Fertilising with enhanced efficiency nitrogen – representative economic analysis, Burdekin region

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Summary

Enhanced Efficiency Nitrogen (EEN) fertilisers may improve nitrogen (N) use efficiency under certain soil and climatic conditions, and reduce the risk of N leaving farms and entering Great Barrier Reef catchments. This report explores two particular types of EEN fertiliser (controlled release and ENTEC fertilisers) and examines whether these fertilisers can maintain farm profitability at relatively lower N application rates (40kg/ha lower, 60kg/ha lower and at the same rate). In particular, four key questions are investigated including:

(1) How do the EEN fertiliser costs compare with conventional fertiliser management?
(2) What yield improvements are necessary when using EEN fertilisers to attain the same profitability as conventional practice?
(3) What risk factors influence the relative profitability of the fertilisers and by how much?
(4) How profitable is it to apply EEN fertilisers at 12 different trial sites located across the lower Burdekin region?

The 12 trial sites were established on a variety of different soil types, cane varieties and crop classes and the trials were arranged to explore different harvesting times. Also, two different trial designs have been examined:

- Group A – includes nine trial sites and compares a urea product applied at 220 kilograms of N per hectare (220kgs N/ha – control treatment) with a lower N rate urea product (180kg N/ha) and three lower N rate EEN fertiliser products; 'ENTEC 180N', controlled release 25 per cent of N blend ('CR25% 180N') and a controlled release 50 per cent of N blend ('CR50% 180N')
- Group B – includes three trial sites and compares urea, ENTEC and 'CR25%' products applied at 220kgs N/ha with the same products applied at a lower N rate (160kgs N/ha).

When applying EEN fertilisers at rates 40 kgs N/ha less than the control treatment ('Urea 220N'); ENTEC has approximately the same cost ($/ha), 'CR25% 180N' is around $70/ha more expensive and 'CR50% 180N' is around $200/ha more expensive. As the ENTEC treatment is around the same cost, it does not need to improve cane yield to break-even with the control. In contrast, the relatively higher cost of the controlled release fertiliser requires the 'CR25%' treatment to improve cane yields by two to three tonnes of cane per hectare (TCH) and the 'CR50%' treatment to boost cane yield by five to nine TCH. Logically, applying the EEN fertilisers at lower N rates would also reduce the yield improvement needed by controlled release fertilisers, and vice versa.

Using the 2015 harvest results, the Urea, ENTEC and 'CR25%' treatments applied at 180kgs N/ha were found in most cases to have the highest mean gross margins among the nine trial sites in Group A. In contrast, the 'Urea 220N' treatment did not have the highest mean gross margin at any of the trial sites. However, none of the individual trials revealed a significant treatment effect. The combined statistical analysis for Group A found a significant effect of treatment, while pairwise comparisons identified that the 'CR50%' treatment was found to be significantly less profitable than all other treatments except the 'CR25%' treatment.

In contrast to Group A, the 'Urea 220N' treatment had the highest mean gross margin at all three sites in Group B. This result may suggest that applying EEN fertilisers in the Burdekin at N rates 60kg per hectare below the control, or at the same rates as the control (220kg of N/ha), are not economically optimal. However, the statistical results were too inconsistent to confirm this theory. The combined statistical analysis for Group B found no significant effect of treatment, which was surprising given that a treatment effect was identified at two of the three sites. However, the relative performance of the EEN fertiliser treatments at each trial site were not consistent, which may give premise to the possibility that certain biophysical factors are influencing the performance of the EEN fertilisers.

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Table of contents

Table of figures

Table of tables

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1 Introduction

The NQ Dry Tropics Sugarcane Innovations Programme explores innovative and aspirational practices to reduce nutrient and pesticide losses from Burdekin sugarcane farms. The programme is funded through a number of organisations including: Project Catalyst, a pioneering partnership funded by the Coca-Cola Foundation through the World Wide Fund for Nature (or WWF); the Australian Government Reef Programme GameChanger project; and the Australian Government Reef Programme through Reef Water Quality Grants that allow early adoption of practice changes to ultimately improve water quality outcomes. These projects are delivered in partnership with the Department of Agriculture and Fisheries, Farmacist, Burdekin Productivity Services and the Burdekin Bowen Integrated Floodplain Management Advisory Committee (BBIFMAC).

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

The aim of this report is to examine the economic feasibility of using EEN fertilisers on 12 different sugarcane farms in the Lower Burdekin catchment. By examining a variety of farms, this study is able to incorporate regional farm heterogeneity and determine the impacts to farm profitability on a broader scale that is representative of the wider Burdekin region.

EEN fertilisers may improve nitrogen (N) use efficiency and reduce the risk of N leaving farms and entering Great Barrier Reef catchments. Two particular types of EEN fertiliser are examined as part of this study; controlled release (Agrocote®) and nitrification inhibiting (ENTEC®) fertiliser. A central question underlying the investigation is whether these fertilisers can maintain farm profitability at relatively lower N application rates. This report investigates four different questions, including: (1) How much does it cost to use EEN fertilisers? (2) What yield improvements are necessary when using EEN fertilisers to attain the same profitability as existing practice? (3) What risk factors influence profitability? (4) How profitable is it to use EEN fertilisers at 12 different Burdekin trial sites?

2 Enhanced efficiency nitrogen fertilisers

The use of N as a fertiliser in Australia has increased dramatically since the 1960's. However, contemporary research has found that conventional N fertiliser applications to the soil are not being utilised efficiently (Chen, et al., 2008). N applied in the urea form converts to ammonium after a period of time, which then oxidises rapidly to nitrate. In this form, it can be lost from plant-soil systems easily via numerous pathways including ammonia volatilisation, leaching, nitrification and denitrification. A study examining N losses on well drained, friable clay soils at South Johnstone during a first ratoon crop found that 59 per cent of total applied N was lost via various pathways when urea was applied to the surface and 46 per cent was lost when applied subsurface (Prasertsak, et al., 2002). Lost N has not only environmental implications but also affects the profitability of farming businesses.

EEN fertilisers are additives or treatments that, in comparison to conventional fertilisers, increase the availability and uptake of N by plants (Ferguson, et al., 2010). Two particular forms of EEN fertilisers are being trialled in the Sugarcane Innovations Programme–controlled release fertilisers and fertilisers with additives that inhibit nitrification. Controlled release fertilisers are designed to release nutrients when the crop requires them, thus increasing availability and maximising crop uptake, while reducing the probability of losing surplus nutrients. ENTEC® (or DMPP[1]) is a type of nitrification inhibitor that can be added to granular fertiliser. Nitrification inhibitors slow the rate of nitrification and reduce the risk of losses from nitrous oxide emissions and the leaching of nitrate.

Both soil and climatic conditions are central to the performance of EEN fertilisers. If soil and climatic conditions are not conducive to N losses during periods of crop N uptake then the potential benefits that these products provide may go unexploited (Ferguson, et al., 2010). These products could therefore be appreciated as insurance of yield potential in contrast to assurance of higher yields.

While many studies have examined the efficacy of EEN fertilisers to reduce nutrient losses[2] (Prasertsak, 2002; Merino et al, 2005; Yu et al, 2007; Akiyama, Yan and Yagi, 2010; Chen, Suter, Islam and Edis, 2010), little emphasis has been placed on comparing the financial implications of using these products with common practice.

3 Burdekin trials

Image 1 shows the locations of the 12 EEN fertiliser trial sites in the lower Burdekin region. All trial sites were established by Farmacist during 2014.

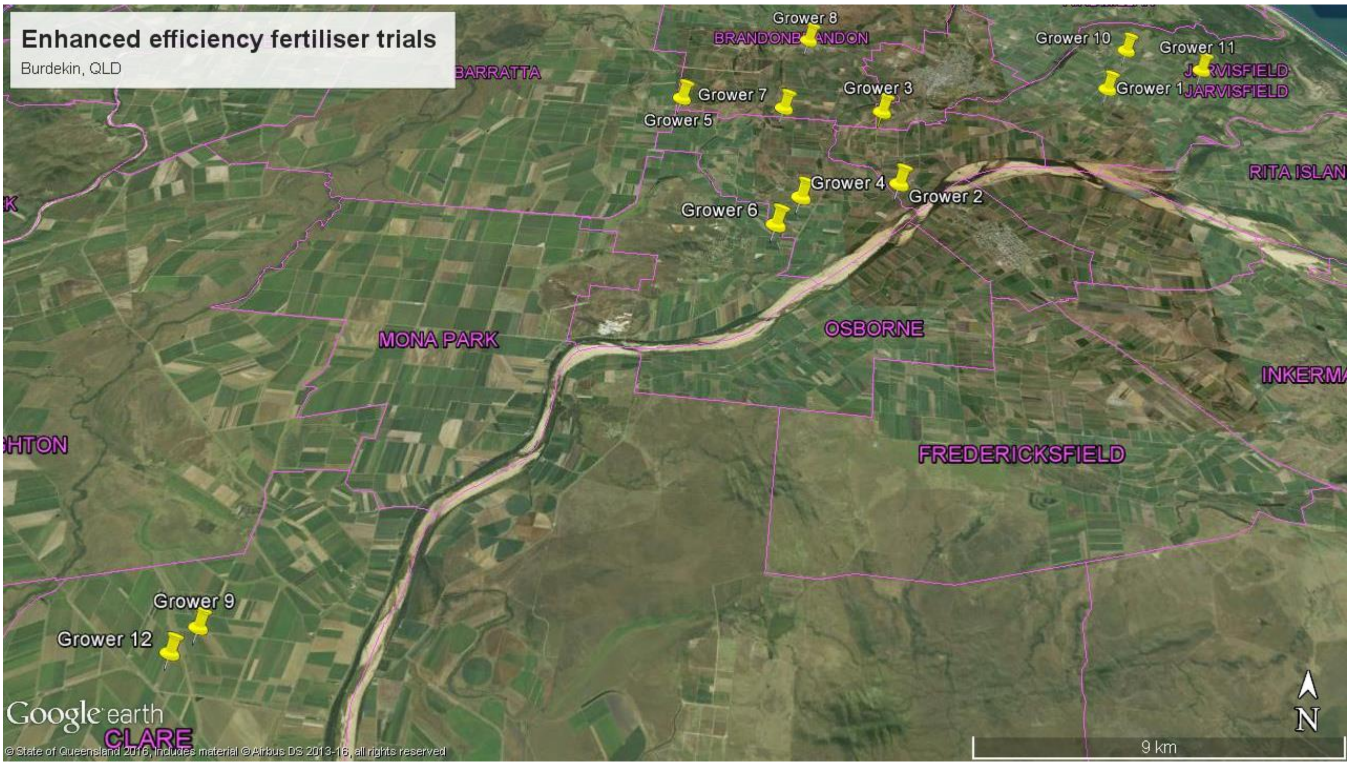

Image 1: Trial site locations.

Due to the configuration of the trials, a number of important research questions can be explored including:

- How do EEN fertilisers compare to conventional fertiliser?
- What is the most efficient application rate of N when using these fertilisers?

[1] 3,4-Dimethylpyrazole phosphate (DMPP) is the active ingredient in ENTEC®.
[2] See Chen et al. (2008) for a review of studies that have examined nutrient losses.

The following subsections provide a description of the trial sites along with their corresponding trial designs.

3.1 Trial site characteristics

The 12 sites can be organised into two groups that examine different treatments. Table 1 outlines the key characteristics of the nine trial sites in Group A, while Table 2 describes the three trial sites in Group B. The examination of a variety of trial sites enables the performance of EEN fertiliser treatments to be measured against a range of variables including soil type, harvest time, location and cane variety.

Table 1: Characteristics of trial sites - Group A.

Element	GROUP A				
	Grower 1	*Grower 2*	*Grower 3*	*Grower 4*	*Grower 5*
Soil type:	Sand	Loam	Delta loam	Sandy loam	Loam
Harvest time:	Early	Mid	Late	Early	Mid
Crop stage:	2nd ratoon	2nd ratoon	1st ratoon	1st ratoon	2nd ratoon
Variety:	KQ228	Q183	Q208	Q183	Q183
Row spacing:	1.55m	1.5m	1.52m	1.6m	1.83m

Element	GROUP A (cont.)			
	Grower 6	*Grower 7*	*Grower 8*	*Grower 9*
Soil type:	Loam	Clay	Clay	Clay
Harvest time:	Late	Early	Mid	Late
Crop stage:	1st ratoon	1st ratoon	1st ratoon	1st ratoon
Variety:	Q253	Q183	Q208	Q183
Row spacing:	1.55m	1.52m	1.52m	2m dual rows

Table 2: Characteristics of trial sites - Group B.

Element	GROUP B		
	Grower 10	*Grower 11*	*Grower 12*
Soil type:	Sand	Sand	Clay
Harvest time:	Early	Mid	Late
Crop stage:	2nd ratoon	1st ratoon	3rd ratoon
Variety:	Q208	KQ228	Q183
Row spacing:	1.52m	1.55m	2m dual rows

3.2 Trial designs

The nine trial sites in Group A examine ENTEC® and two controlled release blends (25 per cent and 50 per cent), whereas the three sites in Group B examine ENTEC® and one controlled release blend (25 per cent). A fundamental question underlying the investigation is whether EEN fertilisers can maintain productivity at relatively lower N application rates to offset the relatively higher fertiliser product costs. Therefore, to examine the efficiency of the EEN fertilisers, an N rate 40 and 60 kilograms per hectare below the control scenario (220 kilograms of nitrogen applied with urea) were selected for the comparative treatments, while all treatments apply the same quantity of phosphorus, potassium and sulphur.

Table 3 shows the type of fertiliser product and the elemental content for each of the treatments examined in Group A's trials (nine growers). For each of these trials, there are two treatments that have fertiliser applications of urea (1) at the rate of 220 kilograms of N per hectare (control treatment), and (2) 180 kilograms of N per hectare, while all of the EEN fertiliser treatments received an N rate of 180 kilograms per hectare. Two controlled release blends are investigated in these trials. The first has 25 per cent of the urea coated with polymer/sulphur, while the second has 50 per cent of the urea coated. All treatments are replicated three times using a randomised complete block layout.

Table 3: Description of treatments - Group A.

Treatment	Fertiliser product	Nutrient rate (kg/ha)				Abbreviation
		Nitrogen	*Phosphorus*	*Potassium*	*Sulphur*	
1	Urea*	220	20	80	33	220N
2	Urea	180	20	80	33	180N
3	ENTEC	180	20	80	33	ENTEC 180N
4	CR25%	180	20	80	33	CR25% 180N
5	CR50%	180	20	80	33	CR50% 180N

* Control scenario

Table 4 provides a description of the treatments in Group B (three growers). These trials compare urea, ENTEC® and controlled release fertiliser at two different N rates; 220 and 160 kilograms per hectare.

Table 4: Description of treatments - Group B.

