Project Catalyst Trial Report

Reduction N&P Based on Yield Potential

Grower Information	
Grower Name:	John Muscat (Mac)
Trial Farm No/Name:	MKY-04621A
Mill Area:	Mackay Sugar
Total Farm Area ha:	50ha
No. Years Farming:	>40
Trial Subdistrict:	Lower Pioneer Catchment
Area under Cane ha:	45ha

Trial Status

Completed

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Background Information

Aim: To improve sugarcane yield outcomes on potentially high yielding soils via staggered and reduced nitrogen (N) rates.

Background:

Many growers producing sugarcane on highly productive well drained soils have expressed disappointment in achieving low Tonnes of Cane per Hectare (tC/ha), Commercial Cane Sugar (CCS) and Tonnes of Sugar per Hectare (tS/ha) under well-managed, supplementary irrigated farming systems. To address these issues growers will often apply Nitrogen (N) above the Six Easy Steps (6ES) rate as they believe that more N will equate to better production outcomes. Previous trial work has indicated that achieving high yields with mill average CCS on productive irrigated soils can be compromised when N rates exceed 6ES guidelines, and by reducing N rates below the 6ES guidelines an increase in CCS can be achieved. Contrary to advise they are often reluctant to reduce N rates due to concerns surrounding an overall decline in productivity.

Well drained productive soils can be defined as having the ability to retain nutrients and moisture whilst minimising waterlogging. On these types of soils sugarcane roots have the ability effectively access N within different sections of the soil profile sourced from mineralised organic matter and previously applied fertiliser inputs.

This project addresses grower production concerns on highly productive soils. A replicated N strip trial was established to annually compare three different N treatments and a "Zero" N control treatment upon (1) Total proportion of Crop N uptake (TN%), (2) tC/ha (3) CCS & (4) Nitrogen Use Efficiency - tonnes of cane per kg of applied N (NUE= tC/kgN).

N treatments used: 6ES N rate (150kg/ha) based upon the soils organic carbon % (Walkley and Black), grower standard application rate (180kg/ha), Stalk N content (110kg/ha); based upon DSITI stalk N uptake research, and a N rate annually alternating between the 6ES and the Stalk N rates.

Potential Water Quality Benefit:

This project will demonstrate to growers that overapplying N does not necessarily improve production outcomes and that reducing N rates to reasonable levels will improve on farm gross margins with an associated environmental/water quality benefit via reducing N losses via denitrification, leaching and runoff: less N in equating to less N out.

Expected Outcome of Trial:

It is expected that reducing N rates below the existing Grower standard rate of 180kgN/ha will not negatively impact upon production outcomes.

Service provider contact: Farmacist Pty Ltd

Where did this idea come from: John Muscat raised concerns regarding poor yield outcomes with Department of Agriculture and Fisheries (DAF) representatives. DAF representatives and Farmacist staff have worked together on this trial to address the grower concerns.

Plan - Project Activities		
	Date:	**Activities:**
Stage 1	**July 2016**	Identify site and analyse for uniformity
Stage 2	**September 2016**	Application of treatments
Stage 3	**April 2017**	Biomass sample to identify Crop N uptake
Stage 4	**October 2017**	Harvest site (1)
Stage 5	**October 2017**	Re-apply treatments as per trial design
Stage 6	**April 2018**	Biomass sample to identify Crop N uptake
Stage 7	**October 2018**	Harvest site (2)
Stage 8	**October 2018**	Re-apply treatments as per trial design
Stage 9	**May 2019**	Biomass sample to identify Crop N uptake
Stage 10	**October 2019**	Harvest site (3)
Stage 11	**November 2020**	Re-apply treatments as per trial design
Stage 12	**July 2020**	Biomass sample to identify Crop N uptake
Stage 13	**December 2020**	Harvest site (4)

Project Trial site details	
Trial Crop:	Sugar cane
Variety: **Rat/Plt:**	Q242 Pl
Trial Block No/Name:	10-3
Trial Block Size Ha:	6.2ha
Trial Block Position (GPS):	149.105456, -21.155759
Soil Type:	Marian – Brown Chromosol

Block History, Trial Design

A trial plan was developed and Figure 1 provides the design of the trial and treatment plots. The five N treatments were replicated four times.

