Project Catalyst Case Studies: Economic Analysis

2019-2020 Trial Summary Report

Project Catalyst is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation, and the Coca-Cola Foundation with support from WWF-Australia and Catchment Solutions Pty Ltd.

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Preamble

Project Catalyst fosters the adoption of innovative sugarcane farming management practices and technologies that aim to improve the quality of water leaving farms in Great Barrier Reef Catchments. Project Catalyst is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation, and the Coca-Cola Foundation with support from the Worldwide Fund for Nature (WWF)-Australia and Catchment Solutions Pty Ltd. Other service providers include Natural Resource Management (NRM) groups, agronomic service providers (Farmacist, Herbert Cane Productivity Services Ltd (HCPSL), T.R.A.P. Services and Mossman Agricultural Services (MAS)) and agricultural economists from the Department of Agriculture and Fisheries Queensland (DAF). Importantly, the project draws on the innovative ideas, time and resources of grower participants from across the sugarcane industry.

The four key focus areas of the project include trials to better manage nutrients, chemicals, water and soil. Understanding the production, economic and environmental impacts of farm management practices enables farmers to make informed decisions regarding the adoption of these practices. Consequently, measuring these impacts by undertaking field trials and farm demonstrations with participating growers is an important component of the project.

For a selection of trials, DAF worked closely with participating growers and agronomic service providers to determine the profitability of adopting different farm management practices. Case studies for each of the trials were prepared to assist with communication of the economic results at various meetings, including the annual Project Catalyst Forum. This report contains a collection of the final 2019/20 and 2020/21 economic case studies from the three participating regions (Wet Tropics, Burdekin and Mackay Whitsundays).

Acknowledgements

Project Catalyst is funded by the partnership between the Australian Government's Reef Trust and the Great Barrier Reef Foundation, and the Coca-Cola Foundation with support from WWF-Australia and Catchment Solutions Pty Ltd.

We also wish to acknowledge the contributions of the following partner organisations, individuals and service providers who played an important role Project Catalyst:

Farmacist

Grower Participants

Herbert Cane Productivity Services Limited

Mossman Agricultural Services

NQ Dry Tropics

Reef Catchments

Terrain Wet Tropics NRM

TRAP Services

Project Summary

A summary of economic results for each Project Catalyst trial are included in Tables 1.1 to 1.4. Tables categorise trials relevant to their role and impact on nutrients (e.g. application of nitrogen (N)), nutrients and water (e.g. ground water nitrates), soils (e.g. legume fallows), and water (e.g. irrigation). Information includes a trial's location, period (years), crop class, variety, soil type, trial design (treatments/reps), key gross margin results and statistical analysis outcomes. There are also additional points of note on each trial and a final summary of the overall results relating to each category.

Table 1.1: Nutrients (varying rates and delivery methods)

Practice	Location/ Sub-district	Trial period/ crop class	Variety/soil type	Treatments (Treat)/ Reps	Gross Margin (GM) impact	Statistics	Notes
Staggered N rates (pp 12)	Mackay-Whitsundays: Mackay	2018-2020 (R2 to R4)	Q242 on a Brown Chromosol.	Treat-5 Reps-4	The alternating rate (110/150N*) had a $149/ha higher average GM compared to applying 180N.	GM differences were not statistically significant.	Applying 0 Nitrogen had consistently lower yields and sugar (t/ha).
Variable N rates (pp 16)	Mackay-Whitsundays: Eton	2019-2020 (R2-R3)	Q240 on a Sandiford.	Treat-3 Reps-5	The Six-Easy-Steps® (6ES) average GM was $56/ha higher than the highest N rate (6ES+25%).	GM differences were not statistically significant.	There was no economic advantage from applying a rate of N above the 6ES rate.
Solid vs liquid fertiliser (pp 19)	Burdekin: Bria	2020 (R2)	Q252 on a loam.	Treat-3 Reps-4	Results showed a $581-$660/ha higher GM for Granular side dressed fertiliser compared to the other two treatments (Granular stool-split and Liquid fertiliser stool-split).	The difference in GM was statistically significant.	Further investigation is required to validate this result given there is only one year of data.
DunderUnder (subsurface liquid fertiliser) (pp 22)	Mackay-Whitsundays: Eton	2019 (R2)	Q240 on a Victoria Plains (Black Earth).	Treat-2 Reps-3	Results showed a $147/ha reduced GM for the subsurface treatment.	GM differences were not statistically significant.	Further investigation is required where previous trials gave yield improvements for the subsurface treatment.

**110/150N denotes alternating between 110kg and 150kg of nitrogen (N) per ha.*

There was no economic benefit from nitrogen rates exceeding Six Easy Steps® (6ES) guidelines. The longest-term trial (Staggered N Rate trial) did show some promise in alternating between 6ES and a lower rate. However, an overall lack of statistical significance highlighted the variability of results from most nutrient trials. The only trial result showing a significant difference in gross margin included the Solid versus Liquid fertiliser trial where the granular side dressed application had a higher gross margin compared to both granular stool-split and liquid fertiliser application methods.

Table 1.2: Nutrients and water (reducing rates with ground water N)

Practice	Location/ Sub-district	Trial period/ crop class	Variety/soil type	Treatments (Treat)/ Reps	Gross Margin (GM) impact	Statistics	Notes
Ground water N (1) (pp 26)	Burdekin: Delta	2019-2020 (R3 & R4)	KQ228 on a medium clay.	Treat - 3 Reps - 4	The 155N treatment had the highest average GM for both years. This was followed by the 185N ($140/ha less) and 125N treatment with the lowest GM ($236/ha less).	GM differences were not statistically significant.	Further investigation is required to validate the effect of accounting for Nitrates from groundwater.
Ground water N (2) (pp 29)	Burdekin: Bria	2019 (R3)	Q183 on various soil types.	Treat - 2 Reps - 4	The 170N treatment had a $301/ha higher GM than the 130N treatment.	GM differences were not statistically significant.	Further investigation is required to validate the effect of accounting for Nitrates from groundwater.

There were mixed results from the ground water nitrate case studies. Given previous trials have shown the potential to reduce N rates, further investigation is required. Under conditions where ground water contributions of nitrates are significant, it is recommended that future trials include ground water nitrate tests that can be linked to alternate application rates of N.

Table 1.3: Soils (biofert, fallows and ameliorants)

Practice	Location/ Sub-district	Trial period/ crop class	Variety/soil type	Treatments (Treat)/ Reps	Gross Margin (GM) impact	Statistics	Notes
Soil ameliorants (pp 32)	Wet Tropics: Herbert	2018-2020 (Plant-R2)	Q231 on a clay/terrace loam.	Treat - 3 Reps - 3	Ag Lime had a $12-$117/ha higher average GM compared to the kiln dust/ag lime mix and prilled lime.	There were no statically significant differences between treatment GM's.	Over the full trial period, there was no statistical difference in GM's between soil ameliorants.
Sub-surface mud and ash (pp 35)	Mackay-Whitsundays: Eton	2018-2020 (Fallow-R1)	SP80 on a Victoria Plains (clay) & Calen (Brown Chromosol)	Treat - 3 Reps - 1	For the mill mud and ash combination, the subsurface treatment had a $182/ha higher GM than surface applied treatment.	Not available (demonstration).	There were different yield responses between the mud and mud/ash plots. Results remain inconclusive where treatments lack replication.
				Treat - 3 Reps - 1	For mud alone, the surface application had a $27/ha higher GM compared to subsurface application.		
Sub-surface mill mud (1) (pp 39)	Wet Tropics: Mossman	2018-2020 (Plant-R2)	Q208 on a Clifton.	Treat - 4 Reps - 3	The subsurface with reduced N application had the highest GM in R1 and R2 as well as the overall average GM (but only $4/ha higher than the standard 6ES rate).	Not available (trial replicated but not randomised).	GM differences between treatments could not be validated due to non-randomised trial design.
Sub-surface mud (2) (pp 43)	Mackay-Whitsundays: Sarina	2018-2020 (Fallow-R1)	KQ228 on a Sodic soil.	Treat - 3 Reps - 3	The surface application had a $46/ha higher average GM than sub-surface treatment for mill mud. Both treatments	GM differences between sub-surface and surface treatments were	It will be important to monitor the implications over a full crop cycle.

					had lower GM's compared to the control.	not statistically significant.	
Biofert and mixed species fallow (soil health/ nutrition) (pp 47)	Wet Tropics: Tully	2018-2020 (Fallow-R1)	No details.	Treat - 2 Reps - 3	The average GM for the standard practice (this included a legume fallow) was $355/ha higher than the RegenAG treatment.	Statistically significant differences in the combined gross margin from plant and first ratoon results.	It will be important to monitor the implications over a full crop cycle.
Mixed species fallow (pp 51)	Wet Tropics: Herbert	2019-2020 (Fallow-Plant	Q253 on an Alluvial soil.	Treat - 21 Reps - 3	A number of fallow crop options had a higher plant cane GM compared to the bare fallow ($150/ha). The Tropical Mustard fallow resulted in the highest plant cane GM ($487/ha).	GM differences were not statistically significant.	It will be important to monitor the implications over a full crop cycle.
Legume fallow (pp 55)	Mackay-Whitsundays: Proserpine	2020 (Fallow)	Q208 on a Wagoora soil.	Treat - 2 Reps - 3	The Soybean fallow had a $234/ha GM (at $900/t) when compared to the cost (-$136/ha) of a bare fallow. At long-term pricing the low-cost soybean strategy would need a minimum 1.2t/ha yield to remain viable.	Not available.	Due to an error in the fertiliser application on the plant cane, a break-even investment analysis was completed.

In both lime and mixed species fallow trials there was no significant difference between the treatments. For the Biofert trial there was a significantly higher gross margin from the standard practice against the RegenAg practice. This was largely due to the higher yield and lower costs relating to the standard practice. Longer-term impacts of RegenAg would need to be investigated. Sub-surface trials showed mixed results and, in some cases, contradicted previous Project Catalyst trials. More research is thus required in this area.

Table 1.4: Water (alternate row irrigation)

Practice	Location/ Sub-district	Trial period/ crop class	Variety/soil type	Treatments (Treat)/ Reps	Net Revenue (NR) impact	Statistics	Notes
Alternate row irrigation (pp 60)	Burdekin: Delta	2018-2019 (R3-R4)	Q240 on a mixture of Black Sandy to Clay Loams.	Treat - 2 Reps - 1	Alternate row irrigation had an $812/ha higher average NR for the two years when compared to conventional practice.	Not available (trial not randomised).	Alternate row irrigation showed promising results. Further investigation with a randomised trial would help with validation.

The significant savings from the alternate row irrigation system may be a viable option for growers. It remains difficult to properly test the production outcomes in the absence of replicated and randomised trials. Going forward this may continue to be a challenge given the nature of irrigation infrastructure.

Methodology

The Farm Economic Analysis Tool (FEAT) was used to undertake a comprehensive evaluation of estimated revenues and costs of each treatment. A FEAT analysis required the grower to provide detailed information regarding their production system including planting, fertiliser and chemical applications, weeding, machinery operations, irrigation scheduling, and fallow arrangements. Input prices (e.g. fertilisers and cartage) were collected from local suppliers in the respective regions. From these data, the directly allocable costs, i.e. variable costs, associated with each treatment are estimated. In addition, the harvesting costs and levies which are in direct proportion to the harvested tonnage of cane were also included. Harvesting costs and levies together with other variable costs constituted the total variable costs.

Grower revenue was calculated for each replicate using the respective cane payment formulae, cane yield and CCS data from the trial and the five-year average sugar price ($417 per tonne). Gross margins were calculated by taking the revenue received from the crop and subtracting variable costs (Figure 1.1).

The gross margin data (where treatments were replicated and randomised) were then analysed using analysis of variance (ANOVA) to determine if the mean gross margins between treatments were significantly different from each other at the 5% level of significance. The 95% least significant difference (LSD) were also calculated.

Figure 1.1: Formulas used to calculate gross margins ($/ha)

Grower Revenue ($/ha)

Price of cane ($/t)

[Final sugar price x 0.009 x (CCS – 4)/100 + constant]

X

Tonnes cane (t/ha)

Less

Harvesting costs and levies ($/ha)

Harvesting cost ($/t) x harvested tonnes (tc/ha)

\+ Levies ($/t) x harvested tonnes (tc/ha)

Less

Planting costs ($/ha)

Less

Growing costs ($/ha)

Costs associated with tillage, nutrients, pest control and irrigation management, etc.

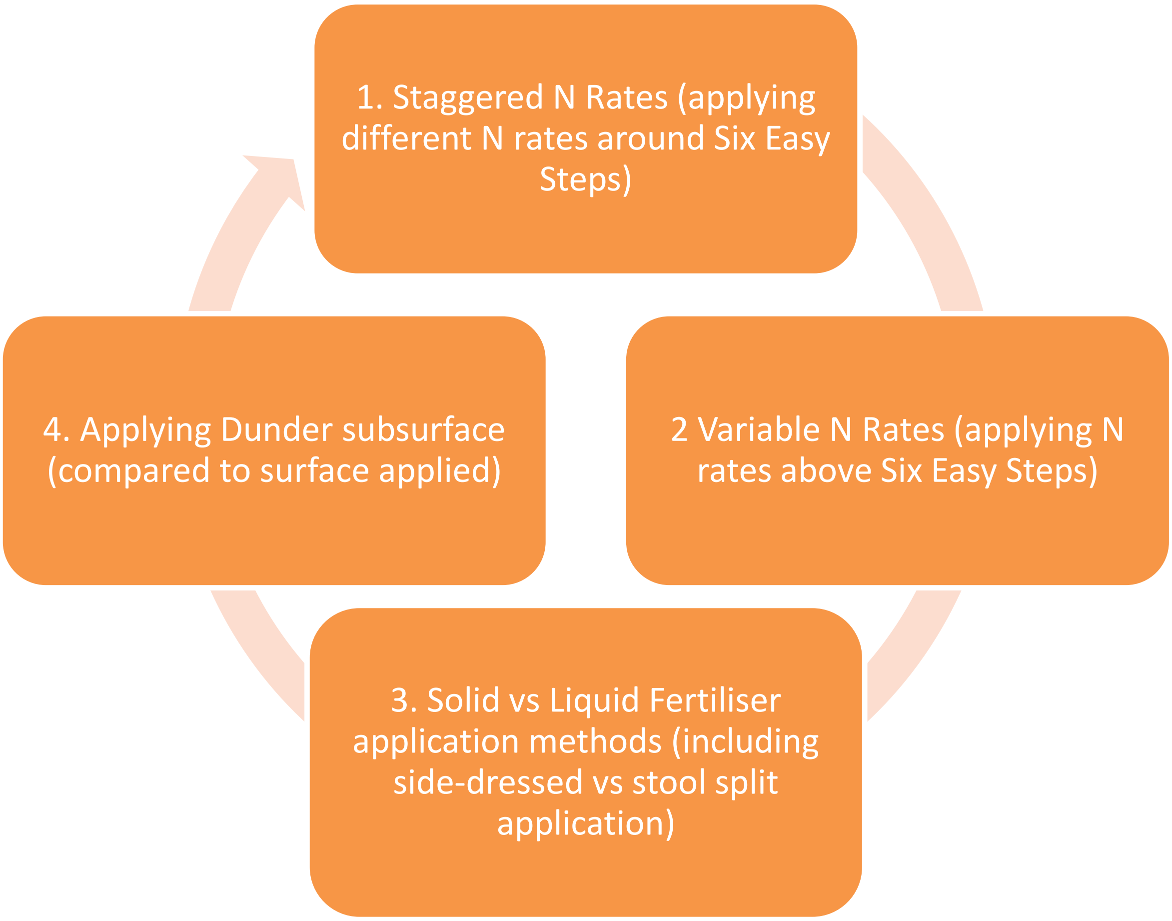
=

Gross Margin ($/ha)

Nutrients: varying rates and delivery methods

Improving nutrient management is a key focus area of Project Catalyst. This section explores various strategies trialled by Project Catalyst growers that aim to refine nutrient management on their farms. Figure 1.2 outlines each of these strategies and case studies in order of appearance in this section.

Figure 1.2: Case studies exploring nutrient management strategies



Staggered N Rate Economics: 2018-20 Case Study

Mackay grower: John 'Mac' Muscat

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries (DAF) to identify costs and benefits of the trials. In this study, John Muscat and DAF (assisted by Farmacist) trialed the application of varied Nitrogen (N) rates.

The trial objective was to determine the impact on yield, CCS and economic performance of applying varied N rates against the recommended "Six-Easy-Steps" (6ES) rates to manage early lodging. Trial results were analysed for the full ratoon cycle (2017 to 2020) but due to Severe Tropical Cyclone Debbie, 2017 results (1st ratoon) are excluded from the case study as cane damage had a significant effect on overall yield and CCS.

Key findings

- There was no economic benefit in applying a higher rate of N (above "Six-Easy-Steps" rates).
- Despite a significantly higher yield in 2020, the gross margin was significantly lower due to the CCS impact relative to previous years.
- Applying 0N had consistently lower yields and sugar (t/ha).

Trial design

John Muscat (and DAF) conducted the trial between 2016 and 2020 on his farm, located west of Mackay, using variety Q242. Nitrogen was applied on each ratoon at one of five rates, 180kg/ha (180N), 150kg/ha (150N, 6ES rate), 110kg/ha (110N), 0kg/ha (0N, control), and an 'alternating rate'. The 'alternating rate' (110N/150N) applied 150kg/ha of N to the 2017 and 2019 crops, and 110kg/ha to the 2018 and 2020 crops.

The trial was randomised and replicated with 10 plots in two blocks (north and south of the tow path), with two plots within each block randomly allocated to one of the five N rate treatments. Hence, there were four replications for all five treatments on a uniform soil (see Figure 2.1). The control (0N) plots were 20 metres at the row end of two randomly selected treatments from each block, thus minimising the impact on overall paddock yield.

The products used to apply different N levels included: Liquid One Shot® (LOS) for 180 kg/ha, Econo LOS for 150 kg/ha and Liquid 50/50 for 110 kg/ha. Sulphate of Potash (SOP) was added for the 0N treatment to ensure a consistent application of other macro-nutrients. Yield data were obtained from both weigh trailer measurements and mill records for all treatments except the 0N rate (i.e. not enough bins allowing for a mill sample). Economic analyses were, however, only applied to mill results as they are the most reliable source of data relating to grower payment calculations.

