# AN ECONOMIC EVALUATION OF CONTROLLED RELEASE AND NITRIFICATION INHIBITING FERTILISERS IN THE BURDEKIN

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## Abstract

THE USE OF controlled release and nitrification inhibiting fertilisers may improve the availability and uptake of Nitrogen (N) by sugarcane under certain soil and climatic conditions, while reducing losses via leaching, runoff and denitrification, and increasing nitrogen use efficiency. This paper utilises production and operational data from twelve Burdekin trial sites during the 2014–15 growing season to evaluate the profitability of using these fertilisers. In particular, this paper examines whether these fertilisers can maintain farmer profitability at N application rates lower than a conventional rate based on the Six Easy Steps guidelines. Out of the 12 trial sites, nine tested rates 40 kg N/ha lower and three tested rates 60 kg N/ha lower. Two controlled release blends were investigated in these trials. One treatment had 25% of total N coated with sulphur and polymer, while the other had 50% coated. For the nine sites that tested rates 40 kg N/ha lower than a conventional rate, analyses of variance were completed for each individual trial site but none identified a significant treatment effect. As all sites in each group had identical fertiliser treatments, multi-environment trial analyses were undertaken to improve statistical power. The results identified that the controlled release treatment with a 50% blend was significantly less profitable than all the other treatments except for the controlled release treatment with a 25% blend. In contrast, for the three sites comparing the conventional N rate with rates 60 kg N/ha less, treatment effects were identified at two of the three individual sites. However, the multi-environment trial analysis indicated no significant effect of treatment.

## Introduction

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 via numerous pathways. Lost N has implications for both the environment and the profitability of farming businesses.

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. Nitrification inhibitors slow the rate of nitrification and reduce the risk of losses from nitrous oxide emissions and the leaching of nitrate. However, 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. 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 these fertilisers to reduce nutrient losses (Prasertsak *et al.*, 2002; Merino *et al.*, 2005; Yu *et al.*, 2007; Akiyama *et al.*, 2010; Chen *et al.*, 2010), little emphasis has been placed on comparing the financial implications of using these products with common practice. The aim of this paper is to present the economic results from strip trials in order to lessen this gap.

## Materials and methods

### *Trial designs*

During mid-to-late 2014, 12 trial sites were established on ratooning crops in the Burdekin region. These sites are organised into two groups (A and B) that examine different treatments as outlined in Table 1. Nine trial sites in Group A examine ENTEC® (nitrification inhibiting additive applied to urea fertiliser) and two controlled release blends (25 and 50% of the urea is coated with polymer/sulphur respectively–Agrocote®), whereas the three trial sites in Group B examine ENTEC® and one controlled release blend (25% coated).

In Group A, the trials test a conventional N rate (220 kg N/ha), based on the Six Easy Steps guidelines, against each of the fertiliser products at N rates 40 kilograms lower than the conventional rates. In contrast, the trials in Group B compare each of the fertiliser products at the conventional N rate as well as a rate 60 kilograms lower (160 kg N/ha). All treatments received the same quantity of phosphorus, potassium and sulphur, and, at each trial site, the treatments were replicated three times in a randomised complete block layout.

**Table 1**—Description of treatments.

| Group A | | | | Group B | | | |
|---|---|---|---|---|---|---|---|
| Treatment | Fertiliser product | N rate *kg/ha* | Abbrev. | Treatment | Fertiliser product | N rate *kg/ha* | Abbrev. |
| T1* | Urea | 220 | Urea-220 | T1* | Urea | 220 | Urea-220 |
| T2 | Urea | 180 | Urea-180 | T2 | CR25% | 220 | CR25%-220 |
| T3 | ENTEC | 180 | ENTEC-180 | T3 | ENTEC | 220 | ENTEC-220 |
| T4 | CR25% | 180 | CR25%-180 | T4 | Urea | 160 | Urea-160 |
| T5 | CR50% | 180 | CR50%-180 | T5 | CR25% | 160 | CR25%-160 |
| * Conventional fertiliser treatment | | | | T6 | ENTEC | 160 | ENTEC-160 |

### *Economic methodology*

This paper examines three key questions:

(1) How do the costs of the controlled release and nitrification inhibiting fertilisers compare with conventional fertiliser practice?

(2) If these costs are higher, how much extra cane yield is required to offset the higher costs so that treatments break-even with conventional practice?

(3) What is the relative profitability of each fertiliser treatment at the 12 different lower Burdekin trial sites?