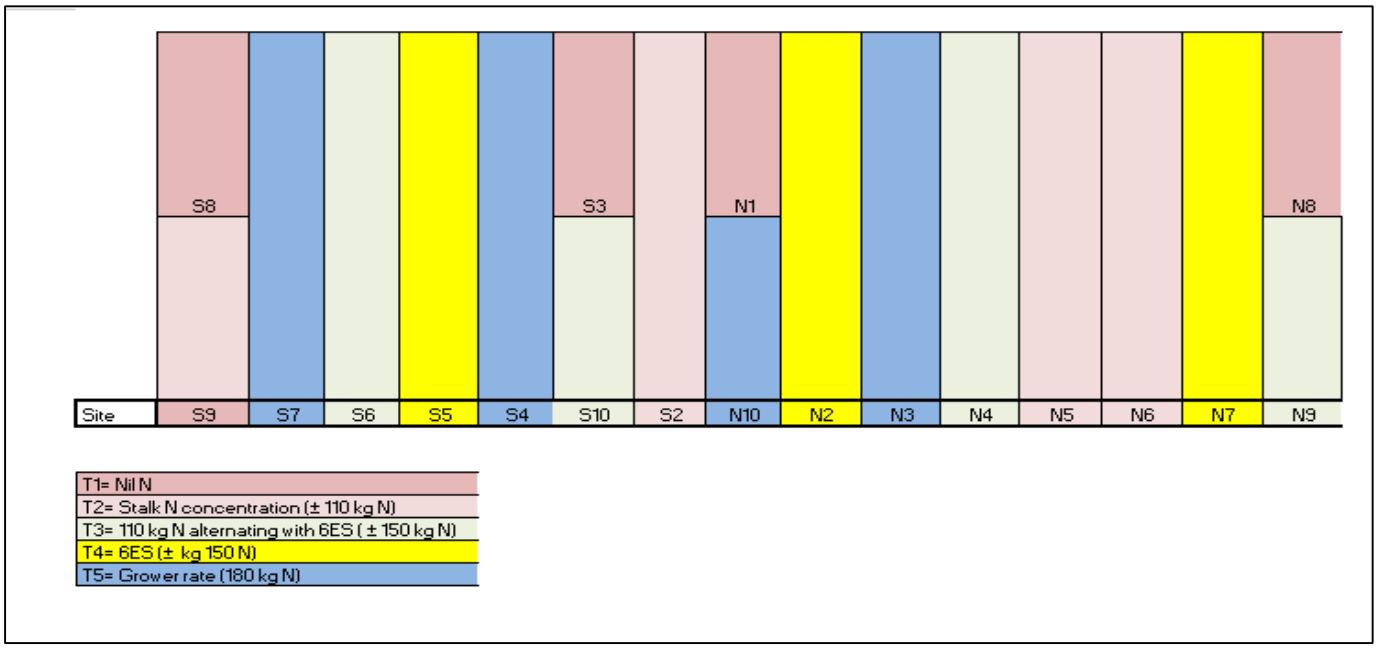


Figure 1 - Trial layout of treatments and replicates

Treatments:

- **T1:** '0'N control
- **T2:** 110kgN/ha based on average stalk N concentration (DSITI trials)
- **T3:** 110kgN/ha (average stalk N concentration) alternating with 150kgN/ha (6ES rate) over the ratoon cycle.
- **T4:** 150kg/Nha 6ES N rate based upon soil Organic Carbon mineralisation index (Walkley Black)
- **T5:** Grower rate (180 kg N/ha)

Prior to application of treatments, the trial site was Electromagnetic (EM) surveyed and a yield map was developed (Figure 2.), using satellite imagery, to ensure uniformity between soil type and yield outcomes.