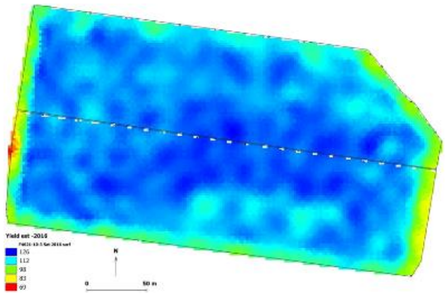


Figure 2.1: Processed satellite yield map (2016) (source: Farmacist)

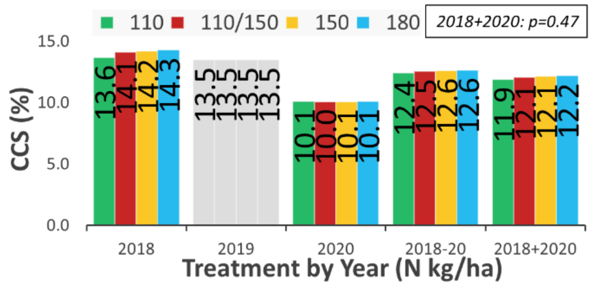


Figure 2.3: Average mill CCS results (t/ha)

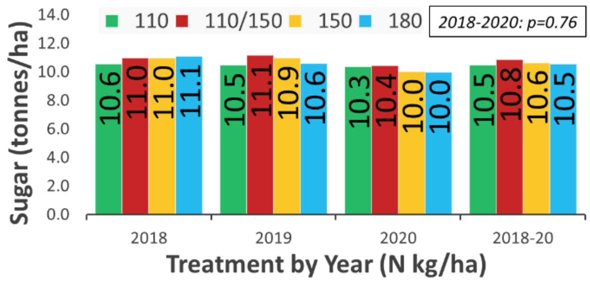


Figure 2.4: Average mill sugar results (t/ha)

Agronomics

Figure 2.2 presents mill yield data for 2018, 2019, 2020 and all three years combined. Neither annual, nor combined data, differed significantly between treatments, with combined average yields ranging from 85 t/ha for the 180N treatment, to 88 t/ha for the alternating treatment. Similarly, there was no difference in either CCS (Figure 2.3) or sugar yield (Figure 2.4) among treatments.

Average yield (for all treatments) was greater in 2020 than in 2018 and 2019 (101 vs 78 and 80 t/ha; $p<0.001$) while CCS decreased from 14.0% in 2018 to 13.5% in 2019 and to 10.1% in 2020 ($p<0.001$). This resulted in sugar yield being less in 2020 than in 2018 or 2019 (10.2 vs 10.9 and 10.8 t/ha; $p=0.002$).

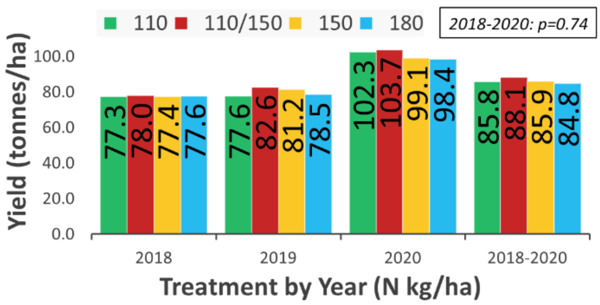


Figure 2.2: Average mill yield results (t/ha)

Note: Care should be taken when interpreting average CCS results as mill average CCS was used in 2019. However, given there was no significant difference in mill CCS for 2018 and 2020 (Figure 2.3), the average CCS for 2019 was included for the final economic analysis.

Due to the small plot size of the 0N treatment, mill data was not available. To enable comparison of the N treatments with the 0N treatment, an analysis was done to combine the mill and the weigh trailer data. Yields were significantly greater for the N treatments compared with the 0N treatment ($p=0.002$; Figure 2.5). This difference was clearly visible in the aerial photograph (Figure 2.6; lighter colour for 0N treatments).

It should be noted that this may have been due to the other nutrients and organic carbon contribution of the BioDunder applied. Similarly, sugar yield was significantly lower for the 0N treatment when compared with the others (Figure 2.7; $p=0.011$).

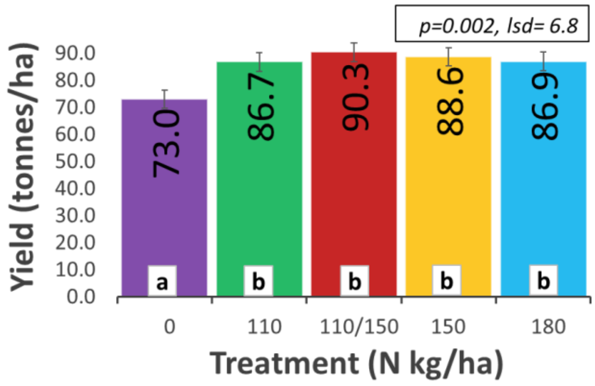


Figure 2.5: Combined average mill and weigh trailer yield results for years 2018-2020 (t/ha)
Error bars indicate 95% least significant difference and different letters indicate statistically significant differences. Note: same applies to figure 2.7.

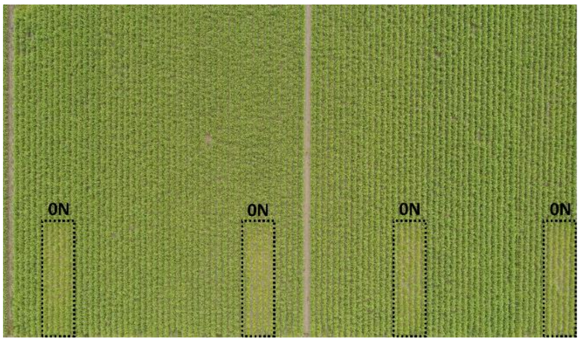


Figure 2.6: Visible lower 0N treatment yields
(Source: DAF 2018)

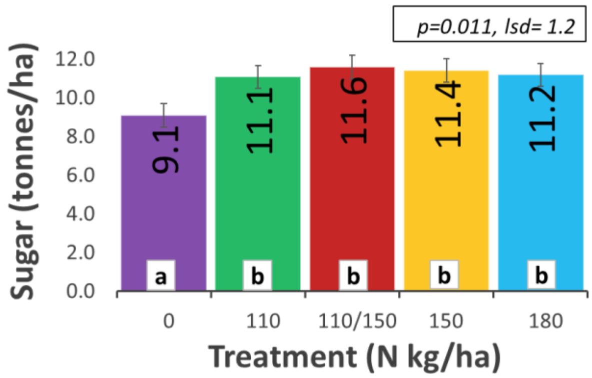


Figure 2.7: Combined average mill and weigh trailer sugar results for years 2018-2020 (t/ha)

Costs

Figure 2.8 presents the combined average annual variable costs for 2018, 2019 and 2020 seasons. Similar cost line items were included for 2018 and 2019, with additional irrigation and insect control costs added for 2020 (0.5ML of irrigation water and 1.2L of Confidor).

The difference in treatment variable costs were largely due to fertiliser costs and costs that varied with changes in yield (i.e. harvesting costs and levies). The 180N treatment had variable costs that were $58/ha and $112/ha higher than the 150N (6ES) and 110N treatments respectively.

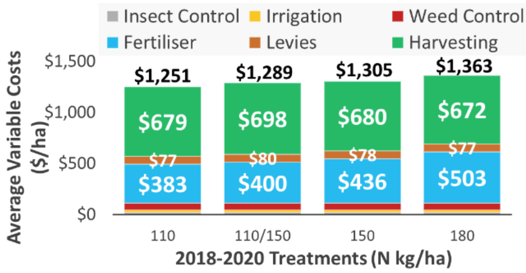


Figure 2.8: 2018 Average annual variable costs per treatment ($/ha)

Gross Margins

Gross margin results (revenue less variable costs) are presented in Figure 2.9 based on a 5-year average sugar price ($417/t). Although the alternating treatment showed a $149/ha higher average annual gross margin than the 180N treatment, the difference was not statistically significant so differences among treatments cannot confidently be attributed to the N rates.

Average annual gross margins decreased from $1,898/ha in 2018 to $1,741/ha in 2019 and to $890/ha in 2020 (p<0.001). This was likely due to significantly lower CCS results for 2020 compared to 2018 (p<0.001), despite 2020 having a significantly higher yield (p<0.001).

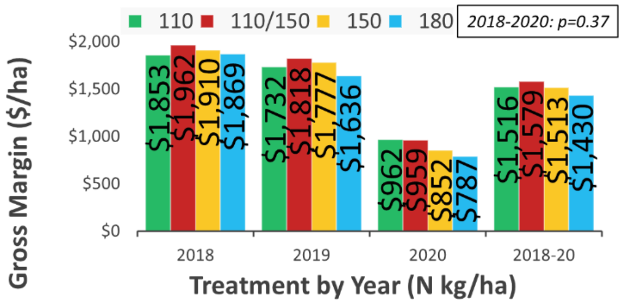


Figure 2.9: Average gross margin ($/ha)

Conclusion

Although gross margins did not differ significantly among the applied N treatments, further exploration of alternating nitrogen rates between 6ES (150N) and marginally lower N rates may be worthwhile given the potential environmental benefits (i.e. lower N runoff with no material change in profitability). Over the full crop cycle there remains no indication that it would be beneficial to apply N rates (e.g. 180N) above the 6ES guidelines given the savings in fertiliser costs at the lower rates.

The control (0N) treatment consistently produced lower yields and sugar (t/ha). These results suggest that the under-application (further reducing rates below 110N) may result in a negative gross margin (based on previous economic analyses). Further trials providing mill data on lower rates would be useful to explore minimum rate applications.

Interestingly, there was a significantly higher average yield in 2020 (late season harvest) compared to 2018 and 2019. However, due to significantly lower CCS and higher costs (relating to higher yields), the gross margin for 2020 was significantly lower. This highlights the importance of considering sugar production and economic outcomes over yield improvement alone.

Previous research trials (that explored variable N rates, e.g. RP20 Project taken over 5-years for 23 replicated/randomised trials) have shown that CCS reduces with higher N application rates. Using an average CCS value in the absence of individual treatment mill CCS data may have impacted gross margin results. However, 2018 and 2020 CCS results did not show significant differences and thus the mill average CCS for 2019 was the most suitable given trial specific conditions.

Note: the trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Farmacist in collection of trial data used in this publication and to David Reid (DAF) for the statistical analysis and guidance.

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Variable N Economics: 2019-20 Case Study (trial D)

Mackay grower: Tony Bugeja

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries (DAF) to identify costs and benefits of the trials. In this study, grower Tony Bugeja and Farmacist trialled varied N (nitrogen) rates.

The trial objective was to examine both the sugar yield and profitability of varying nutrient rates from three treatments in a high yielding block. Treatments included a "Six-Easy-Steps" (6ES) rate, a 6ES + ~15% N rate and a 6ES + ~25% N rate. The average agronomic and economic results are presented for data collected in 2019 and 2020 for 2nd and 3rd ratoons respectively.

Figure 3.1: Tony Bugeja on his farm (Mackay region)

Trial Design

The trial was conducted by Farmacist and Tony Bugeja on his farm located 15km south-west of Mackay. The trial was harvested during the 2019 and 2020 seasons from a paddock planted with variety Q240.

Key findings

- There was no economic advantage from applying a higher rate of N (above the Six-Easy-Steps rate).
- Despite a significantly higher average yield at both higher N rates, gross margins were not significantly different due to the CCS impact.

The trial included a base application of N (6ES rate) with an additional application of N using urea to meet trial specifications. It was both a replicated and randomised strip trial. Table 3.1 presents the average N application rates for each treatment as applied to each ratoon.

Table 3.1: Average N applied (kg/ha, 2nd & 3rd ratoon)

Product (+ N %)	6ES	6ES +15%	6ES +25%
Econo LOS	150	150	150
Urea	0	20	40
Total N	150	170	190

Agronomics

Figures 3.2 and 3.3 present average yield and CCS results for each treatment from the 2019 and 2020 seasons. Both 6ES+15% and 6ES+25% resulted in higher yields compared to the base 6ES rate of N. However, both also resulted in significantly lower CCS translating to no statistical difference in sugar yields (Figure 3.4). This follows results from previous studies (e.g. the RP20 project taken over 5-years for 23 replicated/randomised trials) where higher N rates also resulted in lower CCS.

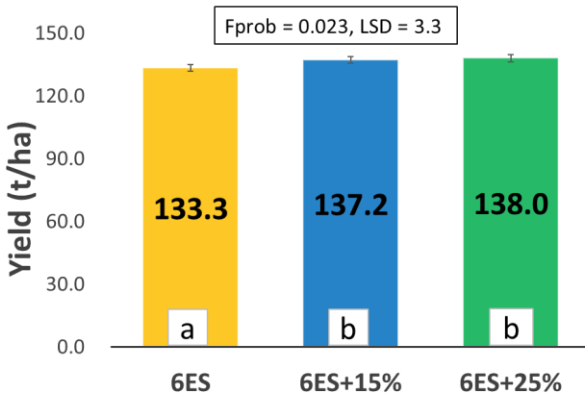

Figure 3.2: Average yield (t/ha) 2019-2020
Source: Farmacist. Error bars indicate 95% least significant difference and different letters indicate statistically significant differences. Note: same applies to figure 3.3.

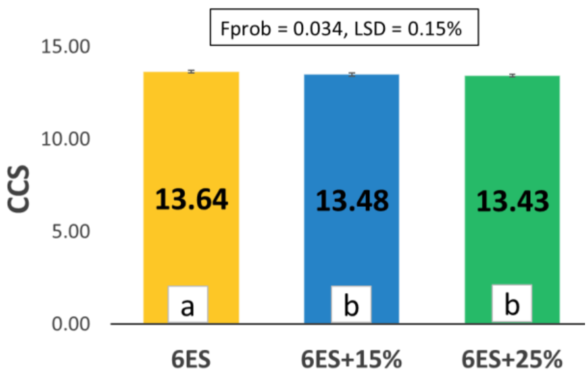

Figure 3.3: Average CCS (units) 2019-2020
Source: Farmacist.

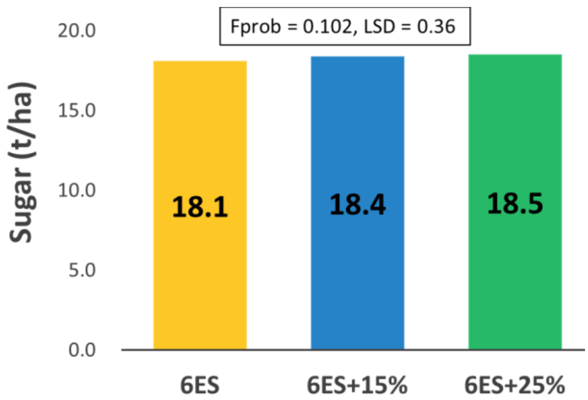

Figure 3.4: Average sugar yield (t/ha) 2019-2020
Source: Farmacist.

Costs

Differences in average variable costs were largely attributed to fertiliser cost variations. Fertiliser costs were calculated as a single application to reflect commercial practice (product pricing included application costs).

Figure 3.5 shows that an additional 40 kg of N cost an average of $89/ha more for the 6ES +25% treatment. Other cost differences were linked to changes in harvesting costs and levies due to variations in yield.

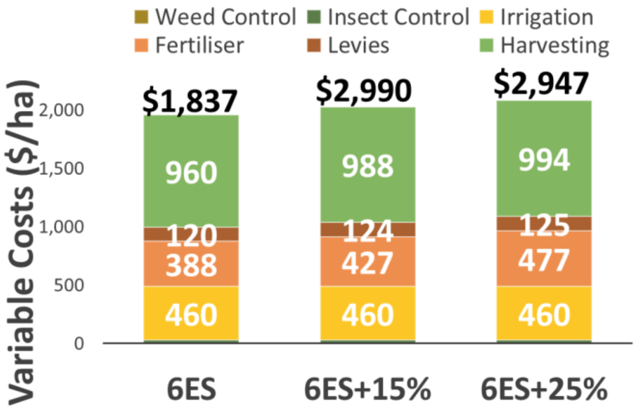

Figure 3.5: Average variable costs 2019-2020

Gross Margins

Gross margins (revenue less variable costs) were not significantly different between N treatments (figure 3.6, based on a 5-year average sugar price of $417/t). With the lowest average gross margin found at the highest N rate ($56/ha less compared to the 6ES treatment), there is likely no benefit in applying an N rate above the 6ES rate.

A sensitivity analysis shows that for the 6ES+15% treatment gross margin to break-even with the 6ES treatment, a sugar price of $531/t is required. This is higher for the 6ES+25% treatment at $796/t.

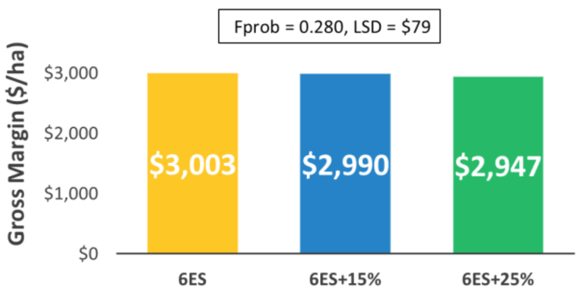

Figure 3.6: Average gross margins 2019-2020

Conclusion

Although higher N rates gave statistically significant improvements in yield, they also showed significantly lower CCS results when compared to the 6ES treatment. Overall, sugar yields were not significantly different.

Given similar sugar yields, the marginally higher variable costs to apply more N gave a slightly higher mean gross margin for the 6ES treatment. This was also due to lower costs related to lower yields (e.g. harvesting and levies), and the higher marginal grower revenue benefit of a CCS improvement relative to yield. However, the difference in gross margins were not statistically significant.

To-date, results from the trial follow previous research outcomes where N rates above industry recommendations produced higher yields offset by lower CCS values. Incorporating results from the 4th ratoon would confirm whether the full crop cycle follows this trend but unfortunately due to grub and pig infestation the block sustained severe damage and requires replant.

Results from the second crop cycle is required to determine longer-term effects as Tony anticipates mineralisation to play a role in later crops.

"It's going to be interesting to see how 6ES compares over a longer-term trial given the effect mineralisation and farming practice has on yields. This will be important when considering vertical expansion and the impact on our industry."

Tony Bugeja.

Note: the trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the significant contribution made by Farmacist to this publication and to David Reid (DAF) for the statistical analysis and guidance.

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Solid vs Liquid Fertiliser Economics: 2020 Case Study

Burdekin grower: Warren Viero

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries to identify costs and benefits of the trials. In this study, Warren Viero together with Farmacist compared liquid fertiliser to granular fertiliser (applied via side dress and stool splitting).

The objective of the trial was to assess the yield, CCS and economic performance of cane under a granular against liquid fertilizer comparison. Applying liquid fertilizer would also be more convenient in terms of calibration and ease of handling. A further objective was to determine the difference between side-dress and stool-spilt granular application methods on both agronomic and economic outcomes.

Costs and production data for each treatment were collected to compare profitability. This included examining differences between the side dressed granular fertiliser, the stool split applications of granular fertiliser, and the liquid fertiliser.

Given the trial block's history of poor soakage, the grower was interested in determining which method of fertiliser application would be the most effective with furrow irrigation. The analysis presents the second ratoon yields, CCS, variable costs, and gross margins.

Trial design

Farmacist conducted the trial with Warren Viero on his farm located in the Burdekin region. The randomised strip trial was established in 2019 on a second ratoon crop of Q252 harvested in 2020.

Key findings

- The granular side-dressed treatment had significantly higher yields, sugar and gross margin results when compared to the stool split and liquid fertiliser treatments ($p<0.05$).
- Further validation of results over multiple seasons, on similar soil types and conditions are required. The agronomic impact of stool splitting should also be further examined.

Warren's standard practice in the ratoons is to apply granular fertilizer side-dressed at 177 kg nitrogen/ha (N/ha). The trial compared the same level of N (177kg N/ha) under three treatments, each with four replicates: Granular fertiliser stool-split; Granular fertiliser side-dressed and Liquid fertilizer stool-split. There were differences in the P-K-S combinations between the granular and liquid fertilisers due to the availability of commercially equivalent products (see Table 4.1). However, from an industry perspective, these differences were not expected to have a significant impact on production.

