Variable rate nutrient application – economic case study, Homebush

Grower: Steve Young

Key Points:

- The case study shows that within-block variable rate application of nutrients can lower total variable costs on farms that have sufficient variation in soils;
- For farms that already operate under GPS guidance, and have similar soil to the trial property, we estimate that the investment in variable rate technology will add value over land areas of 72 ha or above, where yield is maintained; and
- There is a continued need for extension and trials to support the up-take of variable rate technologies in the region.

The adoption of precision agriculture techniques, specifically variable rate (VR) nutrient application, may have the potential to reduce the quantity of Dissolved Inorganic Nitrogen (DIN) being lost from sugarcane farms to the Great Barrier Reef. Targeted trials undertaken as part of Project Catalyst have shown some potential to improve Nitrogen Use Efficiency (NUE), without compromising yields, by varying nutrient application rates within paddocks.

Steve Young is investigating full VR fertiliser application according to zone yield potential on his 42ha farm in Homebush. Through an analysis of his soils, remote sensing of yield and historic yield records (undertaken by Farmacist-Mackay), Steve Young has determined that he has three distinct yield zones on his farm: a High Yield Zone (HYZ), Medium Yield Zone (MYZ) and Low Yield Zone (LYZ). He is investigating varying the rate of fertiliser application for ratooning sugarcane on his farm within these three yield zones. A satellite image showing an overlay of the yield map on Steve's Homebush property is shown in Figure 1 below.

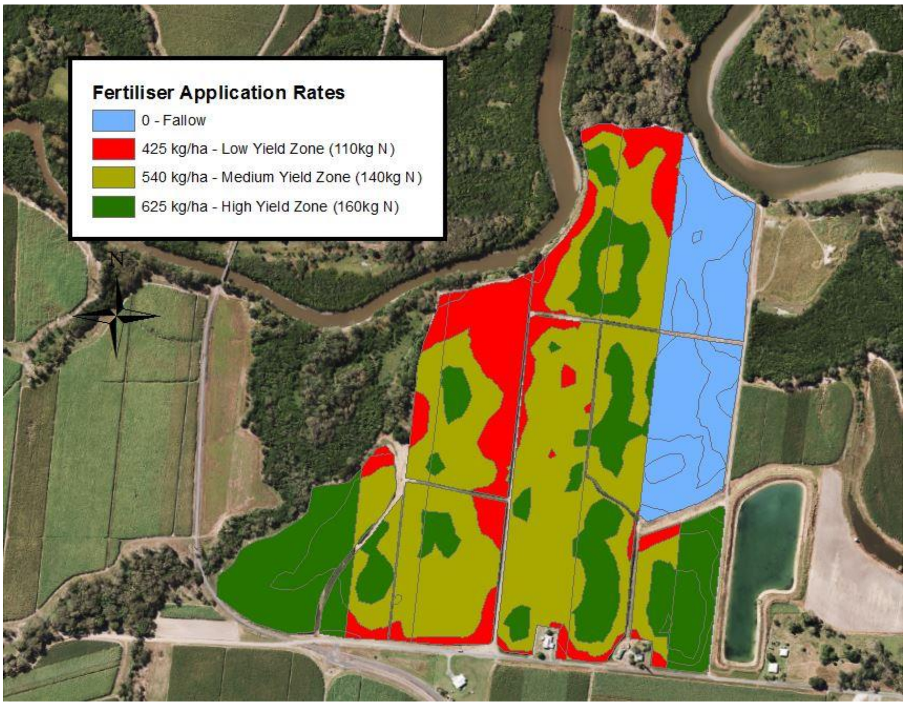

Figure 1 Satellite image and yield map of Steve Young's property in Homebush

The trial design is summarised below in Table 1. Steve's normal rate of nitrogen (N) application for his sugarcane ratoons is 160kg/ha, which he applies at a uniform rate across 32 ha of his farm, which comprises multiple blocks of ratoon cane. This practice is shown in the 'Conventional' row of the table, and consists of a fertiliser application rate of 625 kg/ha of Gargett Ratooner at a cost of $445/ha, for a total expenditure in ratoon cane of $14,240. In this whole-of-farm trial, Steve has varied his application rate to correspond with a rate of 110kg N/ha in the LYZ, 140kg N/ha in the MYZ and 160kg N/ha in the HYZ. These rates are shown in the 'Variable rate' rows of the table, and correspond to fertiliser application rates of 425 kg/ha, 520 kg/ha and 625 kg/ha of the Gargett Ratooner product in each of the management zones respectively. The table shows that these management zones cover approximately 6ha, 20ha, and 6ha respectively of Steve's ratoon cane. The total cost of the fertiliser applied to ratoon cane in the variable rate system is $12,175 which represents a saving of $2,065 when compared to the 'Conventional' practice. It is also worth noting that, as a result of varying the N application rate under the 'Variable rate' system, Steve simultaneously varied the application of the other nutrient components contained in the fertiliser. The agronomist for this trial advised, however, that nitrogen is the limiting factor for sugarcane growth on the trial blocks.

