system under 'normal' growing conditions.

Table 30: Adam Keilbach VR trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	76.7*	16.8*	14.5	-8	12
T2 - Control	71.0	17	13.6	0	0

* Assumed that each yield zone was 50% of the block, based on trial designs.

Adam's trial was undertaken on a single block of sugarcane, so that the change in production and gross margin for the related whole-of-farm system is still not known from these trial results. Consequently, this analysis has focused on the marginal change in gross margin per hectare for the conversion of the trial block to a VR nutrient regime, but has not considered the additional overheads that are introduced by the VR system at a whole-of-farm level. A VR system would normally introduce additional fixed costs for ECa mapping and agronomic advice that are incurred at one level for the entire farm. These costs represent an economy of scale to a farming operation, which means that the change in farm profitability that is due to the VR system will increase with the number of hectares that are under such a system. The typical values for the additional fixed costs are shown below in Table 31. The ECa mapping component is necessary to establish the management zones for the farm and will typically be undertaken in a staged fashion, with mapping being done on fallow blocks in each year. Once the entire farm has been ECa mapped, the additional on-going fixed costs for the VR system will reduce to just the annual fee for agronomic advice.

Table 31: Additional on-costs required to implement his VR system

Additional cost	Description
EC mapping	$35 per ha
Agronomic advice	10 hours per year

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 32 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% increase or decrease in both the treatment yields; while the right-most columns show variation in the sugar price in $50 increments. The table shows that T1 is more profitable than T2 in all scenarios. Interestingly, as the treatment yields improve, there is approximately a 1% increase in gross margin regardless of the sugar price scenario. In other words, as seasonal factors improve yield, the VR system performs marginally closer to the uniform rate in Adam's control treatment. This may affirm the importance of seasonal factors in the economic performance of a VR system. Given the dry conditions during the trial year, it may also suggest a slightly lower improvement in gross margin due to the precision application system in a more 'normal' year on Adam's farm.

Table 32: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	15%	13%	12%
	T2	0%	0%	0%
0%	T1	14%	12%	11%
	T2	0%	0%	0%
+10%	T1	13%	12%	11%
	T2	0%	0%	0%

Tony Bugeja – Walkerston – Farmacist

Tony Bugeja's sugarcane farm is located 10 km south of Walkerston, near Mackay. Tony's farm is 400 hectares and runs on a controlled traffic system. Tony is investigating the use of VR nutrient application on his farm. Through extensive analysis of his soils, remote sensing and historical yield data, Tony has determined that he has two distinct yield zones in his paddocks. To better manage nutrient runoff, particularly nitrogen, he is investigating lowering nitrogen application on the LYZ area of these paddocks. A description of the treatments in Tony's trial is shown below in Table 33 and a satellite image of the trial paddock is in Figure 12.

This nutrient trial has employed a contractor who is set up for VR application, so that there has been no capital investment required on the part of Tony. As per Table 33, Tony's usual nitrogen rate is 182kg N/ha across the whole paddock, and his trial splits this rate within-block to apply a high level of 182kg N/ha in the HYZ and a low level of 164kg N/ha in the LYZ. While Tony's VR system also varies phosphorus, potassium and sulfur in the LYZ and HYZ, it is anticipated that nitrogen will be the limiting factor for sugarcane growth on Tony's paddock. The proportion of Tony's block in the HYZ is two thirds and the proportion in the LYZ is one third.

Table 33: Variable Rate application of fertiliser in two yield zones

No	Description
T1	LOS at 3.6m³/ha – 0.33 ha (LYZ) LOS at 4m³/ha – 0.66 ha (HYZ) Total Nitrogen = 164 units (LYZ) Total Nitrogen = 182 units (HYZ) Total cost/ha = $503.61
T2 - Control	LOS at 4m³ Total Nitrogen = 182 units Total Cost/ha = $526.24

Figure 12: Trial paddock on Tony's Farm

Results

Results from Tony's VR trial are presented in Table 34. According to the results in this table, the yield in the VR treatment T1 was 8% higher than the control T2, and the grow costs were 2% lower. As a result, the gross margin per hectare for T1 was 15% higher than T2. However, an ANOVA analysis for this trial did not reveal a statistically significant difference in yield (p-value of 0.23) or PRS (p-value of 0.58) between the two treatments, at the 95% confidence level. On the whole, therefore, the results seem to suggest that there is *at least* no production penalty from adopting the VR system and that it can reduce grow costs per hectare.

Table 34: Tony Bugeja's trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	117.8	16.3	16.5	-2	15
T2 - Control	109.5	16.1	15.1*	0	0

Tony's trial was undertaken on a single block of sugarcane, so that the change in production and gross margin for the related whole-of-farm system is still not known from these trial results. As a result, this analysis has focused on the marginal change in gross margin per hectare for the conversion of the trial block to a VR nutrient regime, but has not considered the additional overheads that are introduced by the VR system at a whole-of-farm level. A VR system would normally introduce additional fixed costs for ECa mapping and agronomic advice that are incurred at one level for the entire farm. These costs represent an economy of scale to a farming operation, which means that the change in farm profitability that is due to the VR system will increase with the number of hectares that are under such a system. The typical values for the additional fixed costs are shown below in Table 35. The ECa mapping component is necessary to establish the management zones for the farm and will typically be undertaken in a staged fashion, with mapping being done on fallow blocks in each year. Once the entire farm has been ECa mapped, the additional on-going fixed costs for the VR system will reduce to just the annual fee for agronomic advice.

Table 35: Additional on-costs required to implement his VR system

Additional cost	Description
EC mapping	$35 per ha
Agronomic advice	10 hours per year

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 36 examines the sensitivity of the change in gross margin between T1 and he control treatment T2. The left column shows a 10% increase or decrease in yield in both treatments T1 and T2, reflecting a seasonal variation, while the right-most columns show price variation in $50 increments. The results in Table 36 show that the VR system (T1) has a higher gross margin than Tony's control treatment (T2) in all cases.

Table 36: Change in gross margin in response to a change in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	18%	16%	15%
	T2	0%	0%	0%
0	T1	16%	15%	14%
	T2	0%	0%	0%
+10%	T1	15%	14%	13%
	T2	0%	0%	0%

Gerry Deguara – North Eton- Farmacist

Gerry normally applies nitrogen on his property at a uniform rate according to the Six Easy Steps approach. In this trial he is investigating an increased rate of nutrient application in the high yielding zones and a decreased rate of nutrient in the low yielding zones. An image of Gerry's block is shown below in Figure 13. The LYZ comprised 29% of the area of this block under the VR application.

Figure 13: Gerry Deguara trial paddock

Gerry is using Liquid One shot, and applies 160 kg N/ha across an entire paddock. In the trial, Gerry will apply a high rate of 170kg/ha in the high yield zone (HYZ) and a low rate of 132 kg N/ha in the LYZ. The levels of other macronutrients (P, K and S) will also be raised and lowered at the new application rates of Liquid One Shot. Gerry's trial is summarised below in Table 37.

Table 37: Gerry Deguara VR of all nutrients on block with two yield zones

No	Description
T1	LOS at 2.9m³/ha in LYZ LOS at 3.7m³/ha HYZ Total Nitrogen = 132kg N/ha LYZ Total Nitrogen = 170kg N/ha HYZ Fertiliser cost/ha =
T2 - Control	LOS at 3.5m³/ha Total Nitrogen = 160kg N/ha Fertiliser cost/ha = $460.60

Results

The economic analysis for this trial is shown below in Table 38, however caution must be used in interpreting these results. Due to gaps in the data provided for this trial, we have had to estimate the yield and PRS for the control treatment based on the production data that were received for the different management zones of the VR system. In most cases, these yield and PRS data pertain to *differentiated nutrient application rates*, and as such the true 'control' information for the trial is not known.

On the basis of the available information, however, an economic analysis for Gerry's trial is shown in Table 38. A slight increase in PRS resulted in a 3% increase in tonnes of sugar/ha under the VR system in T1. Given the drop in fertiliser rates in the LYZ, grow costs decreased by 2%. The reduction in grow costs, combined with a possible small increase in yield and recoverable sugar, resulted in a 27% increase in gross margin. Because of the missing data points for control treatment T2, an ANOVA analysis was not able to be conducted.

Table 38: Gerry Deguara VR trial results

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1	75.2	17.52	11.84	-2	27
T2 - Control	67*	17.00*	11.39*	0	0

* Estimated the control yield and the PRS due to incomplete data.