Treatment	Fertiliser product	Nutrient rate (kg/ha)				Abbreviation
		Nitrogen	*Phosphorus*	*Potassium*	*Sulphur*	
1	Urea*	220	20	80	33	220N
2	CR25%	220	20	80	33	CR25% 220N
3	ENTEC	220	20	80	33	ENTEC 220N
4	Urea	160	20	80	33	160N
5	CR25%	160	20	80	33	CR25% 160N
6	ENTEC	160	20	80	33	ENTEC 160N

* Control scenario

4 Methodology and parameters

Four key questions are examined in this study. The first question compares the costs of the fertiliser treatments relative to conventional fertiliser management. The main cost difference is the added cost of the EEN fertilisers, however, many of the EEN fertiliser treatments have been applied at lower rates.

As the relative cost of the fertiliser treatments are different, the second question investigates the yield change necessary for each fertiliser treatment to achieve the same profitability as conventional practice (control scenario - urea treatment with 220 kilograms of N applied per hectare). To calculate revenue, the analysis uses past block production data to estimate ratoon crop yields. Table 5 displays these production figures expressed as tonnes of cane per hectare (TCH) and Commercial Cane Sugar (CCS) for each of these sites.

Table 5: Historical production from trial blocks (averages).

Grower	1	2[3]	3	4	5	6	7	8	9	10	11	12
Cane yield (TCH)	162	111	165	123	131	139	151	134	90	132	109	77
CCS	11.4	14.2	13	12.2	14.6	15.1	14.4	16.4	15.1	13.4	14.9	13.3

While the initial analysis uses some standardised variables, it is important to look at how certain risks may influence the relative profitability of the fertiliser treatments. Consequently, the third question examines two key risks; sugar price fluctuations changes in the price of EEN fertilisers. Over the past decade, the sugar price has fluctuated within a wide range. In 2007-08, the price Queensland cane farmers received for their sugar fell to under $280 per tonne, while in 2011-12 the price rose to almost $520 per tonne[4]. As the sugar price influences revenue and, in effect, the profitability of different fertiliser treatments, a sensitivity analysis has been carried out around variations in the price of sugar. In particular, the analysis examines how the break-even yield for each treatment would be influenced if the sugar price either rose up to $520 per tonne, or fell to $280 per tonne.

As the use of controlled release fertilisers by Burdekin canegrowers has been fairly limited, it is possible that the price these fertilisers are supplied at may change if the quantity demanded changes dramatically[5]. To take into account possible variations, the yield increase required for the EEN fertiliser treatments to break-even with the control scenario are examined at a range of prices; either falling by up to 50 per cent, or rising by up to 25 per cent of their current prices.

While the initial analysis uses some standardised variables, it is important to look at how certain risks may influence the relative profitability of the fertiliser treatments. Consequently, the third question examines two key risks; changes in cane yield and fluctuations in the sugar price. A vital unknown is the influence EEN fertilisers will have on sugarcane crop yields. To examine this uncertainty in further detail, this case study explores how changes in yield influence the profitability of the EEN fertiliser treatments by calculating the difference in gross margin from conventional fertiliser management. Another risk factor that can influence the profitability of EEN fertilisers is the sugar price. Over the past decade, sugar prices have fluctuated between $280 and $520 per tonne. At high sugar prices, growers may be more willing to trial EEN fertilisers if they anticipate potential production benefits. Consequently, the influence of the sugar price on the break-even yield is explored.

[3] Farm average yields were used as no sugarcane yield data existed for the trial block.
[4] Queensland Sugar Limited (QSL) seasonal and harvest pool prices (nominal).
[5] For example, if suppliers are able to benefit from economies of scale, then they may pass these savings onto users. On the other hand, suppliers may need to upgrade their facilities to keep up with demand and decide to raise prices in order to recover their investments.

Due to the wide range of environmental factors that may influence performance (e.g. location, soil type, variety, crop stage, harvest time), the fourth question investigates the relative profitability of the various EEN fertiliser treatments at 12 different trial sites around the Burdekin. This analysis draws on 2015 harvest data from the trial site to calculate and compare the gross margin for each treatment. The gross margin of each treatment replicate is calculated using 2015 harvest production data along with farm operational costs specific to each fertiliser treatment.

The Farm Economic Analysis Tool (FEAT) was used to undertake a comprehensive evaluation of the implied revenues and costs of each treatment. A FEAT analysis requires the grower to provide detailed information regarding their production system, which includes machinery operations, land preparation and fallow management, as well as pesticide, fertilising and irrigation management. From these results, the gross margin of each treatment is compared, which is calculated by taking the revenue received from the crop and subtracting the variable[6] costs involved with growing the crop. The analysis uses the five-year average net sugar price[7] of $430 per tonne, while input prices (e.g. fertiliser and chemical) were sourced from local suppliers. Labour has been costed at $30 per hour.

4.1 Statistical analysis

For the 2015 trial production analysis, a statistical analysis of the economic observations has been undertaken to examine whether there is a statistically significant difference (significant effect of treatment) between the mean gross margins of the various fertiliser treatments. The analysis draws on the gross margin outcomes that are derived from the economic evaluation. Each trial was laid out as a randomised complete block design. Table 6 shows the number of replicates that were tested within each respective treatment and trial.

Table 6: Treatment replication at each trial site.

Group	Grower	Urea (N)			ENTEC (N)			CR25% (N)			CR50% (N)
		160	*180*	*220*	*160*	*180*	*220*	*160*	*180*	*220*	*180*
A	**1**	0	3	3	0	3	0	0	3	0	3
	2	0	3	3	0	3	0	0	3	0	3
	3[8]	0	2	2	0	2	0	0	2	0	2
	4	0	3	3	0	3	0	0	3	0	3
	5	0	3	3	0	3	0	0	3	0	3
	6	0	3	3	0	3	0	0	3	0	3
	7	0	3	3	0	3	0	0	3	0	3
	8	0	3	3	0	3	0	0	3	0	3
	9	0	3	3	0	3	0	0	3	0	3
B	**10**	3	0	3	3	0	3	3	0	3	0
	11	3	0	3	3	0	3	3	0	3	0
	12	3	0	3	3	0	3	3	0	3	0

To evaluate the economic results from each trial site (in isolation), an analysis of variance (ANOVA) was performed. As all sites in each group (e.g. Group A) have the same fertiliser treatments, multi-environment trial (MET) analyses were undertaken to improve the power of the statistical analyses.

[6] Variable costs include fertiliser, chemical, irrigation, machinery and harvesting costs.
[7] Using net sugar prices from Queensland Sugar Limited's seasonal and harvest pools between 2010 and 2014 (Queensland Sugar Limited, 2015).
[8] While Grower 3's trial site was replicated three times, one particular replication of treatments was unbalanced due to being planted with a mix of cane varieties. Consequently, this replicate was discarded due to associated yield discrepancies.

Residual maximum likelihood (REML) was used to perform these MET analyses, which was fitted with both fixed and random effects. The fixed effects are the fertiliser treatments and the trial sites, while the random effects are the interaction of fertiliser treatment and trial site, plus the interaction of trial site and the replicate blocks within each trial.

By fitting the interaction of treatment and trial in the random model, the treatment term is effectively compared with the interaction of treatment and trial, unless it is zero. A significant treatment effect would then imply that the effect is consistent and large compared to its variation across the trials. This is a more stringent test than testing the treatment term using the within-trial error weighted according to the precision within each trial. A separate residual variance is fitted for each trial.

The null hypothesis assumes that there is no statistically significant difference in the gross margin values of the fertiliser treatments. To test the null hypothesis, F-tests were employed to assess whether the mean gross margin value of any fertiliser treatment was significantly different to any of the other treatments at the 5 per cent significance level ($\alpha=0.05$). Adhering to Fisher's protected least significant difference (LSD) test methodology, whenever statistically significant outcomes emerge from an F-test then pairwise comparisons were carried out by comparing the treatment means using the 95 per cent LSD.

Treatment means for each analysis have been graphed along with 95 per cent LSD bars wherever obligatory. Letters (a, b, c, etc.) have also been positioned above each 95 per cent LSD bar to indicate statistical significance. These are assigned based on the results of pairwise comparisons. Treatments with a common letter indicate that differences in mean gross margin are not statistically significant and vice versa.

5 Results

The results of the economic analyses are divided into three sections. Initially, the fertiliser costs associated with each treatment are evaluated. This is followed up by a break-even yield analysis, which includes an examination of the risk posed by sugar price fluctuations and possible EEN fertiliser price movements. The final section examines the production and economic outcomes from harvest data collected in 2015 from 12 trial sites.

5.1 Fertiliser costs

The examination of fertiliser costs allows for a comparison between different treatments when taking into consideration the price and application rate. Table 7 displays the fertiliser prices and application rates for each treatment and Figure 1 illustrates the fertiliser costs for each treatment. Fertiliser application rates were determined by the blend necessary to deliver the respective quantity of nutrients for each treatment. Fertiliser prices were obtained from local suppliers[9] and are exclusive of goods and services tax.

Comparing each of the treatments in Group A reveals that the urea treatment that applies 180 kilograms of N per hectare (180N) has the lowest fertiliser cost, while the controlled release treatment with a 50 per cent blend ('CR50% 180N') has the highest cost. Interestingly, the 220 kilograms of N per hectare treatment and the ENTEC® treatment, which delivers 40 kilograms less N per hectare, both have similar costs.

Table 7: Fertiliser application rates and prices - Group A.

	220N	*180N*	*ENTEC 180N*	*CR25% 180N*	*CR50% 180N*
Rate (kg/ha)	773	685	685	673	661
Price ($/t)	$695	$700	$779	$903	$1,108

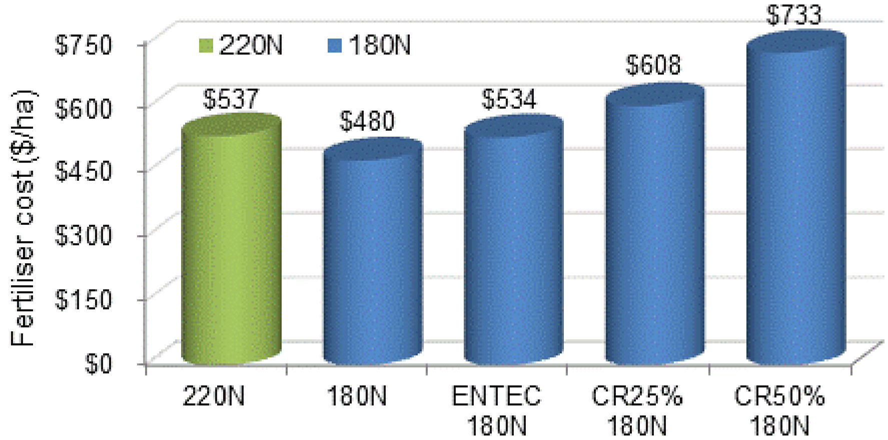

Figure 1: Fertiliser costs - Group A.

The relative cost of treatments in Group B are similar to those in Group A (see Table 8 and Figure 2). At any particular application rate, the controlled release treatments are more expensive than both the ENTEC® and urea treatments. Nevertheless, at a rate of 160 kilograms of N per hectare, the controlled release treatment ('CR25% 160N') is less than $30 per hectare more expensive than the

[9] Prices were collected in July, 2015.

control scenario. When comparing the control scenario with the ENTEC® treatment that delivers 160 kilograms of N per hectare ('ENTEC 160N'), the ENTEC® treatment costs $40 per hectare less.

Table 8: Fertiliser application rates and prices - Group B.

	220N	*ENTEC 220N*	*CR25% 220N*	*160N*	*ENTEC 160N*	*CR25% 160N*
Rate (kg/ha)	773	773	758	642	642	632
Price ($/t)	$695	$786	$915	$703	$775	$896

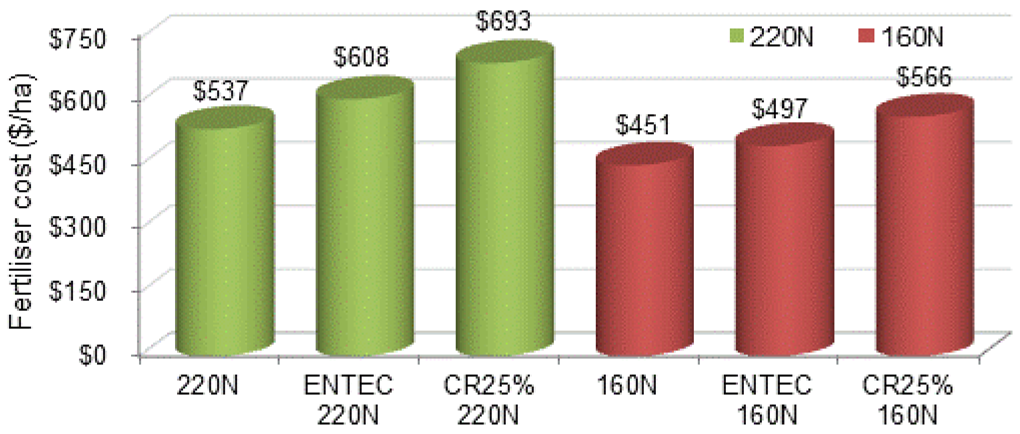

Figure 2: Fertiliser costs – Group B.

Table 9 shows the N application rate required for each EEN fertiliser product to have approximately the same cost as the urea treatment with 220 kilograms of N per hectare. However, it is important to note that these rates are estimates based on current prices and are dependent on particular suppliers as well as the relative cost of fertiliser products.

Table 9: Nitrogen rates necessary to equalise fertiliser costs.

	Urea	*ENTEC*	*CR25%*	*CR50%*
Nitrogen rate (kg/ha)	220	181	145	109
Approximate cost ($/ha)	$537	$537	$537	$537

5.2 Break-even yield analysis

This section investigates the yield change necessary for each fertiliser treatment to achieve the same profitability as the control treatment ('Urea 220N'). Firstly, the gross margin is calculated for each treatment using the respective operating costs at each trial site as well as the specific fertiliser cost for each fertiliser treatment. Production is assumed equal among treatments to enable a break-even yield analysis to be carried out; to identify the change in tonnage (cane) necessary for each particular fertiliser treatment to break-even with the control scenario. To take into account sugar and fertiliser price risk, the sensitivity of the break-even yield to variations in the price of sugar and EEN fertilisers is examined.

5.2.1 Gross margin analysis

Undertaking a gross margin analysis is a useful way to compare the annual profitability of different treatments when there is no capital investment. As mentioned earlier, it is calculated by subtracting all variable crop growing expenses (e.g. fertilising, pest control and harvesting costs) from revenue. Figures 3 and 4 compare the gross margin of each treatment for all trial sites when the specific production levels are held constant at each site. Nutrient management is the only variable cost that is different amongst the treatments due to other growing expenses being approximately the same (e.g. weed control and irrigation). Because of this factor, relative differences in gross margin between treatments are solely a function of crop nutrition expenses. Consequently, the Figures below show similar results to those presented in the preceding fertiliser cost analysis. It is interesting to note the substantial variation in gross margins amongst trial sites due mostly to differences in productivity and variable growing expenses.