Table 1 Steve Young full VR application trial of all macro nutrients.

Nutrient management	Zone/s	Rate (kg/ha)	Product	N (kg/ha)	Cost ($/ha)	Area (ha)	Total cost ($)
Conventional	All	625	Gargett Ratooner	160	$445	32	$14,240
Variable rate	LYZ	425	Gargett Ratooner	110	$303	6	$1,816
	MYZ	520	Gargett Ratooner	140	$384	20	$7,690
	HYZ	625	Gargett Ratooner	160	$445	6	$2,670
					Total	**32**	**$12,175**

The following table shows a summary of the additional ongoing fixed costs (on-costs) that have been borne by Steve Young for the adoption of his granular VR system. Steve was required to purchase a variable rate speed drive for his fertiliser applicator for a once-off cost of $12,836, as well as undertake annual EC mapping of his fallow blocks to migrate his farm to the new system. These mapping costs were approximately $1,460 per year, and continue until the whole farm has been migrated to the VR system. The table also shows annual costs for soil sampling of $500 per year, and satellite imagery of $125 per year; which continue indefinitely. Steve already operates his farm under RTK Guidance and our analysis did not consider the grower's costs and benefits for the adoption of GPS guidance. Because of the broad range of farming practices that are possible under GPS guidance, the growers' decision to move their farm to this system will create the capacity to implement an increasing range of cultivation, weed management and other precision agriculture practices.

Table 2 additional on-costs required for Steve Young to implement his VR system

Additional cost	Description
EC mapping	$1,460 per year
Soil sample	$500 per year
Satellite imagery	$125 per year
Agronomic advice	10 hours per year
VR speed drive	$12,836 once off

Steve has gradually moved blocks of his Homebush farm to this granular VR nutrient regime, as he has become increasingly confident in the system. However, the switch to VR nutrient application can be accomplished in a much shorter period of time: once the yield map has been determined for the property then the VR nutrient application can commence (J. Markley, *per. comm*.).

Results

For the economic analysis presented in this information sheet, the Farm Economic Analysis Tool (FEAT) software program developed by the Queensland Department of Agriculture and Fisheries (DAF) has been used to determine the gross margins of each treatment. 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. 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 $435/tonne and all fertiliser and chemical prices are current for the Mackay Whitsunday as the time of the trial. Population of the FEAT spreadsheets required detailed information of cane yields, percentage recoverable sugar (PRS), 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 practices. Irrigation in this model has been held constant through the analysis, and this is due to the variation in irrigation systems and environmental conditions which face each different farm.

Our economic analysis is presented below in Table 3. Based on advice and data obtained from the project agronomist, the yield and PRS were unchanged from previous years when Steve used the HYZ rate as a blanket rate across this farm. The analysis shows that VR management has 7% lower growing costs than the conventional nutrient management practice, and a 6% higher farm gross margin.

Table 3 Steve Young Gross Margin Analysis

Nutrient management	t/ha	PRS	ts/ha	% change grow cost	% change GM/ha
Variable rate	70*	15*	10.5	-7%	6%
Conventional	70*	15*	10.5	0	0

* Based on advice from the project agronomist.

Net Present Value of Investing in VR Nutrient Application

Taking into account the potential variation in yield and sugar price, Table 4 examines the Net Present Value (NPV) of Steve's investment in the variable rate drive equipment required for the VR system, combined with the added agronomic services over a ten year investment period. A GPS guidance system is required to undertake VR nutrient application. As Steve already owns this system, the cost to purchase one was not taken into account in this case study.

The economic outcome of management practice changes can be influenced by a variety of factors. Two key variables are cane yield and the sugar price. While the trial identified that VR nutrient management did not affect cane yield, some growers may at first be hesitant to reduce nitrogen rates on underperforming blocks in case cane yield potential was not realised. Consequently, this analysis investigates the value added by the additional investment in VR technology under various yield improvement and sugar price scenarios.

Our NPV analysis is shown below in Table 4. The row divisions of this table show a 10% decrease or increase 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 $36,120 at 9% per annum discount rate and a cane price of $385 per tonne, to $64,643 at a 5% discount rate and a sugar price of $485 per tonne. Under the assumption of 7% discount rate and no change in yield, Table 4 shows that the investment in the VR system is negative at all sugar prices, and has thus not added value to the farming enterprise.