As with many of the other VR trials in the Game Changer project, Gerry's trial was undertaken on a single block of cane, so that the change in production and gross margin for the whole-of-farm system is not known from his trial results. Consequently, our analysis has focused on the marginal change in gross margin per hectare for the conversion of the trial block to a VR nutrient regime, but has not considered the additional overheads that are introduced by the VR system at a whole-of-farm level. A VR system would normally introduce additional fixed costs for ECa mapping and agronomic advice that are incurred at one level for the entire farm. These costs represent an economy of scale to a farming operation, which means that the change in farm profitability that is due to the VR system will increase with the number of hectares that are under such a system. The typical values for the additional fixed costs are shown below in Table 39. The ECa mapping component is necessary to establish the management zones for the farm and will typically be undertaken in a staged fashion, with mapping being done on fallow blocks in each year. Once the entire farm has been ECa mapped, the additional on-going fixed costs for the VR system will reduce to just the annual fee for agronomic advice.

Table 39: Additional on-costs required to implement his VR system

Additional cost	Description
EC mapping	$35 per ha
Agronomic advice	10 hours per year

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 40 examines the sensitivity of gross margins between treatments. The left column shows a 10% change in yield and the right columns show a $50 variation in the sugar price. The table shows that the VR practice in T1 is more profitable than the control treatment T2 in all scenarios.

Table 40: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	33%	29%	27%
	T2	0%	0%	0%
0	T1	30%	27%	25%
	T2	0%	0%	0%
+10%	T1	28%	26%	24%
	T2	0%	0%	0%

John and Phil Deguara – North Eton- Farmacist

John and Phil Deguara have two variable rate (VR) nutrient trials in the Game Changer project, and we distinguish between them using their paddock identifiers paddock 15_1 and paddock 13_1.

Paddock 15_1 - John and Phil Deguara trial one

John and Phil's usual nitrogen application rate is 155kg N/ha across this paddock. Due to issues with topography and irrigation, areas of the paddock have been identified as high and low yielding zones. This trial has investigated applying a rate of 170kg N/ha in the HYZ and a lesser rate of 130kg N/ha in the LYZ, as shown in Table 41. The HYZ comprised one half of the trial block, and the LYZ made up the remaining half.

Table 41: John and Phil Deguara paddock 15_1 VR trial for two yield zones description

No	Description
T1	Liquid 50/50 at 3.8m3 Urea S at 65kg/ha - LYZ Urea S at 155kg/ha - HYZ Total Nitrogen = 130kg N/ha - LYZ Total Nitrogen = 170kg N/ha - HYZ Total Fertiliser Cost/ha = $413.50
T2 - Control	Liquid 50/50 at 3.8m3 Urea S at 120kg/ha Total Nitrogen = 155kg N/ha Total Fertiliser Cost/ha = $418.66

Figure 14: John and Phil Deguara trial block - Paddock 15_1

Results

The economic analysis for this trial is shown in Table 42. The yield in T1 improved by 7% compared with the control and the grow costs were 1% lower; and the PRS was slightly lower in treatment T1 compared with the control. Overall these trial results lead to a 7% improvement in gross margins for the VR system in treatment T1, primarily driven by the improvement in yield. However, according to an ANOVA analysis of the trial results, there was no statistically significant difference in yield (p-value of 0.17) or PRS (p-value of 0.17) between the two treatments, at a 95% confidence level. More trials are needed, with increased replication with treatment groups, in order to make more robust findings for VR nutrient application at this site.

Table 42: John and Phil Deguara Paddock 15_1 VR application where two yield zones exist

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1	103.5	17.5	18.11	-1	7
T2 - Control	96.9	17.72	17.17	0	0

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 43 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% increase or decrease in treatment yield and the right-most columns show variation in the sugar price in $50 increments. The table shows that the VR system in treatment T1 was more profitable than John and Phil's control practice T2 in all cases.

Table 43: Change in gross margin in response to an increase/decrease in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	7%	7%	7%
	T2	0%	0%	0%
0	T1	7%	7%	6%
	T2	0%	0%	0%
+10%	T1	7%	6%	6%
	T2	0%	0%	0%

Paddock 13_1 - John and Phil Deguara trial two

John and Phil's second trial is a full VR nutrient trial that has varied the application of all the major nutrients throughout the paddock. The variability in the paddock, especially in low yielding areas, is primarily driven by high sodicity (detected from both soil tests and remote sensing data). According to the trials results, this paddock has been split into two yield zones and fertiliser application rates have been varied according to these zones. The nitrogen application rate in the HYZ was 175kg N/ha, and in the LYZ it was 110kg N/ha. The HYZ represents 30% of the paddock area, and the remaining 70% has been classified as a LYZ. This trial design is shown below in Table 44; and an image of paddock 13_1 is shown in Figure 15.

Table 44: John and Phil Deguara paddock 13_1 full VR trial detailed description

No	Description
T1	Spring 1 at 2.7m³/ha – LYZ (70% area) Total Nitrogen = 110kg N/ha Fertiliser Cost for LYZ = $ 269.36 Spring 1 at 4.3m³/ha – HYZ (30% area) Total Nitrogen = 180kg N/ha Fertiliser cost for HYZ = $ 183.85 Total Fertiliser Cost/ha = $ 453.21
T2 - Control	Spring 1 at 3.8m³/ha – Control Total Nitrogen = 160kg N/ha Total Fertiliser Cost/ha = $541.58

Note: A MYZ was identified in the initial description the department received for this trial, however no results were received for that management zone.

Figure 15: John and Phil Deguara trial block - Paddock 13_1

Results

The economic analysis for this trial is shown below in Table 45. The grow costs for T1 were 10% lower than for T2, and the gross margin was 5% higher than T2. There was a slight reduction in yield for the whole paddock from 59.10 t/ha to 58.30 t/ha (i.e. 1%) between the control treatment T2 the VR system in treatment T1. Taken together, the results of this trial suggest that there is minimal yield penalty due to the VR technology, and savings in fertiliser costs may generate improvements in farm gross margin. However, incomplete data was obtained for this trial, and in order to undertake the economic analysis we have had to estimate the control yield and PRS. Control yield has been estimated using zonal yields for the HYZ and the LYZ in each of the 2013 and 2014 seasons, which were provided to the department as part of the trial results. We were also required to estimate the PRS under the VR system (i.e. T1), and we have assumed that there has been no change in this measure in order to proceed with our analysis. The findings in this section, however, should be treated with caution.

Table 45: John and Phil Deguara paddock 13_1 full VR trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1	58.30	14.57**	8.50	-10	5
T2 - Control	59.10*	14.57	8.61	0	0

* Control yield is the average of 2013 and 2014 yields for the control practice.
** Assumed no change, based on discussions with the project agronomist.

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 46 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% increase or decrease in treatment yields and the right-most columns show variation in the sugar price in $50 increments. For all scenarios, the table shows that treatment T1 had a higher gross margin than the control T2.

Table 46: Change in gross margin in response to an increase/decrease in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	16%	12%	10%
	T2	0%	0%	0%
0	T1	8%	5%	4%
	T2	0%	0%	0%
+10%	T1	6%	4%	3%
	T2	0%	0%	0%

Additional on-costs and the whole-of-farm system

As with many of the other VR trials in the report, John and Phil's trials have related to individual blocks of sugarcane, so that the change in production and gross margin for the whole-of-farm system is still not known from their trial results. As a result, the analyses presented here have focused on the change in gross margin per hectare for the conversion of the trial block to a VR nutrient regime, but have not considered the additional overheads that are introduced by the VR system at a whole-of-farm level. A VR system would normally introduce additional fixed costs for ECa mapping and agronomic advice that are incurred at one level for the entire farm. These costs represent an economy of scale to a farming operation, which means that the change in farm profitability that is due to the VR system will increase with the number of hectares that are under such a system. The typical values for the additional fixed costs are shown below in Table 47. Please note that the ECa mapping component is necessary to establish the management zones for the farm and will typically be undertaken in a staged fashion, with mapping being done on fallow blocks in each year. Once the entire farm has been ECa mapped, the additional on-going fixed costs for the VR system will reduce to just the annual fee for agronomic advice.

Table 47: Additional on-costs required to implement his VR system

Additional cost	Description
EC mapping	$35 per ha
Agronomic advice	10 hours per year

John Fox – Calen – Farmacist

Traditionally John applies nitrogen on his property at a constant rate, determined under the Six Easy Steps approach. In this trial, John is testing the feasibility of a VR system for nitrogen application on ratoon cane on his farm, and he is hoping that reducing fertiliser application in low yielding areas will not only save him money, but will maintain yields and improve the quality of water leaving his farm. John's current rate of nutrient application is 155 kg N/ha. He is trialling increasing this rate to 180 kg N/ha in the HYZ, and decreasing it to 135 kg N/ha in the LYZ. In John's trial, the HYZ comprises half of the trial paddock and the LYZ occupies the remaining half. A description of this trial is presented below in Table 48.