Table 4.1: Nutrient application rates

Treatment	Kg/ha			
	N	P	K	S
Granular (side-dressed)	177	12	73	18
Granular (stool split)	177	12	73	18
Liquid fert. (stool split)	177	11	70	15

Agronomics

Trial results (Figure 4.1) show that the Granular side-dressed treatment achieved the highest average yield (9t/ha more than the liquid fertiliser treatment). This difference was statistically significant (p<0.05).

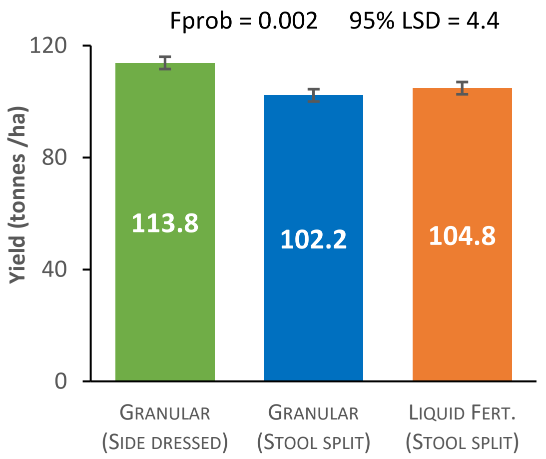

Figure 4.1: Average cane yields (Tc/ha)

There was also a significant difference in sugar (Figure 4.3) between the treatments with the Granular side-dressed treatment having a 1.8ts/h higher sugar yield when compared to liquid fertiliser (p<0.05). There was, however, no significant difference in CCS (Figure 7.2).

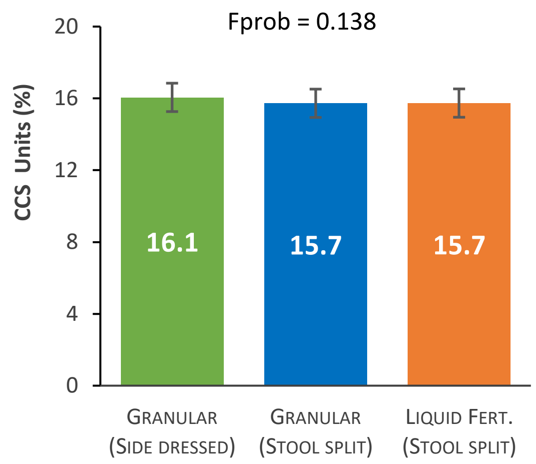

Figure 4.2: Average CCS

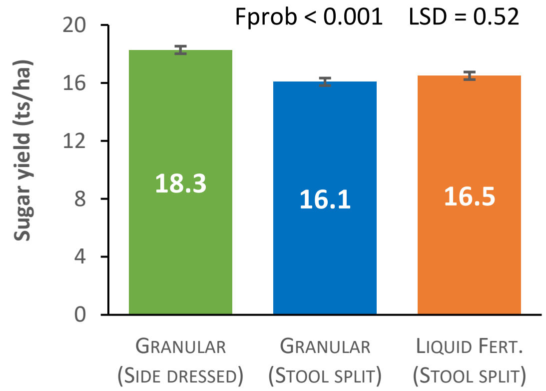

Figure 4.3: Sugar yield (Ts/ha)

Costs

Figure 4.4 presents the variable costs for the second ratoon. Differences in costs were due to differences in fertiliser prices, method of application, and costs that changed with yield (harvesting costs and levies). The liquid fertiliser had a higher product cost compared to the granular fertiliser treatments, with stool splitting also increasing costs against side dressing application.

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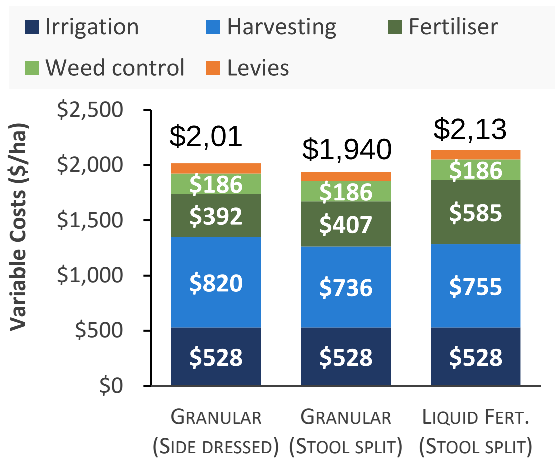

Figure 4.4: Treatment variable costs

Gross margins

The gross margins (revenue less variable costs) for each treatment are presented in Figure 4.5. The Granular side dressed treatment had a signficantly higher gross margin ($581-$660/ha higher) when compared to the other two treatments (p<0.05). This was largely due to the higher sugar yield but also due to lower fertiliser product and application costs.

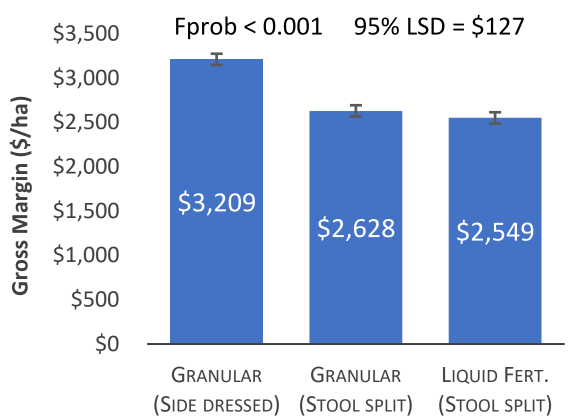

Figure 4.5: Gross margins ($/ha)

Conclusion

Results show the Granular fertiliser side-dressed treatment had a significantly higher yield and gross margin (p<0.05) when compared to both stool split treatments (i.e. liquid and granular). These differences could confidently be attributed to the treatment effects.

There was very little difference in gross margin between the granular stool split and liquid fertiliser stool split treatments which may suggest that application method rather than product type was the most important factor impacting the overall economic results.

To further validate the results, it would be worthwhile to extend the trial over a full crop cycle and across a number of seasons, locations and soil types to see if the similar results are observed.

Note: the trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Farmacist in collection of trial data used in this publication, and Angela Anderson (DAF) for the statistical analysis and guidance.

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Queensland Government

DunderUnder Economics: 2019 Case Study

Mackay growers: Sam, Gerry & Joe Deguara

Key findings

- Subsurface application of BioDunder resulted in an unexpected lower yield and reduced gross margin, although this was not statistically significant.
- Further investigation is necessary since previous trials have shown that subsurface application of BioDunder resulted in yield improvements.

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries (DAF) to identify costs and benefits of the trials. In this study, the Deguaras' and Farmacist trialled surface and subsurface application methods of BioDunder (Dunder) fertiliser.

The objective of the trial was to determine the water quality and economic impact of both subsurface and traditional surface application methods of Dunder. Through cost effective methods of applying Dunder subsurface, it was expected that both water quality outcomes and yields would improve, while having little impact on the overall profitability of the system.

Trial Design

Farmacist assisted the Deguara family on their Eton farm in conducting the trial over the 2018 and 2019 period. This trial was a repeat trial for the Deguaras following their DunderUnder trial run between 2016 and 2018 on a separate block.

The Deguaras applied Dunder on 2nd ratoon cane (Q240) in 2018 that was harvested in 2019. The trial was a randomised strip trial and included three replications for both treatments. Using both a traditional (surface) and subsurface method, the Deguaras applied 3.9 m^3/ha of MKY Econo LOS (Liquid One-Shot) to both treatments. A modified applicator was used to apply subsurface.

Figure 5.1: Sam and Gerry Deguara alongside their modified subsurface Dunder applicator

Agronomics

Yields were 3.8 t/ha lower from the subsurface treatment. This was unexpected given the subsurface application method was expected to reduce both runoff and volatilisation losses of nitrogen, previously evident from results of the Deguara 2017-18 DunderUnder trial. Although CCS was marginally lower (0.17%) for the subsurface treatment, this was not statistically significant.

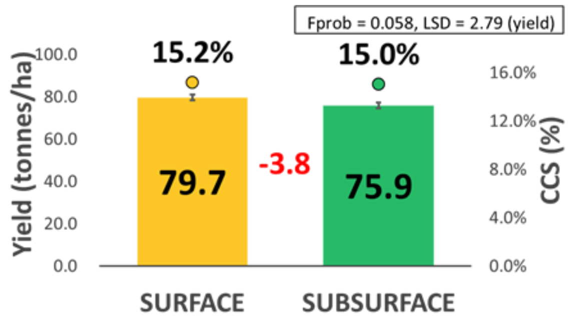

Figure 5.2: Treatment yields (t/ha)
Source: Farmacist. Error bars indicate 95% least significant difference (overlapping indicate no significant difference).

Costs

The Deguaras' estimated the replacement value of the subsurface applicator at $100,000. Due to a lower tank capacity, this was approximately $50,000 less than the surface applicator. Although this translated to marginally lower capital costs per hectare ($6/ha) depreciated over 20 years, the variable machinery costs were $27 per hectare higher due to the longer machinery cycle times. The subsurface applicator averaged a far lower 3 ha per hour work rate against 7 ha per hour for the surface applicator. This was the result of more tank fills, slower speed to apply subsurface, and less cane row pass coverage (three rows instead of seven).

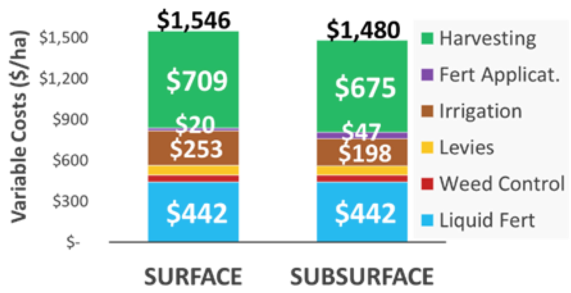

Figure 5.3: Treatment variable costs 2019-2020

Despite the higher cost of using a modified applicator for the Dunder, the economic analysis identified savings in irrigation costs. Subsurface application of Dunder did not require the usual 'watering in' (25mm applied), which amounted to an irrigation cost saving of $55 per hectare in the trial (*given this would be the common practice on a commercial scale the cost difference is considered, however, in the trial both treatments still received the additional irrigation water due to the trial layout*).

Figure 5.3 shows the average variable cost of the subsurface treatment to be $66 per hectare lower which included the effect of lower yields on both harvesting costs and levies.

Gross Margins

The economic results showed a $147/ha reduced gross margin (revenue less variable costs) for the subsurface treatment (Figure 5.4) based on a 5-year average sugar price. Despite lower variable costs, these were outweighed by the reduced sugar yield in the subsurface treatment (0.7 ts/ha lower).

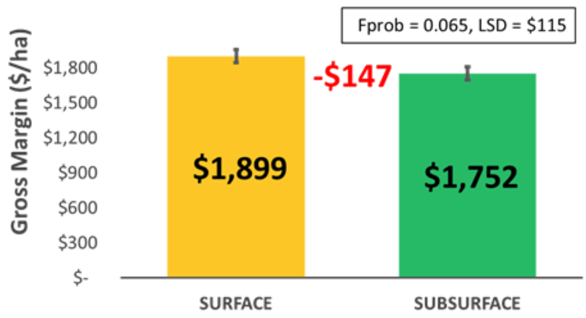

Figure 5.4: Average gross margins
Error bars indicate 95% least significant difference (overlapping indicate no significant difference)

Conclusion

In comparison to the previous trial's results where gross margins were similar, the 2019 harvest results showed a loss in yield through the application of Dunder subsurface. Further ratoon results will be monitored as this outcome contrasted previous trials.

It may also be necessary to analyse commercial implement capital cost differences over a shorter planning horizon as the trial showed negligible differences where in-house modifications had been made.

"Previous trials, comparing similar application methods showed very little difference in yield. These were measured over a number of years so initial results of this trial are surprising." **Natalie Fiocco (Farmacist).**

Note: the trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Farmacist to this publication and to David Reid (DAF) for the statistical analysis and guidance.

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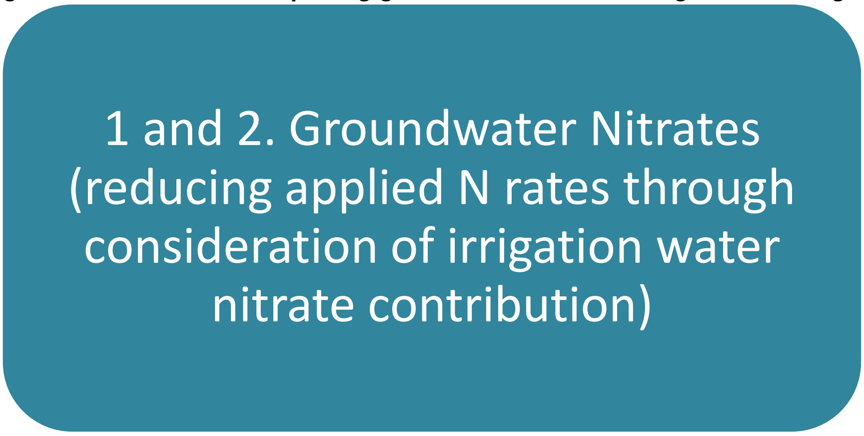
Nutrients and Water: reducing rates with groundwater N

Refining nutrient management is a key focus area of Project Catalyst. This section explores various strategies trialled by Project Catalyst growers that aim to refine the management of nitrogen while considering nitrate supplies in their irrgation water. Figure 6.1 outlines each of these strategies in order of appearance for individual case studies in this section.

Figure 6.1: Case studies exploring groundwater nitrate management strategies.



Department of Agriculture and Fisheries

Project Catalyst

Groundwater Nitrates Economics: 2019-20 Case Study

Burdekin growers: Paula and Bryan Langdon

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries to identify costs and benefits of the trials. In this study, Paula and Bryan Langdon together with Farmacist trialled the application of reduced Nitrogen (N) rates to account for nitrates in irrigation water.

The objective of the trial was to determine the impact on production through varying the N rate in late ratoons to account for the additional nitrates supplied by irrigation water on the Langdon's farm. Yields and profitability were measured to compare the performance of different nitrogen (N) rates. The analysis presents third and fourth ratoon yields, CCS, variable costs, and gross margins.

Trial design

Farmacist conducted the trial with Paula and Bryan on their farm located in the Burdekin region. The randomised strip trial was established in 2018 on a third ratoon crop of KQ228 harvested in 2019. The trial was repeated on the fourth ratoon harvested in 2020.

The Langdon's standard N application rate for later ratoons irrigated with high nitrate bores is 185kg N/ha. The trial compared three different N rate treatments to determine the impact of reducing N rates to account for the groundwater nitrates contribution. These were 185kg, 155kg and 125kg of N/ha with each treatment having four replicates.

Key findings

- There was no significant difference in sugarcane yield, CCS or gross margin between varied N rates for the two ratoons included in the study.
- Further investigations into the ground water nitrate contributions to overall N uptake would be beneficial.

Agronomics

Trial results (Figure 7.1) show no statistically significant difference in yield across the three treatments ($p>0.05$). There was also no significant difference in CCS (Figure 7.2) or sugar (t/ha) between treatments.

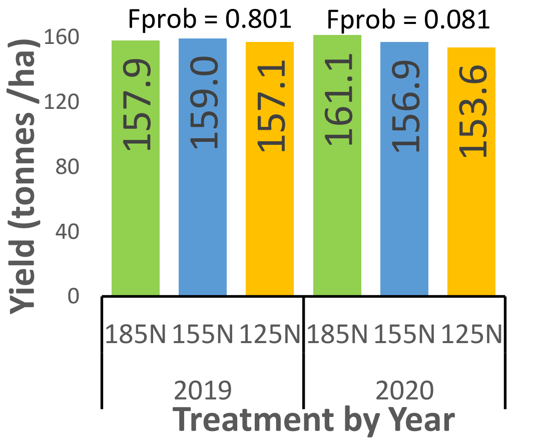


Figure 7.1: Average cane yields (t/ha, 2019-2020)

The groundwater used for irrigation on the Langdon's farm contains nitrates which should allow them to lower their amount of applied N particularly in the later ratoons. However, the amount of available N supplied by the

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groundwater has not been measured to accurately ascertain N requirements.

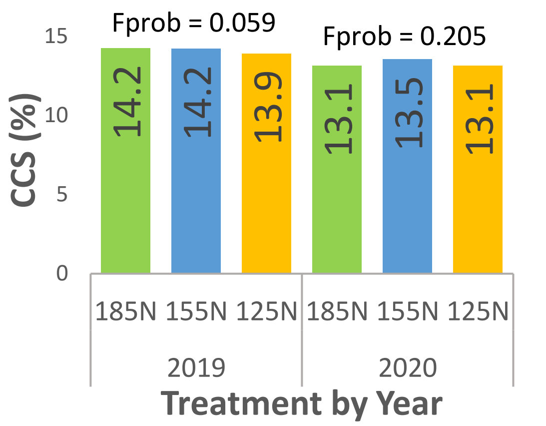

Figure 7.2: Average CCS (2019-2020)

Costs

Figure 7.3 presents the variable costs for the third ratoon. Differences in costs were due to the varied fertiliser rates and costs that changed with yield, namely harvesting costs and levies.

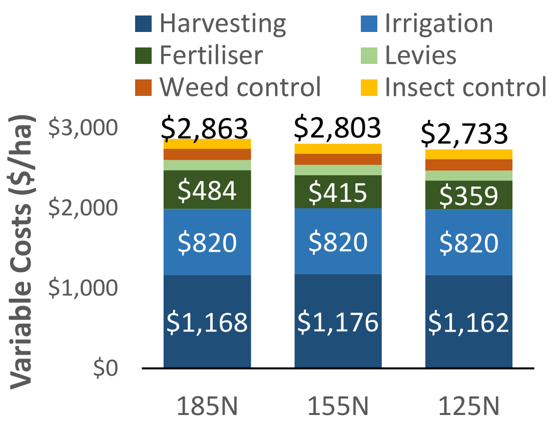

Figure 7.3: Third ratoon treatment variable costs (2019)

Figure 7.4 presents the total variable costs per treatment for the fourth ratoon.

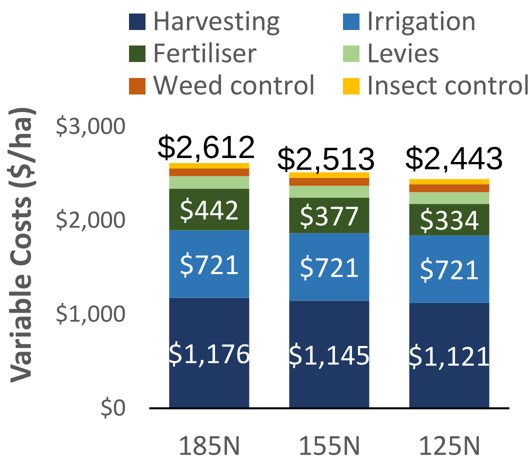

Figure 7.4: Fourth ratoon treatment variable costs (2020)

Gross margins

The gross margins (revenue less variable costs) for each treatment from the third and fourth ratoons, and the average total gross margin for the two years are presented in Table 7.1. These are based on a 5-year average sugar price ($417/t).