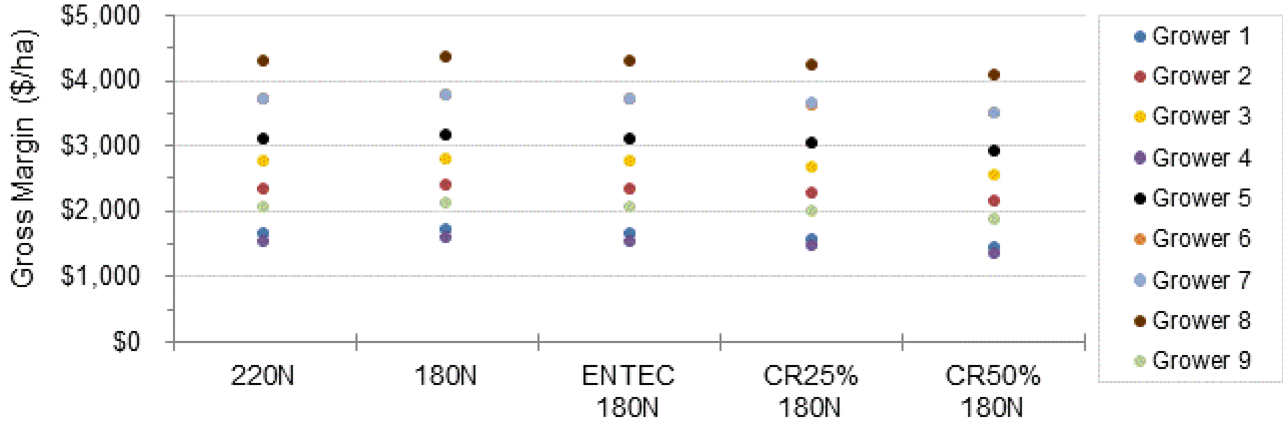

Figure 3: Gross margin comparison (Group A).

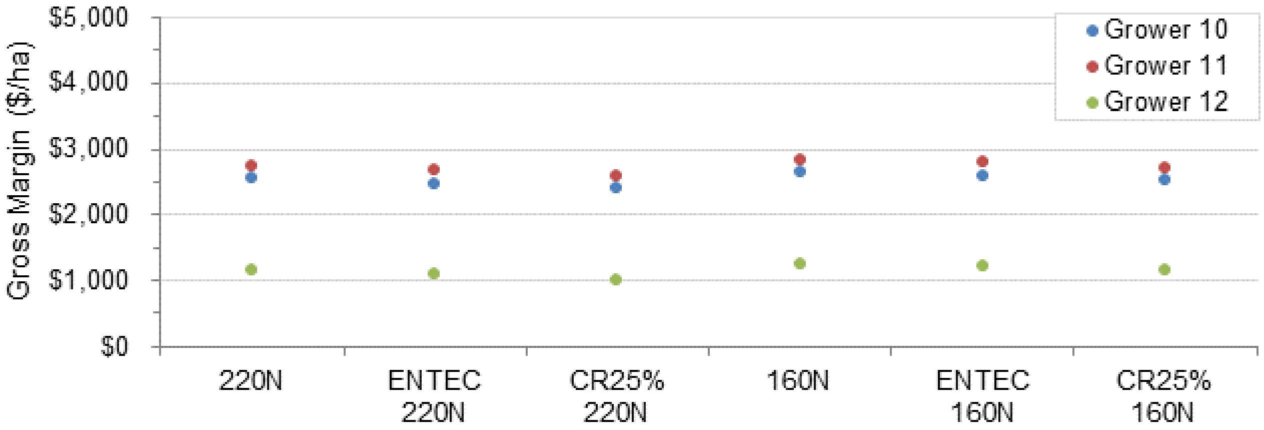

Figure 4: Gross margin comparison (Group B).

5.2.2 Yield improvement required to maintain farm profitability

To put the fertiliser cost differences into perspective, Figures 5 and 6 illustrate the yield increase required by each treatment to attain the same profitability as the control scenario (Urea 220). The analysis assumes a constant CCS level and that all other input costs remain constant (weed control, harvest costs, etc.). By examining a variety of growers, it is possible to gain a better understanding of the variation that is likely to be experienced by growers in the broader Burdekin region. Figure 5 shows the break-even yield required by the treatments for Group A.

As the urea treatment that applied 180 kilograms of N per hectare has the lowest fertiliser costs, a slight reduction in yield, between 1.4 and 2.7 TCH (or -1.1per cent and -1.7 per cent), can occur and the treatment will still break-even with the control scenario. On the other hand, the controlled release treatment with a 50 per cent blend requires a yield increase of between 4.8 and 9.1 TCH (or 3.6 per cent and 5.6 per cent). Interestingly, if the ENTEC® treatment attains a similar yield as the control scenario then it would be marginally more profitable due to slightly lower fertiliser costs.

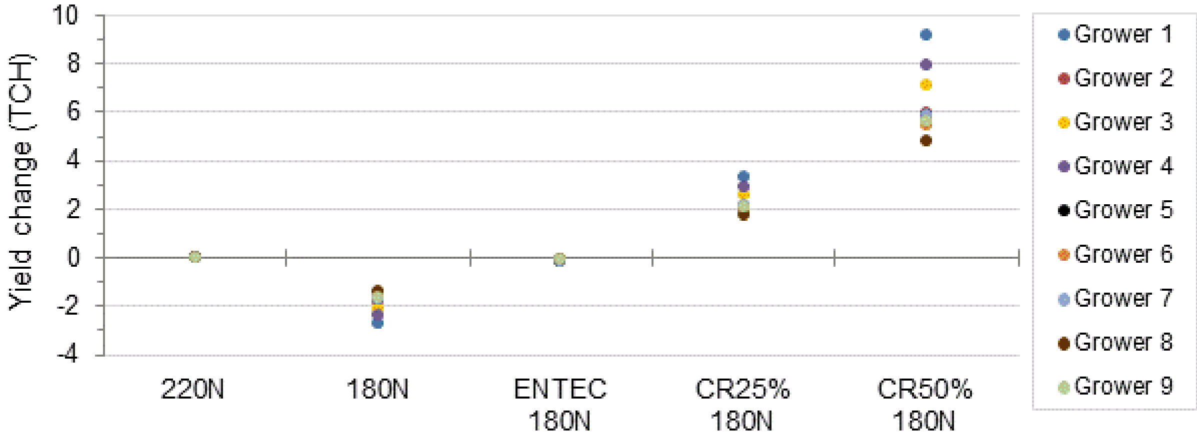

Figure 5: Break-even yield – Group A.

The break-even yields for Group B's treatments are comparable to those in Group A (see Figure 6). Having the lowest fertiliser costs, the urea treatment with 160 kilograms of N per hectare can sustain a lower yield of between 2.5 and 3.1 TCH (or -2.3 per cent and -4 per cent) and still break-even with the control scenario. Likewise, the 'ENTEC 160N' treatment could also decrease by between 1.2 and 1.5 TCH (or -1.1 per cent and -1.9 per cent). At a rate of 160 kilograms of N per hectare, the controlled release treatment ('CR25% 160N') would only need an extra 0.8 to 1 TCH (or 0.8 per cent and 1.3 per cent) to break-even with the control scenario. When applying N at a rate of 220 kilograms per hectare, the ENTEC® and controlled release treatments would need cane yield increases of around 2 to 2.6 and 4.4 to 5.6 TCH (or 1.8 per cent to 3.3 per cent and 4.1 per cent to 7.3 per cent), respectively.

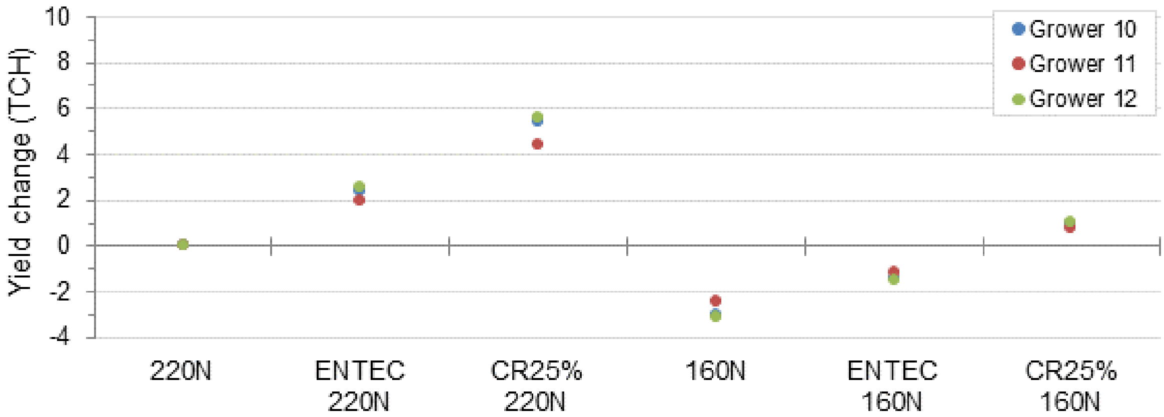

Figure 6: Break-even yield – Group B.

5.2.3 Risk analysis

While the previous section ascertained the break-even yield for each treatment at the five-year average sugar price and current EEN fertiliser prices, this section extends on these findings to examine the sensitivity of the break-even yield to variations in the price of sugar and EEN fertilisers.

Sugar price

To take account of possible variations in the price of sugar, Figures 7 and 8 demonstrate the yield increase required by each treatment to attain the same profitability as the control scenario at a range of sugar prices[10]. In these Figures, each thick unbroken line represents the mean break-even yield of all growers for a particular treatment at the respective price, whereas the thin broken lines denote the minimum and maximum break-even yields.

Examining the nine growers in Group A, Figure 7 shows that at sugar prices below $430 per tonne the controlled release treatments require a larger yield increase to break-even with the control scenario. This is because more expensive treatments have greater sensitivity to sugar prices as they require a relatively higher yield improvement if sugar prices decline. For example, at $430 per tonne the mean break-even yield for the ‘CR50% 180N’ treatment is 6.4 TCH, however if the sugar price fell to $280 then the break-even yield would rise to 11.4 TCH. Conversely, if the sugar price jumped up to $520 per tonne then the break-even yield would decrease slightly to 5.1 TCH. In comparison, the sugar price has little influence on the break-even yield for the ENTEC® treatment.

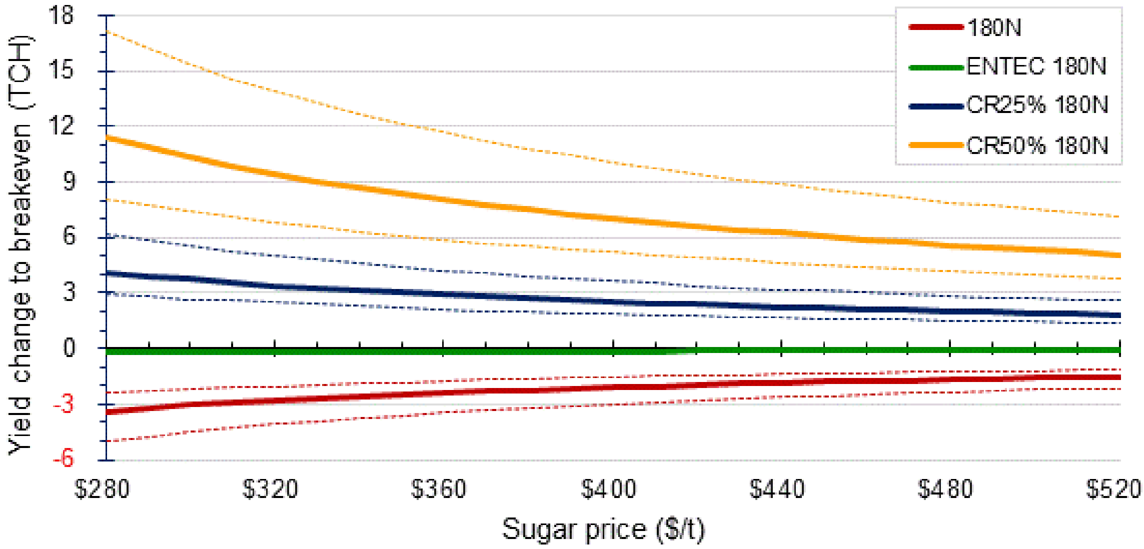

Figure 7: Sensitivity to the price of sugar – Group A.

Due to relative differences in fertiliser costs, the sensitivity of Group B’s break-even yields to the sugar price are more mixed than Group A’s (see Figure 8). For instance, at lower sugar prices the ‘ENTEC 160N’ treatment could sustain slightly higher yield losses. Moreover, the ‘CR25% 160N’ treatment (in Group B) is less sensitive to the sugar price than the ‘CR25% 180N’ treatment (in Group A), particularly at lower sugar prices.

[10] When assuming a constant CCS level.

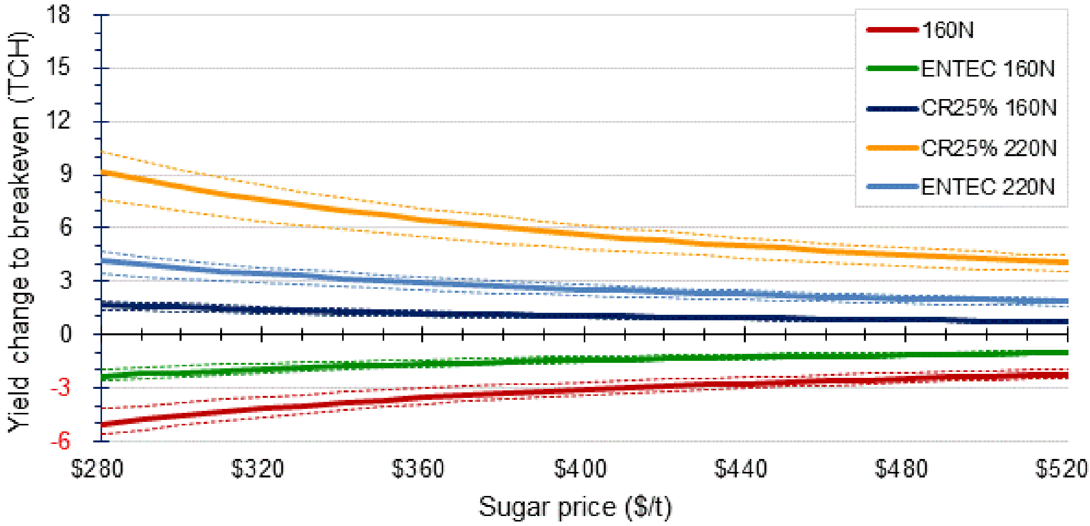

Figure 8: Sensitivity to the price of sugar – Group B.

The price of enhanced efficiency nitrogen fertilisers

Depending on the performance of ENTEC® and controlled release fertilisers in the Burdekin region, the use of these products in the region could change markedly. These possible changes in demand, among other things, may affect the price that suppliers would be willing to charge for their products, which could impact on the relative profitability of using these products. Figures 9 and 10 illustrate the risk of deviations in the current ENTEC® additive price and the price of controlled release fertiliser, respectively. More specifically, the Figures show the yield increase that is necessary for the EEN fertiliser treatments to break-even with the control scenario if the price of EEN fertilisers either fell by up to 50 per cent, or rose by up to 25 per cent of their current price.