Table 48: John Fox reduced nitrogen for varying yield zones

No	Description
VR system	LOS+P at 3m³/ha (50% of the paddock) – LYZ LOS+P at 4m³/ha (50% of the paddock) - HYZ Total Nitrogen = 135kg – LYZ Total Nitrogen = 180kg - HYZ Fertiliser cost = $495/ha
Control	LOS+P at 3.4m³/ha Total Nitrogen = 155kg Fertiliser cost = $481/ha

Figure 16: John Fox's variable rate trial paddock

Results

The Game Changer economic analysis is presented below in Table 49. Caution should be exercised in interpreting these results, since the Control treatment consisted of just two replicates and this meant that some estimates have been necessary in order to undertake our economic analysis. The results show the grow costs for the VR system were 2% higher than the control practice; which translated to a 7% drop in gross margin, when compared to the Control practice. This change in gross margin mostly reflects the production differences between the Control and VR systems. However, John has observed that dry weather conditions affected the sugarcane in this trial, so that it struggled to perform during the season.

Table 49: John Fox Variable Rate trial results

Treatment	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
VR system	77.8	16.5	12.8	2	-7
Control	79.4*	16.8*	13.3*	0	0

* Only two replicates available in the trial and the average of these two replicates has been used to estimate the third replicate for the Control practice.

Table 49 above shows that the VR system in John's trial marginally increased grow costs, and this was due to the historial nutrient application on the trial block being greater than the average nutrient application for the VR system. This is not generally the case for VR systems, which will normally deliver a reduction in nutrient use as the previous uniform application rate is lowered to match the nutrient requirement of the sugarcane in low yielding areas. To further understand John's results, therefore, we have undertaken an analysis of the change in gross margin per hectare within each of the management zones on John's block. This analysis is presented below in Table 50.

Table 50: John Fox Variable Rate trial results

Management Zone	Treatment	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
LYZ	VR system	62	16.35	10.1	-7	-3
	Control	66	16.15	10.7		
HYZ	VR system	94	16.69	15.7	10	-10
	Control	93	17.49	16.3		

As can be seen from Table 50 above, the VR system has reduced grow costs in the LYZ (7%) and increased grow costs in the HYZ (10%) as expected. However, the system has also resulted in a decline in gross margin per hectare for the land under each management zone (i.e. a drop of 3% in the LYZ and 10% in the HYZ). In the LYZ this decline was due to a drop in yield under the VR system, and in the HYZ the decline resulted from a combination of higher fertiliser costs (i.e. an increase the application rate under VR) and a drop in CCS. While these results show that the VR system has not improved gross margin on John's trial block, they also demonstrate the reduction in grow costs that has been achieved within the low yield management zone. If there is no statstically significnat diffenrece in yield after the VR system has been introduced, then John's trial results both illustrate the beednfits of reduced fertilier application in the LYZ and also that it has not been necessary to increasse fertilsier application in the HYZ for this trial block.Because of low replication in the Control practice, an ANOVA analysis was not undertaken for the VR trial. However, given our assumed data points (as described in the note to Table 49 below), an analysis can be made of the production differences that would be needed for the VR system to meet the gross margin of the Control practice. The VR system would need to yield an extra 4.29 t/ha (i.e. 5%) or 0.56 units of PRS (i.e. 3%), above the values that have been measured in the trial, for the gross margin per hectare for this practice to match the Control treatment. Therefore, given that the typical harvester losses in sugarcane can range from 5 to 15% (Sugar Research Australia 2013), the observed yield and PRS differences in John's trial are not large enough to indicate a clear difference in production for the VR system.

Finally, John's trial was undertaken for a single block of his sugarcane farm. The change in production and gross margin for the whole-of-farm system is still not known from his trial results. As a result, our analysis has focused on the change in gross margin per hectare for the conversion of the trial block to a VR nutrient regime, but has not considered additional fixed costs that are associated with the VR system at the whole-of-farm level. A VR system would normally introduce costs for ECa mapping and agronomic advice that are incurred at a whole-of-farm level. These costs represent an economy of scale to a farming operation, so that the change in farm profitability that is due to the VR system will increase with the number of hectares that are under the system. Typical values for these additional fixed costs are shown in Table 51. The ECa mapping component is necessary to establish the management zones for the farm and will typically be undertaken in a staged fashion, with mapping being done on fallow blocks in each year. Once the entire farm has been ECa mapped, the additional on-going fixed costs for the VR system will reduce to just the annual fee for agronomic advice.

Table 51: Additional on-costs required to implement his VR system

Additional cost	Description
EC mapping	$35 per ha
Agronomic advice	10 hours per year

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 52 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% increase or decrease in treatment yields and the right-most columns show variation in the sugar price in $50 increments. The table shows that the Control practice was more profitable than the VR system in all scenarios.

Table 52: Change in gross margin in response to a change in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	VR system	-8%	-7%	-7%
	Control	0%	0%	0%
0	VR system	-8%	-7%	-7%
	Control	0%	0%	0%
+10%	VR system	-7%	-7%	-6%
	Control	0%	0%	0%

Diffusion of the VR System in the Mackay-Whitsunday Region

Using data provided by Reef Catchments, Figure 17 below presents an investigation of the diffusion of the zonally-applied VR nutrient technology in the Mackay-Whitsunday region. The linear series shows the number of farms under VR nutrient in each year, and the bar graphs shows the area under VR nutrient in each year. The data have been used to fit a Bass diffusion model. The dashed linear and hollow bar series represent out-years, which have been projected according to the fitted diffusion curve. The Bass model is usually for fully developed technologies; and since VR system is still 'under investigation' in sugarcane growing, the diffusion analysis presented below represents the adoption dynamics at the current point in time.

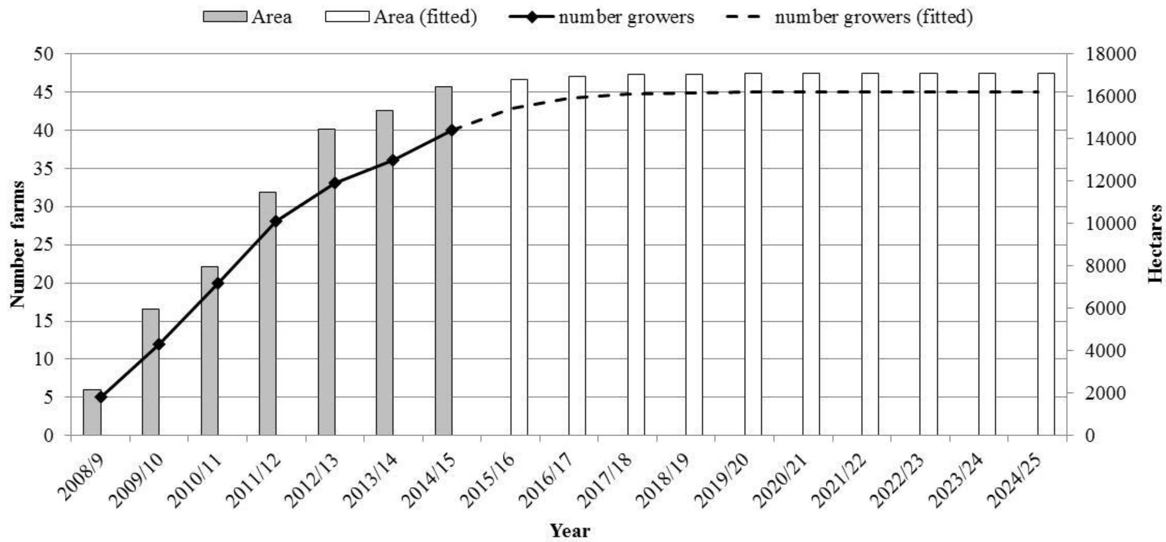

Figure 17: Bass model diffusion cure fitted to adoption data provided by Reef Catchments for the Mackay-Whitsunday region.

The estimated coefficients are in the Bass diffusion model are shown in Table 53 below

Table 53: Estimation results for diffusion model

Parameter	Fitted value (std. err)
Coefficient of innovation, p	0.08 (0.02)*
Coefficient of imitation, q	0.54 (0.12)*
Current market (growers)	45 (4.02)*

Notes: *- significant at 1%; ** - significant at 5%; *** - significant at 10%.

In the Bass diffusion model, the coefficient of innovation (p) measures the propensity for self-motivated propensity for adoption among growers; and the coefficient of imitation (q) represents the propensity for copy-cat adoption, i.e. where people mimic a neighbour or other member of the target group known to them. Typical values for these coefficients are 0.03 and 0.38, respectively, so that the values estimated in Table 53 are high by comparison. However, this is most likely due to the fitted market potential (i.e. ‘current market’) being just 45 growers, so that the ‘market’ potential is fully met by the end of the analysis period in Figure 17; so that there are no more growers projected to take up the technology under the diffusion process investigated here.