For both the third and fourth ratoons, the 155 kg N/ha treatment had the highest gross margin, although this difference was not statistically significant.

Table 7.1: Gross margins ($/ha)

Crop	Treatment			p-value
	185N	155N	125N	
3rd Ratoon (2019)	$3,315	$3,400	$3,214	0.261
4th Ratoon (2020)	$3,005	$3,201	$2,913	0.187
Average	**$3,160**	**$3,300**	**$3,064**	**0.138**

Conclusion

With no significant differences in the mean yield, CCS or gross margin between treatments over the two years ($p>0.05$), the results suggest it may be worthwhile to further investigate the contribution of groundwater nitrates to crop N uptake.

A better understanding of the amount and availability of nitrates in the irrigation water may enable optimisation of applied N in late ratoons. This could potentially improve the profitability of the Langdon's farm through savings in fertiliser costs.

Note: the trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Farmacist in collection of trial data used in this publication, and Angela Anderson (DAF) for the statistical analysis and guidance.

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Publication date: February 2021

Groundwater Nitrates Economics: 2019 Case Study

Burdekin BRIA grower: Brendan Swindley

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries to identify costs and benefits of the trials. In this study, Brendan Swindley and Farmacist trialled the application of a reduced Nitrogen (N) rate to account for the nitrates supplied through irrigation water.

The objective was to assess whether applied N rates for high groundwater nitrate areas could be reduced without reducing yield or profitability. If the trial yields positive results, Brendan would like to adopt lower N application rates in late ratoons to compensate for nitrates supplied by irrigation water.

Key findings

- A higher average yield and CCS for the higher N rate (170kg N/ha) resulted in a higher average gross margin, although not statistically different (at 5% significance level).
- Results suggest there is a need to further investigate the contribution of ground-water nitrates to crop N uptake in early ratoons.

Trial Design

The replicated and randomised strip trial was established during 2018 in a first ratoon crop of Q183 harvested in 2019. The trial compared the yield and profitability of applying a reduced rate of 130 kg N/ha against 170 kg N/ha. Each treatment had four replicates with a randomised complete block design. Yields and profitability were measured to compare the treatments. The trial followed a similar methodology to the trial Brendan conducted during 2017-18 on a different block.

Costs

Applying 130kg N/ha reduced fertiliser costs by $98/ha. Harvesting costs and levies also varied as these were dependent on yield. All other costs were the same for both treatments. Figure 8.1 shows a breakdown of the average variable cost for each treatment.

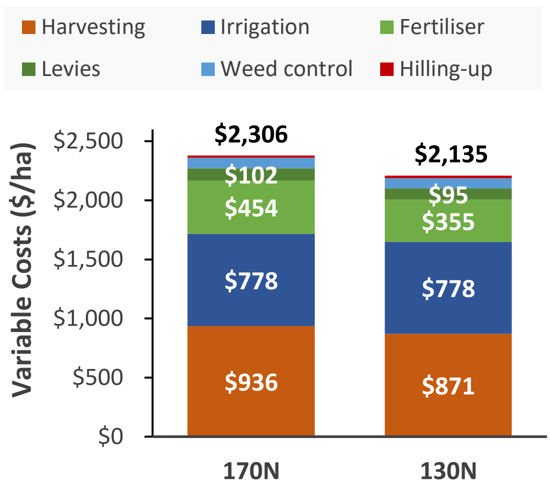

Figure 8.1: Variable cost breakdown

Results

Table 8.1 shows the higher N rate treatment (170 kg N/ha) had a higher average cane yield and CCS. The differences in both yield and CCS were not statistically significant and therefore could not confidently be attributed to the different N rates.

Table 8.1: Average cane yield and CCS.

	170N	130N	p-value
Cane yield, tch	126.5	117.7	0.397
CCS, units	15.46	15.28	0.616

Gross margins (revenue less variable costs) were determined to compare the profitability between treatments. Figure 8.2 shows that the average gross margin for 170N was $293/ha higher than for the 130N treatment, although a statistical analysis of the economic results indicated that the differences in gross margins were not statistically significant.

It is also important to note that there was a wide variation in production results within treatments, particularly for the 170N treatment whose yields ranged from 108 to 139 t/ha. This suggests that other factors may be influencing production.

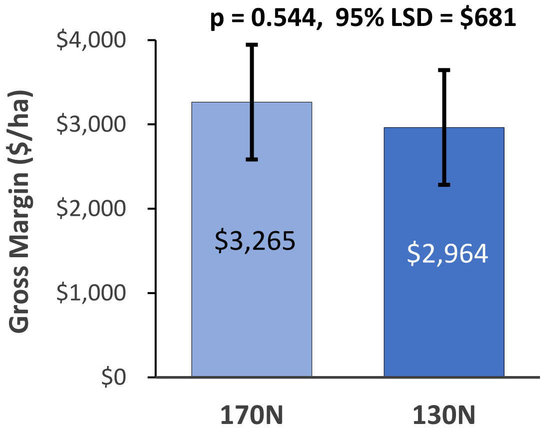

Figure 8.2: Average gross margin
Error bars indicate the 95% least significant difference (overlapping bars indicate no significant difference).

In contrast, Brendan's 2017-18 trial showed the lower rate of N (107kg N/ha) obtain a higher average yield and CCS. This resulted in a higher average gross margin (+$306/ha), although this difference was also not statistically significant.

Conclusion

The ground water used for irrigation at the trial site was identified as being high in nitrates. The trial sought to determine if applied N could be reduced, while maintaining yield and profitability in the first ratoon.

The higher gross margin for the 170 kg N/ha treatment was driven by a higher average cane yield and slight improvement in CCS. However, the difference was not statistically significant and further investigation is necessary to validate the results. This would include measuring nitrate levels in irrigation water, introducing additional treatments (including a zero N treatment) and further trials.

With a better understanding of the nitrates being supplied to the crop through irrigation water, adjusted nutrient rates may help improve farm profitability in ratoon crops and water quality outcomes.

Note: The trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Farmacist in collection of trial data used in this publication, and Angela Anderson (DAF) for the statistical analysis and guidance.

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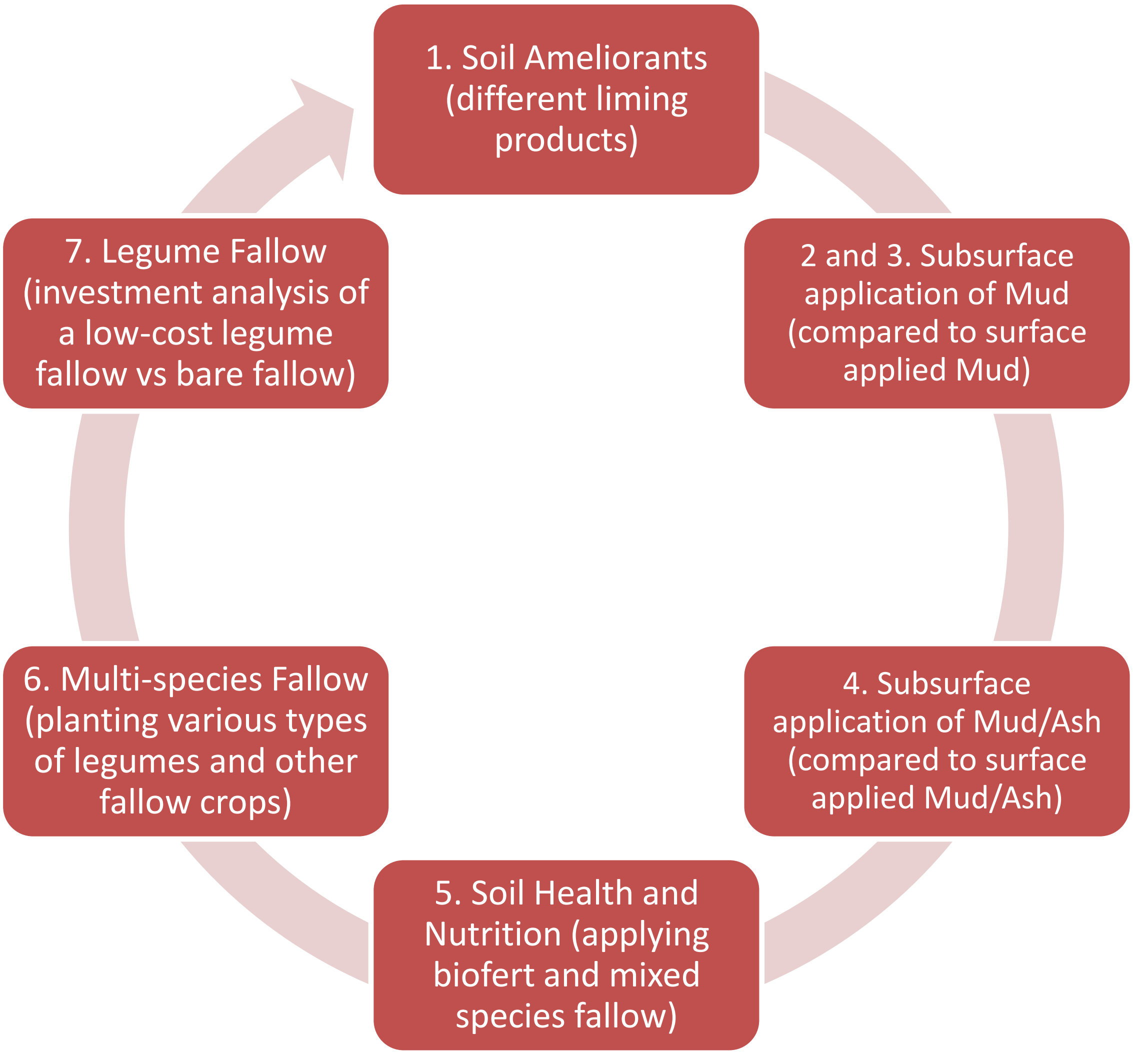
Publication date: August 2020

Queensland Government

Soils: biofert, fallows and ameliorants

Improving soil conditions is a key focus area of Project Catalyst. It is important to note that short-term trials may not show longer-term impacts of improved soil conditions. This section explores various strategies trialled by Project Catalyst growers that aim to improve soil health linked into nitrogen management strategies on their farms. Figure 9.1 outlines each of these strategies in order of appearance of individual case studies in this section.

Figure 9.1: Case studies exploring soil enhancement strategies.



Department of Agriculture and Fisheries

Project Catalyst

Soil Ameliorant Economics: 2018-20 Case Study

Herbert grower: Alan Lynn

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries to identify costs and benefits of the trials. In this study, Alan Lynn and HCPSL trialled the application of different forms of soil ameliorants.

The objective of the trial was to determine the impact of applying three different ameliorants on sugar yield and economic outcomes. Variable costs and mill data were used to undertake an interim economic analysis and compare the profitability of the treatments over the full crop cycle. Trial results were analysed over three years for the plant cane, first and second ratoons.

Trial design

The randomised strip trial was harvested in 2018 (plant), 2019 (1st ratoon) and 2020 (2nd ratoon). The trial compared three lime product treatments. In the first two treatments, 4 t/ha of agricultural lime (Ag Lime) and a kiln dust/Ag Lime mix (KD-AL mix) were applied once on the fallow. Applied at these rates, the ameliorants are expected to provide a benefit over the full crop cycle. For the third treatment, 350 kg/ha of Prilled Lime was applied in three stages, at plant and in the first and second ratoons.

The trial had three replicated blocks with the three treatments randomly assigned within each of the replicates (as shown in Figure 10.1).

Key findings

- The KD-AL mix achieved a significantly higher average CCS ($p<0.05$) in 2019.
- There were no significant differences in average yield or gross margins between treatments ($p>0.05$) for any year.
- From the first three years data, there is not enough evidence to suggest that any single ameliorant resulted in higher profitability.

Headland	Rep 3			Rep 2			Rep 1		
	T2	T1	T3	T2	T1	T3	T3	T2	T1
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9

Key

T1	Ag Lime
T2	KD-AL mix
T3	Prilled Lime

Figure 10.1: Trial Layout
(source: HCPSL)

Agronomics

Figure 10.2 presents 2018, 2019, and 2020 yield data. Neither annual, nor combined data were significantly different between treatments ($p<0.05$). The combined average yields (Figure 10.3) ranged from 89 t/ha for the Prilled Lime treatment up to 93 t/ha for AG-Lime.

Average yield (for all treatments) was highest in plant cane followed by the first and second ratoons respectively.

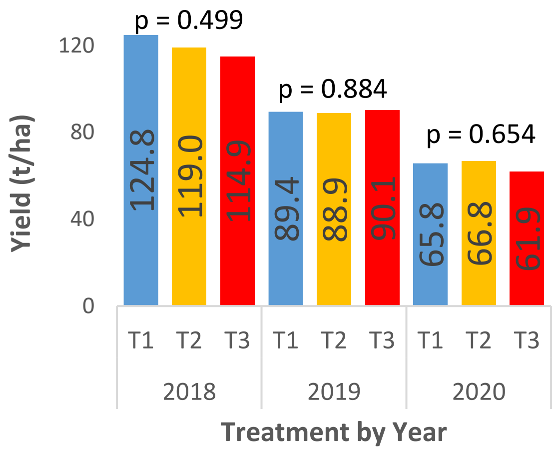


Figure 10.2: Average mill yield results (t/ha)

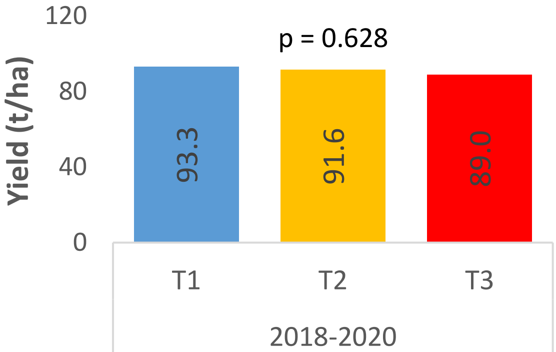


Figure 10.3: Combined average annual mill yield results 2018-20 (t/ha)

Figure 10.4 presents the average CCS for each treatment from 2018 to 2020. For these two years, there were no statistically significant differences in CCS between treatments (p>0.05). In 2019, CCS was significantly higher for the KD-AL (p<0.05) when compared to the Ag Lime and the Prilled Lime treatments. This could confidently be attributed to the treatment differences.

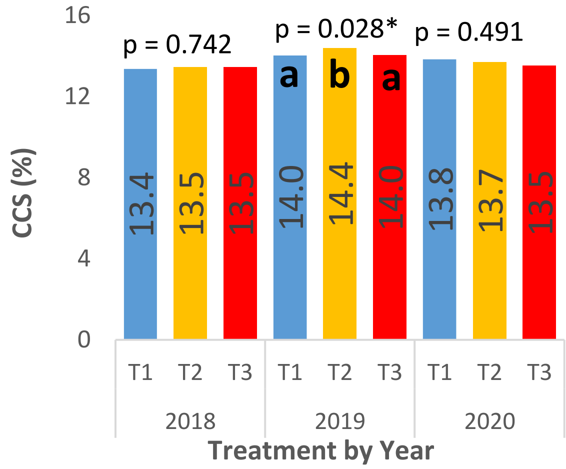


Figure 10.4: Average mill CCS results (%)
Different letters indicate statistically significant differences.

Costs

The combined average annual variable costs for 2018, 2019 and 2020 seasons are presented in Figure 10.5. The difference in treatment variable costs were largely due to differences in the cost of ameliorant and application cost. There were also differences in harvesting costs and levies, as these were proportional to yield. All other operations and costs were the same between treatments.

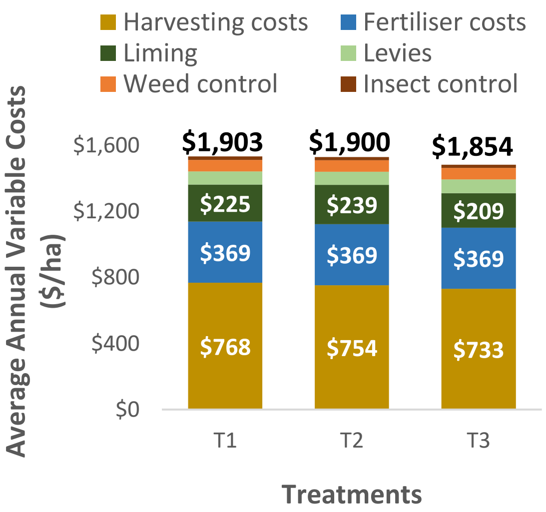


Figure 10.5: 2018-20 Average annual variable costs per treatment ($/ha)

Gross Margins

Gross margin results (revenue less variable costs) are presented in Figure 10.6. There were no significant differences between average treatment gross margins (p>0.05) in any of the years.

Average annual gross margins were lowest in the plant cane (2018), and highest in the first ratoon (2019) (p<0.05).

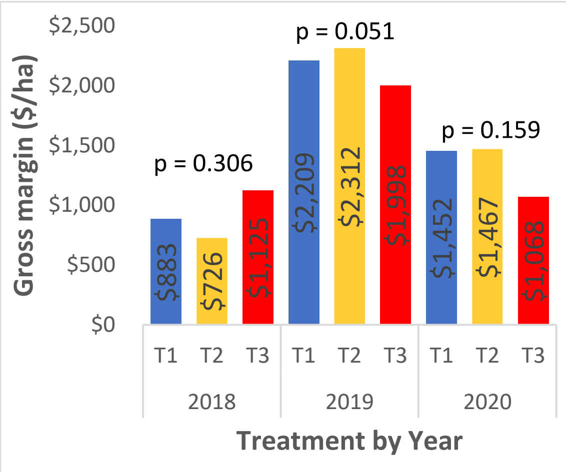


Figure 10.6: Average gross margin ($/ha

The average of the combined gross margins over all the years (Figure 10.7) did not show significant differences between treatments.

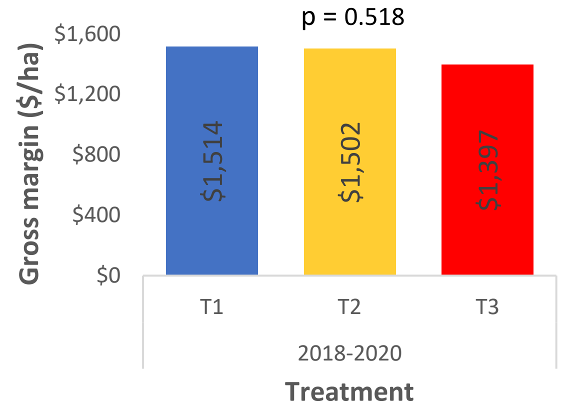


Figure 10.7: Average gross margin 2018-2020 by treatment ($/ha)

Conclusion

Overall, there were no statistically significant differences in yields or gross margins between treatments in any of the three years. This indicates that any observed differences in the variables could not be attributed to the treatment effects.

The second ratoon results include the last instalment of Prilled Lime. With all treatments having received full liming requirements, the production and economic results of the treatments are directly comparable for the first three crops. Based on the results from this trial, there is not enough evidence to suggest that any of the three soil ameliorants trialled would provide Alan with greater economic or production benefits over another up to the second ratoon.