Figure 9 shows the respective ENTEC® treatments for growers in Group A ('ENTEC 180N') and Group B ('ENTEC 160N' and 'ENTEC 220N'). An increase in the ENTEC® additive price by 25 per cent would require the 'ENTEC 220N' treatment to deliver 0.6 TCH more yield to break-even with the control scenario. On the other hand, if the price decreased by 25 per cent then it could yield 0.5 TCH less and break-even. Both of the ENTEC® treatments with lower N application rates are affected similarly by the price changes.

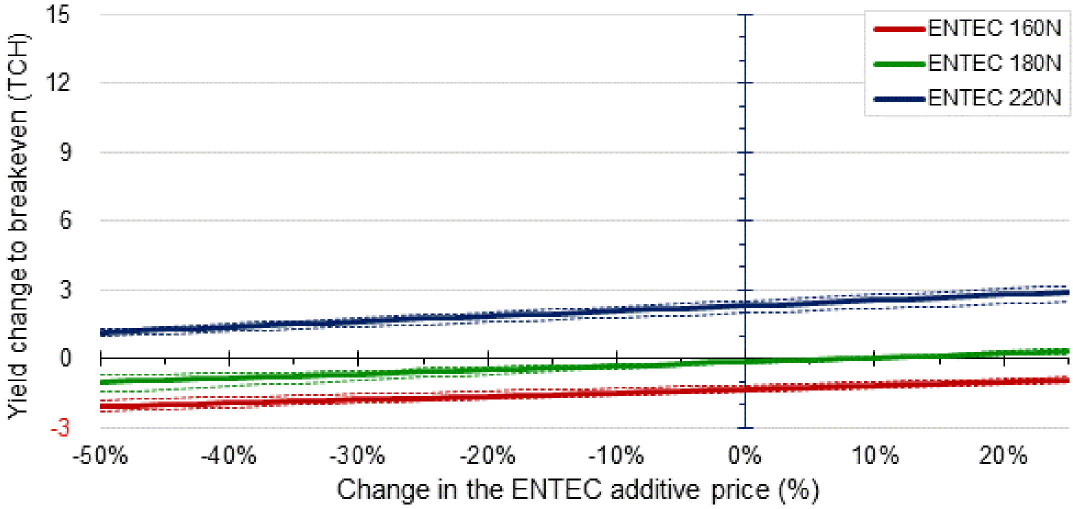

Figure 9: Sensitivity to the ENTEC® additive price.

Figure 10 investigates the risk of variations in the current price of controlled release fertiliser. The graph depicts the growers in Group A for the ‘CR25% 180N’ and ‘CR50% 180N’ treatments and the growers in Group B for the ‘CR25% 160N’ and ‘CR25% 220N’ treatments. Noticeably, the break-even yields for the controlled release treatments are far more price sensitive than those for the ENTEC® treatments. In particular, the ‘CR50% 180N’ treatment (in orange) is very price sensitive. An increase in the price of controlled release fertiliser by 25 per cent would require it to produce an extra 3.3 TCH to break-even with the control scenario. Alternatively, if the price decreased by 25 per cent then it could yield 3.3 TCH less and break-even. In comparison, a 25 per cent price increase would require the ‘CR25% 160N’ treatment to yield an additional 1.5 TCH to break-even, while a 25 per cent decrease would enable it to drop by 1.5 TCH.

Also evident in the Figure is the increasing disparity between growers at higher fertiliser prices. This factor is exemplified by progressively larger variation in the break-even yields at higher fertiliser prices for any given treatment, particularly those from Group A due to the broad range of trial sites.

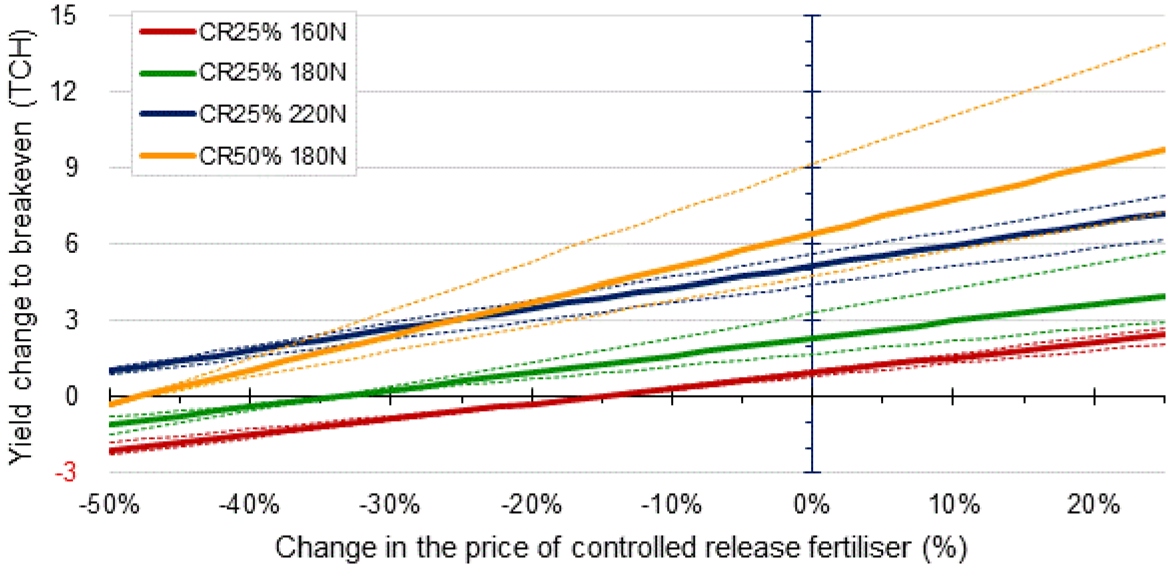

Figure 10: Sensitivity to the price of controlled release fertiliser.

5.3 2015 production analysis

This subsection is delivered as two smaller sections to examine Group A and B separately due to the different nitrogen rates that were investigated within each group.

5.3.1 Group A

To begin with, each grower is examined in isolation and then as a group. As the group analysis has more power to identify differences between treatments, more emphasis should be placed on these results in terms of the impacts to profitability in the whole of the Burdekin region. On the other hand, the group analysis is unable to distinguish peculiarities between different trial sites, such as different soil types, varieties, harvest dates, etc.

Grower 1

Location:	Jarvisfield, Delta
Harvest time:	Late - 25/09/15

Crop stage:	2nd ratoon
Variety:	KQ228

Soil type:	Sand

Table 10 compares the production results (TCH and CCS) from Grower 1's trial. For both TCH and CCS, the ANOVA found that the F-tests were not statistically significant at the 5 per cent significance level indicating no significant effect of treatment.

Table 10: Mean TCH and CCS results - Grower 1.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	146.0 a	141.3 a	141.1 a	146.6 a	144.4 a	*0.671*
CCS	15.10 a	15.25 a	14.98 a	15.30 a	15.26 a	*0.372*

Figure 11 below compares the mean (average) sugar yield from each fertiliser treatment during the second ratoon crop. The F-test was not statistically significant indicating no significant effect of treatment (Prob. (F) = 0.33 > 0.05). Consequently, no pairwise comparisons were carried out.

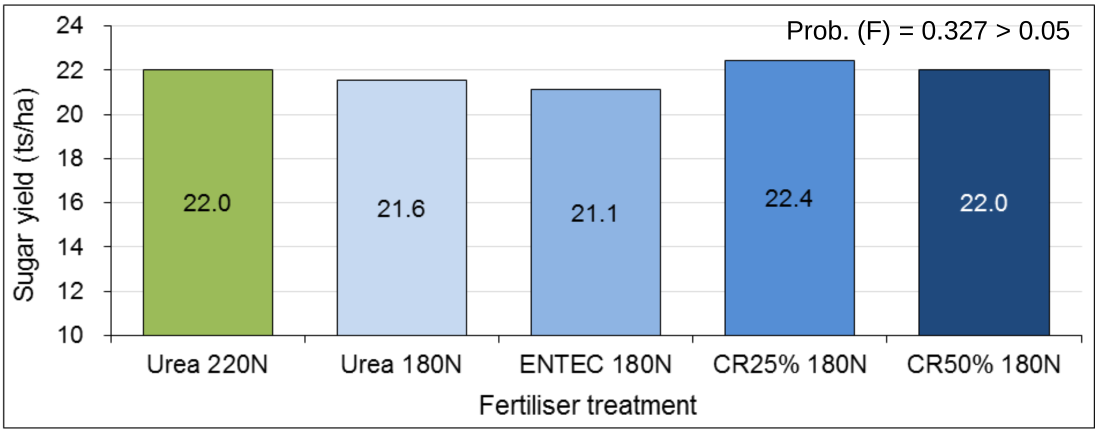

Figure 11: 2015 mean sugar yields – Grower 1.

Figure 12 shows the mean gross margin for each of the fertiliser treatments. Comparing the treatment means shows that the 'CR25% 180N' treatment attained the highest mean gross margin followed by the control treatment and the 'Urea 180N' treatment. However, the ANOVA found that the F-test was not statistically significant at the 5 per cent significance level indicating no significant effect of treatment.

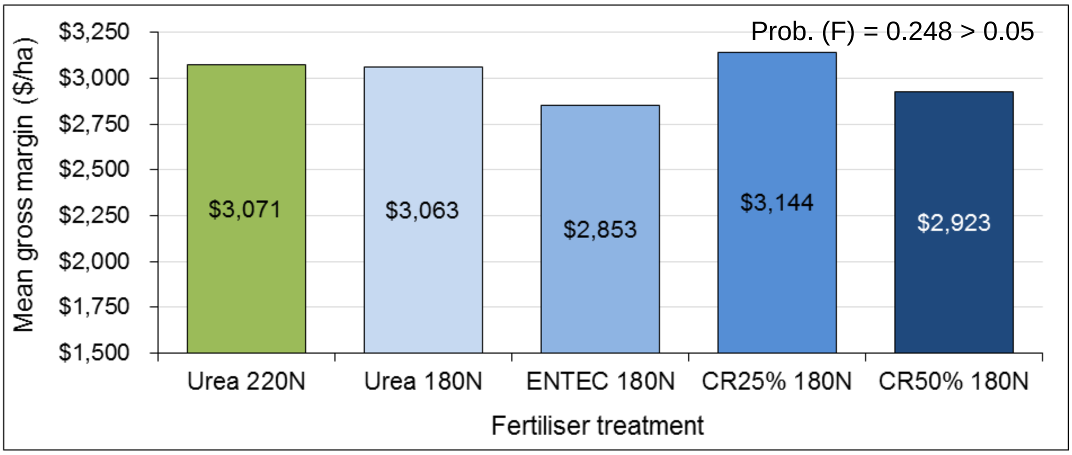

Figure 12: 2015 mean gross margins – Grower 1.

Grower 2

Location:	McDesme, Delta
Harvest time:	Mid - 5/09/15

Crop stage:	2nd ratoon
Variety:	Q183

Soil type:	Sand

Table 11 and Figure 13 compare the production results from Grower 2's trial during the second ratoon crop. Similarly to Grower 1's trial, no significant effects of treatment were determined for any of the production results.

Table 11: Mean TCH and CCS results - Grower 2.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	122.7 a	123.0 a	122.0 a	125.6 a	126.7 a	*0.907*
CCS	16.53 a	16.20 a	16.70 a	16.40 a	16.53 a	*0.288*

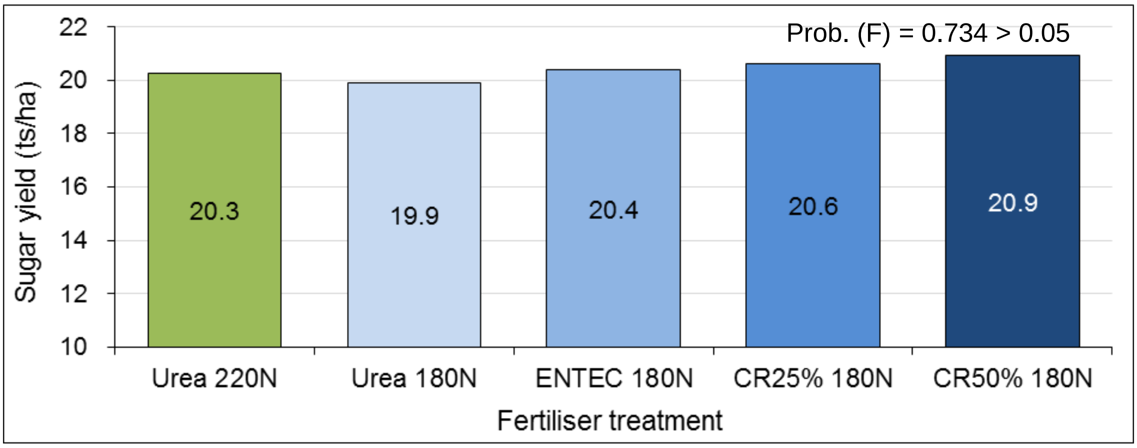

Figure 13: 2015 mean sugar yields – Grower 2.

A comparison of the mean gross margins from each treatment in Figure 14 shows that the ENTEC treatment attained the highest mean followed by the control treatment ('Urea 220N') and the controlled release treatment with a 25 per cent blend. Nevertheless, a statistical analysis of the economic results determined no significant effect of treatment.

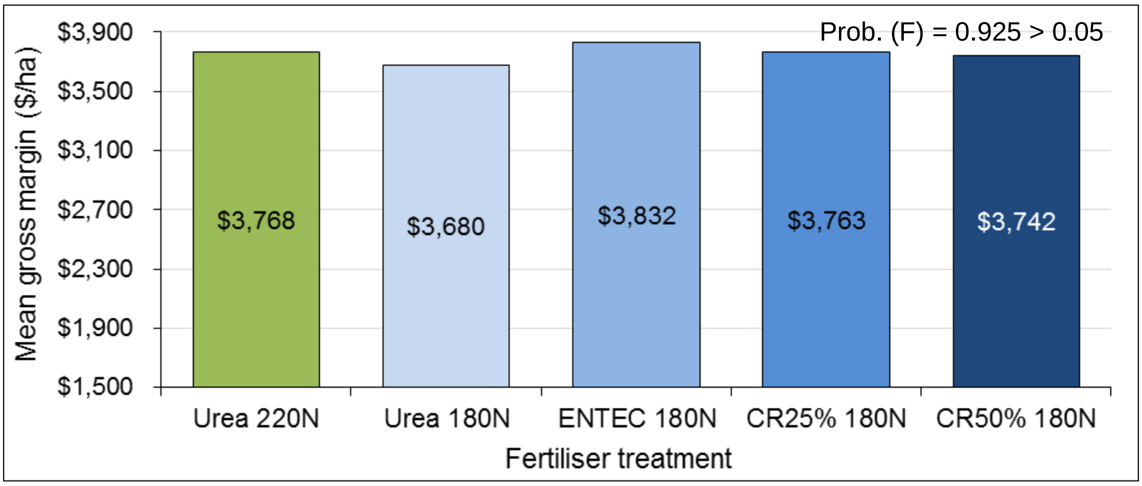

Figure 14: 2015 mean gross margins – Grower 2.