The results in Table 53 suggest a key issue in relation to the depth of penetration for this type of technology in the Mackay-Whitsunday region. In an agricultural context, this type of problem is often due to a number of factors, including: risks induced by the brevity of trials; the ‘option value’ for farmers in delaying adoption events; as well as the role of social networks in the communication and dissemination of data among growers. The ‘option value’ associated with a farmer’s decision to trial a new technology refers to the natural benefit farmers accrue from delaying an adoption event and waiting to observe the technology in practice on another farmer’s property. This gives information about the technology and its effectiveness without the farmer having to incur the economic cost of trialling it themselves. A social network refers to the structure of social interactions and personal relationships within a population. In the case of the Mackay-Whitsunday sugarcane farming region, it may be that the existing social networks in the farming community may be influencing the penetration of new farming technologies. These connections are important for the communication of ideas, and understanding and working with these existing networks may have a key role to play in improving the penetration of innovative technologies. There is a continued need to foster regional networks that are both trusted by growers, and which support the uptake of precision technologies

Use of enhanced efficiency urea

Ratooning sugarcane blocks generally receive their nutrient in one uniform application, shortly after harvest. However, the combination of soil properties and wet season rainfall means that there is a significant risk of nutrient loss within this system. Enhanced efficiency urea products, also known as controlled release urea (CR-Urea), potentially offer the opportunity to better match nitrogen supply to plant growth needs, therefore increasing NUE on farms. These products release nutrient gradually over a longer period of time that conventional fertiliser blends. By having access to more nutrients in the later stages of the growing season the plant will hopefully add more biomass and increase sugar content.

Daryl Thomsett – Koumala – Farmacist

Daryl is trialling a combination of CR-Urea and liquid fertiliser on late harvest ratoons in order to compare this to his usual practice of applying MKY190P on these crops. Late harvest ratoons have a shorter growing season before the next cut, so that the plant cane has less time to process the nutrients into biomass and sugar. In this trial, Daryl is looking to see if a lower rate of nitrogen delivered via a liquid product will still ensure vigorous early season growth, while the new CR-Urea product will support increased growth throughout the season. He is hoping that this combination of CR-Urea and conventional urea will also increase NUE and thereby reduce the potential for applied nutrients to move offsite. The trial design for Daryl Thomsett is shown in Table 54, and an image of the trial block is presented in Figure 18. As shown in treatment T2, Daryl’s normal practice is to apply liquid fertiliser (MKY190P) in one application after harvest for a total nitrogen application rate of 168kg N/ha. Daryl has trialled a reduction in this rate to 120kg N/ha using the blend of CR-Urea and conventional urea, as is shown in treatment T1.

Table 54: Daryl Thomsett trial design

No	Description
T1	Soy Starter at 3.7m³/ha CR-Urea at 300kg/ha (25% Agrocote, 75% Urea) Total Nitrogen = 120kg N/ha Total Fertiliser Cost/ha = $611.03
T2 - Control	MKY190P at 4.2m³/ha Total Nitrogen = 168kg N/ha Total Fertiliser Cost/ha = $527.56

Figure 18: Daryl Thomsett trial block

Results

The economic analysis for this trial is shown below in Table 55. The grow costs for T1 were 19% higher than T2, primarily due to the added cost of the granulated fertiliser and application. Liquid fertilisers have been applied using contract services, and the granular CR-Urea and conventional urea mix had to be applied manually using a fertiliser box. However, according to our analysis, the higher grow costs for the CR-Urea treatment only reduced gross margin per hectare by 2%. The NUE increased as a result of the CR-Urea practice in T1, although an ANOVA test did not find a statistically significant difference in yield between the two treatments (p-value of 0.67).

The analysis presented in this subsection should be treated with caution, and considered highly contingent on the actual CCS of the cane with and without the use of this CR-Urea product. No CCS data was available for this trial, and our analysis has been undertaken on the basis of the assumed values identified in Table 55. We have assumed no change in the CCS as a result of the enhanced efficiency urea; but in reality, the increased availability of nitrogen later in the growing season may mean that the sugar content is higher. Further trials, with more replicates would be of benefit to understanding the economic implications of the agricultural practice being trialled by Daryl on this site.

Table 55: Daryl Thomsett trial results

No	t/ha	CCS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1	85	15*	12.75	19	-2
T2 - Control	83	15*	12.45	0	0

* Assumed CCS, based on advice from the project agronomist.

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 56 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% increase or decrease in treatment yields and the right-most columns show variation in the sugar price in $50 increments. In all scenarios, this table shows that T2 is more profitable than T1.

Table 56: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	-4%	-2%	-2%
	T2	0%	0%	0%
0	T1	-3%	-2%	-1%
	T2	0%	0%	0%
+10%	T1	-2%	-1%	-1%
	T2	0%	0%	0%

Joe Muscat – Oakenden- Farmacist

Joe is trialling the effect of using enhanced efficiency urea on sandy soils. Nutrients in sandy soils, particularly nitrogen, are readily leached in significant rainfall events and could potentially end up in the GBR. These soils are prone to leaching nutrient due to their low clay content. Joe hopes that by utilising an enhanced efficiency urea, nutrients can be made more stable and remain in the soil profile for longer, thus increasing Joe's NUE on his farm. An image of Joe Muscat's block for this trial is shown in Figure 19. Table 57 presents a description of the trial design on Joe's block. The control treatment T1 represents Joe's usual practice of applying nitrogen at the rate of 184kg N/ha using

Urea S and Lo N Planter. Joe has dropped this rate to 135 kg N/ha in treatment T2, where he applies a 25% Agrocote urea blend together with Lo N Planter. This represents a 26% drop in nitrogen application.

Table 57: Joe Muscat Enhanced efficiency urea on sandy soil

No	Description
T1- Control	Urea S at 336.48 kg/ha Lo N Planter at 4.2m³ Total Nitrogen=184 units Total Fertiliser Cost/ha=$579.22
T2	Urea/Agrocote 25% at 203.36kg/ha Lo N Planter 4.2m³ Total Nitrogen=135 units Total Fertiliser Cost/ha = $766.93

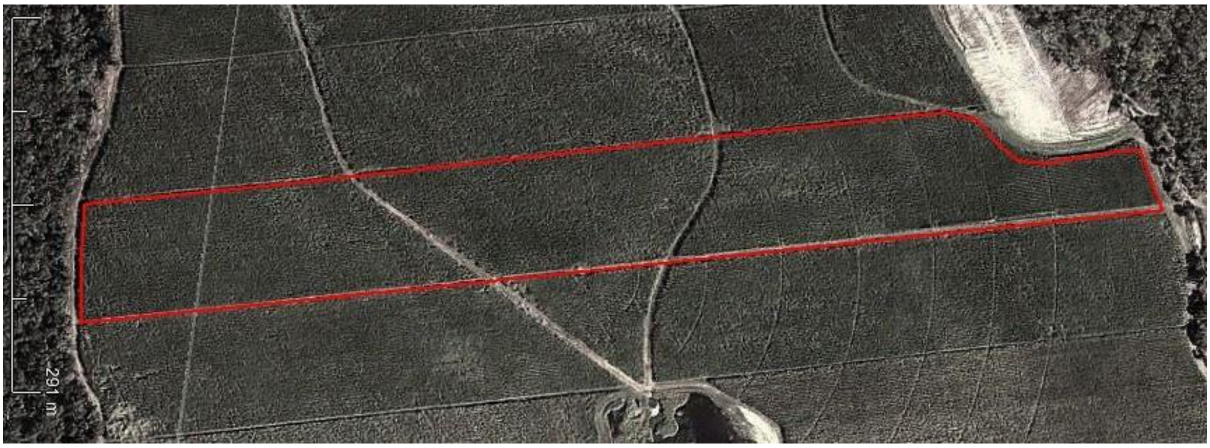

Figure 19: Jo Muscat's trial block

Results

The economic analysis for this trial was is shown below in Table 58. These results show negligible difference in yield, PRS, grow costs and gross margin between treatments T1 and T2. The reduction in nitrogen application in T2 compared with T1 has increased NUE, however because of the higher price of the Agrocote product, the grow costs have increased by 16.14%, and the gross margin has decreased by 5.81%. An ANOVA analysis of the trial results has indicated no statistically significant difference between yield (p-value of 0.43) and PRS (p-value of 0.73) for this trial (at the 95% confidence level), however the increased grow costs for the enhanced efficiency urea treatment T2 would still indicate that Joe's control treatment T1 is economically optimal.

Table 58: Joe Muscat trial results

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1 - Control	90.2	18.7	17.2	0	0
T2	88.9	18.9	16.8	16.14	-5.81

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 59 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% change in yield and the right-most columns show variation in the sugar price (in $50 increments). The table shows that the enhanced efficiency urea treatment T2 was less profitable than Joe's normal practice T1 for all cases of the table.