For the break-even analysis, past block production data from the sites were used to estimate crop yields, and assume a constant CCS level. For question three, the analysis draws on 2015 harvest data from the trial sites to calculate revenue. A gross margin was calculated by taking the revenue received from the crop and subtracting the variable costs spent on growing and harvesting the crop. The Farm Economic Analysis Tool (FEAT) was used to calculate the gross margin for each treatment replicate using production data along with farm operational costs specific to each fertiliser treatment. The analysis uses the five-year average (2010–15) net sugar price of $430 per tonne (Queensland Sugar Limited, 2015), while input prices (e.g. fertilisers and chemicals) were sourced from local suppliers and labour was costed at $30 per hour.

To evaluate the economic results, an analysis of variance (ANOVA) was performed for each individual trial site. As all sites in each group have the same fertiliser treatments, multi-environment trial (MET) analyses were also undertaken to improve the power of the statistical analyses. Residual maximum likelihood or REML (Patterson and Thompson, 1971) was used to perform the MET analyses, which was fitted with both fixed and random effects.

Fixed effects were the fertiliser treatments, while random effects are trial site and its interaction with fertiliser treatment and the replicate blocks within 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 from any of the other treatments at the 5% significance level (p=0.05). A significant treatment effect implies that the effect is consistent and large compared with its variation across the trials. If the tests were statistically significant, pairwise comparisons were carried out using Fisher's protected 95% least significant difference or LSD (Fisher, 1935). Letters (a, b, c, etc.) are used to indicate statistical significance. Treatments with common letters indicate that differences in mean gross margin are not statistically significant.

***Fertiliser costs and break-even yields***

Table 2 displays the fertiliser costs and break-even yields for each treatment. While the cost of nitrification inhibiting fertiliser is higher per tonne, these fertilisers were tested at relatively lower application rates, which made them slightly cheaper than conventional practice (Urea-220). Due to the high cost of controlled release fertiliser, these treatments were more expensive than conventional practice even at the lower rates.

The break-even yield results identify the cane yield increase that was required by each treatment to attain the same profitability as conventional practice. As the Urea-180 treatment had the lowest cost, a small decrease in yield, between 1.4 and 2.7 tonnes of cane per hectare (TCH), could have occurred and the treatment would still have broken-even. Interestingly, if the ENTEC-180 treatment attained a similar yield to conventional practice then it would have been marginally more profitable. On the other hand, the controlled release treatment with a 50% blend (CR50%-180) required a yield increase of between 4.8 and 9.1 TCH.

**Table 2**—Fertiliser costs and break-even yields.

| Group A | | | | Group B | | | |
|---|---|---|---|---|---|---|---|
| Treatment | | Cost *$/ha* | Breakeven yield *(TCH)* | Treatment | | Cost *$/ha* | Breakeven yield *(TCH)* |
| T1* | Urea-220 | $537 | 0 | T1* | Urea-220 | $537 | 0 |
| T2 | Urea-180 | $480 | –2.7 to –1.4 | T2 | CR25%-220 | $693 | 4.4 to 5.6 |
| T3 | ENTEC-180 | $534 | –0.2 to –0.1 | T3 | ENTEC-220 | $608 | 2 to 2.6 |
| T4 | CR25%-180 | $608 | 1.7 to 3.3 | T4 | Urea-160 | $451 | –3.1 to –2.5 |
| T5 | CR50%-180 | $733 | 4.8 to 9.1 | T5 | CR25%-160 | $566 | 0.8 to 1 |
| * Conventional fertiliser treatment | | | | T6 | ENTEC-160 | $497 | –1.5 to –1.2 |

## Results

***Group A farms***

Table 3 shows the results from the 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 conventional practice is shown.

Negative values indicate that treatments had lower mean gross margins than conventional practice, while positive values indicate that treatments performed better. The treatment with the highest mean gross margin at each trial site has been shaded in grey to identify commonalities between sites.

In most cases, the Urea-180, ENTEC-180 and CR25%-180 treatments achieved the highest mean gross margins. In contrast, conventional practice did not attain the highest gross margin at any site, while the CR50%-180 treatment performed worse than the control treatment at every site except one. However, the statistical results revealed no significant treatment effect at any of the sites.