Grower 3

Location:	Ayr, Delta
Harvest time:	Late - 25/09/15

Crop stage:	1st ratoon
Variety:	Q183/Q208

Soil type:	Sand

Table 12 and Figure 15 compare the production results from Grower 3's trial. Similarly to the previous two trials, no significant effects of treatment were determined for any of the production results.

Table 12: Mean TCH and CCS results - Grower 3.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	124.7 a	120.3 a	124.3 a	121.9 a	131.6 a	*0.164*
CCS	14.30 a	14.22 a	14.20 a	14.23 a	14.10 a	*0.974*

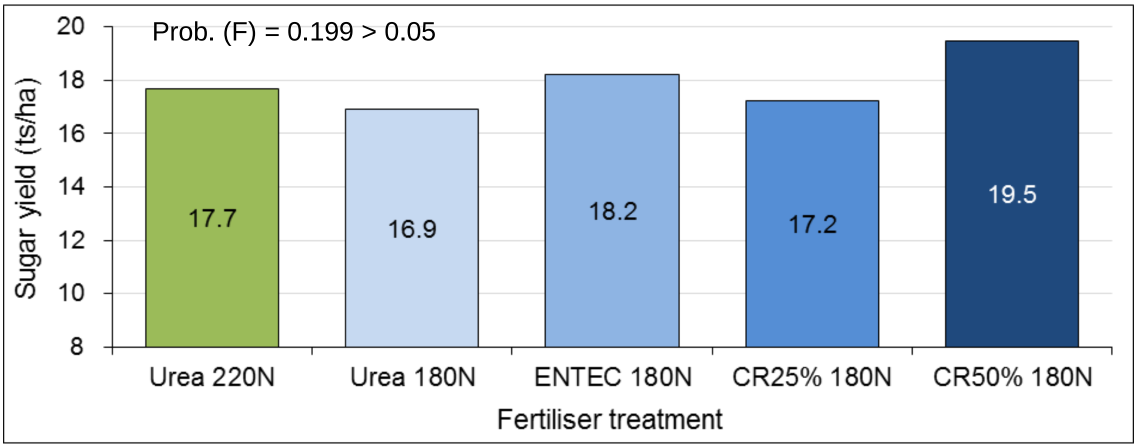

Figure 15: 2015 mean sugar yields – Grower 3.

Comparing treatments in Figure 16 identifies that the controlled release treatment with a 50 per cent blend attained the highest mean gross margin followed by the control and 'ENTEC 180N' treatments. Despite some large differences between the treatment means, a statistical analysis identified that these differences were not statistically significant.

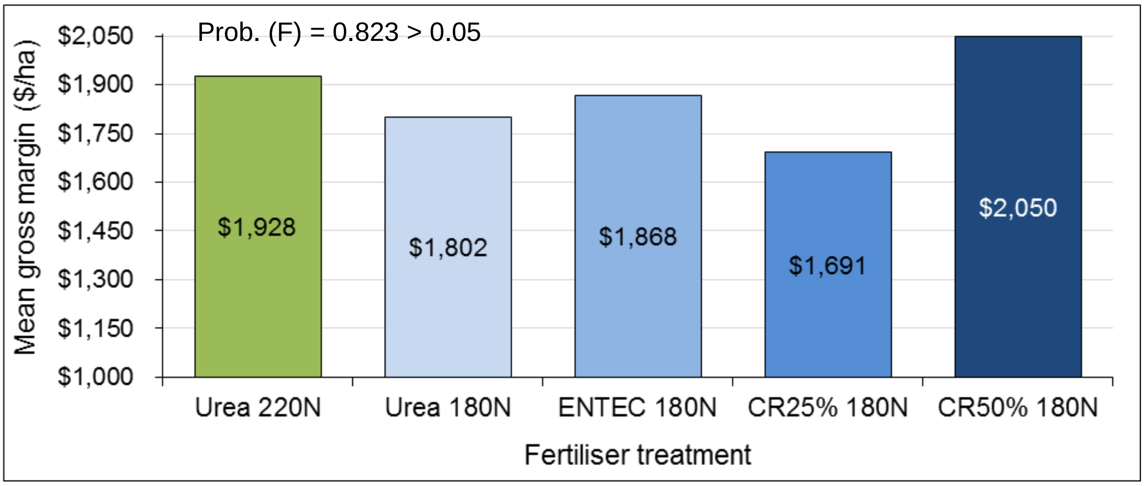

Figure 16: 2015 mean gross margins – Grower 3.

Grower 4

Location:	Airville, Delta
Harvest time:	Early - 2/08/15

Crop stage:	1st ratoon
Variety:	Q183

Soil type:	Loam

Table 13 and Figure 17 compare the production results from Grower 4's trial. For this trial, no significant effects of treatment were observed for any of the measures.

Table 13: Mean TCH and CCS results - Grower 4.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	137.7 a	140.9 a	140.5 a	129.6 a	130.0 a	0.557
CCS	15.28 a	15.47 a	15.37 a	15.57 a	15.63 a	0.666

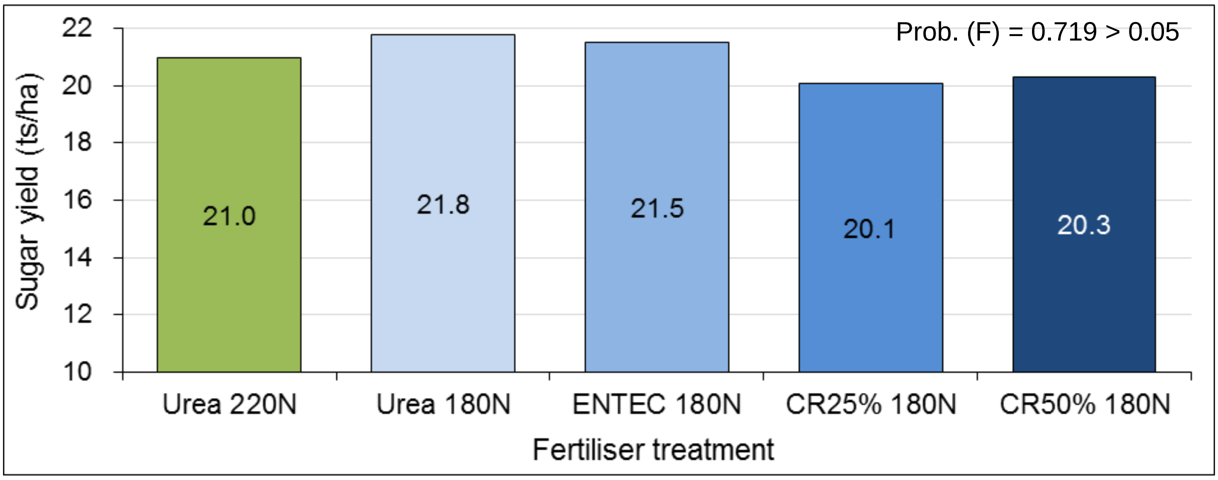

Figure 17: 2015 mean sugar yields – Grower 4.

Figure 18 illustrates the mean gross margin for each of the fertiliser treatments. The 'Urea 180N' treatment attained the largest mean gross margin shadowed by the ENTEC and control treatments. While considerable differences existed between some of the treatments, the ANOVA analysis found that the F-test was not statistically significant indicating no significant effect of treatment.

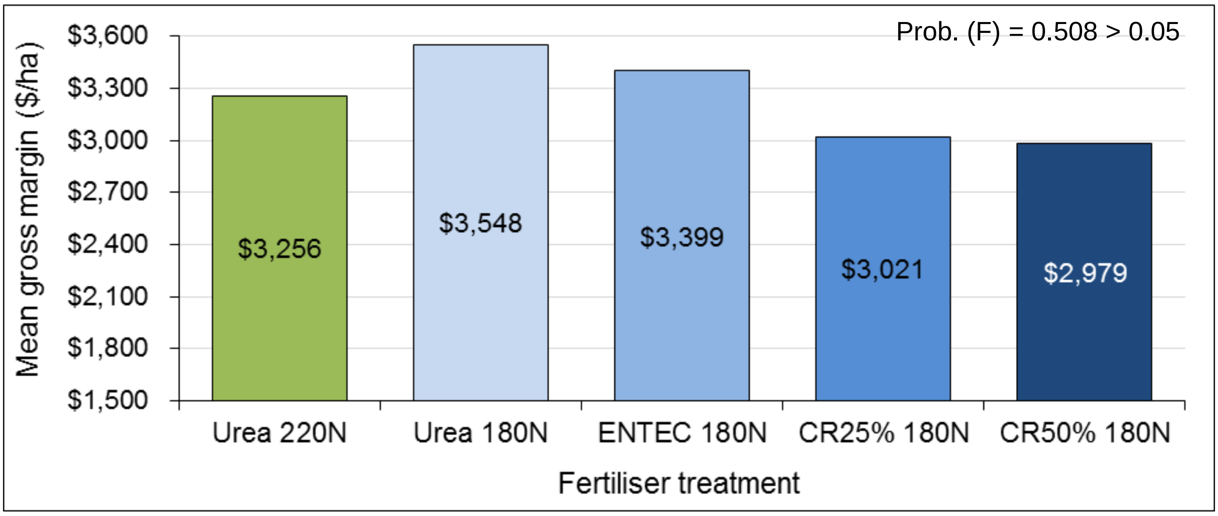

Figure 18: 2015 mean gross margins – Grower 4.

Grower 5

Location:	Airville, Delta
Harvest time:	Mid - 6/09/15

Crop stage:	2nd ratoon
Variety:	Q183

Soil type:	Loam

Table 14 and Figure 19 compare the production results from Grower 5's trial. Similar to many of the previous trials, no significant effects of treatment were determined for any of the production results.

Table 14: Mean TCH and CCS results - Grower 5.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	134.4 a	144.1 a	139.0 a	135.1 a	136.3 a	0.198
CCS	15.40 a	15.48 a	15.28 a	15.27 a	15.44 a	0.639

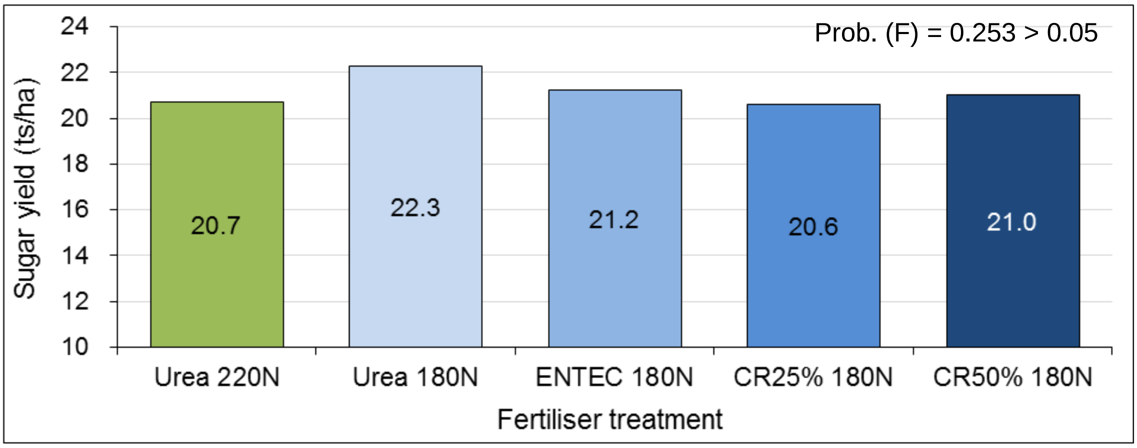

Figure 19: 2015 mean sugar yields – Grower 5.

A comparison of the gross margins from each treatment in Figure 20 shows that the 'Urea 180N' treatment attained the highest mean followed by the control treatment ('Urea 220N') and the ENTEC and control treatments. Again, large differences between the mean gross margins of each treatment are evident but the statistical analysis determined no significant effect of treatment at the 5 per cent significance level.

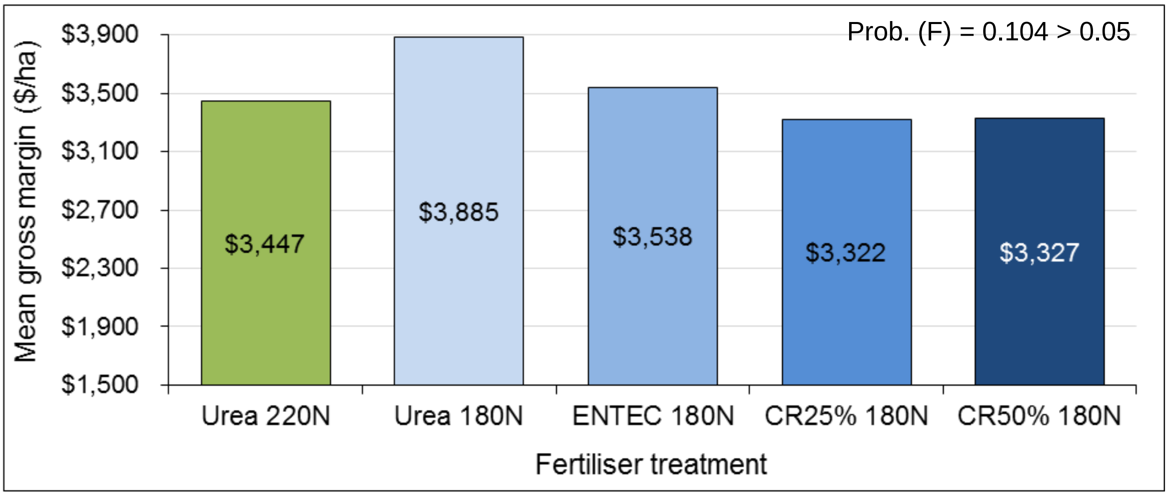

Figure 20: 2015 mean gross margins – Grower 5.

Grower 6

Location:	Mt Kelly, Delta
Harvest time:	Late - 2/10/15

Crop stage:	1st ratoon
Variety:	Q253

Soil type:	Loam

Table 15 and Figure 21 compare the production results from Grower 6's trial. Again, the same result occurred in this trial as many of those previous; no significant effects of treatment for production.