Table 59: Change in gross margin in response to an change in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	-8.59%	-6.85%	-5.70%
0	T1	0%	0%	0%
	T2	-7.19%	-5.81%	-4.88%
+10%	T1	0%	0%	0%
	T2	-6.18%	-5.05%	-4.27%

Blackburns – North Eton - Mackay Area Productivity Services

The Blackburn's are investigating the productivity, profitability and change in NUE between four different fertiliser products on predominantly sandy soils in North Eton, Queensland. These products are: Reef Choice 329, Reef Choice 329 with 50% of the nitrogen from Agrocote, Reef Choice 329 with 25% of the nitrogen from Agrocote and CK140S with Entec coating. The nutrient application rates that have been used in this trial correspond to 100%, 90% and 80% of the Six Easy Steps nutrient regime for nitrogen: Reef Choice 329 at 170 kg N/ha corresponds to 100% of the Six Easy Steps rate, while the application rate for CK140S at 151 kg N/ha equates to 90% of the Six Easy Steps rate; and Reef Choice Blends of 25% and 50% Agrocote at 136 kg N/ha correspond to 80% of the Six Easy Steps rate. By varying the rate (kg/ha) of Reef Choice fertiliser and CK140S, the proportion of phosphorus, potassium and sulfur are also varied. The trial key parameters and trial description are presented below in Table 60 and the trial paddock is pictured in Figure 20.

Table 60: Treatment and fertiliser key parameters

Trial Number	Product	Rate Kg/ha	% of Six Easy Steps and rate in kg/ha	Nutrient status
T1 – Control	Reef Choice 329	680	100% - 170 kg/ha (N) 11 kg/ha (P) 127 kg/ha (K) 25 kg/ha (S)	N:24.8 - P:1.6 - K:18.6 - S:3.7
T2	Reef Choice 329 50% Agrocote	620	80% - 136kg/ha (N) 11 kg/ha (P) 129 kg/ha (K) 26 kg/ha (S)	N:22 - P:1.8 - K:20.8 - S:4.2
T3	Reef Choice 329 25% Agrocote	630	80% - 136kg/ha (N) 11 kg/ha (P) 131 kg/ha (K) 27 kg/ha (S)	N:22.1 - P:1.8 - K:20.8 - S:4.3
T4	CK140S Entec	660	90% - 151kg/ha (N) 13 kg/ha (P) 116 kg/ha (K) 25 kg/ha (S)	N:23.23 - P:2.0 - K:17.5 - S:3.76

Figure 20: Trial paddock on Blackburn's farm North Eton

Results

The results from the economic analysis are shown below in Table 61. These results show that T3 and T4, i.e. Reef Choice 329 with 25% Agrocote and CK140S (Entec), represent the best economic outcomes for the grower. T3 had a 9% higher gross margin than the control treatment T1, while T4 had an 8% higher gross margin than T1. The highest yield of all treatments was observed for T2, and in this treatment the higher cost of the 50% Agrocote blend was outweighed by increased production for a 2% improvement in gross margin relative to T1. The highest gross margin was observed for the 25% Agrocote treatment T3, followed closely by the Entec treatment T4. An ANOVA analysis did not reveal a statistically significant difference in yields (p-value of 0.22) or PRS (p-value of 0.69) between the four treatments (at a 95% confidence level); so that it cannot be said with confidence that the production outcomes for the 25% Agrocote treatment in T3 will be superior to those in the control treatment T1. Given this, the Entec practice in T4 may be economically optimal, since it represents a 2% reduction in grow costs in comparison to the control T1.

Table 61: Blackburn's trial results

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1 – Control	89.71	16.48	14.78	0	0
T2	96.11	16.29	15.65	12	2
T3	95.03	16.64	15.81	4	9
T4	93.03	16.53	15.38	-2	8

Sensitivity Analysis

Table 62 presents a sensitivity analysis of the Blackburn's Game Changer trial. The sensitivity analysis shows the percentage change in gross margin for the Blackburn's property for a 10% increase or decrease in treatment yields (due to seasonal factors) and a $50 increase or decrease in the price of sugar. The most profitable treatment is highlighted in each cell of the table. In all cases the treatment T3 is at least as profitable as the other treatments, and in majority of cases it is more profitable. Since there is no statistically significant difference in yield or PRS between the four treatments, however, it remains possible that T4 is optimal due to its cost effectiveness.

Table 62: Change in gross margin in response to a change in yield and sugar price

Yield	Treatment	Cane price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	-1%	1%	2%
	T3	10%	10%	9%
	T4	10%	8%	8%
0	T1	0%	0%	0%
	T2	1%	2%	2%
	T3	10%	9%	9%
	T4	9%	8%	7%
10%	T1	0%	0%	0%
	T2	1%	2%	3%
	T3	9%	9%	9%
	T4	8%	7%	7%

Rate of ameliorant application

Changing ameliorant application to improve nitrogen use efficiency

Two growers in the Game Changer project are investigating the use of ameliorant application to improve the health of soils to achieve increased NUE. During excessively wet conditions, high soil sodicity will cause the clay particles in the soil to swell and separate from the soil aggregates. This destabilises the soil structure, so that the sand and silt also separate, which results in the dispersion of soils. Dispersive soil hardens during drying to form a crust which blocks the soil pores. This restricts the movement of air and water through the soil, and inhibits the root penetration of plants. This is an issue for sugarcane crops, which rely on biological and chemical processes that are supported by aeration and water content of the soils, as well as nutrient availability from the soil colloid. Calcium, liming material, gypsum, compost and other ameliorants can be applied to address problems of sodicity and improve pH, tilth, nutrient availability and general soil health. No results were received by the DAF economics team for either of these trials, and the analyses presented in this subsection have been based on the trial designs.

Tony Large - Proserpine – Farmacist

Tony Large is investigating mill mud application with ameliorants and liquid fertiliser to improve his soil health and consequently also NUE. Tony's soil has a low pH that has resulted in high aluminium levels; and soil samples taken from his low yielding areas have indicated potential calcium deficiency. Tony's ameliorant trials were designed to address this. Using MKY170, he is trialling two rates of nitrogen - 170kg/ha and 140kg/ha – and is also investigating the different ameliorant products Calcipril, Gypsum and CalMag.

Table 63: Tony Large compare differing nitrogen application rates on blocks with differing ameliorant treatments

No	Description	No	Description
T1	Mud at 102t/ha MKY170 at 3.2m^3/ha Calcipril at 1t/ha Total Nitrogen = 170kg N/ha Fertiliser Cost = $1392.60/ha	T1.1	Mud at 102t/ha MKY170 at 2.5m^3/ha Calcipril at 1t/ha Total Nitrogen = 140kg N/ha Fertiliser Cost = $1313.50/ha
T2	Mud at 102t/ha MKY170 at 3.2m^3/ha Gypsum at 1t/ha Total Nitrogen = 170kg N/ha Fertiliser Cost = $1482.60/ha	T2.1	Mud at 102t/ha MKY170 at 2.5m^3/ha Gypsum at 1t/ha Total Nitrogen = 140kg N/ha Fertiliser Cost = $1403.50/ha
T3	Mud at 102t/ha MKY170 at 3.2m^3/ha CalMag at 1t/ha Total Nitrogen = 170kg N/ha Fertiliser Cost =$1590.60/ha	T3.1	Mud at 102t/ha MKY170 at 2.5m^3/ha CalMag at 1t/ha Total Nitrogen = 140kg N/ha Fertiliser Cost =$1511.50/ha

Results

We have undertaken consultation with Tony in relation to his usual farming practices, and the department's farming system model (i.e. FEAT) has been used to undertake the analysis in this section. Unfortunately Tony was unable to harvest his trial, and this was largely due to an outbreak of Yellow Canopy Syndrome after planting, and also because of the poor performance of the Q242 sugarcane variety in the soil type of his block. While no results were received for Tony's ameliorant application trial, we have undertaken informal discussions with Tony in relation to his trial, and present an analysis here that is based on the proportionate change in grow costs per hectare between his six treatments. Our analysis is shown below in Table 64. From this table it can be seen that the greatest reduction in grow costs occur for treatment T1.1, i.e. Mill Mud and Calcipril combined with a low rate of MKY170. This is almost double the next greatest reduction in grow costs, which occurs for treatment T2.1 and also for treatment T1. These treatments relate to the use of Gypsum with a low rate of MKY170 and Calcipril with a high rate of MKY170, respectively, and both reduce grow costs by approximately the same amount relative to Tony's normal practice. The treatments T3 and T3.1, both of which relate to the CalMag product, have increased grow costs.