**Table 3**—Summary of gross margin results (Group A).

| Grower | Urea-220 | Urea-180 | ENTEC-180 | CR25%-180 | CR50%-180 | *p-value* | *95% LSD* |
|---|---|---|---|---|---|---|---|
| 1 | $0 a | –$8 a | –$218 a | $73 a | –$148 a | *0.248* | *$300* |
| 2 | $0 a | –$88 a | $64 a | –$4 a | –$25 a | *0.925* | *$386* |
| 3 | $0 a | –$126 a | –$60 a | –$236 a | $122 a | *0.823* | *$872* |
| 4 | $0 a | $291 a | $143 a | –$235 a | –$278 a | *0.508* | *$837* |
| 5 | $0 a | $438 a | $91 a | –$125 a | –$120 a | *0.104* | *$455* |
| 6 | $0 a | $86 a | $86 a | $100 a | –$166 a | *0.244* | *$280* |
| 7 | $0 a | $72 a | $36 a | –$62 a | –$229 a | *0.152* | *$256* |
| 8 | $0 a | $62 a | $138 a | –$86 a | –$36 a | *0.091* | *$166* |
| 9 | $0 a | –$25 a | –$6 a | $47 a | –$137 a | *0.726* | *$311* |

A MET analysis was carried out incorporating the results from all nine growers in Group A. Figure 1 presents the mean gross margin for each treatment along with error bars. The error bars represent the 95% LSD ($94), while the letters at the top of each LSD bar indicate statistical significance. The results suggest that the CR50%-180 treatment had a significantly lower mean gross margin than the Urea-180, ENTEC-180 and conventional practice treatments, which is illustrated by the non-overlapping LSD bars.

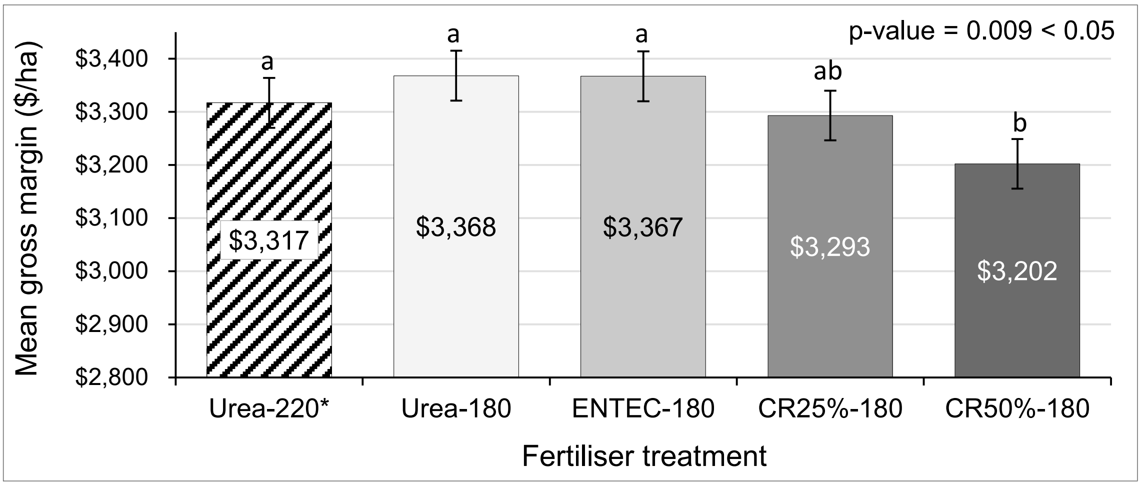


Fig. 1—Results from the MET analysis (Group A).

### *Group B farms*

The results from the three trial sites in Group B are presented in Table 4. In contrast to Group A, the conventional practice achieved the highest mean gross margin at all three sites, which suggests that applying controlled release or nitrification inhibiting fertiliser in the Burdekin at the same N rate as conventional practice, or 60 kilograms below conventional practice, may not be optimal.

However, the statistical results were not consistent across all three trial sites. For instance, Grower 12's trial site did not reveal a significant treatment effect and pairwise comparisons for the other two sites indicated that conventional practice was not significantly higher than all the other treatments.

Also, the results show that many of the treatments performed differently at each trial site. For example, the CR25%-220 treatment showed best performance of the non-conventional treatments at one site but worst at the other two sites. This highlights the possibility that certain biophysical, irrigation regime and/or environmental factors (e.g. soil type, varieties, harvest date, crop class and fertilising date) are influencing the performance of the fertilisers at the trial sites.