Note: The trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by HCPSL in collection of trial data used in this publication, and Angela Anderson (DAF) for the statistical analysis and guidance.

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Queensland Government

Subsurface Mud/Ash Economics: 2018-20 Case Study

Mackay (Eton) grower: Phil Deguara

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries to identify costs and benefits of the trials. In this study, grower Phil Deguara and Farmacist examined surface and subsurface application methods of Mill Mud (mud) and Ash on two demonstration plots.

The objective of the demonstrations was to examine both the agronomic and economic impact of applying mud and ash subsurface against the standard surface application method. Through cost effective means of applying ash and mud subsurface, it was expected that both water quality outcomes and yields would improve, while having little impact on the overall economics of the system. The analysis presents yield, CCS, sugar, variable costs, and gross margins for the preceding soybean crop (2018), plant cane (2019) and first ratoon (2020).

Figure 11.1: Phil Deguara on his farm in Eton (Mackay)

Key findings

- There were different yield responses between the Mud and Ash plots.
- A full crop cycle is required to determine overall effects on sugar yield and profitability where initial high ameliorant costs overestimate the economic advantages of the Ash plot control.

Trial Design

Two non-randomised plots were established by Farmacist and Phil Deguara on his Eton family farm in 2017. In the first demonstration plot (Mud plot), 50 t/ha of a mud/ash mix was applied with both surface and subsurface methods before planting soybeans (two treatments). The third treatment (control) received no mud.

The second plot (Ash plot) had the same 50 t/ha mill mud/ash mix applied across all treatments (surface, subsurface and control). An additional 100t/ha of ash was then applied to the surface and subsurface treatments. In this case the third treatment (control) received no ash. Table 11.1 outlines the mud and ash application rates per treatment.

Surface treatments of mud/ash and ash were applied in a band. The subsurface method involved applying the band into a slot for covering later with a mounder. Both demonstrations were conducted under similar conditions on neighbouring paddocks and planted to the variety SP80.

Table 11.1: Ameliorant application rates (tonnes/ha)

Ameliorant	Application Rate (t/ha)		
	Control	Surface	Subsurface
Mud Plot			
Mud / Ash	0	50	50
Ash	0	0	0
Ash Plot			
Mud / Ash	50	50	50
Ash	0	100	100

Agronomics

Figures 11.2 and 11.3 present plant cane, ratoon and average yields for the Mud and Ash plots respectively. The Mud plot showed consistently higher yields for the surface applied treatment, while the Ash plot showed little difference between application methods with yield rankings reversing between plant and first ratoon.

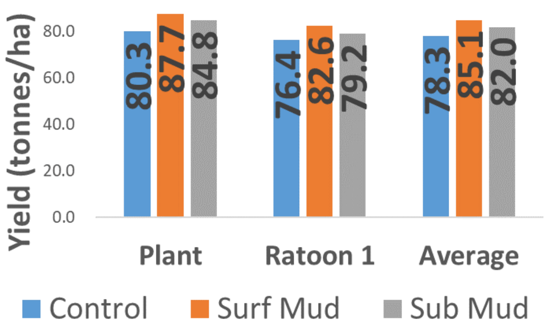

Figure 11.2: Cane yields (t/ha) - Mud plot

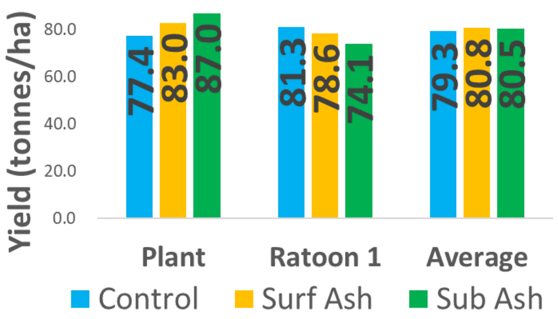

Figure 11.3: Cane yields (t/ha) - Ash plot

For both plots average CCS was slightly higher for the subsurface treatments with the surface applied methods giving the lowest overall average CCS (see Figures 11.4 and 11.5). The gain in CCS for the subsurface treatments was evident in the first ratoon for both plots.

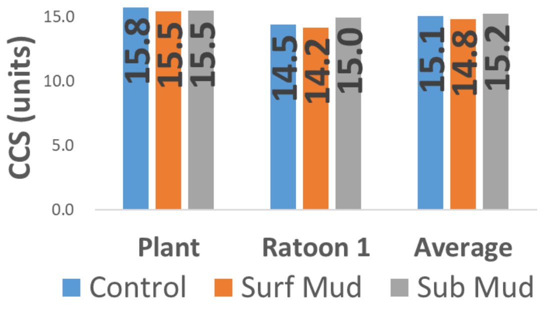

Figure 11.4: CCS - Mud plot

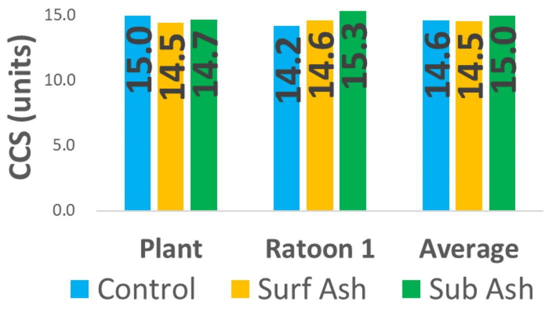

Figure 11.5: CCS - Ash plot

Average sugar yields (Figure 11.6) from the Mud plot were higher in both mud/ash treatments when compared to the control. However, there was little difference in yield between application methods.

For the Ash plot, the subsurface treatment showed a higher sugar yield when compared to both the surface and control treatments.

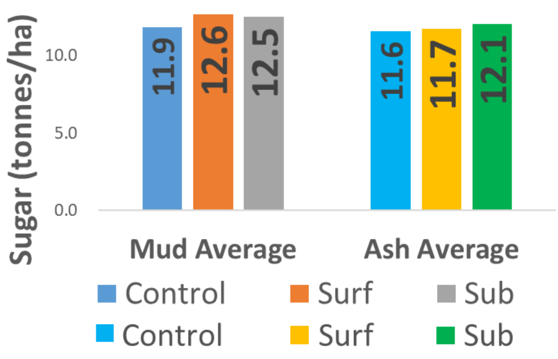

Figure 11.6: Sugar (t/ha) – Mud & Ash plots

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Yields and CCS will continue to be monitored for the full crop cycle to demonstrate longer-term effects on profitability.

Costs

Differences in average variable costs were largely attributed to mud/ash and ash cost variations prior to planting of the soybeans (see Figures 11.7 through to 11.10). This included $349/ha more for the mud/ash mix in both plots and an additional $330/ha for the ash application. To place the mud/ash subsurface, an additional $53/ha was required for the subsurface treatment in both plots (two passes with the mounder).

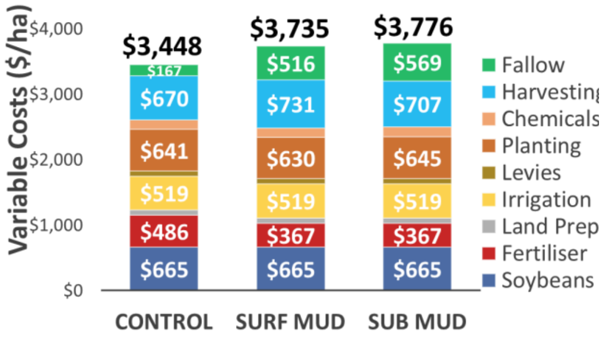

Figure 11.7: Soybean/Plant variable costs – Mud plot

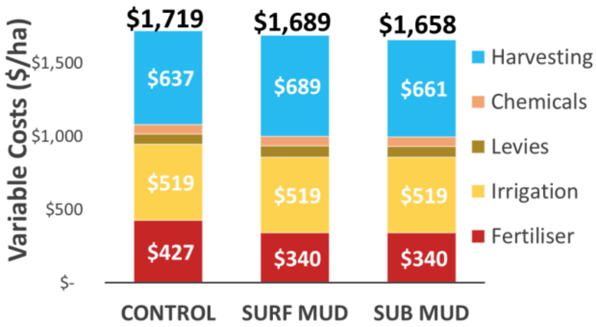

Figure 11.8: 1st Ratoon variable costs – Mud plot

Due to the mud plot control receiving no mud, costs for the application of ammonium polyphosphate (APP) are included in both the plant and ratoon crops (45l/ha applied to ensure the availability of phosphorous). Other cost differences were linked to changes in harvesting costs and levies due to variations in yield.

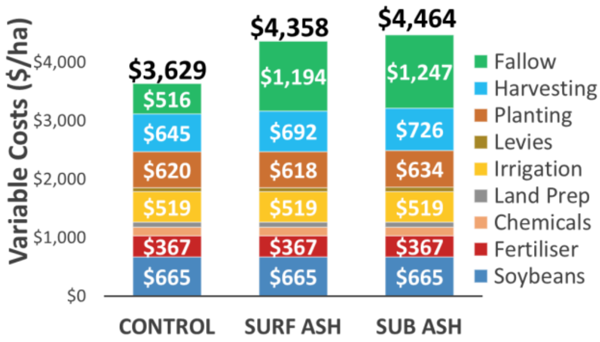

Figure 11.9: Soybean/Plant variable costs – Ash plot

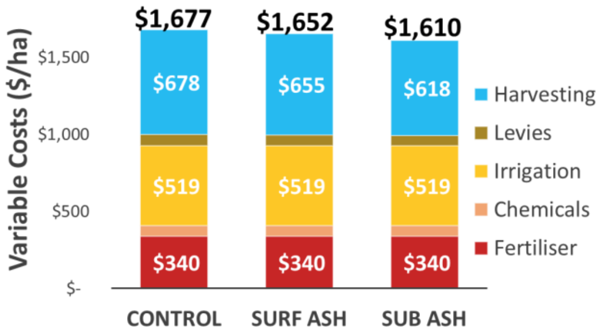

Figure 11.10: 1st Ratoon variable costs – Ash plot

Gross Margins

Total gross margin (revenue less variable costs) for the soybean, plant and ratoon crops in the mud plot was $27/ha higher for the surface compared to the subsurface treatment (Table 11.2). The control resulted in the lowest gross margin.

For the ash plot the control had the highest average gross margin. This was due to the high initial costs of applying both mud and ash in the other treatments. However, where ash was applied, the subsurface treatment had a $182/ha higher gross margin compared to the surface application.

Table 11.2: Gross margins ($/ha), Mud & Ash plots

Product/Crop	Treatment		
	Control	Surface	Subsurface
Mud Plot			
Fallow/Soybeans	$1,058	$710	$657
Plant Cane	$1,026	$1,319	$1,212
1st Ratoon	$1,364	$1,569	$1,702
Total	**$3,449**	**$3,598**	**$3,571**
Ash Plot			
Fallow/Soybeans	$710	$31	-$22
Plant Cane	$832	$854	$1,030
1st Ratoon	$1,531	$1,563	$1,621
Total	**$3,072**	**$2,448**	**$2,630**

Note: The case studies were not randomised or replicated and thus no statistical comparison was done. Any difference observed in gross margins can therefore not confidently be attributed to the treatment difference.

Conclusion

Although the results remain inconclusive in the initial plant crop and first ratoon, the anticipated future benefits of ameliorants in the follow-up ratoons are expected to improve the sugar yield at a reduced cost (e.g. lower phosphorous requirements when compared to the Mud plot control). However, the initial high cost of applying the additional ash (Ash plot) will require significant gains in the ratoons to offset the savings in the control. A full crop cycle analysis would therefore be important to validate the overall economic impact of the ash treatments against the control.

"By including phosphorous in the initial ameliorant program, the nutritional program is also simplified for the remaining crop cycle. This is beneficial against currently complex nutrient program requirements."

John Turner.

Note: The trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the significant contribution made by Farmacist to this publication.

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Queensland Government

Subsurface Mill Mud Economics: 2018-20 Case Study

Mossman grower: Chris McClelland

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries (DAF) to identify costs and benefits of the trials. In this study, Chris McClelland and Mossman Agricultural Services (MAS) trialled subsurface mill mud application and reduced N rates on his farm.

Key findings

- Average yields were higher for both mud treatments when compared to the others, although differences could not be validated statistically.
- Although inconclusive due to non-randomised replicates, the sub-surface mill mud and reduced N rate treatment (T4) had the highest total gross margin for the plant to 2nd ratoon crops.

The objective of the trial was to determine the impact of applying mill mud subsurface and reduced N, on both sugar yield and the resultant economics. Variable costs and mill data were used to undertake an economic analysis and compare profitability between the treatments over three crop classes. Trial results were analysed from the plant cane, first and second ratoons.

Trial design

The replicated strip trial was established in 2017 and was harvested in 2018 (plant), 2019 (1st ratoon) and 2020 (2nd ratoon). The trial compared four treatments as shown in Table 12.1.

Table 12.1: Treatment N application rates

Treatment	Description
T1	Full fert (Six-Easy-Steps N Rate)
T2	75% Full fert
T3	Full fert + Subsurface mill mud
T4	75% Full fert + Subsurface mill mud

Each treatment included three replicates applied in the same order across rows (non-randomised). Mill mud was applied subsurface at 54t/ha to two of the treatments (T3 and T4) before planting.

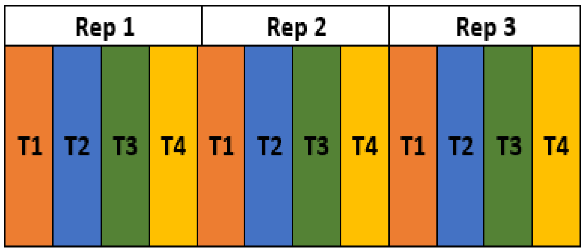

Figure 12.1: Trial Layout
(source: MAS)

Agronomics

Average yields (for all treatments) were highest in plant cane when compared to the first and second ratoons. Figure 12.2 presents 2018, 2019, and 2020 cane yield data. In every year, yields were also generally higher for the mud treatments, but this could not be confirmed in the absence of a statistical analysis where replicates were non-randomised.

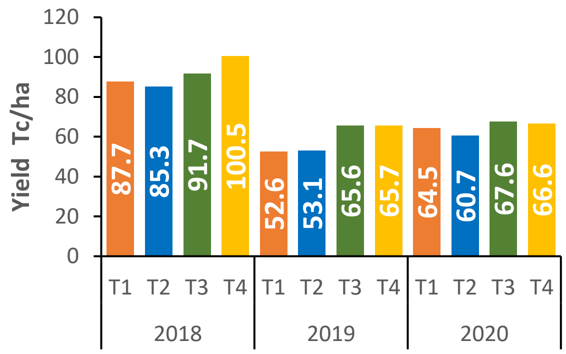

Figure 12.2: Sugarcane yield results (t/ha)

Figure 12.3 presents average sugarcane yield over three years from the four treatments. Treatments containing mud show a higher average yield from the plant cane. However, this could not be confirmed in the absence of a statistical analysis.

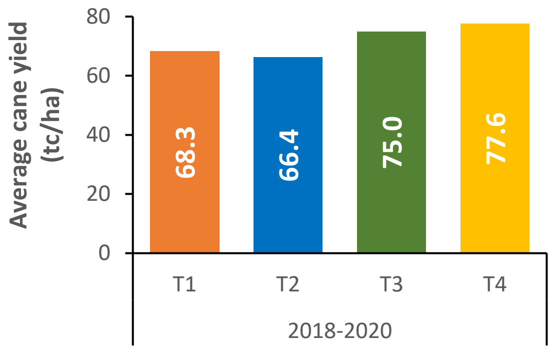

Figure 12.3: Combined average sugarcane yield results for each treatment 2018-20 (t/ha)

Figures 12.4 and 12.5 present the average CCS and sugar results for each treatment from the plant cane harvested in 2018, to the second ratoon harvested in 2020.

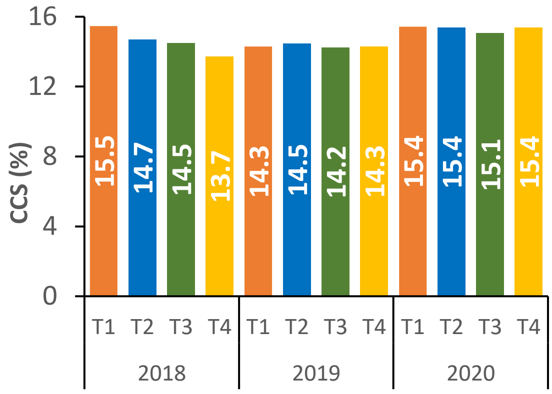

Figure 12.4: Average mill CCS results (%)

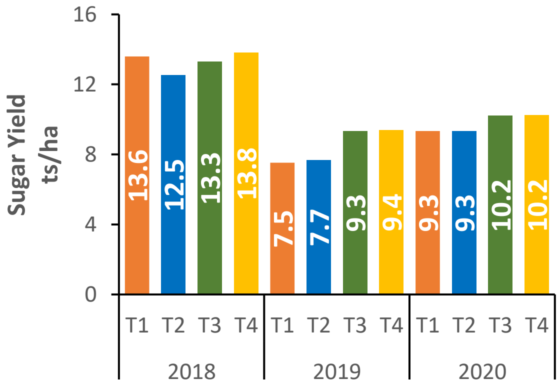

Figure 12.5: Sugar yield (ts/ha)

In the plant crop, CCS was marginally lower in each year for the mud treatments. However, differences in CCS or sugar could also not confidently be attributed to the treatment effect in the absence of statistical data.

Costs

The combined average annual variable costs for 2018, 2019 and 2020 seasons are presented in Figure 12.6. The difference in treatment variable costs were largely due to the initial mill mud and application cost differences in the fallow ($446/ha added cost of mud), annual differences in fertiliser costs (based on treatment differences), and harvesting costs and levies, which were proportional to yield. All other operational and treatment costs were the same.

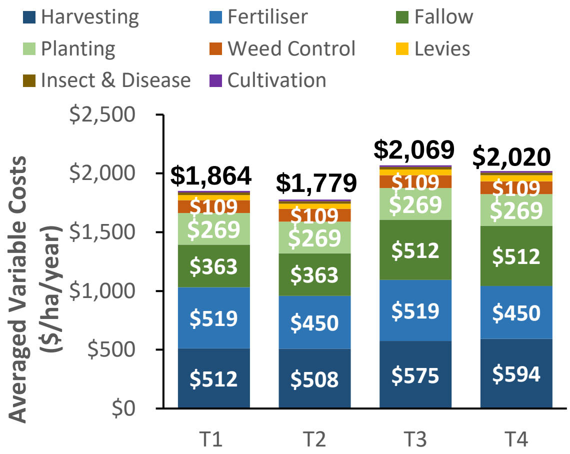

Figure 12.6: 2018-20 Average annual variable costs per treatment, fallow to 2nd ratoon ($/ha)

Gross Margins

Gross margin results (revenue less variable costs) are presented in Table 12.2 for the fallow, plant cane, first and second ratoons, including the average for each treatment. Treatment 4 had the highest average gross margin with the lowest from Treatments 2 & 3. However, no statistical analysis could be performed and therefore the observed differences could not confidently be attributed to the treatments.

