An assessment of controlled release fertiliser in the Herbert cane-growing region [of Australia]*

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Abstract

Loss of nitrogen from sugarcane fields is of serious environmental concern and also limits sugarcane production. Losses can be significant in high rainfall environments, where nitrogen is subject to surface runoff, leaching and denitrification. Large-scale field trials were established to compare the efficiency of controlled release (CR) nitrogen (N) (39-0-0 and 37-0-0) fertiliser against urea (46-0-0) in sugarcane crops grown in the Herbert valley. Rate response curves for CR N and urea were measured on clay and solodic soils. Fertiliser was applied and cane harvested using commercial equipment. Cane yield and CCS were measured in cane supplied to the mill. Controlled release N was significantly ($P \leq 0.05$) more effective than urea 46-0-0 on both soil types. On the solodic soil, Agrocote® CR N was twice as efficient as urea-N; cane yield at 80 kg Agrocote®-N was equivalent to that achieved with 160 kg urea-N. On the same soil type, CR N significantly ($P \leq 0.05$) increased cane yields by 10 t/ha above that achieved with 160 kg urea-N/ha, the maximum recommended N rate under Six Easy Steps. Compared to urea, Agrocote® increased ($P \leq 0.05$) cane yield by an average of 4.8 t/ha on the clay soil. There were no significant yield responses to controlled release K. In the Herbert valley, controlled release was an effective tool to increase N-use efficiency and to manage risks associated with N-loss during heavy rainfall events. Controlled release fertilisers may reduce environmental losses and provide productivity gains in high rainfall environments.

Keywords: ***controlled release fertiliser, Agrocote, nitrogen, potassium, sugarcane***

Introduction

The Australian sugar industry is highly regulated to limit the potential off-site impacts of fertiliser use. Legislation limits the amounts of nitrogen (N) and phosphorus (P) that growers can apply. The inefficient use of agricultural fertilisers has contributed to the eutrophication of Australia's fresh and marine waters (Shafron, 2008). Therefore, the industry is currently under considerable pressure to minimise nutrient runoff from cane farms draining into the Great Barrier Reef and other freshwater ecosystems.

Management of nutrient inputs is essential to maintain soil fertility to optimise and sustain crop yield. Managing nutrient (especially nitrogen) inputs in tropical cane growing regions can be difficult when nutrient losses associated with volatilisation, leaching, runoff, and denitrification are regular occurrences (Chapman and Haysom, 1991; Denmead *et al.*, 2008; Prasertsak *et al.*, 2002; Rasiah *et al.*, 2003a; Weier *et al.*, 1998). Nitrogen loss can be high especially under high rainfall and water logged conditions leading to offsite movement into environmentally sensitive areas like the Great Barrier Reef lagoon (Faithful *et al.*, 2007; Rasiah *et al.*, 2003b). Potassium (K) can also leach from lighter textured soils, or those with low CEC's, in high rainfall environments (Gilman *et al.*, 1989).

In the Herbert Valley, nitrogen applications of up to 160 kg N/ha are confined to a short period between harvest and the onset of the wet season. Growers may be reluctant to split N applications due to increased application costs and the risk of not being able to access the fields after heavy rainfall.

Controlled release (CR) fertilisers may offer an opportunity to minimise nutrient losses and increase productivity in cane production systems. Lawrence Di Bella and Ashton Benson from the Herbert Cane Productivity Services Ltd met with Everris USA staff Keith Santer and Ward Gunter in Florida during February, 2011 to view the USA CR trials first-hand and review management strategies used by the Florida industries in relation to the commercial use of CR fertilisers. Research trials in sugarcane are still on going, however numerous growers are using the products commercially on Florida's sandy soils. It must be noted that the number of fertiliser applications (in Florida) had decreased by 2–3 applications per year since the introduction of CR products to sugarcane and citrus crops. Previous studies have measured improved efficiency and reduced N loss, particularly via leaching, in potato and

citrus crops fertilised with Agrocote® and other controlled release fertilisers in Florida (Hutchinson and Simonne, 2003; Hutchinson et al. 2003; Pack *et al.*, 2006; Paramasivam *et al.*, 2001).

Over the past 18 months a series of trials was conducted in the Herbert cane-growing region to compare the relative efficiencies of controlled release and conventional urea. The 2012 Herbert harvested trials, and commercial experience in Florida, show significant promise for the Agrocote® CR urea to manage leaching losses (Pack *et al.*, 2006) and to sustain crop yields.

Materials and methods

Fertiliser trials were established to measure the relative efficiency of CR N and K compared to conventional urea and muriate of potash. The trials consisted of large replicated commercial strips (between 0.5–1.0 hectares) in size in a split-plot design with soil type as the main plot factor and fertiliser type and rate in subplots. Trial results were statistically analysed using ARM9 (Gylling Data Management, Inc.). Means separation was by Fisher's protected LSD at the 0.05 and 0.1 levels of significance. Unless otherwise stated, significance was determined at the 5% level of probability.

Due to the large plot sizes and the difficulty finding large enough fields, sites were paired according to soil type and two replications were established per paired site. The Hamleigh and Seymour sites (clay soils) were paired, as were the Yuruga and Wharps sites (solodic soils) for N trials (Table 1) and the Yuruga and Ingham K trials (Table 2). This provided a total of four replications per soil type. The Macknade trial site (alluvial), which tested blended Agrocote® fertilisers, was a randomised complete block design with three replications and was unpaired.

The trials were fertilised using application equipment available on farm and harvested green by the harvesting contractor nominated by the grower. The fertiliser was applied sub-surface using a stool splitter on the solodic soil. Heavy rainfall prevented sub-surface application of fertiliser on the clay soil because coulters would not effectively operate in the wet clay soils and crop stands were well advanced. Fertiliser was applied to the clay soil in a band directly above the stool. All trials were established in first ratoon crops and managed under a green cane trash blanket farming system.