Table 64: Tony Large results

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1	-	-	-	-6	-
T1.1	-	-	-	-11	-
T2 - Control	-	-	-	0	-
T2.1	-	-	-	-5	-
T3	-	-	-	7	-
T3.1	-	-	-	2	-

Tony Jeppesen – Bloomsbury – Farmacist and Sugar Services Proserpine Limited

Tony Jeppesen is investigating compost as a way to increase NUE by improving the health of his soil. Tony's trial design is shown below in Table 65. Tony is applying base rates of liquid fertiliser at plant, and is trialling three compost treatments: no compost (T1), compost applied at 5t/ha (T2) and compost at 10t/ha (T3). He hopes that the compost will aid in nutrient cycling, and will improve NUE, offering a buffer when the cane season suffers climatic variation. Tony is applying nutrient to plant cane at the rate of 180 kg N/ha using the 'Spring 1' fertiliser product.

Table 65: Tony Jeppesen using compost to improve nitrogen use efficiency

No	Description
T1 -Control	No Compost 4m³ Spring 1 $131.13/m³ 80L/ha Flowphos 1.80/L Total Nitrogen = 180kg N/ha Total Fertiliser Cost/ha = $668.52
T2	5t Compost 4m³ Spring 1 $131.13/m³ 80L/ha Flowphos 1.80/L 5t/ha compost $280 Total Nitrogen = 180kg N/ha Total Fertiliser Cost/ha= $948.52
T3	10t Compost 4m³ Spring 1 $131.13/m³ 80L/ha Flowphos $1.80/L 10t/ha compost $560 Total Nitrogen = 180kg N/ha Total Fertiliser Cost/ha= $1228.52

Results

Economic data was collected for Tony's farm was undertaken early in the Game Changer project. However, during the growing season it was clear that there was no difference in the three treatments, and following discussions with the project agronomists from Farmacist and also Plane Creek Productivity Services, it was decided to scrap the trial on the basis that it would be too costly to proceed to harvest. Consequently no production data was available for Tony's trial. However, on the basis of the trial design, we have been able to undertake a cost-minimisation analysis for the three treatments. Since there was no observed difference in production between the three treatments, our analysis most likely also reflects the changes in gross margin per hectare for the trial. The results are shown below in Table 66.

Table 66: Tony Jeppesen's ameliorant results

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1 - Control	-	-	-	0	-
T2	-	-	-	42	-
T3	-	-	-	84	-

As shown in Table 66, there is a significant increase in grow costs for treatments T2 and T3, in which the compost is applied at plant time on Tony's farm. Assuming that there has been no production difference between these three treatments, as would be indicated from Tony's observations, Tony would need to reduce his grow costs in some other area(s) of his operation in order to meet the added cost of his compost treatments. This may prove difficult given that Tony is already a very efficient operator.

Efficacy of buried or surface (banded) mill mud application

Dennis and John Werner- Septimus- Farmacist

Mill mud, a by-product of the milling process, has long been used in the sugar industry as a source of nitrogen, phosphorus, potassium and sulfur. Traditionally, mill mud is applied at the stool, on the surface of each row. In this trial, John and Dennis Werner are investigating the sub-surface application of mill mud. The Werners have built a precision sub-surface mill mud applicator that will place mud in a side dress position to the sugarcane stool. The Werner's aim to use mill mud as a partial nutrition source for their crop, and will top up the remaining nutrient gap with a commercial granulated fertiliser. They are looking to see whether the sub-surface application of mill mud will have any yield benefits compared to the conventional surface applied technique. The trial is summarised in Table 67; and as can be seen from this table, both treatments in this trial apply 122kg N/ha to the standing crop, and differ only in the application method. The Werner's trial block is shown in Figure 21. Mill mud banded atop the stool, followed by heavy rain, may result in losses to the environment, and mill mud in direct contact with the stool may also cause germination and growth stunting due to root burn off. It is also possible that the sub-surface application will lower extraneous matter during harvesting as a result of reduced surface roots, which will be a benefit in comparison to the banded approach.

Figure 21: Werner trial location

Table 67: Werner's treatment and site description

No	Description
T1 - Control	Surface applied mill mud 450kg Nitra king S $ 311.40/ha
T2	Sub-surface applied mill mud 450kg Nitra King S $311.40/ha

Results

The economic analysis for this trial is shown below in Table 68. These results indicate a 7% lower gross margin for the sub-surface treatment T2, which was driven by the yield and PRS results for the trial. There was a reduction in NUE for the buried treatment T1, although this trial has only been going for one season and further trials would be needed confirm this result. An ANOVA analysis of the trial data did not indicate a statistically significant difference in yield (p value of 0.43) or PRS (p value of 0.73) between treatments T1 and T2 at the 95% confidence level; suggesting that the observed differences in yield and PRS for the trial may just reflect statistical variation. The Werners' mill mud applicator cost approximately $50,000 to build. In order to break-even on this capital outlay, in net present value terms over a 10 year period, and assuming a 7% per annum real discount rate, the sub-surface application technology would need to yield an additional 204.45 t/ha or 185.86% over and above the yield observed for treatment T2 in this trial.

Table 68: Werners' comparison of banded surface applied mill mud to banded sub surface applied mill mud.

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1 – Control	113	16.00	17.93	0	0
T2	110	15.85	17.56	0	-5

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 69 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% change in yield and the right-most columns show variation in the sugar price (in $50 increments). The table shows that the control treatment T1 remained more profitable than sub-surface application T2 in all cases.

Table 69: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	-5%	-5%	-5%
0	T1	0%	0%	0%
	T2	-5%	-5%	-5%
+10%	T1	0%	0%	0%
	T2	-5%	-5%	-4%

Pesticide trials

Comparison and efficiency of knockdown and residual herbicides on in-crop weeds

Residual herbicides that inhibit photosynthesis at Photo System II (PSII) mode of action have been identified as a significant risk for the Great Barrier Reef, and are also detected in significant quantities in the Mackay Whitsunday region. These trails aim to reduce the potential for the offsite movement of PSII herbicides by reducing the level of spraying, being more strategic with the application of sprays or eliminating PSII herbicide use altogether.

Rod Hindle – Carmila – Farmacist – Plane Creek Catchment

Rod is evaluating the use of knockdown herbicides, instead of residual herbicides, in fields that generally have low weed pressure. Rod normally applies Velpar K4 in his ratoon cane, a PSII inhibiting residual herbicide containing Diuron (468g/L) and Hexazinone (132g/L). In this trial Rod is investigating the use of the knockdown herbicide Gramoxone on his block shown in Figure 22. The trial has compared Rod's usual practice of boom spraying Velpar K4 (treatment T1) at a cost of $59.70/ha, with the directed spray of Gramoxone (treatment T2) at a cost of $17.64/ha. These treatments are shown below in Table 70.

Figure 22: Rod Hindle's trial block

Table 70: Rod Hindle treatment description

No	Description
T1 - Control	Velpar K4 (boom spray) – 3kg/ha Cost = $59.70/ha
T2	Gramoxone (directed spray) – 1.5L/ha Cost = $17.64/ha

Results

The economic analysis for this trial is shown below in Table 71. The trial results for this grower indicate an improvement in gross margin per hectare *for the trial block during the trial year*. The knockdown application in treatment T2 represented a 6% reduction in grow costs when compared to treatment T1, which translated to a 3% improvement in gross margin. However, because of Rod's exceptional past management, this block turned out to be free of weeds in the trial year. As such, it would not be appropriate to generalise these results to other farms, or even other blocks within Rod's farm, where weed pressure has been historically higher.

Also, in terms of future trials, it is worth noting that yield and CCS may be poor proxies for effective weed control. Collecting weed counts in transects on the trial block over a prolonged period of time might allow for an economic analysis that would provide more functional information required by farmers in implementing a cost effective weed management strategy.

Our ANOVA analysis indicated no statistically significant difference in yield (p-value 0.97) and CCS (p-value 0.63), at the 95% confidence level. However, conducting more trials with greater replication within treatment groups would increase the power of statistical tests to detect smaller differences in yield and CCS.

Table 71: Rod Hindle trial results

No	t/ha	CCS	ts/ha	% Change Grow Cost	% Change GM/ha
T1 - Control	79.6	17.7	14.1	0	0
T2	79.7	17.8	14.2	-6	3

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 72 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% change in yield and the right-most columns show variation in the sugar price (in $50 increments).The table shows that the knockdown treatment T2 is more profitable than the control practice T1 in all cases.

Table 72: Change in gross margin in response to an increase/decrease in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	4%	3%	3%
0	T1	0%	0%	0%
	T2	3%	3%	3%
+10%	T1	0%	0%	0%
	T2	3%	3%	2%

Kevin Grech – Sarina – Farmacist – Plane Creek Catchment

Kevin is investigating the use of knockdown herbicides as opposed to residuals herbicides in fields with low weed pressure. The trial was undertaken in a 6th ratoon block with low weed pressure, and is summarised below in Table 73. Kevin generally applies Velpar K4 on his ratoon cane, a PSII inhibiting residual herbicide that contains Diuron (468g/L) and Hexazinone (132g/L). Instead of this product, Kevin is considering the use of a knockdown herbicide consisting of 1L/ha Gramoxone (i.e. Paraquat at 250g/L) and 1.2L/ha Zephyr (i.e. 2,4-Diuron at 625g/L). No capital investment has been required for Kevin to undertake his trial, and it is anticipated that using the knockdown will clean the block and not affect the efficacy of weed control. An image of Kevin's block is shown below in Figure 23.