Table 15: Mean TCH and CCS results - Grower 6.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	136.0 a	135.4 a	135.8 a	137.5 a	134.4 a	0.663
CCS	13.63 a	13.72 a	13.80 a	13.88 a	13.77 a	0.719

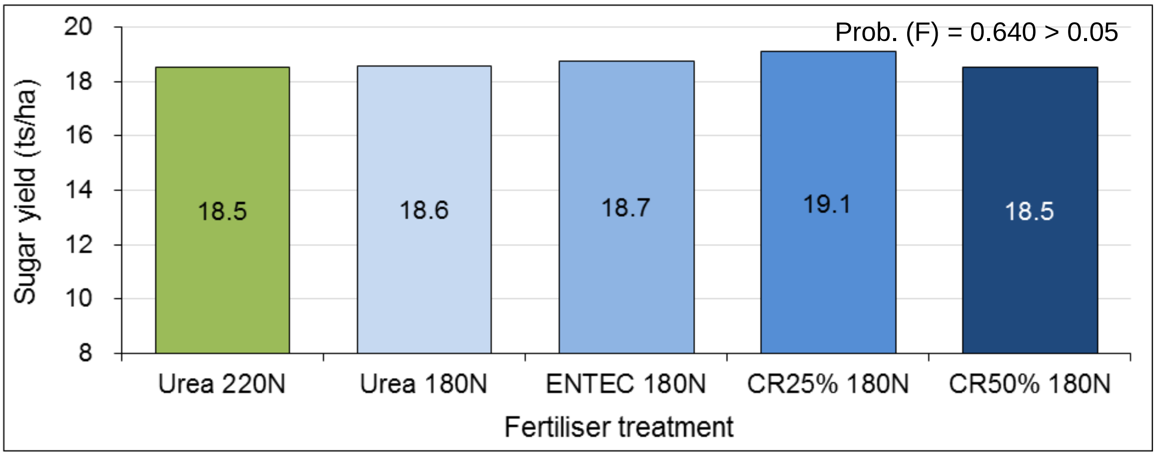

Figure 21: 2015 mean sugar yields – Grower 6.

Comparing treatments in Figure 22 identifies that the 'Urea 180N' treatment, ENTEC treatment and controlled release treatment with a 25 per cent blend attained very similar gross margins. A statistical analysis of the economic results identified that differences between the treatment means were not statistically significant.

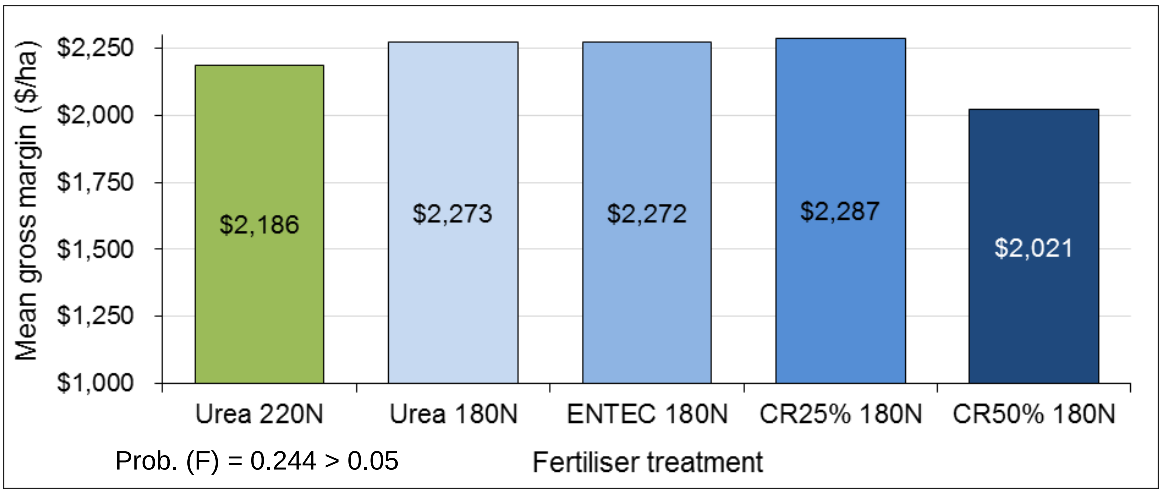

Figure 22: 2015 mean gross margins – Grower 6.

Grower 7

Location:	Brandon, Delta
Harvest time:	Early - 28/06/15

Crop stage:	1st ratoon
Variety:	Q183

Soil type:	Clay

Table 16 and Figure 23 compare the production results from Grower 7's trial. Yet again, no significant effects of treatment were identified for production.

Table 16: Mean TCH and CCS results - Grower 7.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	152.7 a	150.8 a	153.2 a	153.5 a	150.9 a	0.849
CCS	13.40 a	13.53 a	13.42 a	13.37 a	13.45 a	0.787

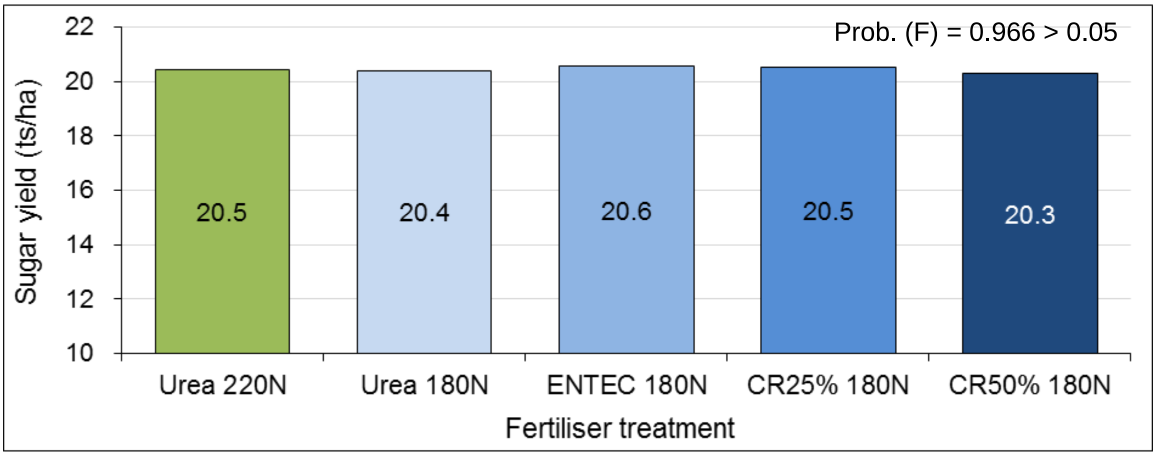

Figure 23: 2015 mean sugar yields – Grower 7.

Figure 24 illustrates the mean gross margin for each of the fertiliser treatments. The 'Urea 180N' treatment attained the highest mean gross margin followed by the ENTEC and control treatments. The results from the ANOVA were not statistically significant indicating no significant effect of treatment.

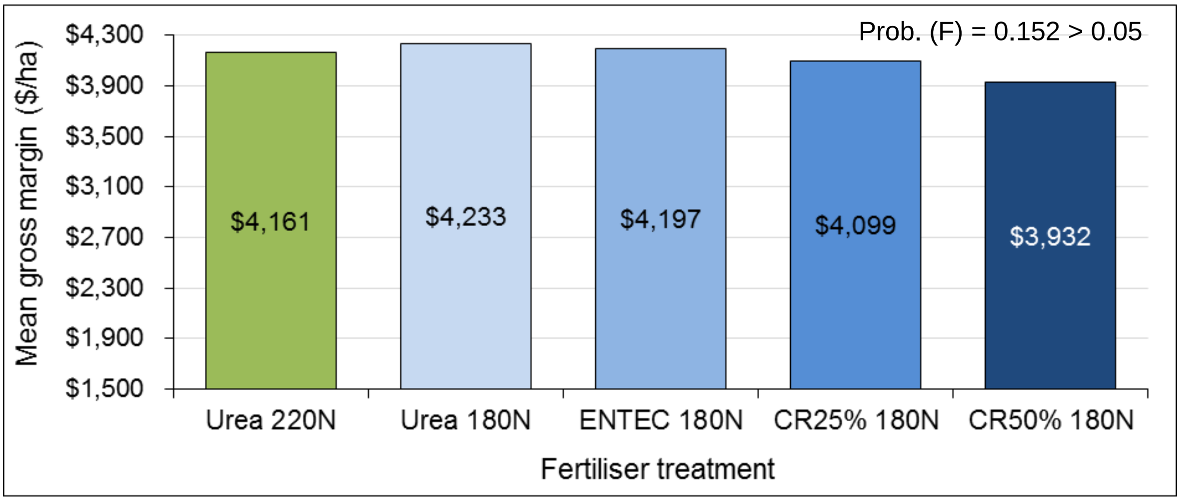

Figure 24: 2015 mean gross margins – Grower 7.

Grower 8

Location:	Brandon, Delta
Harvest time:	Early - 17/07/15

Crop stage:	1st ratoon
Variety:	Q208

Soil type:	Clay

Table 17 compares the TCH and CCS results from Grower 8's trial. While no significant effect was found for TCH, the CCS for the controlled release treatments was determined to be significantly higher than the 'Urea 220N' treatment.

Table 17: Mean TCH and CCS results - Grower 8.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	166.5 a	163.1 a	164.9 a	158.0 a	161.0 a	0.067
CCS	14.17 b	14.37 ab	14.47 ab	14.63 a	14.73 a	0.049

Figure 25 below compares the mean sugar yield from each fertiliser treatment. The F-test was not statistically significant indicating no significant effect of treatment (Prob. (F) = 0.128 > 0.05).

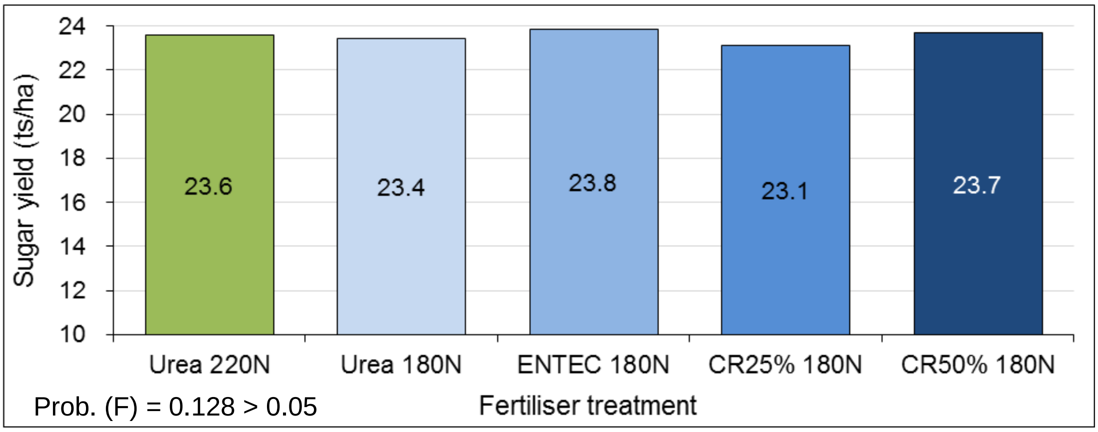

Figure 25: 2015 mean sugar yields – Grower 8.

A comparison of the gross margins from each treatment in Figure 26 shows that the 'ENTEC 180N' treatment attained the highest mean gross margin followed by the 'Urea 180N' and control ('Urea 220N') treatments. The statistical analysis determined no significant effect of treatment at the 5 per cent significance level.

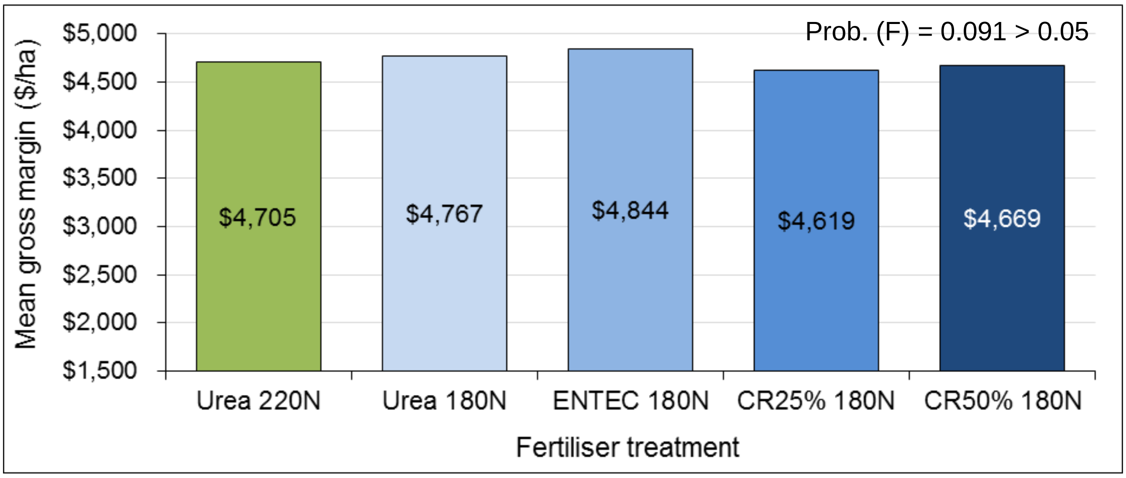

Figure 26: 2015 mean gross margins – Grower 8.

Grower 9

Location:	Clare, BHWSS
Harvest time:	Mid - 18/09/15

Crop stage:	1st ratoon
Variety:	Q183

Soil type:	Clay

Table 18 and Figure 27 compare the production results from Grower 9's trial. The observed results were similar to many of the previous trials in Group A; no significant effects of treatment for production.

Table 18: Mean TCH and CCS results - Grower 9.

	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
TCH	121.3 a	115.6 a	112.9 a	117.1 a	116.6 a	0.162
CCS	16.40 a	16.70 a	17.12 a	17.00 a	16.91 a	0.173

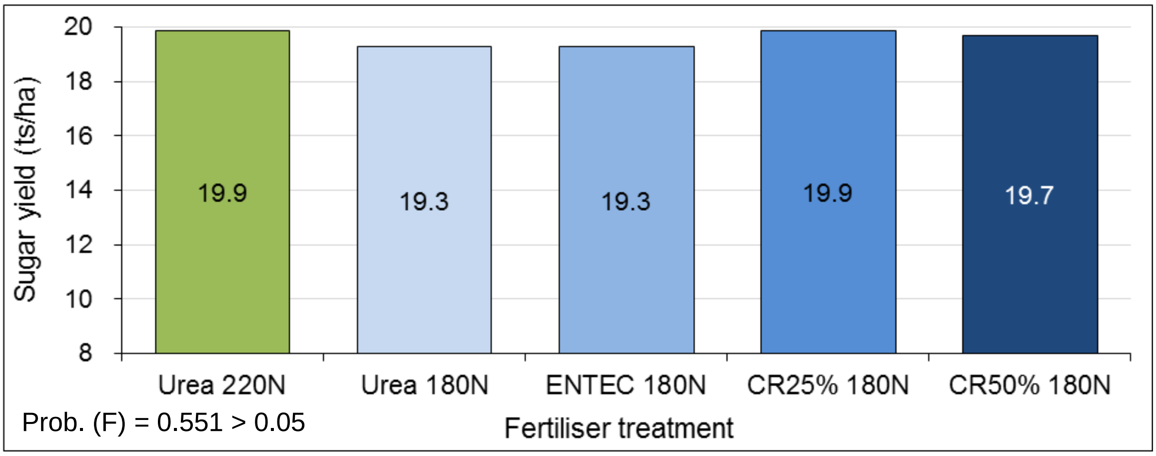

Figure 27: 2015 mean sugar yields – Grower 9.