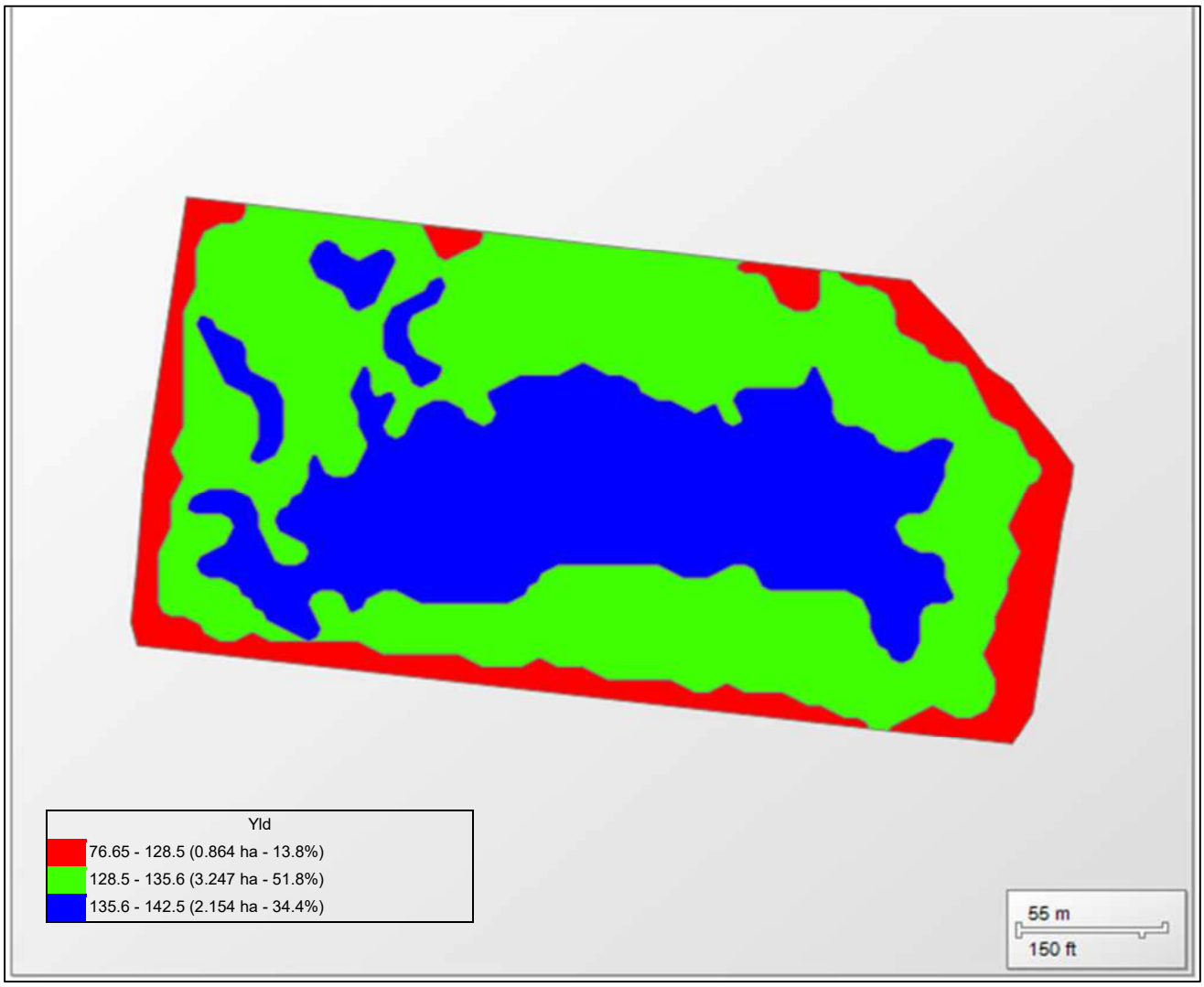


Figure 2 - Yield map of site showing relative uniformity.

Results

Table 1. Staggered N rate trial. Crop Total N % content, by N treatment. All years combined average.

Treatment name	N rate (kgN/ha)	Total N%, Crop N uptake
6ES	150	0.76
Alternate rate	150/110	0.75
Control	0	0.67
Grower rate	180	0.81
Stalk Nitrogen content	110	0.72

Note: Numbers followed by letters are significantly different (P<0.05).

Analysis of TN% Crop uptake for all years combined shows no significant difference (P>0.05) between treatments however as seen in Table 1., the control treatment achieved the lowest TN%, the grower rate the highest and minimal difference was observed between the remaining treatments.

Table 2. Staggered N rate trial. Crop Total N % content, by N treatment. Individual year(s) combined average.