Table 73: Kevin Grech site and treatment description

No	Description
T1 - Control	Velpar K4 (boom spray) - 3kg/ha - $52.20/ha
T2	Gramoxone (directed spray) - 1L/ha - $11.76/ha 2,4-Diuron (directed spray) - 1.2L/ha - $7.14/ha

Figure 23: Grech trial paddock

Results

During the growing season no visual difference between the two treatments was evident, however when the harvest was cut there was a one tonne difference in yield. The PRS was not recorded for the trial, so that the figures presented below in Table 74 were assumed (based on discussions with the project agronomist) for the purpose of this analysis. The results show that T2 had a 2% lower growing cost than T1, but that there was no improvement in gross margin in that treatment. Because the trial was not replicated it has not been possible to conduct a statistical analysis on these results. However, it the small difference in yield between treatments T1 and T2 probably reflects statistical variation, and on this basis the lower grow costs for the knockdown treatment T2 will most likely prove more cost effective in the long run.

Table 74: Kevin Grech trial results

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1 - Control	84	14.48*	12.16	0	0
T2	83	14.48*	12.02	-2	0

* Assumed PRS, based on advice from the project agronomist.

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 75 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% change in trial yields and the right-most columns show variation in the sugar price (in $50 increments). The table shows that the knockdown treatment T2 remains more or less as profitable as the residual herbicide treatment T1 for the majority of these cases. The treatment T2 performs slightly worse than Kevin's normal practice of residual herbicide application in the case of either an increase in the sugar price, or an increase in the sugar price and yield, relative to the base scenario highlighted in red.

Table 75: Change in gross margin in response to a change in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	0%	0%	0%
0	T1	0%	0%	0%
	T2	0%	0%	-1%
+10%	T1	0%	0%	0%
	T2	0%	0%	-1%

Shielded sprayer versus conventional boom for weed control

A number of growers in the Game Changer project have investigated using shielded sprayer units to reduce their reliance on PSII and acetolactate synthase inhibitor mode of action herbicides, which have been identified as posing an environmental health risk for the Great Barrier Reef. These units allow a grower to spray over both the sugarcane and the inter-row, with different products, in a single pass, which in turn saves the grower's time and labour costs, and reduces repairs and maintenance on machinery, therefore offers the potential for economic improvements. These trials aim to both improve farming efficiency and encourage better environmental outcomes for the Great Barrier Reef.

Wayne Schmidtke – Plane Creek Productivity Services

Wayne Schmidtke was investigating reducing the dependence on residuals through the use of a shielded spray unit**.** Wayne has recently built a hooded sprayer and this trial was investigating the initial setup and the use of the hoods in his farming system (see Table 76). Complications in the initial trial design, weed pressure concerns, lack of communication and adverse weather conditions meant that Wayne sprayed his paddock without consultation and the spraying was not consistent with the trial design. A change in agronomic project management at PCPSL meant that the trial was abandoned close to the 2015 harvest. A preliminary desktop economic analysis was undertaken that shows the weed control differences.

Table 76: Wayne Schmidtke site and trial description

No	Description
T1	Weedmaster DST– 6L/ha $25.36 Asulux– 8.5L/ha $144.75 Actril–1L/ha $28.10 Agritone– 1.5L/ha $18.30 Comet– 0.4L/ha $5.22 Total Cost/ha = $222
T2	Gramoxone– 6L/ha $5.10 Asulux– 8.5L/ha$144.75 Actril–1L/ha $28.10 Agritone– 1.5L/ha $18.30 Comet – 0.4L/ha $5.22 Total Cost/ha = $201

John, Ann, Rob Hand – Koumala – Plane Creek Productivity Services

Economic data for the Hand's has been recorded in the FEAT model. At the time of writing no trial information, i.e. either designs or results, have been received.

Alan and Scott Mclean – Kuttabul - Mackay Area Productivity Services (MAPS)

Alan and Scott McLean are investigating using a shielded sprayer as part of their integrated weed management program. By utilising shielded sprayers, Alan and Scott aim to restrict residual herbicide spraying to the stool, and implement more knockdowns in their weed management program. In this trial Alan and Scott are comparing three treatments: the use of a boom spray with residual herbicide over the entire block (T1); a combination of residual herbicide on the stool, and knockdowns on the interspace (T2); and knockdowns on the interspace only (T3). These treatments are summarised in Table 77. Alan and Scott's trial block is shown in Figure 24.

Table 77: Alan and Scott Mclean trial design

No	Description	Application Method
T1 - Control	Flame – 300mL/ha	Boom spray
T2	Flame – 300mL/ha Glyphosate 570 –1L/ha Amicide 700 – 1L/ha	Banded on the stool Banded on the interspace Banded on the interspace
T3	Glyphosate 570 – 1L/ha Amicide 700 – 1L/ha	Banded on the interspace Banded on the interspace

Figure 24: Mclean trial block

Results

The economic analysis for this trial is shown below in Table 78. From this table it can be seen that the change in gross margin for T2 and T3 was -3% and -9% respectively (compared to T1). In terms of grow costs, T2 had a 4% higher grow cost, and T3 had a 1% lower grow cost than T1. While the gross margin outcome for Alan and Scott's normal practice in T1 was superior to that of T2 and T3, an ANOVA analysis did not indicate that there was any statistically significant difference in yield or PRS between the three treatments. Therefore, based on grow cost alone, the application of the knockdown herbicide in the interspace in T3 would be economically optimal.

Table 78: Results for Alan and Scott McLean's herbicide trial

No	t/ha	PRS	ts/ha	% Change Grow Cost	% Change GM/ha
T1 - Control	81.23	17.05	13.84	0	0
T2	79.24	17.19	13.62	4	-3
T3	77.61	16.63	12.91	-1	-9

There are a number of important caveats to the analysis presented here: the variability of weed pressure will mean that the farmer's management practice normally changes from year to year and across their farm; so that the treatments in this trial do not represent comprehensive management practices that would be applied on the farm over time. Also, the trial block was relatively free from weeds during the trial period so it is difficult to ascertain the effectiveness of the three herbicide treatments from the yield and PRS data collected in this trial.

This trial would ideally be replicated in a high weed pressure environment to gain sufficient understanding of the effectiveness of the treatments in this trial. Using weed counts in place of, or together with, production could also increase the robustness of this trial.

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 79 examines the sensitivity of the farm gross margins between treatments. The left column shows a 10% change in yield and the right-most columns show variation in the sugar price (in $50 increments). The table shows that T1 is more profitable than T2 or T3 in all scenarios.

Table 79: Change in gross margin in response to an increase in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	0%	0%	0%
	T2	-3%	-3%	-3%
	T3	-9%	-9%	-9%
0%	T1	0%	0%	0%
	T2	-3%	-3%	-3%
	T3	-9%	-9%	-8%
10%	T1	0%	0%	0%
	T2	-3%	-3%	-3%
	T3	-9%	-9%	-8%

Assessment of variable rate application of Balance (isoxaflutole) herbicides

Serge Beradi - Economic assessment of variable rate application of herbicide

Serg Beradi's sugarcane farm is located 60 kilometres south of Mackay, in Koumala. Serg's farm is 170 hectares and runs on a controlled traffic farming system. Serg is investigating varying the rate of application of Balance herbicide, a PSII inhibiting residual herbicide, according to soil type. The trial paddock was selected due to diverse soil properties (Figure 25 and Figure 26). Soil characteristics identified by ECa mapping, paddock boundaries and laboratory analysis enable the VR application of herbicide to occur. The four treatments that were undertaken as a part of the trial are shown in Table 80. These treatments are the VR Balance system (T1); a uniform application of the low zonal application rate from this system (T2-Control), which also corresponds to Serge's regular practice; and two treatments that are uniform application rates of the medium and high zonal rates from the VR system (T3 and T4, respectively). Undertaking a VR application of pesticide would normally require a VR controller, GPS guidance and ECa mapping. These items were already owned by Serg prior to this trial, and have not been considered in our economic analysis. The items represent a level of capital investment that enables a suite of management practices that change an entire farming operation, and as such should not be considered in isolation for a single year trial.