Table 12.2: Gross margins ($/ha)

Crop Class	Treatment			
	T1	T2	T3	T4
Fallow	-$1,089	-$1,089	-$1,535	-$1,535
Plant cane	$1,449	$1,194	$1,251	$1,338
1st Ratoon	$1,073	$1,236	$1,452	$1,589
2nd Ratoon	$1,728	$1,577	$1,750	$1,785
Average	$790	$730	$730	$794

Conclusion

Chris wanted to determine if the added benefits of nutrients from mill mud and the extra cost of subsurface application would outweigh the option of not applying mill mud.

Average sugarcane yields for the plant, first and second ratoons were higher for the mud treatments. While there was no clear difference in CCS between treatments, the application of mud resulted in higher sugar yields. Despite the additional cost of mud application in fallow, the average gross margin over the trial period was quite similar with no consistent difference between mud and no mud treatments. Gross margins were generally higher for the mud treatments in the plant cane, first and second ratoon. Incorporation of follow-up ratoons (third and fourth) could provide further insight into the economic benefits of mud, in particular if the trend of increased sugar yields continues in later ratoons.

The economics on applying mill mud in sugar cane was analysed in the trial. Observed differences could not confidently be attributed to treatment effects due to the non-randomised trial design. Future research work should utilise a randomised trial design to help validate the economic implications of mill mud.

Note: The trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Mossman Agricultural Services (MAS) in collection of trial data used in this publication, and Angela Anderson (DAF) for the statistical analysis and guidance.

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Queensland Government

Subsurface Mud Economics: 2019-20 Case Study

Sarina growers: Grant and Allan Matsen

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries (DAF) to identify costs and benefits of the trials. In this study, Grant and Allan Matsen trialled the subsurface application of Mill Mud (mud).

The trial objective was to compare the crop response and economic outcome from subsurface versus surface mud application methods. It is expected that longer-term benefits in ratoons would outweigh the added application costs of sub-surface mud prior to planting soybeans and cane. The analysis presents soybean, plant cane and first ratoon gross margins.

Key findings

- Mill mud (mud) treatments gave higher yields while the control (no mud) had improved CCS with lower variable costs.
- There was no statistically significant difference in sugar yield or gross margin between surface and subsurface application methods for the combined results.
- Initial gross margins were highest for the control in the plant and first ratoon crops. These gains are anticipated to be offset by longer-term gains in the ratoon for the mud treatments.

Figure 13.1: Grant Matsen on his farm north-west of Sarina (Mackay region)

Trial design

Farmacist conducted the trial with the Matsens on their farm located north-west of Sarina (Mackay region) between 2017 and 2020. The trial was a randomised strip trial with three replications for three treatments. The treatments included a control (no mud) and both a surface (surf) and subsurface (sub) application of mud prior to planting soybeans. The Matsens applied 100t/ha of mud in both mud treatments (banded). Prior to the subsurface application of mill mud, a 'two legged ripper' was utilised to open the furrow which was later closed with a bedformer. Harvesting of the plant and ratoon crops (KQ228 on a sodic soil) took place during 2019 and 2020 respectively.

Agronomics

Trial results (Figure 13.2) show a statistically significant improvement in yield for both mud application methods when compared to the control. However, there was no significant difference in yield between mud application methods from the combined plant and ratoon cane results.

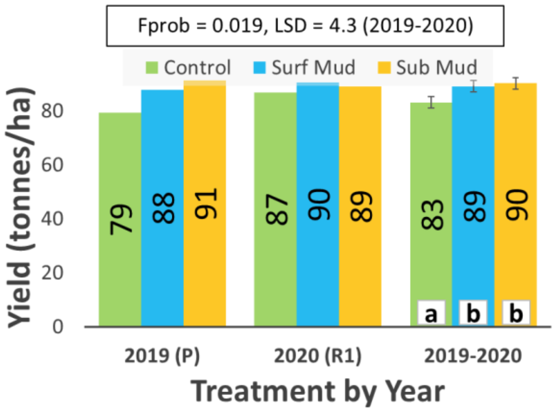

Figure 13.2: Average cane yields (t/ha, 2018-2019)
Source: Farmacist. Error bars indicate 95% least significant difference and different letters indicate statistically significant differences. Note: same applies to figure 13.3.

Both surface and subsurface applications of mud resulted in lower CCS when compared to the control (Figure 13.3). There was however, no overall statistically significant difference in sugar (t/ha) between any of the treatments despite the overall trend showing a marginal increase from the control through to the mud treatments (Figure 13.4).

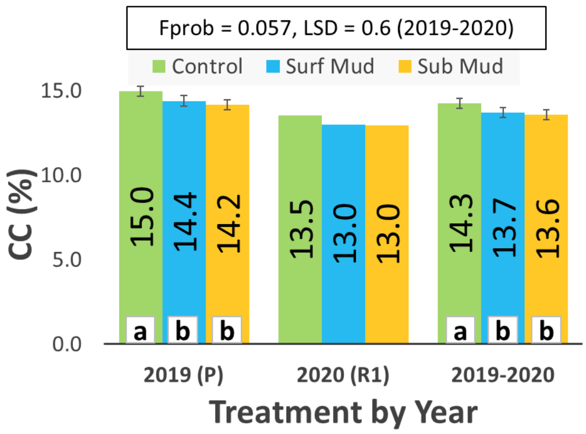

Figure 13.3: Average CCS (2018-2019)
Source: Farmacist.

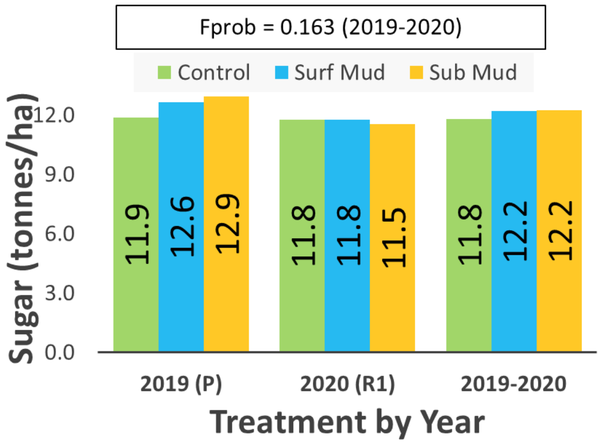

Figure 13.4: Average sugar yield (t/ha, 2018-2019)
Source: Farmacist.

It is understood that mill mud requires time to work into the soil and it is anticipated that nutrients will be made available in later ratoons. The level of availability is however, difficult to ascertain[1]. Longer-term benefits of the subsurface treatment will also need to be monitored.

Note: Soybean yields were included at a constant 2.5 t/ha (payment yield) for all treatments in the preceding year.

Costs

Figure 6.5 presents the total variable costs per treatment for the soybean and plant crops. Both mud treatments had \$599/ha and \$645/ha respectively higher variable costs when compared to the control.

When comparing mud application costs, the subsurface treatment included an additional \$18/ha against the surface treatment (i.e. more narrow width of pass and slower working speed for the ‘two legged ripper’). This contributed to a \$46/ha higher total variable costs in applying mud subsurface. The total difference in cost also accounted for plant cane costs associated

[1] *Reference: Final Report: Reef Water Quality Science Program Project 12C. Mill mud and mill mud products: efficacy as soil amendments and assessment of environmental risk. April 2014.*

with yield differences (i.e. harvesting costs and levies).

Capital costs were a further $15/ha more for the 'two legged ripper' used to apply mud subsurface. This included depreciation over 15 years for both applicators at 3% interest on capital.

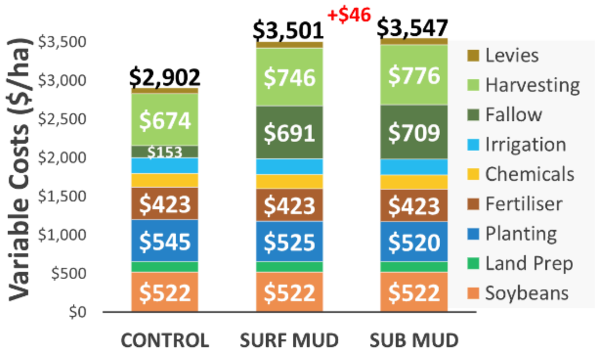

Figure 13.5: Plant cane and Soybean treatment variable costs (2018/19)

The difference between ratoon costs (Figure 13.6) were limited to those arising from yield changes (i.e. harvesting and levies) and were similar between all treatments. The biggest difference being a $34 higher cost for the surface mud treatment compared to the control.

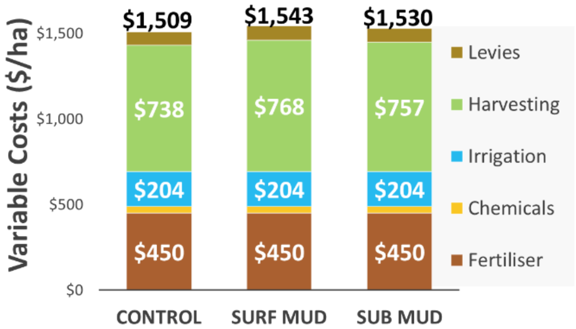

Figure 13.6: Ratoon cane treatment variable costs (2019/20)

Gross margins

The average treatment total gross margins (revenue less variable costs) generated by the soybean, plant cane and ratoon crop are presented in Table 13.1. These are based on a 5-year average sugar price ($417/t). It is expected that the applied mud will improve cane yields in further ratoons despite the control producing a significantly higher average gross margin of $3,796/ha (due to later nutrient availability). This was $527/ha and $573/ha respectively higher than the surface and subsurface mud treatments.

There was no statistically significant difference in average gross margins between the surface and subsurface mud treatments.

Table 13.1: Gross margins ($/ha)

Crop	Treatment		
	Control	Surf Mud	Sub Mud
Fallow/Soybeans	$950	$412	$394
Plant Cane (2019)	$1,122	$1,242	$1,268
1st Ratoon (2020)	$1,697	$1,616	$1,562
Total	**$3,796**[a]	**$3,269**[b]	**$3,223**[b]

Different superscript letters indicate statistically significant differences for gross margin results.

Conclusion

The economic results remain inconclusive from the plant and first ratoon crops, when comparing the subsurface against surface application method (including capital cost differences). However, Grant expects the benefits of mud in the follow-up ratoon crops to show an improvement in sugar yield and profitability over the longer-term. He also anticipates that subsurface application of mud would further improve these results.

Other economic benefits from an improved crop yield are difficult to ascertain and are not included in the overall economic results. These include a thicker trash blanket that would help suppress weeds and improve water retention while maintaining stool structure.

Lastly, while soybean yields were not measured between treatments, this could also have an impact on overall economic results and may prove important to measure in future trials.

"We intend to continue the practice of subsurface application of mill mud and mill ash. Consistency of supply is a significant factor limiting our ability to treat the areas we would like to treat" **Grant Matsen.**

Note: the trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the significant contribution made by Farmacist to this publication and to David Reid (DAF) for the statistical analysis and guidance.

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Soil Health & Nutrition Economics: 2018-20 Case Study

Tully grower: Chris Condon

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries (DAF) to identify costs and benefits of the trials. In this study, Chris Condon and TRAP Services trialled the regenerative agriculture practices of RegenAG including a multi-species fallow on his farm.

The objective of the trial was to determine the impact of a multi-species fallow, together with the application of the RegenAG program and reduced nitrogen (N), on both sugar yield and resultant economics. Variable costs and mill data were used to undertake an economic analysis and compare profitability between the treatments from the fallow to first ratoon. Trial results, including yields, production costs and revenues, were analysed for each treatment.

Trial design

The trial was established on Chris's farm in the Tully region in 2017. The sugarcane crop was planted in 2018 and harvested in 2019 and 2020. The two treatments included in the trial are described in Table 14.1. These are the grower's Standard practice (Std) and a RegenAG program (RegenAG). The trial design was a randomized complete block. There were three replicate blocks with treatments randomly allocated for the two treatments within each block (see Figure 14.1).

Key findings

- Average cane and sugar yields were significantly higher for the Standard treatment ($p<0.05$).
- There were no significant differences in CCS between treatments in either the plant cane or first ratoon.
- Gross margins for the Standard practice were higher compared to the RegenAG in both plant cane and first ratoon, but these were not statistically significant.
- The combined average gross margin was significantly higher for the Standard treatment ($p<0.05$).

Table 14.1: Treatment description and N rates

Treatment	Description/N application rates		
	Fallow (2018)	Plant Cane (2019)	First Ratoon (2020)
(Std)	Growers Standard Fallow (cow peas)	100% Six Easy Steps N-rate	100% Six Easy Steps N-rate
(RegenAG)	Mixed species fallow + RegenAG Pgm	70% Six Easy Steps N-rate + RegenAG Pgm	100% Six Easy Steps N-rate

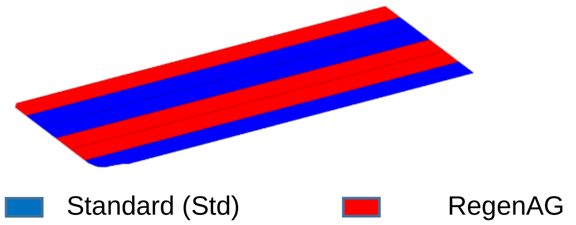

Figure 14.1: Illustration of Trial Layout
(source: TRAP Services)

Agronomics

Figure 14.2 presents the 2019, 2020 and average cane yield data. In the plant cane, the yield for the Standard practice was 15.1t/ha higher compared to RegenAG and this was significant ($p<0.05$). In the first ratoon, the Standard practice also attained a higher yield compared to RegenAG but this was not significant. Overall, the Standard treatment obtained an 11.7t/ha higher average yield and this was statistically significant ($p< 0.05$).

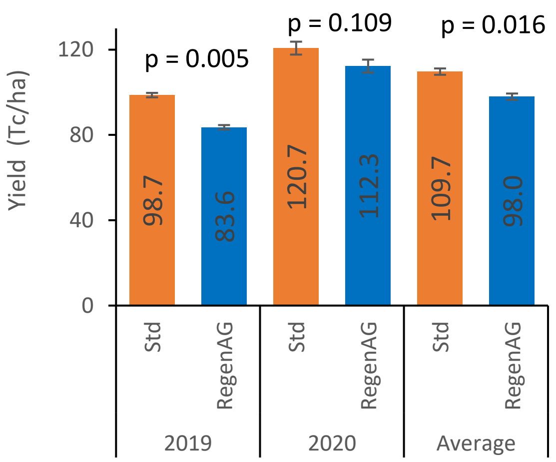

Figure 14.2: Sugarcane yield results (t/ha)

Figures 14.3 and 14.4 present the mean CCS and sugar results from each treatment for the plant cane (2019), first ratoon (2020), and combined average for both years. Results from both individual and combined crop classes showed no statistically significant treatment differences in CCS.

In the both the plant cane and first ratoon, the Standard treatment yielded more sugar (t/ha) when compared to RegenAG. This was largely driven by the higher sugarcane yields. Although individual year differences were not statistically significant ($p>0.05$), it should be noted that the plant cane (2019) sugar yield treatment difference had a significance level of 0.051. Overall, average sugar yield from both years was 1.7ts/ha significantly higher for the Standard treatment when compared to RegenAG ($p<0.05$).

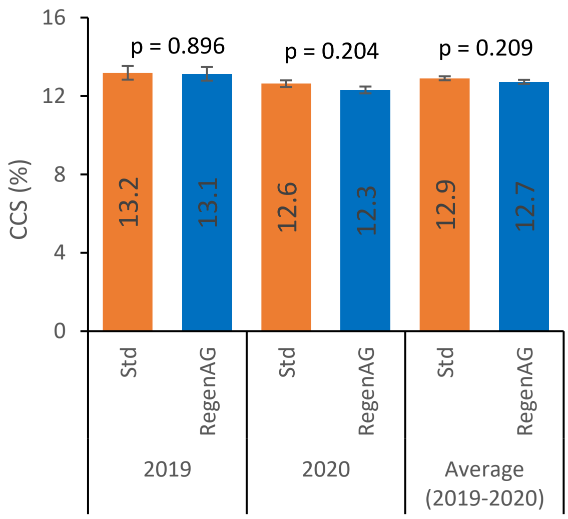

Figure 14.3: Average mill CCS results (%)

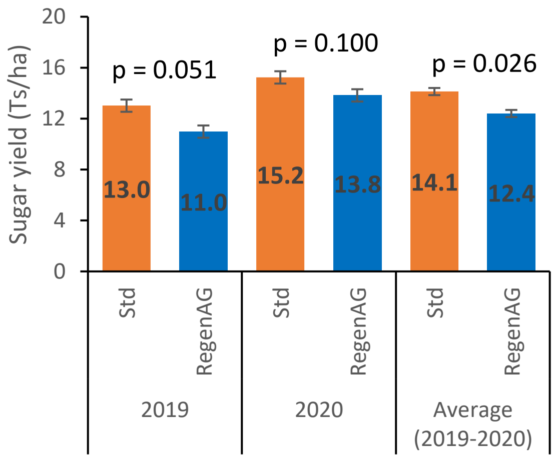

Figure 14.4: Sugar yield (ts/ha)

Queensland Government

Costs

Variable fallow costs (2018) are presented in Figure 14.5. The RegenAG treatment had higher fallow costs (+$362/ha) against the Standard treatment. This was mainly due to the higher legume seed costs at $333/ha more per hectare when compared to the cow pea fallow. The RegenAG program also included additional biofert product and application costs (+$30/ha).

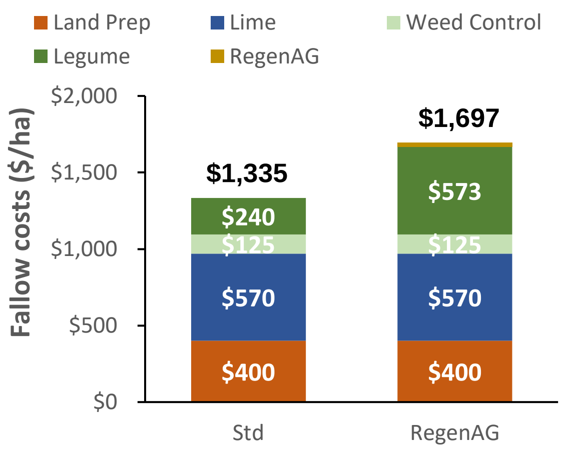

Figure 14.5: Variable fallow costs per treatment, 2018 ($/ha)

The variable costs for the plant cane (2019) and first ratoon (2020) are presented in Figure 14.6. The Standard treatment had slightly higher costs (+$192/ha) due to higher fertiliser costs as well as harvesting costs and levies in the plant cane. In the first ratoon, costs were fairly similar with only a slight difference (+$77/ha) attributable to higher harvesting costs and levies for the Standard treatment (due to the higher yield).