Sampling Year	Treatment	Nitrogen rate (kgN/ha)	Total N% Leaf uptake
2018	**6ES**	150	0.76
	Alternate rate	110	0.81
	Control	0	0.68
	Grower rate	180	0.88
	Stalk Nitrogen content	110	0.80
2018 total average of all treatments combined.			**0.78**
2019	**6ES**	150	0.60
	Alternate rate	150	0.68
	Control	0	0.57
	Grower rate	180	0.71
	Stalk Nitrogen content	110	0.54
2019 total average of all treatments combined.			**0.62**
2020	**6ES**	150	0.85
	Alternate rate	110	0.77
	Control	0	0.70
	Grower rate	180	0.78
	Stalk Nitrogen content	110	0.75
2020 total average of all treatments combined.			**0.77**

Note: Numbers followed by letters are significantly different (P<0.05).

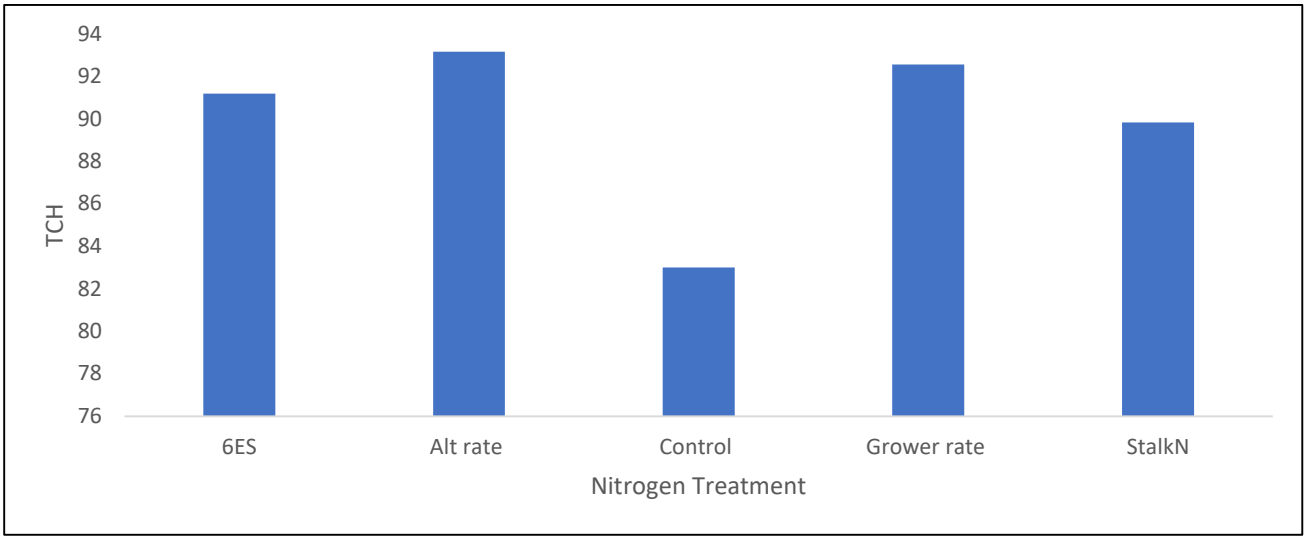
Analysis for individual sampling years identified no significant difference (P>0.05) between treatments (Table 2.). As an observation it can be viewed that for the yearly total average of all treatments combined, TN% decreased from 2018 to 2019 and then increased in 2020. Comparing overall outcomes between individual years shows that

the Grower rate and Alternate rate Treatments displayed comparable results across all trial years. In 2018 and 2019 the Grower rate recorded highest Crop TN%, however in 2020 the 6ES treatment recorded highest Crop TN%.

Harvest Results 2017-2020

Tonnes of Cane per Hectare (TCH).

Averaged data from all years combined shows no significant difference in TCH between the individual treatments (P>0.05). Viewing the data identifies that the Grower N rate recorded similar outcomes to the Alternate N rate which achieved highest tC/ha, minimal difference was recorded between the 6ES and Stalk N rates and the 0N



control recorded least tC/ha (Figure 1).

Figure 1. Staggered N rate trial. 2017-2020 harvest years combined average, Tonnes of Cane per Hectare (TCH) by N treatment.