Table 80: Serg Beradi site and treatment description

No	Description
T1	Balance 100g/ha - (0.82 ha) + 1kg/ha Soccer + 0.8L/ha Paraquat Balance 150g/ha - (0.73 ha) + 1.5kg/ha Soccer + 1.2L/ha Paraquat Balance 200g/ha – (0.96 ha) + 2kg/ha Soccer + 1.6L/ha Paraquat
T2 – Control	Balance 100g/ha + 1kg/ha Soccer + 0.8L/ha Paraquat
T3	Balance 150g/ha + 1.5kg/ha Soccer + 1.2L/ha Paraquat
T4	Balance 200g/ha + 2kg/ha Soccer + 1.6L/ha Paraquat

Figure 25: Serg Beradi's trial location

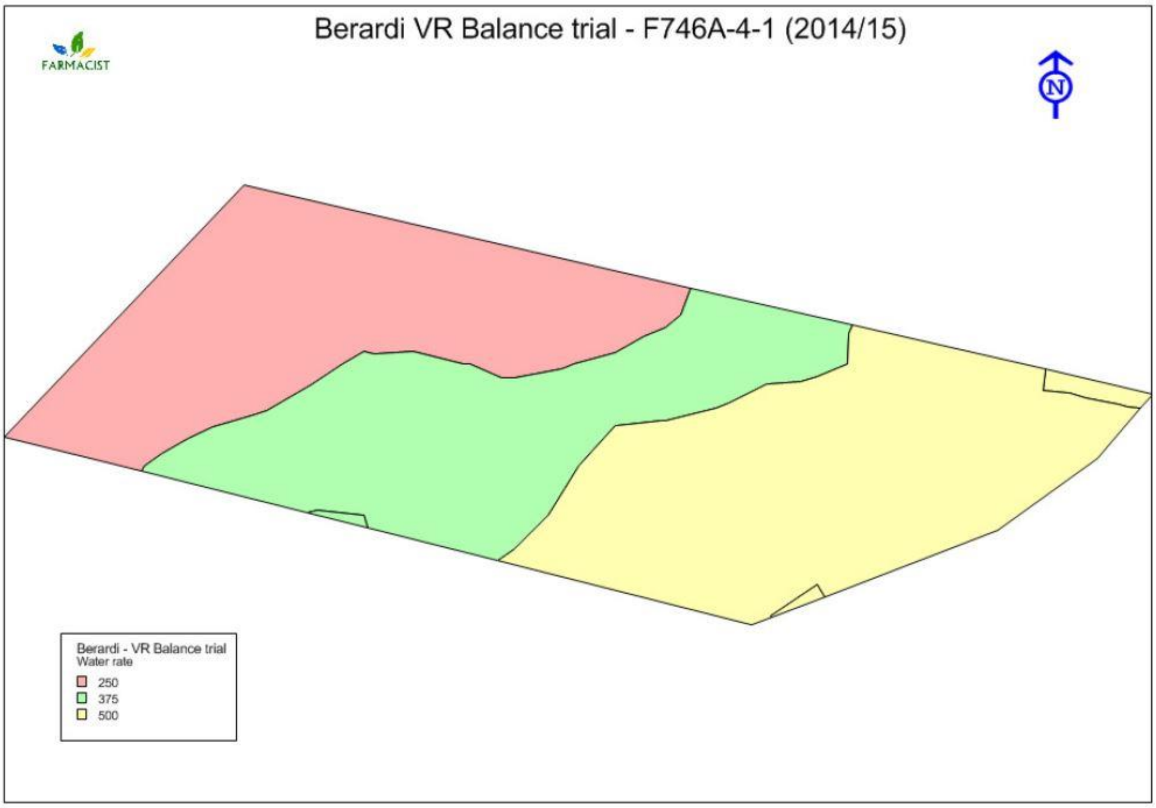

Figure 26: Variable rate Balance trial water rates and paddock sections (Farmacist, 2016)

Results

Results for Serg Berardi's VR herbicide trial are presented in Table 81. These results show that T1, i.e. the VR treatment, represented 3% higher grow costs compared to the control T2. The table also shows that T3 and T4 resulted in a 4% and 7% increase in grow costs respectively. The VR system in T1 had a 5% lower gross margin compared to T2, as did the uniform application rate in treatment T3. Treatment T4 had a 10% lower gross margin than T2. Intuitively, higher herbicide application will result in greater grow costs, and this can be seen from treatments T3 and T4. While weed populations are variable in time and space, the results of this trial indicate that a VR approach did not offer economic benefits on Serge's block over the trial season. However, the actual PRS data was not available for this trial, and the figures used for our analysis (see Table 81) are assumed values that have been based on advice from the project agronomist. PRS is a major driver of profitability, and the absence of this key production parameter means that the results presented here must be interpreted with caution.

Table 81: Serg Berardi trial results

No	t/ha	PRS	ts/ha*	% Change Grow Cost	% Change GM/ha
T1	94.3	15*	14.14	3	-5
T2 – Control	97.1	15*	14.57	0	0
T3	94.3	15*	14.15	4	-5
T4	91.8	15*	13.77	7	-10

* Assumed PRS, based on advice from the project agronomist.

Sensitivity Analysis

To take account of the possible variation in yield and sugar price, Table 82 examines the sensitivity of gross margins between treatments. The row divisions show a seasonal fluctuation resulting in a 10% increase or decrease in yield, and the right-most columns show variation in the price of sugar (in $50 increments). The table shows that the economic outcome for the VR herbicide application is not very sensitive to changes in yield or the sugar price. There are a large number of factors that affect crop production in sugarcane, including: crop nutrition, irrigation/rainfall, variety, cultural practice timing and pest and disease; and it is important to take a holistic view of farm operations. The VR method may be more expensive compared to Serge's control T2, but gaining greater effectiveness in weed management may offer higher yields and recoverable sugar in the long run due to less competition for nutrient, space and light. In this sense, our calculations indicate that both T1 and T3 would require a yield increase of 3.95t/ha (i.e. 4%), and T4 would need a yield increase of 7t/ha (i.e. 8%), in order to match the profitability of the control treatment T2.

Table 82: Change in gross margin in response to a change in yield and sugar price

Yield	Treatment	Sugar price ($/t)		
		390	440	490
-10%	T1	-6%	-5%	-5%
	T2	0%	0%	0%
	T3	-6%	-5%	-5%
	T4	-12%	-10%	-10%
0	T1	-6%	-5%	-5%
	T2	0%	0%	0%
	T3	-6%	-5%	-5%
	T4	-11%	-10%	-9%
+10%	T1	-5%	-5%	-4%
	T2	0%	0%	0%
	T3	-5%	-5%	-5%
	T4	-10%	-9%	-9%

Conclusion

Achieving industry adoption of new management practices requires an understanding of the private benefits and risk implications for the grower making such a change. The ability of the grower to step through the different components of their business allows a broader understanding of where adjustments can be made and greater productivity and efficiency gains can be achieved. In this sense, the economic support to the Game Changer project seeks to understand the economic implications of technologies being trialled on sugarcane farms in the Mackay Whitsunday NRM region.

The economic analysis for the Game Changer project is at its sixth milestone, which involves the preparation of a final report for the trial results. Introductory meetings and economic data collection have been conducted with all growers to gain an understanding of their individual farming systems and businesses. Trial designs have been received for 25 trials and either complete or partial results were available for 21 of these trials. Analysis has been presented in this report for 28 block trials, on

26 sugarcane farms, in the Mackay Whitsunday region. In cases where trial designs or data were not received, an analysis has been undertaken on a combination of known information and assumed values. In all cases these assumptions were validated with the project agronomist, or have been directly based on anecdotal advice provided by these agronomists in relation to the Game Changer trial results. No trial design or results were received for three trials, and trial designs without results were received for a further five trials.

The trials have helped identify the public and private benefits of targeted practices. In particular, the changes in gross margin and/or grow costs have been reported for most trials, together with identifying practices that aim to improve NUE or lead to less residual herbicide application. Some key findings from our analyses are that, in general, reduced nitrogen application on older ratoon cane does not seem to affect farm gross margin; and variable rate nutrient application, whether by sugarcane block or using a full spatially explicit system, does not seem to affect production and may even slightly improve gross margin. Importantly, however, the results presented here are for single-year trials on specific farms, and therefore reflect contingencies related to that location and also the weather conditions for the season just passed. There may not be statistically significant results in some parts of the project due to dry weather and crop health issues.

In carrying out the economic analyses presented in this document, the DAF economics team have met with each of the four agronomic service providers to discuss their trials. In general, the collaboration with the respective agronomists in providing technical advice on the trials has been very effective. However, it still may be possible to improve the communication of trial information for future projects through the development and use of a reporting template to ensure that all the key economic parameters are collected from each trial. A tool such as this would enable more robust analysis and conclusions from the trial data. Also, economic input at the trial design phase would also be of benefit to ensure that the economic analysis continues to provide a useful input to growers' decision making, especially for trials in which only two replicates are used. It is important from an economic perspective to undertake analysis for viable alternative practices by the growers. With robust results and conclusions the economic implications of the trial will be better understood and recommendations about the long term viability and likelihood of industry adoption can be further explored.

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