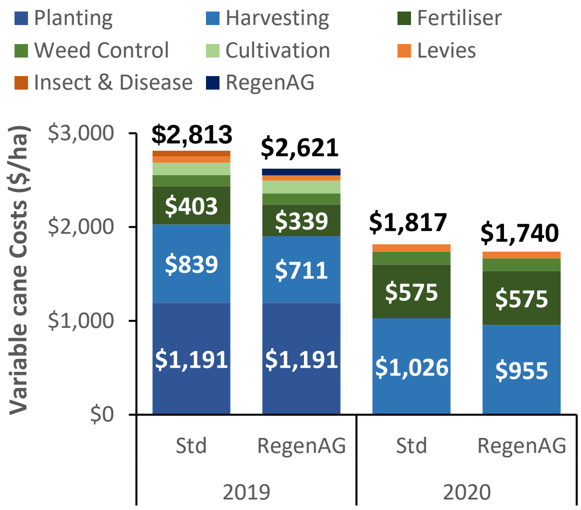

Figure 14.6: Variable cane costs per treatment, 2019 - 2020 ($/ha)

Gross Margins

Gross margin results (revenue less variable costs) are presented in Table 14.2 from the fallow, plant cane, first ratoon, and the combined average for each treatment. In both the plant cane and first ratoon, the gross margin for the Standard treatment was higher when compared to the RegenAg treatment. However, these differences, were not statistically significant due to the high variability of the data. Observed differences could therefore not confidently be attributed to the treatment effect. The three-year average showed a $355/ha significantly higher gross margin for the Standard treatment ($p<0.05$).

Table 14.2: Gross margins (GM) ($/ha)

Crop Class	**Treatment GM**			
	Std	**RegenAG**	**s.e.d***	**p-value**
Fallow	-$1,335	-$1,697		
Plant cane	$707[a]	$343[a]	157.9	0.147
1st Ratoon	$2,231[a]	$1,895[a]	119.9	0.107
Average	**$535[a]**	**$180[b]**	**48.4**	**0.018**

[ab] Different superscripts indicate statistically significant differences.

**s.e.d – Standard error of the differences of the mean.*

Conclusion

Chris trialled a mixed species fallow with RegenAG practices to see if it would improve sugarcane production and profitability by using less inorganic fertiliser and potentially achieving higher yields and CCS.

In the fallow, the RegenAG treatment had higher costs mainly due to the cost of the multi-species legume seeds.

In the plant cane there were statistically significant differences ($p<0.05$) between treatments for cane yield (t/ha) and sugar yield (ts/ha) in favour of the Standard treatment. In the first ratoon, however, these differences were not statistically significant. There was no statistically significant difference in CCS between treatments from either the plant cane or first ratoon results.

Driven largely by cane yield differences, the gross margin for the RegenAG treatment was lower than the standard treatment in both the plant cane and first ratoon, but these differences were not statistically significant. However, the average gross margin from the Standard treatment across all the years combined was significantly higher when compared to RegenAG ($p<0.05$).

Although standard practices were more economically beneficial, results from the trial only present early stages of the crop cycle (up to first ratoon). It will be important to monitor a full crop cycle where RegenAG practices are expected to benefit the soil over the longer-term.

Note: The trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by HCPSL in collection of trial data used in this publication, and Angela Anderson (DAF) for the statistical analysis and guidance.

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Queensland Government

Multi-Species Fallow Economics: 2019-2020 Case Study

Herbert growers: Lawrence & Hayden Di Bella

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries (DAF) to identify costs and benefits of the trials. In this study, Lawrence and Hayden Di Bella and Herbert Cane Productivity Services (HCPSL) trialled a number of legume and multi-species fallows on his farm.

The objective of the trial was to compare the performance of sugarcane following different fallow treatments. Lawrence and Hayden aim to improve their soil health through exploring the possibility of applying less N following a legume or multi-species fallow. To evaluate this opportunity, various legume and multi-species fallows (including a bare fallow) were trialed to compare the yield, sugar and profitability of the subsequent sugarcane crop. The yield, sugar, variable costs and gross margins for the fallow and plant cane for each treatment are compared.

Trial design

The randomised complete bock trial was established with 20 treatments in 2018 (19 legume or multi-species fallow treatments and a single bare fallow treatment). Each treatment included three replicates. Table 15.1 shows the fallow treatment descriptions while Figure 15.1 presents a map of the trial layout. Following the fallow, sugarcane was planted on the trial block in 2019 and harvested in 2020. All treatments received 35 kg/ha of nitrogen (N).

Key findings

- There were no significant differences in cane or sugar yield between the treatments ($p>0.05$).
- While there were large differences in gross margin between treatments, these were not statistically significant due to the high variability within treatments ($p>0.05$).

Note: T4 is excluded from the results due to the canola crop failure (likely due to a seasonal timing issue).

Table 15.1: Description of Fallow treatment

Treatment	Fallow Description
T1	Bare Fallow
T2	Soy Leichardt
T3	Cowpea Ebony
T4	Canola
T5	Jap Millet
T6	Sunn Hemp
T7	Sunflower Greystripe
T8	Sweet Potato
T9	Velvet Bean Dominator
T10	Tropical Mustard
T11	Burgundy Bean
T12	Pigeon Pea
T13	Tillage Raddish
T14	Rice
T15	Soybean Mossman
T16	Mix 1 - Nematode Resistant[2]
T17	Mix 2 - SRA Mix[3]
T18	Mix 3 - High Performer[4]
T19	Mix 4 - Forbes Mix[5]
T20	Mix 5 - Traditional Mix[6]
T21	Soybean Kuranda

[2] Mix 1 – Cowpea (Ebony), Sunn Hemp and Rongai Lablab
[3] Mix 2 – Sunflower, Cowpea (Ebony), Soyabean (Leichardt), Jap Millet, Tropical Mustard, Tillage Raddish
[4] Mix 3 – Soybean (Leichardt), Cowpea (Ebony), Cowpea (Meringa), Sunn Hemp, Rongai Lablab
[5] Mix 4 – Sunn Hemp, Soybean (Leichardt), Pigeon Pea, Cowpea (Ebony), Sunflower, Jap Millet, Tillage Raddish.
[6] Mix 5 – Cowpea (Ebony), Rongai Lablab

Rep 1			Rep 2			Rep 3		
T2	T17	T9	T18	T4	T2	T17	T10	T19
T5	T11	T18	T6	T17	T5	T14	T18	T8
T14	T12	T6	T20	T12	T14	T5	T13	T4
T13	T7	T20	T1	T15	T8	T1	T11	T12
T15	T8	T4	T3	T7	T13	T9	T7	T20
T16	T10	T19	T10	T16	T11	T15	T16	T3
T1	T3	T21	T21	T9	T19	T2	T6	T21

Figure 15.1: Trial Layout
(source: HCPSL)

Agronomics

Figure 15.2 presents the plant cane yield data. Average yields ranged from 95 t/ha to 108 tc/ha (for all treatments) and was highest in the Mix 4 (T19) treatment, but this difference was not significant (p>0.05).

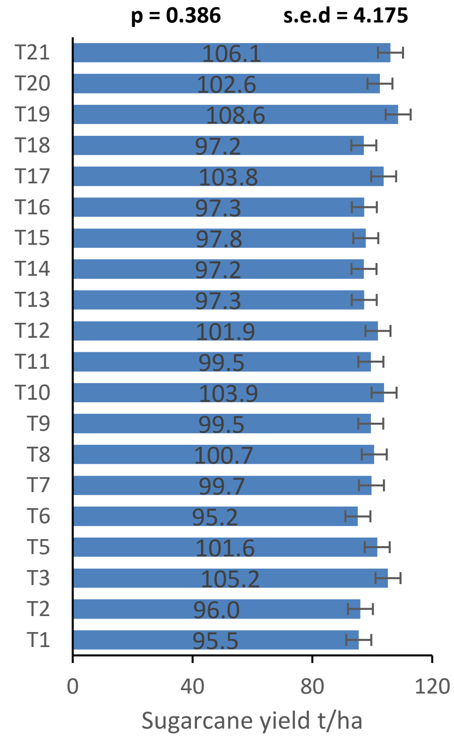

Figure 15.2: Sugarcane yield results (t/ha)

Figure 15.3 shows the average CCS for each treatment. The average CCS ranged from 9.7 to 11.6 units. However, there were no statistically significant differences in CCS between treatments.

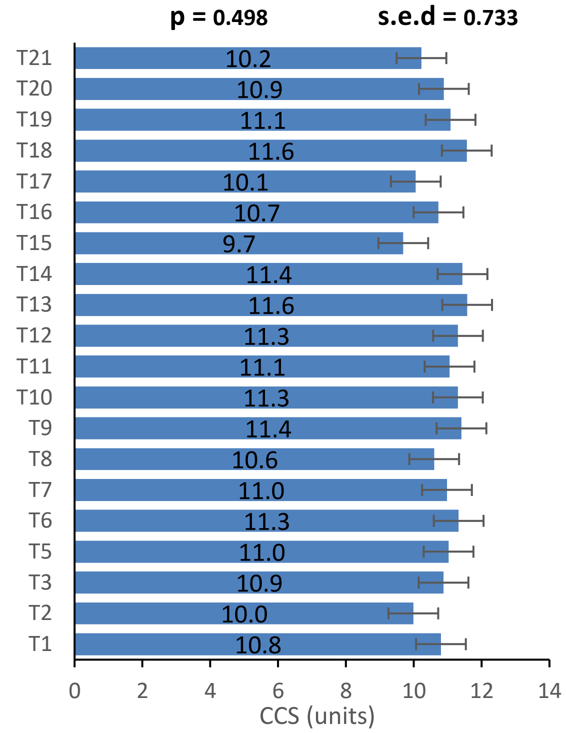

Figure 15.3: Average mill CCS results (units)

Figure 15.4 presents the sugar yield from each treatment. Similarly, there were no significant differences in sugar yield between treatments (p>0.05).

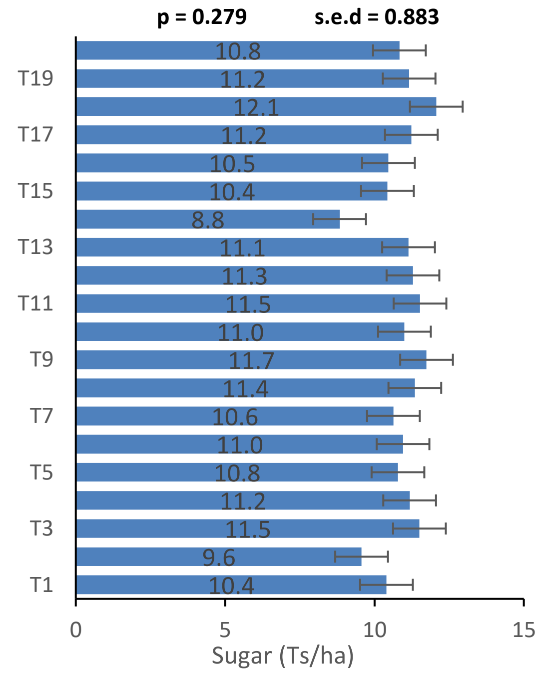

Figure 15.4: Sugar yield results (Ts/ha)

Costs

Fallow costs are presented in Figure 15.5. Land preparation and liming costs were the same for all treatments. The Bare Fallow (T1) had no planting or legume costs but incurred higher weeding costs due to two additional herbicide applications required for the fallow period. Except for seed costs, both planting and weed control costs were the same for all fallow crop treatments. The highest seed cost was for the Sunn Hemp (T6) at $326/ha and the lowest was for the Tropical Mustard (T10) at $42/ha.

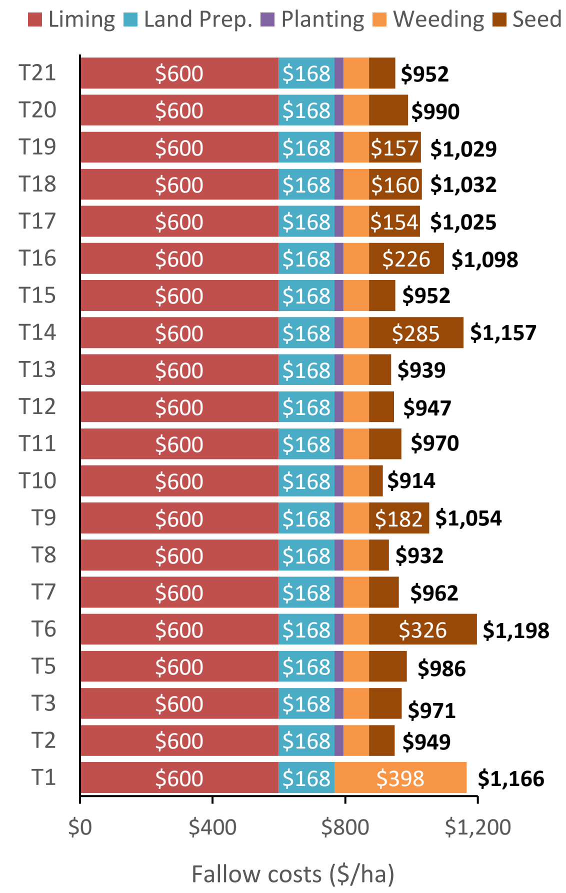

Figure 15.5: Fallow costs per treatment ($/ha)

The variable costs for the plant cane are presented in Figure 15.6. The difference in treatment variable costs were due to differences in harvesting costs and levies, both linked to yield variations. All other variable costs were the same between treatments.

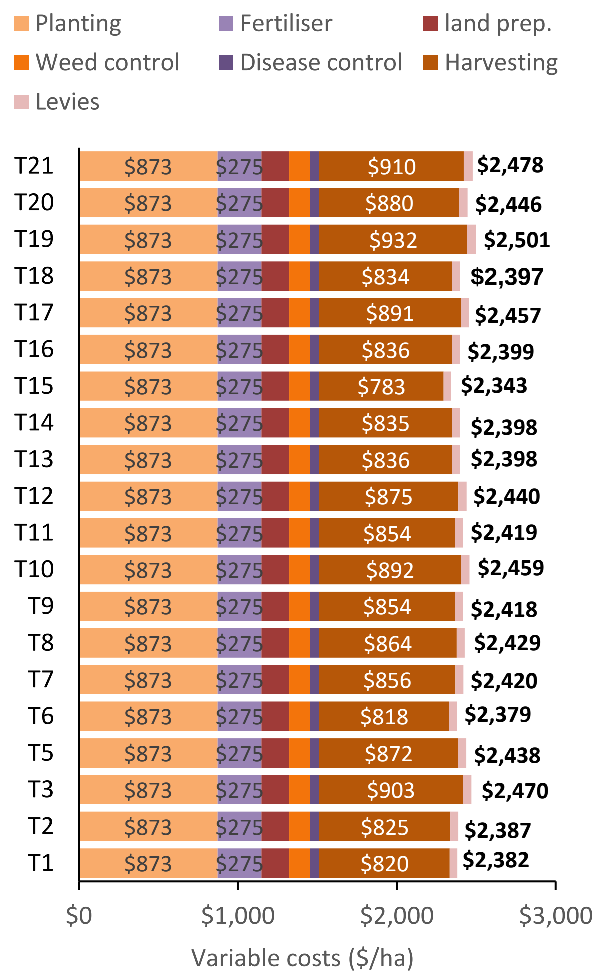

Figure 15.6: Variable costs per treatment, plant cane ($/ha)

Gross margins

Gross margin results (revenue less variable costs) are presented in Figure 15.7 for the plant cane. Gross margins varied across treatments with Tropical mustard (T10) having the highest overall gross margin (+$487/ha) and the Soy Leichardt (T2) having the lowest (-$176/ha). However, these differences were not statistically significant (p>0.05) and could therefore not be attributed to the various fallow treatments.

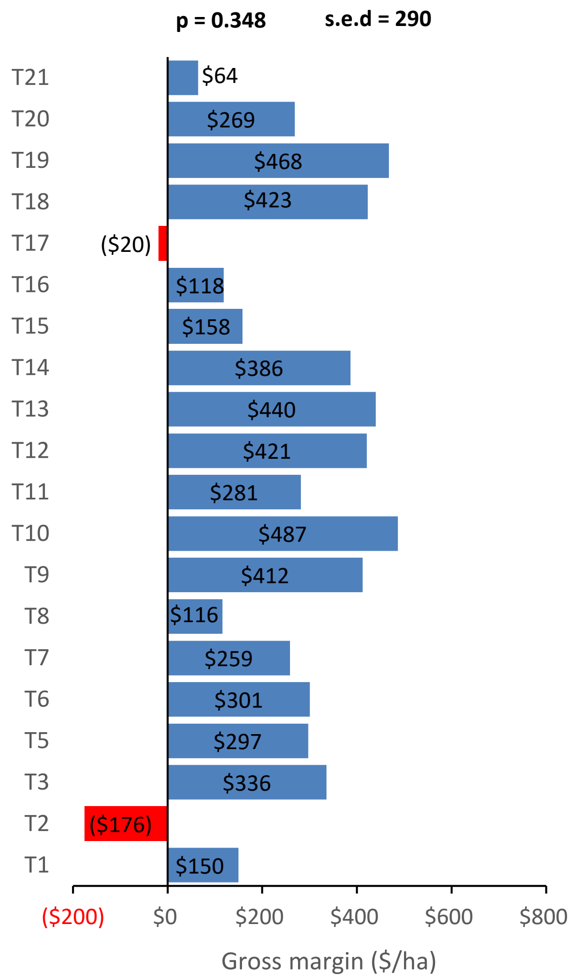

Figure 15.7: Plant cane gross margin ($/ha)

Conclusion

Lawrence and Hayden wanted to assess both the agronomic and economic performance of sugarcane following different legumes, multi-species crops and a bare fallow.

Differences in average yield, CCS, sugar and gross margins were not statistically significant (p>0.05) due to the high variability within treatments. Mean differences could, therefore, not confidently be attributed to the treatment effect.

Benefits from legume and multi-species fallows are expected to improve soil health over the longer-term. Noticeable improvements in sugarcane production and profitability might therefore require a longer trial period to accurately quantify production impacts. This would improve the understanding of fallow treatment impacts on sugarcane production and economics. Utilising a different trial design concept for the randomisation of replicates, such as a spatial design, would improve the layout and better account for variability. More replicates would also be beneficial given the variability in the data.

Note: The trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Soil CRC in supporting this trial, HCPSL in the collection of trial data used in this publication, and Angela Anderson (DAF) for the statistical analysis and guidance.

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Legume Fallow Economics: 2020 Case Study

Proserpine grower: Frank Clayton

Project Catalyst growers worked with economists from the Department of Agriculture and Fisheries to identify costs and benefits of their trials. In this study, Frank Clayton and Farmacist trialled a low-cost legume versus bare fallow strategy.

The objective of the trial is to investigate the yield response and economic benefit of taking soybeans to grain after planting them directly into the cane bed without applying nutrients (low cost strategy). This is compared to a typical bare fallow strategy. It is anticipated that added soybean costs would be offset by grain income and improved cane yield (from added nitrogen). The analysis presents an economic comparison between the soybean and bare fallow, including an investment analysis and yield risk assessment at long-term pricing.

Trial Design & Soybean Yield

Farmacist assisted Frank in conducting the trial between 2019 and 2020 on his farm located south of Proserpine (55ha fallow & 305ha cane land, including leased area). The trial was a randomised strip trial with three replications for two treatments. The treatments included a soybean crop versus bare fallow prior to cane. The soybean crop averaged 1 t/ha across the treatments. Due to limitations with the harvesting method, replicate soybean yields were not available. Harvesting of the plant crop (variety Q208) will take place in 2021.