Individual trial year analysis (Table 3) shows that over the 2017 to 2019 harvest years there was no significant difference in tC/ha between N treatments (P>0.05). Comparing non-significant outcomes shows that in 2017, the Grower N rate achieved the highest tC/ha, and limited difference between the remaining N treatments is observed. In 2018, the Alternate N rate and the Grower N rate Treatments recorded the highest tC/ha, with limited difference in results, the 6ES N rate and the Stalk N rate results were similar and the 0N control lowest. In 2019, the 6ES N rate recorded the highest tC/ha, followed by the Alternate N rate. No difference was recorded between the Grower N rate and the Stalk N rate, and the 0N Control rate recorded the lowest result, however this was only slightly less than the Grower N rate/Stalk N rate. 2020 harvest identifies that the 0N control recorded significantly less tC/ha than the other treatments (P<0.05) and minimal difference in tC/ha was observed between the remaining N treatments.

Commercial Cane Sugar (CCS).

As per TCH outcomes, no significant difference in CCS was observed between N treatments for the averaged data of all years combined, which is reflected in the actual results (Figure 2). Within the individual harvest years (Table 3.), minimal variation occurred between the individual treatments. Scrutinising within year results, 2017 Stalk N

treatment recorded the lowest result with the other treatments showing only slight variation. In 2018, the 0N control and Stalk N recorded the highest CCS, with limited differences in CCS seen between the remaining treatments. In 2019 / 2020 harvest years, the 0N control recorded least CCS with the limited variation between the remaining N treatments.

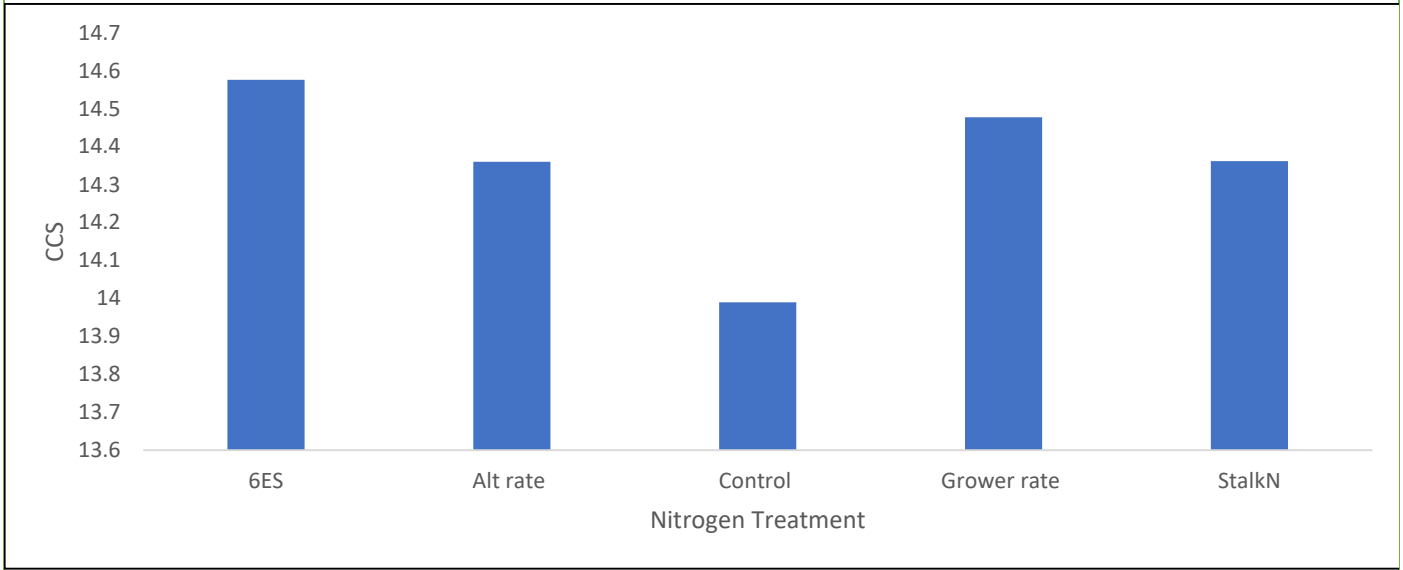


Figure 2. Staggered N rate trial. 2017-2020 harvest years combined average, Commercial Cane Sugar (CCS) by N treatment.