Table 4 Net Present Value of Investing in VR Nutrient Application (given that he already operates under GPS guidance)

		Net present value		
Yield	Discount rate %	Cane price ($/t) 385	435	485
-10%	5	-$75,219	-$84,509	-$93,796
	7	-$69,579	-$78,028	-$86,476
	9	-$64,683	-$72,404	-$80,123
0	5	-$14,575	-$14,577	-$14,577
	7	-$14,418	-$14,420	-$14,419
	9	-$14,282	-$14,283	-$14,283
+10%	5	$46,068	$55,355	$64,643
	7	$40,742	$49,189	$57,638
	9	$36,120	$43,838	$51,558

Net Present Value versus Farm Size

Figure 2 below shows the sensitivity of the NPV to farm size. The horizontal axis of this graph shows the farm size, in hectares; the NPV of the VR system, measured on the vertical axis, is indicated by the upward sloping line; and the 'dash-dot' line shows where NPV=0. The analysis is based on the change in gross margin in Table 3, and assumes a sugar price of $435/tonne, no change in yield or PRS (i.e. as per agronomic advice), and farming practices and input costs as in the FEAT file for this grower. The NPV is calculated over a 10 year period, using a real discount rate of 7% per annum, and also deducts the additional on-costs in Table 2. The farm size needed for the VR system to breakeven is indicated by the point where the upward sloping line (representing the NPV of the VR system) intersects with the 'dash-dot' line (i.e. where NPV=0).

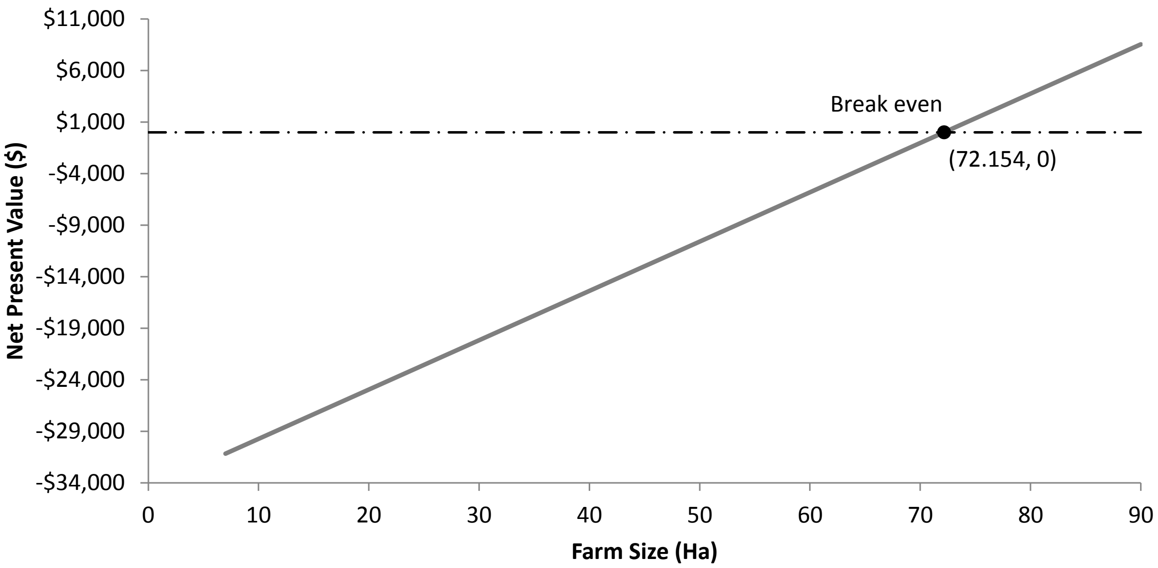

Figure 2 Break even analysis for the NPV of Steve Young's investment required to under his VR fertiliser system (given that he already operates under GPS guidance)

The results in the figure above show that the viability of the VRA 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. While this breakeven point is comfortably below the typical farm size for the region of 150 ha, it is important to note that our analysis is for advanced practice farmers, i.e. those already undertaking activities under GPS guidance prior to the adoption of a VR system, and does not consider the costs and benefits of moving to GPS guidance (which will include the potential to implement a range of other precision agriculture practices on the farm).

Diffusion of the VR System in the Mackay-Whitsunday Region

Figure 3 below presents an investigation of the diffusion of zonally-applied VR nutrient technology in the Mackay Whitsunday region, using data provided by Reef Catchments for the number of projects moving to 'A Class' nutrient management practices. The linear series shows the number of farms under VR nutrient management in each year, and the bar graph shows the total sugarcane farming area under VR management in the same years. 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. According to the advice from Reef Catchments, the data set used here may overestimate the prevalence of within-block VR systems in the region. The Bass model is commonly used for fully developed technologies; and since VR system is still ‘under investigation’, the diffusion analysis presented below represents adoption dynamics at the current point in time.