Key findings

- The soybean fallow crop (at $930/t) provided a positive return compared to that of the bare fallow.
- Considering the grower's capital investment, a longer-term analysis shows that a 1.2t/ha soybean yield is required to remain more profitable than the bare fallow.
- The economic benefits improve significantly when soybean yields increase (i.e. to 1.5t/ha).

Figure 16.1: Frank Clayton and his 'header' on his Proserpine farm

Variable Costs

Figure 16.2 presents the total variable costs for bare fallow (fallow) and soybean treatments. The soybean costs were $560/ha higher than the bare fallow.

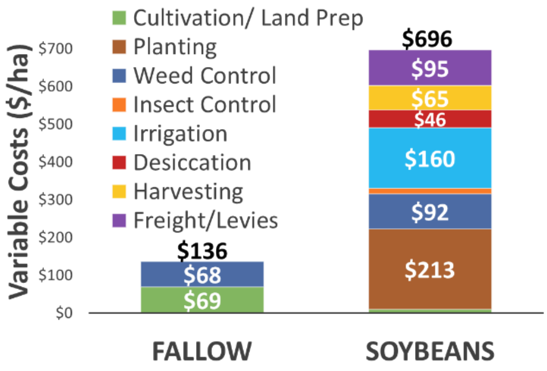

Figure 16.2: Soybean & fallow variable costs ($/ha)

Figure 16.3 presents the plant cane variable costs which were the same for both the soybean and bare fallow. These include actual growing costs and harvesting/levy costs based on an 80t/ha cane yield (grower expected yield).

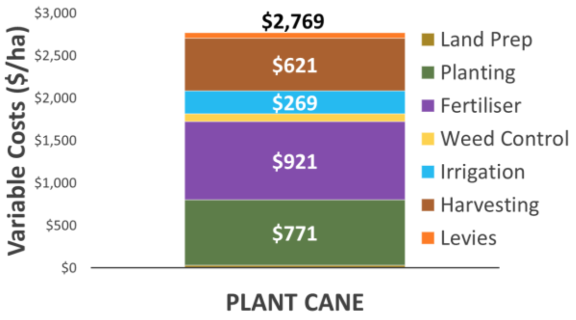

Figure 16.3: Plant cane variable costs ($/ha)

Soybean Gross Margin

With a soybean yield of 1t/ha and price of $930/t (2020 price), the total revenue for soybeans is $930/ha. Less variable costs of $696/ha, the gross margin for soybeans is $234/ha. This is compared to the variable cost of the fallow in Figure 16.4.

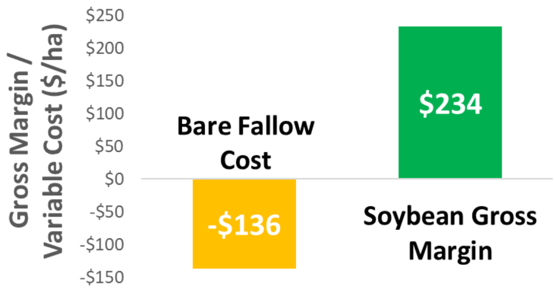

Figure 16.4: Soybean gross margin and fallow cost comparison ($/ha)

Table 16.1 presents the soybean gross margin sensitivity to price and yield changes. It shows yields below 0.7t/ha result in a negative gross margin (at $930/t). It presents the same result for prices falling below $700/t (at 1t/ha). Sensitivities assume the same cane yield in both treatments.

Table 16.1: Soybean gross margin sensitivity to price and yield changes

Yield	Price ($/t)					
(t/ha)	$500	$600	$700	$800	$900	$1000
0	-$582	-$582	-$582	-$582	-$582	-$582
0.5	-$384	-$336	-$287	-$238	-$189	-$140
1	-$187	-$89	$9	$106	$204	$302
1.5	$10	$157	$304	$451	$597	$744
2	$207	$403	$599	$795	$990	$1,186

Soybean Capital Costs

Table 16.2 presents the soybean machinery and equipment costs required for planting and harvesting operations. The planter has an expected life of 10-years. The second-hand header and auger/silo have expected 20-year life spans with machinery investments totalling $54,000.

Table 16.2: Soybean machinery & equipment costs

Type ***(second hand)***	**Purchase Price** **($)**	**Expected Life** **(Years)**
Soybean Planter	$8,000	10
JD Header	$38,000	20
Auger/Silo	$8,000	20
Total	**$54,000**	

Note: affordability of new machinery would likely require a higher gross margin in the soybean crop.

Investment Analysis (at $600/t)

Given a high 2020 soybean price, the investment analysis determines the payback period using a long-term soybean price of $600/t (source: PB Agrifood). It also considers the initial $54,000 investment in soybean machinery and equipment and applies a discount rate of 7%.

The analysis presents three scenarios. The first scenario includes soybean yields at 1t/ha (trial yield) with scenarios two and three increasing to 1.5t/ha and 2t/ha respectively. Scenario 1 shows that with a $2,423 higher annual gross margin from the soybean treatment, the capital investment is unaffordable against the bare fallow (Table 16.3). At 1.5t/ha and 2t/ha, the payback period reduces to 5-years (scenario 2) and 2-years (scenario 3) respectively.

Table 16.3: Payback and return on investment for three soybean versus bare fallow scenarios

Soybean Scenario	**1**	**2**	**3**
Soybean yield (t/ha)	1.0t/ha ⇨	1.5t/ha ⇨	2.0t/ha
Soybean Price ($/tonne)	$600	$600	$600
Gross margin increase ($/year)	$2,423	$14,599	$26,451
Discounted payback period (years)	n/a	5	2
Annual benefit ($/ha/yr)	-$8	$17	$41
Internal rate of return	-2%	24%	47%
Investment Capacity ($)	$27,022	$112,540	$195,781

Table 16.3 shows that over a ten-year investment horizon, the 1t/ha soybean crop incurs an estimated annual farm loss of $26,978 (-$8/ ha/yr). Assuming constant cane yields, an improvement in yield to 1.5t/ha adds $6,060 profit per year ($17/ha/yr) over the bare fallow. The internal rate of return also improves significantly to 24%.

Investment capacity is the maximum amount of money that can be spent before an investment becomes unprofitable. Only a $27,022 investment was affordable for a 1t/ha soybean yield (at the required 7% return on investment). The investment capacity is significantly higher for the improved soybean yield scenarios.

Production Risk (Soybeans)

A production risk analysis for scenario 1 (Figure 16.5) shows that overall soybean yields would need to increase to1.2t/ha before the soybean investment is more profitable than the bare fallow (at a soybean price of $600/t).

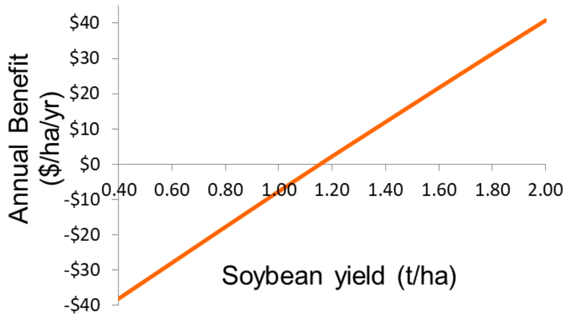

Figure 16.5: Annual benefit of investment ($/ha/yr) sensitivity to soybean yield (at $600/t)

Conclusion

The preliminary economic analysis shows that at high soybean prices (2020), the low-cost soybean strategy was more profitable when compared to a bare fallow. However, this is not the case with prices closer to $600/t (long-term price).

Considering longer-term pricing, an investment analysis and yield risk assessment show that soybean yields would need to improve to 1.2t/ha for the strategy to remain more profitable than the bare fallow. It also shows that a significant improvement in both the annual benefit and internal rate of return occurs with a soybean yield of 1.5t/ha.

It is not yet certain whether significantly higher soybean yields are achievable under a low-cost strategy. It is anticipated that the purchase of a new planter will improve germination and subsequent yield. Frank is also considering fertilising and improving land preparation to reduce harvesting losses (uneven paddock surfaces).

"We expect to improve soybean yields in a low-cost strategy through incorporating better planting machinery and operations. This should give us a better strike (germination) which should also reduce weed control costs. We are also considering a higher-cost strategy where fertiliser is expected to improve soybean yields even further." **Frank Clayton.**

Note: the trial results are specific to this grower, paddock and prevailing conditions.

We acknowledge the contribution made by Farmacist to this publication.

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Irrigation: alternate row irrigation

Refining water runoff and irrigation management is a key focus area of Project Catalyst. This section explores an alternate row irrigation strategy trialled by a Project Catalyst grower that aims to refine irrigation management on their farm (Figure 17.1).

Figure 17.1: Case studies exploring irrigation management strategies.

1. Alternate Row Irrigation

Project Catalyst

Department of Agriculture and Fisheries

Alternate Row Irrigation Economics: 2018-19 Case Study

Burdekin Delta grower: Robert Zandonadi

Growers participating in Project Catalyst trials worked with economists from the Department of Agriculture and Fisheries to identify costs and benefits of the trials.

In this study, Robert Zandonadi and Farmacist compared alternate row irrigation with conventional irrigation. System change impacts on irrigation costs, yields and profitability were examined.

Key findings

- With lower irrigation costs and an improved CCS, alternate row irrigation gave a $624/ha higher net revenue when compared to the conventional treatment. However, further validation is required.
- Alternate row irrigation reduced irrigation related costs by $297 per hectare.

Trial Design

Farmacist and Robert Zandonadi established the trial with two treatments, conventional and alternative row irrigation, on the same paddock. Half the paddock received irrigation down every furrow and the other half, only every second furrow. All other operations and inputs were the same for both treatments. Six measurements of cane yield and CCS were taken within each of the two treatments. The treatments were not randomised and so measurements were not representative of independent replicates but rather an average representation of each treatment. This study presents trial results from the 2018 & 2019 harvest seasons and compares the net revenue generated by each treatment.

Costs

The only variation in growing costs was due to differences in irrigation related costs, harvesting costs and levies. Figure 18.1 shows a breakdown of these costs for each treatment. Each irrigation practice had the same number of irrigation events, but the amount of water received by the alternate row treatment was only half that of conventional practice. There were no variable water costs at the site. Hence, alternate row irrigation costs where half those of the conventional treatment ($298/ha vs $595/ha).

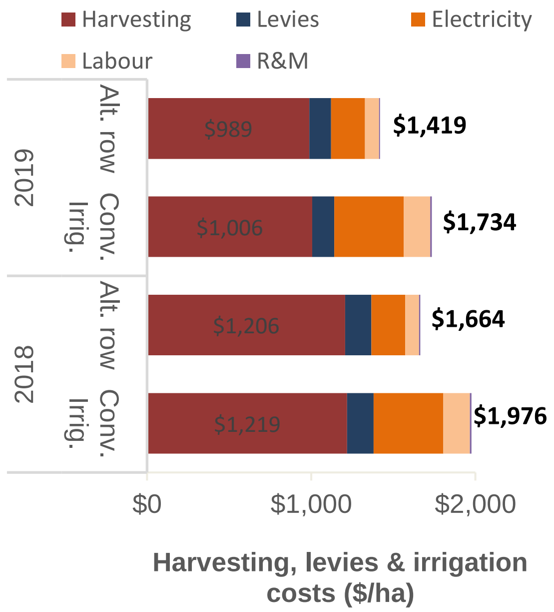

Figure 18.1: Levies, Harvesting & Irrigation cost comparison.

** R&M refers to repairs & maintenance costs.*

PROJECT CATALYST

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Results

The average cane yields and CCS obtained from each irrigation treatment for 2018 and 2019 are shown in Table 18.1. Average cane yields were similar between irrigation practices for both years, but average CCS was higher for alternative row irrigation in both years. Given replicates in the trial were not randomised, ANOVA could not be used to determine if this difference was statistically significant. Instead, confidence intervals (95%) for each mean were determined.

The confidence intervals overlapped for cane yield but did not overlap in the case of CCS in both years. However, non-overlapping CCS confidence intervals do not prove the means were different. Without independent and randomised replicates, the differences in CCS cannot confidently be attributed to the treatments.

Table 18.1: Average cane yield and CCS results

		Cane yield, tch		CCS, units	
		Avg	*Lower/ Upper	Avg	*Lower/ Upper
2018	Alt. row	167.5	158.1 176.9	13.50	13.3 13.7
	Conv.	169.3	158.2 180.3	12.30	12.0 12.7
2019	Alt. row	137.4	129.6 145.2	15.36	14.95 15.76
	Conv.	139.7	124.6 154.7	14.58	14.38 14.77

**Lower and upper bounds of 95% confidence interval.*

Irrigation costs, harvesting costs and levies were subtracted from revenue to compare the net revenues (profitability) of each irrigation treatment. Figure 18.2 shows the net revenues of the two treatments. Alternative row irrigation had a higher net revenue (additional $624/ha) due to the higher average CCS (although not necessarily attributable to the alternate row irrigation treatment).

Figure 18.2: Average net revenue

Conclusion

In 2019, the alternative row irrigation treatment obtained a higher average net revenue (additional $624/ha) compared to conventional irrigation, driven by the higher CCS and irrigation cost saving. Overall, the results obtained for 2018 and 2019 show similar trends, however, due to trial design limitations, statistical testing could not confirm that CCS improvements were due to the treatment effect. The non-overlapping confidence intervals, while not conclusive, suggest a difference in CCS between the irrigation methods, highlighting the need for further investigation. The use of replicates within the trial design, albeit logistically difficult for irrigation, would assist in further validating the impact of irrigation treatments on production and profitability.

Note: The trial results are specific to this grower, paddock and prevailing conditions.

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Discussion

Project Catalyst is driven by the desire of innovative growers to trial new farm management practices on their farms that will lead to more profitable and sustainable outcomes for sugarcane growers and their environment. This section discusses the findings from trials harvested in 2019-2020 for each of the three Project Catalyst themes – Nutrients, Soils and Water. Note: there were no case studies conducted during this period under the Chemicals theme.

Nutrients (including ground water N trials)

Effective nutrient management is vital for profitable and sustainable sugarcane farming. The SIX EASY STEPS® (6ES) guidelines is an invaluable resource to help inform grower decisions. Steps 5 and 6 of the guidelines provide an opportunity for growers to tailor nutrient management to the particular set of circumstances faced on their farms. Due to already squeezed margins, there significant motivation for growers to reduce the loss of expensive inputs from their farms which also have an impact on water quality outcomes (e.g. run-off). Opportunities to improve efficiencies based on their specific conditions remain a key focus of farm managers.

A variety of strategies were selected and trialled by Project Catalyst growers aimed at refining nutrient management on their farms. These included:

- **Staggered and varied N rates in ratoons -** In Mackay, John Muscat (pp12) and Tony Bugeja (pp16) trialled various N rate treatments. John trialled 0, 110, 150 (6ES) and 180 kg N/ha as well as an alternating N rate treatment (150 kg N/ha then 110 in following crop). Tony trialled N rates both 15% and 25% above 6ES. The alternating N rate from John's trial and the 6ES treatment in Tony's trial gave the higher gross margins, however, differences between treatments were not statistically significant in either trial.
- **Solid versus liquid fertiliser** – A single trial conducted by Warren Viero (pp19) in the Burdekin showed a granular fertiliser side-dressed treatment having a significantly higher gross margin when compared to both stool split treatments (i.e. liquid and granular). Similar results for the granular stool split and liquid fertiliser stool split treatments suggest that the application method rather than product type may have been the most important factor impacting on profitability.
- **Subsurface application of BioDunder® -** The Deguara family (pp22) trialled the surface and subsurface application of BioDunder®. They saw no significant difference between treatments despite their previous trial showing a significant increase in gross margin for the subsurface treatment. Longer-term trials under different conditions are required for validation of the results.
- **Accounting for N from groundwater irrigation** – In the Burdekin, Bryan Langdon (pp26) and Brendan Swindley (pp29) trialled whether N application rates could be lowered where nitrates were being supplied via irrigation water. Both trials compared the grower's usual N rate against N rates between 30 and 60 kg N/ha less. Bryan's trial showed an improvement at a 30 kg N/ha lower rate, but the gross margin remained highest for the standard rate in Brendan's trial. In neither case were gross margin differences statistically significant. Results from these and previous trials indicate the potential to lower N rates in certain cases where crop N is being supplied by groundwater nitrates. This suggests further investigations would be worthwhile.

Soils

Soil is an important part of most agricultural activities making it a key focus area for Project Catalyst. Sugarcane farming in Australia has historically practiced monoculture cropping leading to soil health issues and yield decline. This selection of trials aimed to identify the best methods to remove yield constraints faced by Project Catalyst growers. This through improving the condition of their soils by increasing soil organic matter and micro-organism activities.

Strategies selected and trialled by Project Catalyst growers aimed at improving the condition of soil on their farms included:

- **Applying different soil ameliorants (different forms of lime)** – In the Herbert, Alan Lynn (pp32) compared three different soil ameliorants including Agricultural Lime, a Kiln Dust/Ag Lime mix and Calcipril. Although Agricultural Lime obtained the highest average gross margin, statistically, these were not significantly different.
- **Subsurface application of Mud and Ash** - For two trials, no statistical analysis was completed due to trial design limitations and therefore no significant conclusion could be made (Mackay, pp35 and Mossman, pp39). For the third, Grant and Allan Matsen (pp43) trialled the subsurface application of mill mud at their Sarina farm. This resulted in no significant difference between gross margins, but they anticipate longer-term impacts in their older ratoons which they will continue to monitor.
- Chris Condon's **Soil health and nutrition** trial (Tully, pp47)) explored the opportunity to reduce N rates to 70% of 6ES in combination with the RegenAG program. The RegenAG treatment had a lower gross margin than the standard practice (100% of 6ES) and this was statistically significant. Trials are needed to assess the longer-term effects of RegenAg on the soil health given the initial high cost of the program which includes a mixed species fallow.
- **Mixed species and legume fallows** – In the Herbert, Lawrence and Hayden Di Bella (pp51) compared various legume and multi-species fallows with no significant differences in the legume and plant cane gross margins. Again, longer-term impacts on soil health and production outcomes would need to be monitored. An investment analysis on a low-cost soybean production system in Proserpine (Frank Clayton, pp55) showed a positive result against a bare fallow at long-term pricing for soybean yields above 1.2t/ha.

Water

Sugarcane farming hinges on water availability and management. In the Burdekin and Mackay, irrigation can account for a substantial proportion of growers input costs. Given water and electricity costs have increased a lot over the past decade, growers have a strong incentive to improve water application efficiency by making every drop count. An innovative strategy being trialled by a Project Catalyst grower aimed at improving water management on their farm is included:

- **Alternate row irrigation –** In the Burdekin, Robert Zandonadi (pp60) compared his conventional furrow irrigation with alternate row irrigation (water applied in every second furrow). Alternate row irrigation halved the amount of water applied, which in turn halved electricity and labour costs. These lower costs combined with improved CCS generated a higher average net revenue. Due to a lack of replication in the trial, further validation of alternate row irrigation is required.

Conclusion

The trial economic case studies demonstrate the focus of Project Catalyst to improve water quality from agricultural catchments in the sugarcane farming regions through working with innovative farmers. New approaches and management practices continue to be trialled with the aim of driving broader adoption of practices that have been validated. It is anticipated that trials showing to increase grower profitability while lowering the impacts of sugarcane production on the reef are the most likely to be adopted by growers.

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