Tonnes of Sugar per Hectare (TSH)

Combined analysis of all harvest years identified no significant differences (P>0.05) in TSH between treatments (Figure 3.). Comparison between individual treatments identifies that the 0N control, followed by the Stalk N treatment, recorded lowest TSH with the remaining treatments displaying limited variation.

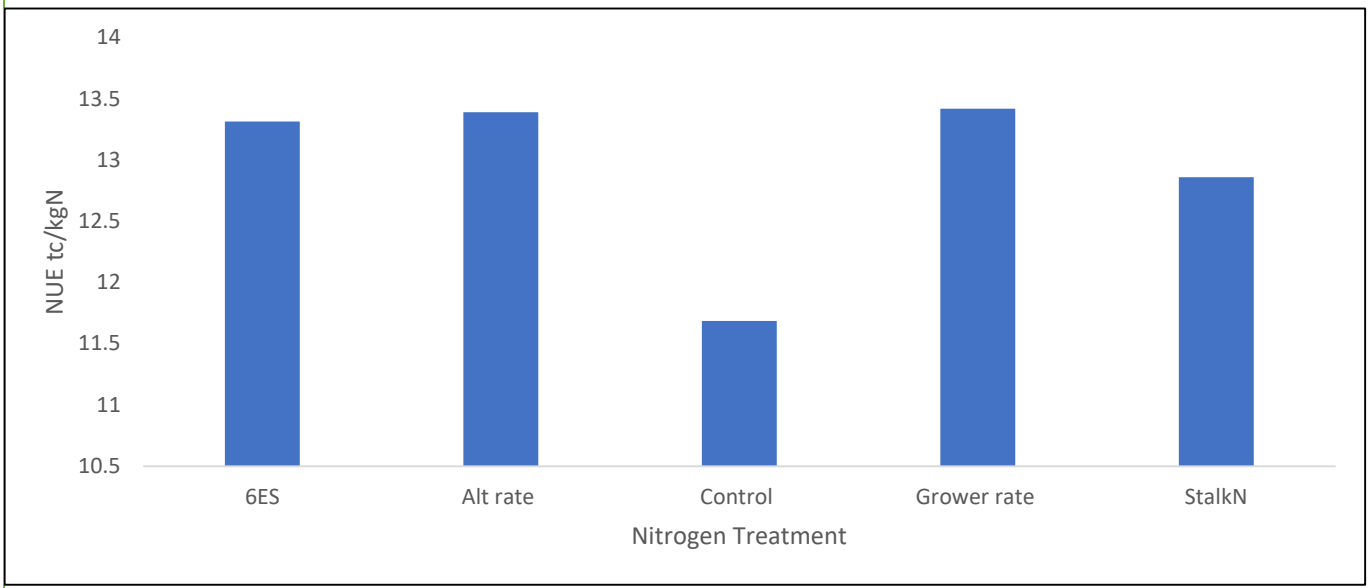


Figure 3. Staggered N rate trial. 2017-2020 harvest years combined average, Tonnes of Sugar per Hectare (tS/ha) by N treatment.

Within harvest year analysis shows no significant N treatment effect (P>0.05) upon tS/ha across 2017-2019 harvest years (P>0.05) (Table 3.). Viewing data for the individual years, 2017 Grower N rate achieved the highest tS/ha and the Stalk N rate the least, with no difference in results for the 6ES and 0N control treatments. In 2018, the Grower N rate and the Alternate N rate achieved comparable results /highest tS/ha and the 0N control recorded the least. In 2019, the 6ES rate recorded most tS/ha and the 0N control the least. In 2020, the Alternate N rate recording the most tS/ha and the 0N control rate recorded significantly less tS/ha (P<0.05) than the remaining treatments which were not significantly different from each other.

Nitrogen Use Efficiency / tonnes of cane per kg of Nitrogen (NUE tc/kgN).

Combined trial year analysis identified a significant difference between N treatments (P<0.05) (Figure 4.) with NUE tC/kgN recorded in the following order: Stalk N/Alternate N > 6ES > Grower N. Significant difference between treatments (P<0.05) was also observed within individual harvest years (Table 3) with the Stalk N rate consistently achieving significantly higher NUE than the Grower N rate. Full outcomes for individual years are listed in Table 3.