**Table 4**—Summary of gross margin results (Group B).

| Grower | Urea-220 | CR25%-220 | ENTEC-220 | Urea-160 | CR25%-160 | ENTEC-160 | *p-value* | *95% LSD* |
|---|---|---|---|---|---|---|---|---|
| 10 | $0 a | –$294 c | –$214 bc | –$58 ab | –$213 bc | –$77 ab | *0.025* | *$174* |
| 11 | $0 a | –$27 ab | –$425 c | –$244 bc | –$382 c | –$240 bc | *0.009* | *$229* |
| 12 | $0 a | –$399 a | –$246 a | –$227 a | –$96 a | –$159 a | *0.355* | *$386* |

The results from a MET analysis of the three sites in Group B are presented in Figure 2. The F-test was not found to be statistically significant (p-value = 0.166, >0.05), indicating no significant effect of treatment and therefore no pairwise comparisons were carried out. These results are surprising, given that a significant treatment effect was identified in two of the three trials. However, as mentioned earlier, the relative performance of each fertiliser treatment was different at each trial site.

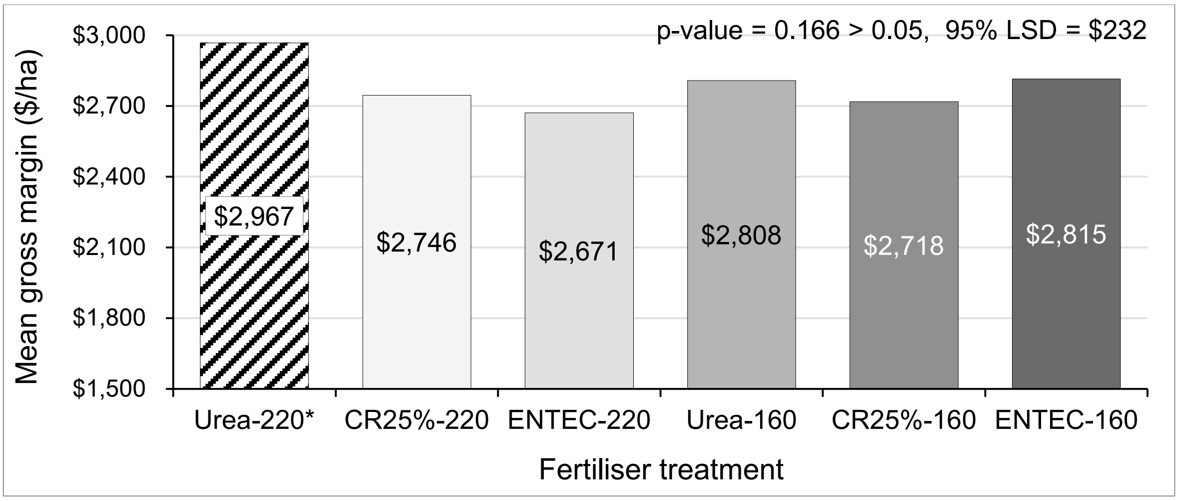


Fig. 2—Results from the MET analysis (Group B).

## Conclusions

Controlled release and nitrification inhibiting fertilisers may improve the efficiency of N fertilisers under certain soil and climatic conditions. This paper compared the cost of applying these fertilisers with conventional practice and assessed the cane yield improvements required to offset the higher fertiliser costs, where applicable. Furthermore, it drew upon farm operational data and 2015 harvest data from 12 Burdekin trial sites to evaluate whether these fertilisers can maintain profitability at N rates lower than a conventional rate based on the Six Easy Steps guidelines.

Applied at N rates 40 and 60 kilograms below the conventional rate, nitrification inhibiting fertiliser was found to be cheaper than conventional practice. Consequently, if they attained similar yields then they would be marginally more profitable. In contrast, controlled release fertiliser blended at 25% or 50% of total N was found to be more expensive at the lower N rates than conventional practice and require yield improvements.

For the nine sites that tested rates 40 kg N/ha lower than a conventional rate, analyses of variance were completed for each individual trial site but none identified a significant treatment effect. As all sites in each group had identical fertiliser treatments, MET analyses were undertaken to improve the power of the statistical analyses. The results identified that the controlled release treatment with a 50% blend was significantly less profitable than all the other treatments except for the controlled release treatment with a 25% blend. In contrast, for the three sites comparing the conventional N rate with rates 60 kg N/ha less, treatment effects were identified at two of the three individual sites. However, the multi-environment trial analysis indicated no significant effect of treatment.

Importantly, the Burdekin received very low rainfall during 2014–15 with the region being drought declared. Consequently, low rainfall may have constrained the ability of these fertilisers to reduce N losses and these results may not be indicative of growing seasons with higher rainfalls.

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