Comparing treatments in Figure 28 shows that there was not much difference between all treatments except for the controlled release treatment with a 50 per cent blend. A statistical analysis of the economic results identified that differences between the treatment means were not statistically significant.

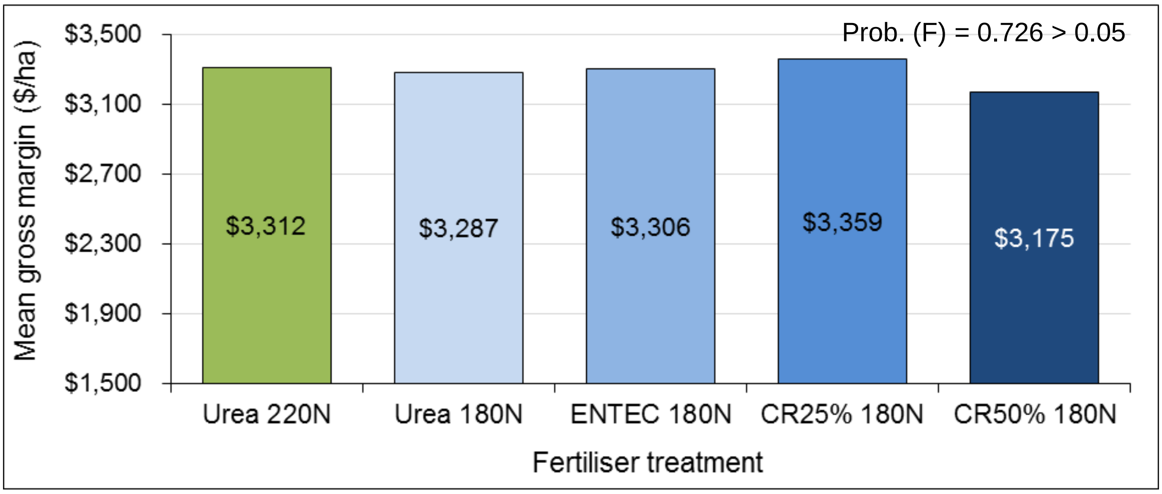

Figure 28: 2015 mean gross margins – Grower 9.

Summary - Group A

Table 19 summarises the gross margin and statistical analysis results from all nine trial sites in Group A. To focus on the variation in gross margin between the treatments, the difference (in gross margin) between each treatment and the control is shown. A negative value (in red) indicates that the treatment had a lower mean gross margin than the control, while a positive value (in black) indicates that the treatment performed better. Also, the treatment in each trial with the highest mean gross margin has been highlighted in yellow to identify any commonalities between the sites. Noticeably, there is a high degree of variation between the trial sites. Overall, the 'Urea 180N', 'ENTEC 180N' and 'CR25% 180N' treatments had the highest mean gross margins in most cases. In contrast, the control treatment ('Urea 220N') did not have the highest gross margin at any of the trial sites, while the 'CR50% 180N' treatment performed worse than the control treatment at every trial site except one. However, the statistical results revealed no significant treatment effects.

Table 19: Summary of gross margin results – Group A.

Grower	Urea 220N	Urea 180N	ENTEC 180N	CR25% 180N	CR50% 180N	*Prob. (F)*
1	$0 a	-$8 a	-$218 a	$73 a	-$148 a	0.25
2	$0 a	-$88 a	$64 a	-$4 a	-$25 a	0.92
3	$0 a	-$126 a	-$60 a	-$236 a	$122 a	0.82
4	$0 a	$291 a	$143 a	-$235 a	-$278 a	0.51
5	$0 a	$438 a	$91 a	-$125 a	-$120 a	0.104
6	$0 a	$86 a	$86 a	$100 a	-$166 a	0.24
7	$0 a	$72 a	$36 a	-$62 a	-$229 a	0.15
8	$0 a	$62 a	$138 a	-$86 a	-$36 a	0.091
9	$0 a	-$25 a	-$6 a	$47 a	-$137 a	0.73

Combined statistical analysis - Group A

A statistical analysis of the combined gross margin results for all of the nine growers in Group A was carried out. The REML analysis found that the F-test was statistically significant at the 5 per cent significance level indicating a significant effect of treatment. Pairwise comparisons were consequently conducted for the five treatments using the 95 per cent LSD ($94). Figure 29 presents the mean gross margin along with the 95 per cent LSD bars for each treatment. The error bars represent the 95 per cent LSD, while the letters at the top of each LSD bar indicate statistical significance. The results suggest that the 'CR50% 180N' treatment has a significantly lower mean gross margin than the Urea and ENTEC treatments (illustrated by the non-overlapping LSD bars).

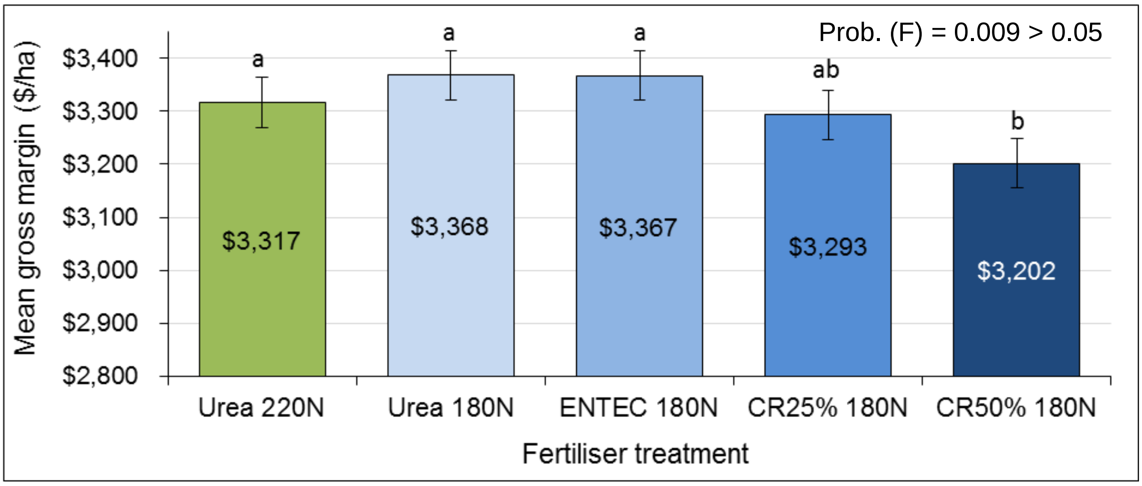

Figure 29: Results from the combined statistical analysis - Group A.

5.3.2 Group B

Similar to Group A, each grower is examined in isolation to examine trial site peculiarities and as a group to determine the expected impact to profitability over the wider Burdekin region.

Grower 10

Location:	Jarvisfield, Delta
Harvest time:	Mid - 8/09/15

Crop stage:	2nd ratoon
Variety:	Q208

Soil type:	Sand

Table 20 and Figure 30 compare the production results from Grower 10's trial during the second ratoon crop. Similar to many of the growers in Group A, no significant effects of treatment were determined for any of the production results.

Table 20: Mean TCH and CCS results - Grower 10.

	Urea 220	CR25% 220	ENTEC 220	Urea 160	CR25% 160	ENTEC 160	*Prob. (F)*
TCH	146.1 a	141.3 a	145.1 a	136.3 a	135.8 a	135.9 a	*0.060*
CCS	14.77 a	14.80 a	14.58 a	15.10 a	15.07 a	15.17 a	*0.103*

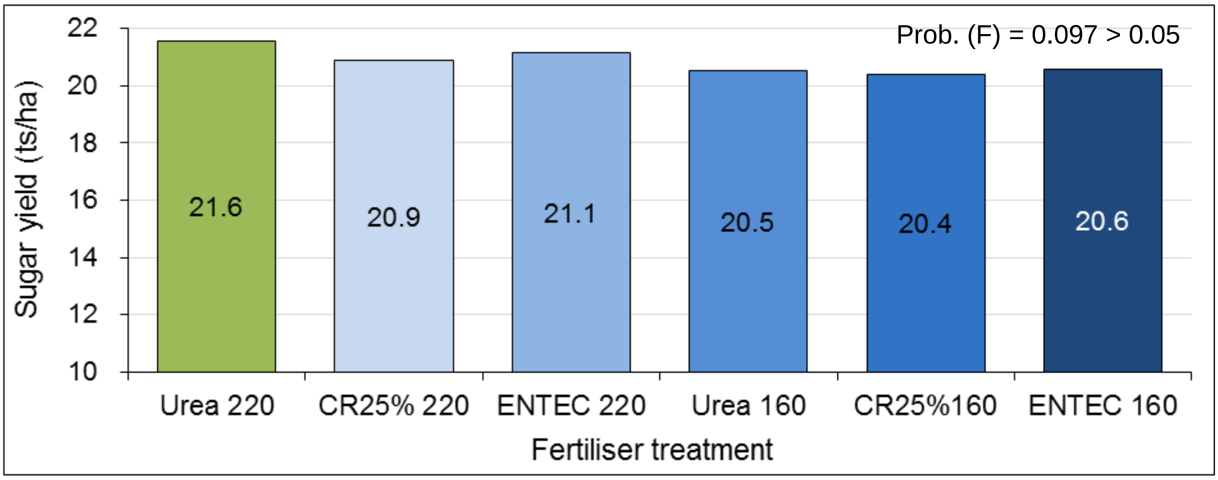

Figure 30: 2015 mean sugar yields – Grower 10.

Figure 31 presents the mean gross margin along with the 95 per cent LSD bars for each of the fertiliser treatments. The error bars represent the 95 per cent LSD, while the letters at the top of each LSD bar indicate statistical significance. Comparing the treatment means shows that the control treatment ('Urea 220N') attained the highest mean gross margin followed by the 'Urea 160N' and the 'ENTEC 160N' treatments. The results from the ANOVA found that the F-test was statistically significant at the 5 per cent level indicating a significant effect of treatment. Pairwise comparisons of the six treatments using the 95 per cent LSD suggest the mean gross margin for the control treatment is significantly higher than both of the controlled release treatments and the 'ENTEC 220N' treatment.

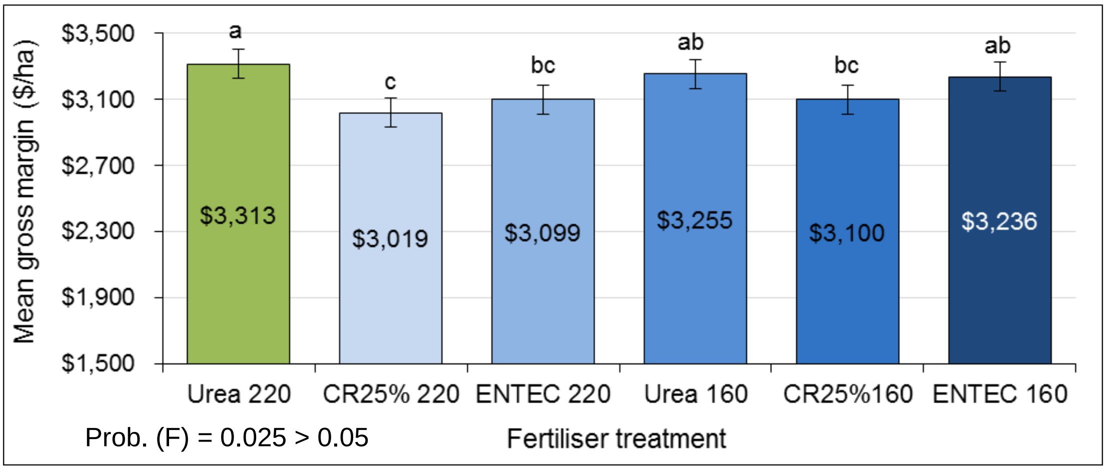

Figure 31: 2015 mean gross margins – Grower 10.

Grower 11

Location:	Jarvisfield, Delta	Crop stage:	1st ratoon	Soil type:	Loam
Harvest time:	Early - 19/07/15	Variety:	KQ228		

Table 21 compares the production results (TCH and CCS) from Grower 11's trial. While no significant effect of treatment was found for CCS, the ANOVA found that the F-tests were statistically significant at the 5 per cent significance level for TCH (Prob. F = 0.002 < 0.05). Pairwise comparisons indicate that both the 'CR25%' and Urea treatments applied at a rate of 220 kilograms per hectare attained significantly more cane yield than the other four treatments.

Table 21: Mean TCH and CCS results - Grower 11.

	Urea 220	CR25% 220	ENTEC 220	Urea 160	CR25% 160	ENTEC 160	*Prob. (F)*
TCH	96.2 b	99.7 b	88.6 a	88.4 a	87.0 a	88.5 a	0.005
CCS	15.93 a	15.90 a	15.80 a	15.90 a	16.00 a	16.03 a	0.194

Figure 32 below compares the mean sugar yield from each fertiliser treatment during the first ratoon crop. The F-test was statistically significant indicating a significant effect of treatment (Prob. (F) = 0.003 < 0.05). Consequently, pairwise comparisons were carried out. Similar to the cane yield analysis, the results show that both the 'CR25% 220N' and the 'Urea 220N' treatments attained significantly more sugar yield than all the other treatments.

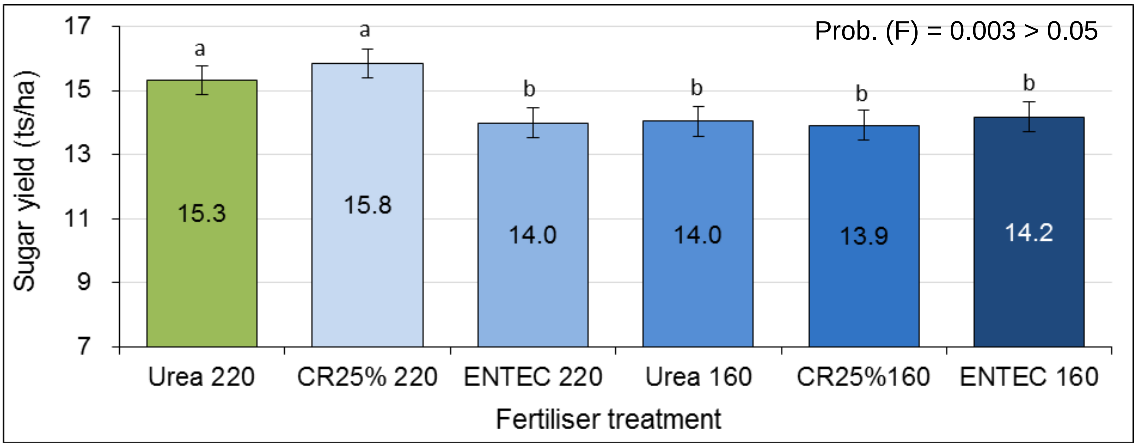

Figure 32: 2015 mean sugar yields – Grower 11.