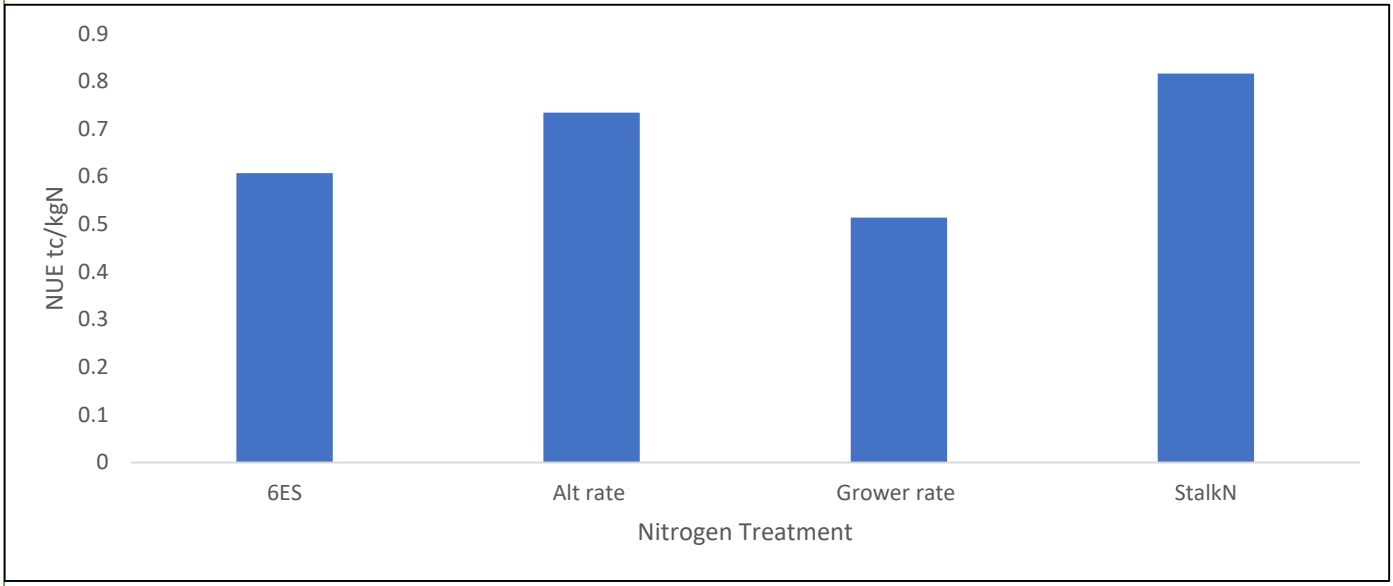


Figure 4. Staggered Nitrogen rate trial. 2017-2020 harvest years combined average, Nitrogen Use Efficiency/tonnes of cane per kg of Nitrogen (NUE tC/kgN) by Nitrogen treatment.

Table 3. Staggered rate N trial. Averaged harvest outcomes by N treatment.

Harvest Year	Treatment	Nitrogen rate	tC/ha	CCS	tS/ha	NUE (tC/kgN)
2017	**6ES N rate**	150	96.08	16.76	16.13	0.64 b
	Alternative N rate	150	97.61	16.10	15.74	0.65 b
	Control 0N	0	97.40	16.56	16.13	NA
	Grower N rate	180	107.75	16.54	17.76	0.60 b
	Stalk N rate	110	96.77	15.72	15.24	0.88 a
2018	**6ES N rate**	150	77.90	13.81	10.76	0.52 b
	Alternative N rate	110	83.90	13.88	11.66	0.76 a
	Control 0N	0	70.70	14.06	9.94	NA
	Grower N rate	180	83.63	13.98	11.67	0.46 b
	Stalk N rate	110	79.75	14.32	11.41	0.73 a
2019	**6ES N rate**	150	91.67	15.37	14.09	0.61 ab
	Alternative N rate	150	87.50	15.23	13.44	0.58 b
	Control 0N	0	78.47	14.17	11.15	NA
	Grower N rate	180	80.56	15.20	12.33	0.45 c
	Stalk N rate	110	80.56	15.21	12.28	0.73 a
2020	**6ES N rate**	150	99.12 a	12.37	12.28 a	0.66 b
	Alternative N rate	110	103.69 a	12.23	12.72 a	0.94 a
	Control 0N	0	85.42 b	11.17	9.5 b	NA
	Grower N rate	180	98.36 a	12.20	11.91 a	0.55 c
	Stalk N rate	110	102.28 a	12.21	12.50 a	0.93 a

Note: numbers followed by letters are significantly different (P<0.05).