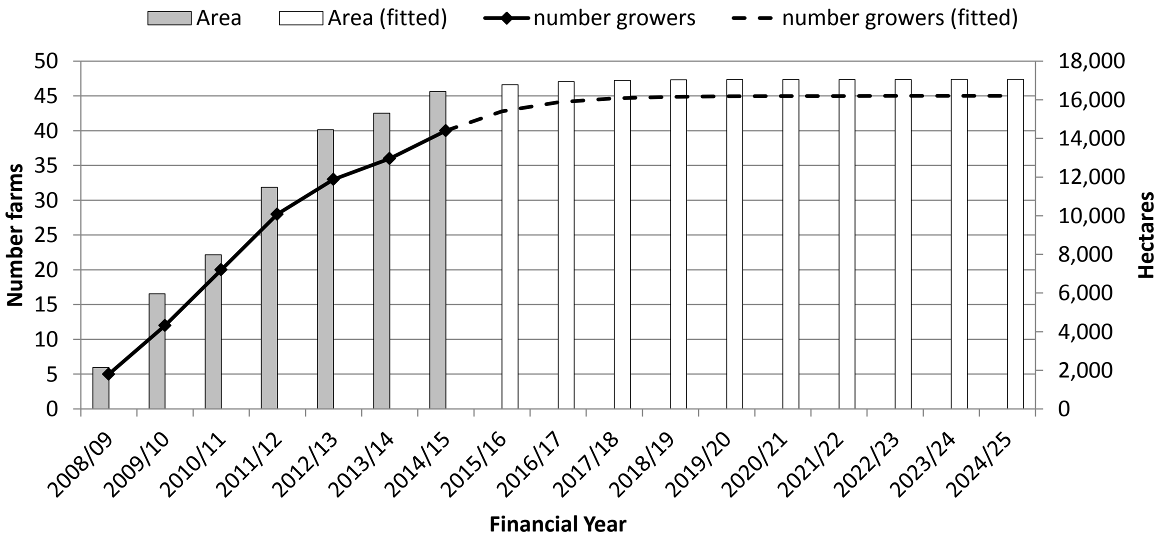

Figure 3 Bass model diffusion curve fitted to adoption data provided by Reef Catchments for the Mackay Whitsunday region.

The estimated coefficients from the Bass diffusion model are shown in Table 5 below.

Table 5: 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 mode, the coefficient of innovation (p) measures the self-motivated propensity for adoption among growers; and the coefficient of imitation (q) represents the propensity for copy-cat adoptions, 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 the values presented in Table 5 are high. However this is most likely due to the fitted market potential (i.e. ‘current market’) being just 45 growers, so that saturation occurs quickly in the out years.

The results in Table 5 suggest that there is an 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 information among growers. The ‘option value’ associated with farmers’ decisions to trial a new technology refers to the benefit they accrue from delaying an adoption event and waiting to observe the technology in practice on another property. This gives information about the technology and its effectiveness without having to incur the economic cost of trialling themselves. A social network is the structure of social interactions and personal relationships within a population. 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. In the case of the Mackay Whitsunday sugarcane farming region, it may be that the existing social networks in the community may be influencing the penetration of new technologies. There is a continued need to foster regional networks that are both trusted by growers and which support the uptake of precision technologies.

Conclusion

In this analysis we have presented case study evidence that a VR nutrient management system can increase farm gross margin, i.e. farming profit before fixed costs. In terms of the value added by the investment in VR technology, the break-even NPV analysis suggests that this VR system is potentially viable on farms greater than 72.154 ha that *already operate under GPS guidance*, and also have sufficient soil variation to warrant differential application of nutrients. The analysis has not considered the economics of the VR system for farmers that do not currently operate under GPS guidance. Finally, our investigation of the rate of uptake of within-block VR nutrient management systems in the region has indicated the continued importance of extension, and in particular with groups of growers that have had poor engagement with past extension initiatives, to encourage independent trials and adoption of innovative farming practices.

Acknowledgements

This publication was compiled by Steven Rust and Andrew Law from DAF. John Markley and Farmacist-Mackay contributed research data and technical expertise to this case study. Steve Young manages a 42-hectare farm in Homebush (Mackay region) and grows mostly sugarcane.

DAF provides economic support to the Game Changer project in Mackay. For further information please contact the Rockhampton DAF Office on (07) 4843 2603.

Citation:

Rust, S., Law, A., and Markley, J. (2017), *Variable rate nutrient application – economic case study, Homebush*. Department of Agriculture and Fisheries (DAF), Queensland.