Figure 33 presents the mean gross margin along with the 95 per cent LSD bars for each of the fertiliser treatments. A comparison of the treatments shows that the highest mean gross margin was achieved by the 'Urea 220N' treatment followed closely by the 'CR25% 220N' treatment. A statistical analysis of the economic results identified a significant effect of treatment at the 5 per cent significance level. Pairwise comparisons of the six treatments using the 95 per cent LSD suggest the mean gross margin for the control treatment is significantly higher than both of the ENTEC treatments, as well as the 'Urea 160N' and 'CR25% 160N' treatments (illustrated by the non-overlapping 95 per cent LSD bars).

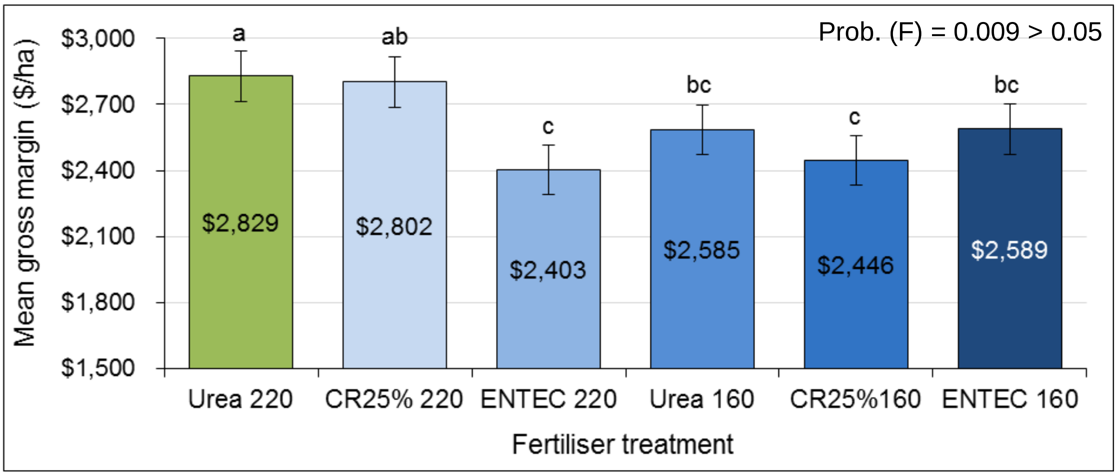

Figure 33: 2015 mean gross margins – Grower 11.

Grower 12

Location:	Clare, BHWSS	Crop stage:	3rd ratoon	Soil type:	Clay
Harvest time:	Late - 22/10/15	Variety:	Q183		

Table 22 and Figure 34 compare the production results from Grower 12's trial. Similar to Grower 10 and many of the Group A trial sites, no significant effects of treatment were identified for any of the production results.

Table 22: Mean TCH and CCS results - Grower 12.

	Urea 220	CR25% 220	ENTEC 220	Urea 160	CR25% 160	ENTEC 160	*Prob. (F)*
TCH	99.3 a	92.4 a	96.3 a	91.4 a	94.9 a	94.2 a	0.468
CCS	16.67 a	16.70 a	16.50 a	16.63 a	16.93 a	16.65 a	0.303

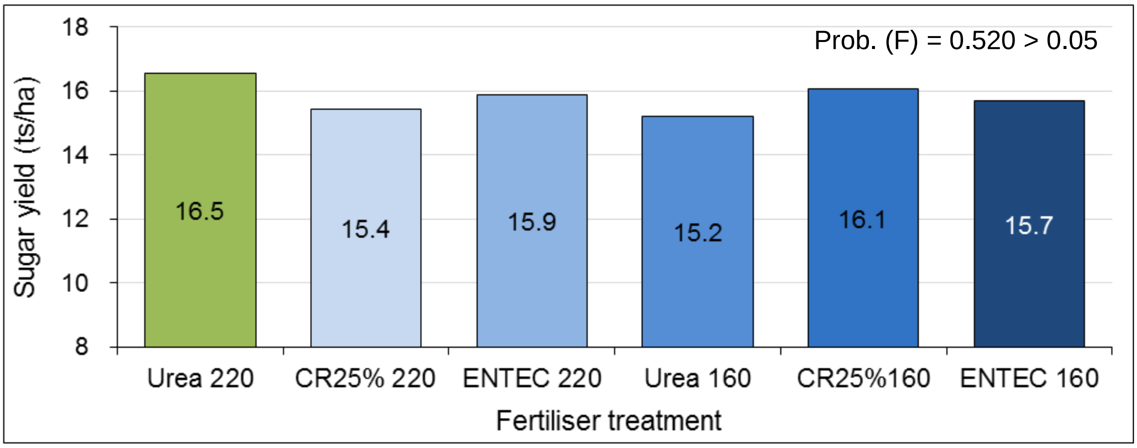

Figure 34: 2015 mean sugar yields – Grower 12.

Comparing between treatment means in Figure 35 shows that the control treatment ('Urea 220N') attained the highest gross margin followed by the 'CR25% 160N' and the 'ENTEC 160N' treatments. A statistical analysis of the economic results identified that differences between the treatment means were not statistically significant; Prob. (F) = 0.355 > 0.05.

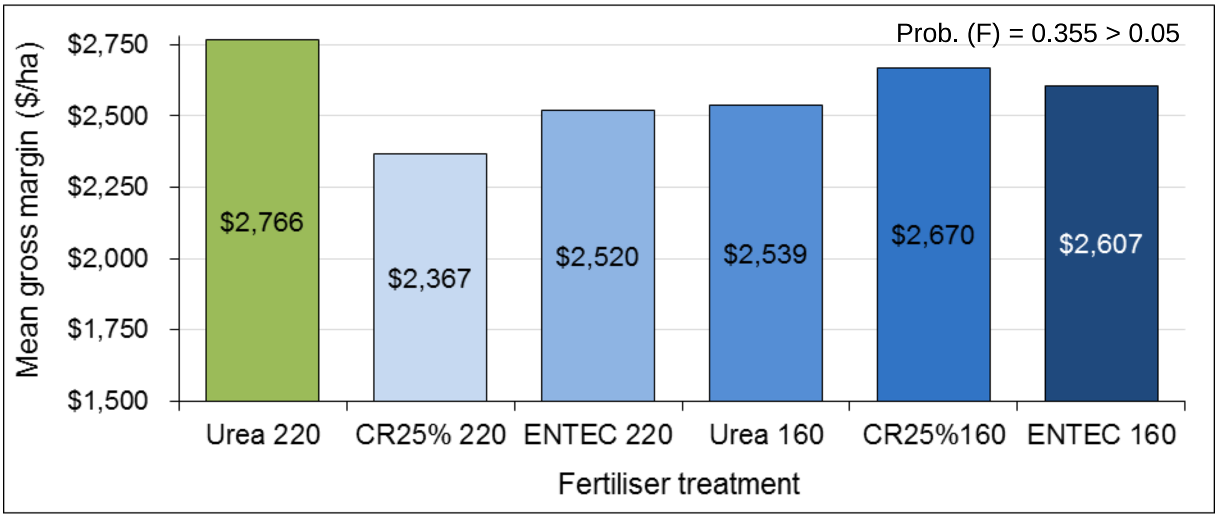

Figure 35: 2015 mean gross margins – Grower 12.

Summary - Group B

Table 23 summarises the gross margin and statistical analysis results from all three trial sites in Group B. Similar to the Group A summary, the difference in gross margin between each treatment and the control is examined. When comparing the relative performance of the EEN fertiliser treatments at each trial site, the differences become evident. For example, at Grower 11's trial site the 220kgs of N controlled release treatment had the second highest mean gross margin, while at the other two sites it had the lowest.

In contrast to Group A, the control treatment ('Urea 220N') had the highest mean gross margin at all three sites. This may indicate that applying enhanced efficiency fertilisers at the 220kg or less than 180kg in the Burdekin is not optimal. However, the statistical results were not consistent. For instance, the statistical results at Grower 12's trial site did not reveal a significant treatment effect. Also, the pairwise comparisons completed for Grower 10 and 12's statistical analysis identified that the gross margins of the control treatments were not significantly higher than the other treatments.

Table 23: Summary of gross margin results – Group B.

Grower	Treatment						Prob. (F)
	Urea 220	CR25% 220	ENTEC 220	Urea 160	CR25% 160	ENTEC 160	
10	$0 a	-$294 c	-$214 bc	-$58 ab	-$213 bc	-$77 ab	0.02
11	$0 a	-$27 ab	-$425 c	-$244 bc	-$382 c	-$240 bc	0.01
12	$0 a	-$399 a	-$246 a	-$227 a	-$96 a	-$159 a	0.36

Combined statistical analysis – Group B

A statistical analysis of the combined gross margin results for all three growers in Group B was also carried out. The REML analysis found that the F-test was not statistically significant at the 5 per cent significance level indicating no significant effect of treatment. Consequently, no pairwise comparisons were carried out between any of the six treatments.

Figure 36 presents the mean gross margin without the 95 per cent LSD bars (LSD = $231.5). The combined statistical results are surprising given that a significant treatment effect was identified in two of the three trials in Group B. However, as mentioned previously, the relative performance of the EEN fertiliser treatments at each trial site were different. As a consequence, when combining the results of the trials together for the group analysis, the variation between the three sites overshadowed the variation between each fertiliser treatment. This highlights the possibility that certain variables (not included in the statistical analysis) are having an influence on the performance of the EEFs (e.g. soil type, variety, harvest date, crop class). Another interesting issue is that the means for each treatment in Group B (shown below) appear to be considerably lower than the treatment means from Group A's combined analysis.

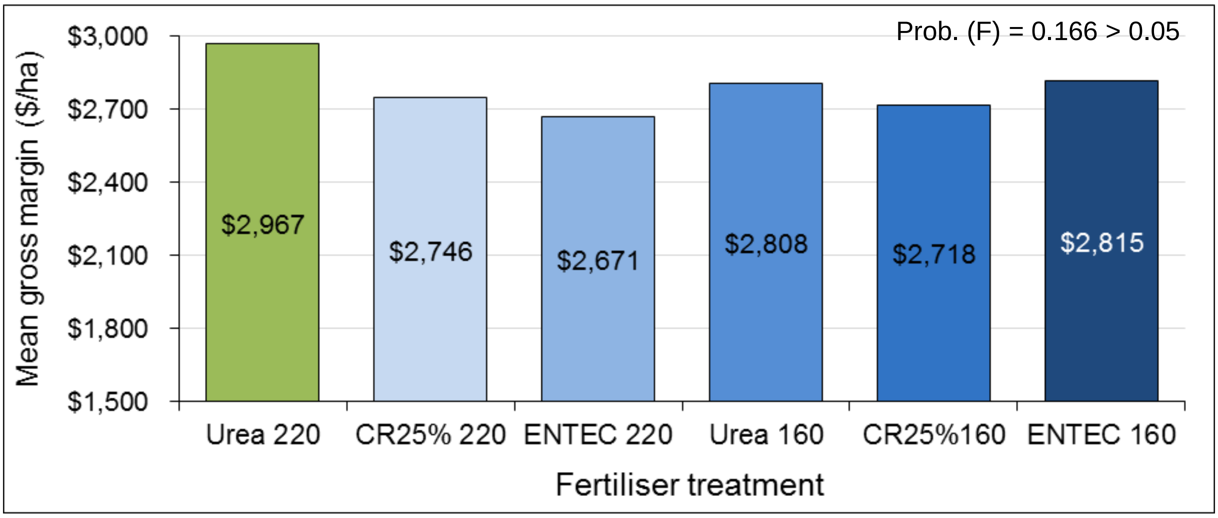

Figure 36: Results from the combined statistical analysis - Group B.

6 Conclusion

EEN fertilisers may improve the N use efficiency of urea based fertilisers under certain soil and climatic conditions. This report examined 12 sugarcane farms to determine the implications to farm profitability from using EEN fertilisers on a regional scale that is representative of the Burdekin. In particular, the costs of fertilising with EEN fertilisers were examined against a control scenario of applying 220 kilograms of nitrogen per hectare with urea. The yield changes necessary to compensate for the higher or lower costs associated with their use were also explored. This report also draws on 2015 harvest data from the 12 trial sites to determine the relative profitability of applying EEN fertilisers in the Burdekin.

When applying EEN fertilisers at rates 40 kilograms of N per hectare less than the control treatment ('Urea 220N'): ENTEC® treated fertiliser has approximately the same dollar per hectare cost; controlled release fertiliser with a 25 per cent blend (25 per cent of N) is around $70 per hectare more expensive, and; controlled release fertiliser with a 50 per cent blend (50 per cent of N) is about $200/ha more expensive. To apply each of the EEN fertilisers at the same cost as the control treatment (220N), the N rate would need to be approximately: 181kg for ENTEC®; 145kg for 'CR25%', and ;109kg for 'CR50%' based on the collected prices.

The results indicate that to break-even when using EEN fertilisers at rates 40 kilograms of nitrogen per hectare lower than the control scenario would: not require the ENTEC® treatment to improve cane yields; require the 'CR25%' treatment to improve cane yields by two to three TCH, and; require the 'CR50%' treatment to improve cane yields by five to nine TCH. Logically, applying the EEN fertilisers at lower (higher) N rates would also reduce (increase) the yield improvement needed by controlled release fertilisers. At low sugar prices, the yield improvement needed by the controlled release fertiliser treatments to break-even intensifies, particularly with higher N rate treatments. Sensitivity analyses of the break-even yield to changes in the price of EEN fertilisers found that the controlled release fertiliser treatments were more price sensitive than the ENTEC® treatments.

Using the 2015 harvest results the Urea, ENTEC and 'CR25%' treatments applied at 180 kilograms of N were found in most cases to have the highest mean gross margins among the nine trial sites in Group A. In contrast, the control treatment ('Urea 220N') did not have the highest gross margin at any of the trial sites. However, none of the individual trials revealed a significant treatment effect. The combined statistical analysis for Group A found a significant effect of treatment, while pairwise comparisons identified that the 'CR50%' treatment was found to be significantly less profitable than all other treatments except the 'CR25%' treatment.

In contrast to Group A, the control treatment ('Urea 220N') had the highest mean gross margin at all three sites in Group B. This result may suggest that applying EEN fertilisers in the Burdekin at N rates 60kg per hectare below the control (160kg of N/ha), or at the same rates as the control (220kg of N/ha), are not optimal. However, the statistical results from each trial site were too inconsistent to confirm this theory (e.g. one trial had no significant treatment effect). The combined statistical analysis for Group B found no significant effect of treatment even though a significant treatment effect was identified at two of the three trial sites. However, the relative performance of the EEN fertiliser treatments at each of the three trial sites were not consistent, which may give premise to the possibility that certain biophysical factors are influencing the performance of the EEN fertilisers (soil type, variety, harvesting dates, etc.).

An important caveat is that the region had very low mean rainfall during the year of the trial (the region was drought declared), which may have limited the benefit provided by the enhanced efficiency fertilisers. Consequently, the results may not be indicative of a growing season with typical or high rainfall. Future trial results (e.g. 2016 harvest results) will improve our understanding of the profitability of EEN fertilisers.

7 References

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