Conclusions and comments

Trial outcomes have demonstrated that reducing N rates below the Grower N rate of 180kgN/ha did not negatively impact crop outcomes. There was also benefit in annually alternating N rates between trial years from the 6ES (150kgN/ha) to Stalk N (110kgN/ha) rates for the Alternate N treatment.

Trial outcomes are as follows:
Crop TN%: Over the three-year sampling period no significant difference in outcomes was observed via either averaged trial results all years combined (Table 1.) or individual trial year outcomes (Table 2.). For both analysis time frames the Alternate N rate and the Grower N rate treatment(s) achieved comparable Crop TN%.

tC/ha: Averaged harvest analysis, all years combined for tS/ha shows that the Alternative N rate and the Grower N rate maintained highest tS/ha (Figure 1.), and as the trial years progressed, the Alternate N rate can be seen to have maintained a high tS/ha relative to the other N treatments (Table 3.).

CCS: Limited treatment effect upon CCS was observed for all years combined average data (Figure 2.) and individual trial years (Table 3.). This is an interesting observation as reduced N rates often results in an increase in CCS. The lack of significant CCS response for the 0N control treatment indicates that high levels of N exist within the soil profile which masked treatment effect for this parameter.

tS/ha: All harvest years combined average (Figure 3.) shows that the Alternative N rate-maintained outcomes with the Grower N rate. In this instance, the 6ES treatment also achieved comparable outcomes. Across individual trial years, the Alternate N rate increased tS/ha post 2017 harvest year, achieving either the highest or second highest tS/ha (Table 3.).

NUE (tc/kgN): NUE provided an interesting outcome. Average results for all years combined identifies that the Alternate N rate maintained significantly ($P<0.05$) comparable outcomes with the Stalk N rate (Figure 4.). NUE (tC/kgN) is calculated by via the following: tC/ kgN applied. High yield and/or low N rates result in improved NUE. Consequently, the Stalk N rate of 110kgN/ha (the lowest N rate in the trial) was an influential factor in this result. For the Alternate N rate, annually changing the N rate from 150kgN/ha to 110kg/ha meant that, over the trial period, less N was applied when compared to either the 6ES rate of 150kgN/ha or the Grower N treatment of 180kgN/ha. However, as seen in Figure 1, the Alternate N rate also achieved high tC/ha. The reduction in total N applied, combined with the high tC/ha achieved, resulted in this outcome. Results for individual harvest years (Table 3.) shows a similar effect with no significant difference ($P<0.05$) in NUE between the Stalk N and the Alternate N treatments in 2018 and 2020 when 110kgN/ha was applied.

Trial results have identified that the Alternate N rate was able to maintain both Crop N% and harvest outcomes when compared to the 6ES and Grower N treatments at the higher N rates whilst improving Crop TN% and harvest outcomes when compared to the Stalk N treatment at the lower N rate.

Figure 5. Participating grower inspecting the Trial site.

Advantages of this Practice Change:
Trial outcomes have demonstrated a clear benefit of alternating N rates annually from a 6ES N rate to a Stalk N rate, resulting in less N inputs over a cropping cycle. Reduced N inputs result in several benefits including decreased rates of soil acidification, increased on farm gross margins and improved environmental outcomes via reducing N losses associated with denitrification, runoff and leaching.

Disadvantages of this Practice Change:
4 years of trial data have demonstrated no negative impacts of reducing N rates at this specific site. Caution should be used when applying this practice change to other soil types and locations as the trial design was site specific.

Will you be using this practice in the future:
Yes. The outcomes of the trial have demonstrated that increased N rates do not increase TCH, CCS or TSH. Annually varying N inputs from the 6ES to a reduced rate have not negatively impacted yield outcomes but have reduced N inputs and improved the farms financial bottom line.

% of farm you would be confident to use this practice:
To start with I'm looking to apply this practice to 25% of the farm and see how it goes.

*Farmacist Mackay would like to acknowledge the work undertaken by Mackay DAF staff in all aspects of this trial.