Controlled release N and K, based on a polymer-sulphur-coating technology, was supplied by Everris Australia Pty Ltd. The polymer and sulphur coating slow the dissolution and release of urea-N and KCl-K into the soil. Nutrient release typically occurs over a three-month period for the 39-0-0 product, a six-month period for 37-0-0 product and a four-month period for 0-0-42 product (Medina *et al.*, 2008; A Ubiera, unpublished data, 2011). All three CR fertilisers are labelled as Agrocote® in Australia.

All sites were soil tested prior to fertilising in 2011. Nutrient deficiencies were addressed for all nutrients other than the nutrient being assessed according to the Six Easy Steps Guidelines. All N trials received a basal application 100 kg K/ha. The K trial sites received 150 kg N/ha.

Basal P rates were 20 kg P/ha at all sites other than Seymour (10 kg P/ha) and Macknade (0 kg P/ha), due to these sites having higher soil test P levels. Basal S was applied to all sites; 5–10 kg S/ha on the clay soil and 15 kg S/ha on the solodic soil.

Cane yield and CCS were measured in the commercial cane supplied to the mill. Juice CCS was based upon large mill sampling in accordance with Queensland mill CCS determination processes (BSES, 1984).

Fertiliser treatments

Controlled release (CR) urea was compared to conventional urea at four paired sites (Table 1). Agrocote® 39-0-0 was applied to the clay soil and 37-0-0 was applied to the solodic soil; the choice of fertiliser analysis was based on product availability at the time of trial establishment. A blend of 25% controlled release and 75% uncoated urea was assessed at one site (Macknade). Controlled release muriate of potash was compared to conventional muriate of potash at two sites (Table 2).

Table 1. Nitrogen fertilisers applied at each trial site

Trial site	Soil type	Variety	Average plot size (ha)	Urea (kg N/ha)	Agrocote® (kg N/ha)
Hamleigh	Clay	Q208⏀	0.6	100, 163	†100, 120, 160
Seymour	Clay	Q208⏀	0.9	97, 163	†97, 124, 160
Yuruga	Solodic	Q208⏀	1.0	80, 121, 160	†80, 105, 160
Wharps	Solodic	Q208⏀	0.5	80, 120, 160	†80, 120, 160
Macknade	Alluvial	Q200⏀	0.5	160	150*, 120*

†Agrocote® 100%

* Blend of Agrocote®-N 25% with urea-N 75%

Table 2. Potassium fertilisers and rates applied to each site					
Trial site	**Soil type**	**Variety**	**Average plot size (ha)**	**KCl (kg N/ha)**	**Agrocote® (kg N/ha)**
Yuruga	Solodic	KQ228A	0.5	50,75,100	†50,75,100
Ingham	Alluvial	Q200A	0.7	75,100	†50,75,100

†Agrocote® 100% ⦶

Table 3. Monthly and total rainfall (mm) at Ingham (BOM station 32078) from October 2011–September 2012												
Month												
Oct	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
74	151	254	322	630	939	101	148	75	113	22	14	2844

Results

Crop growing conditions

Approximately 2400 mm of rainfall was recorded from November 2011 to April 2012 (Table 3). Severe waterlogging was recorded at the Hamleigh, Seymour, Yuruga and Wharps sites. The total annual rainfall was 711 mm above Ingham's long-term average of 2133 mm (Bureau of Meteorology, station 32078). In particular 151 mm of rainfall was recorded only 9–12 days after N applications.

Comparisons between nitrogen treatments

Significant N responses were measured at the trial sites. Averaged across all N rates, Agrocote® significantly ($P \leq 0.05$)

Figure 1. Average sugarcane yield (t/ha) following controlled release N (■) or urea (■) application at similar N rates on two soils. Bars marked with different letters are significantly different ($P \leq 0.05$)

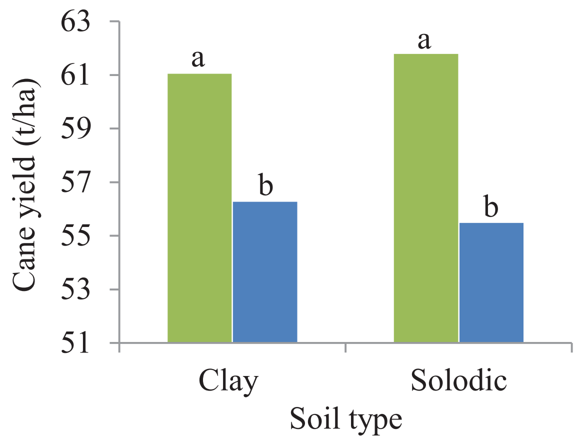


Figure 2. Average sugar yield (t/ha) following controlled release N (■) or urea (■) application. Bars marked with different letters are significantly different ($P \leq 0.05$)

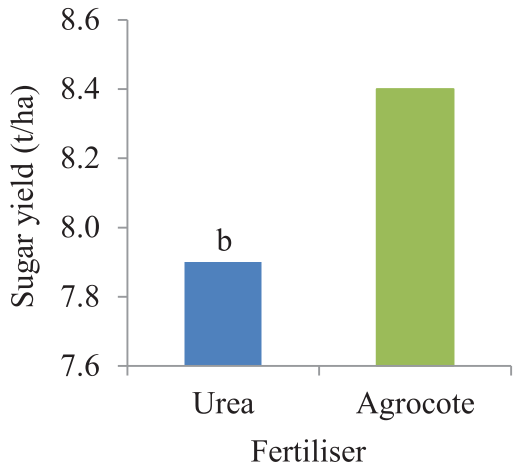
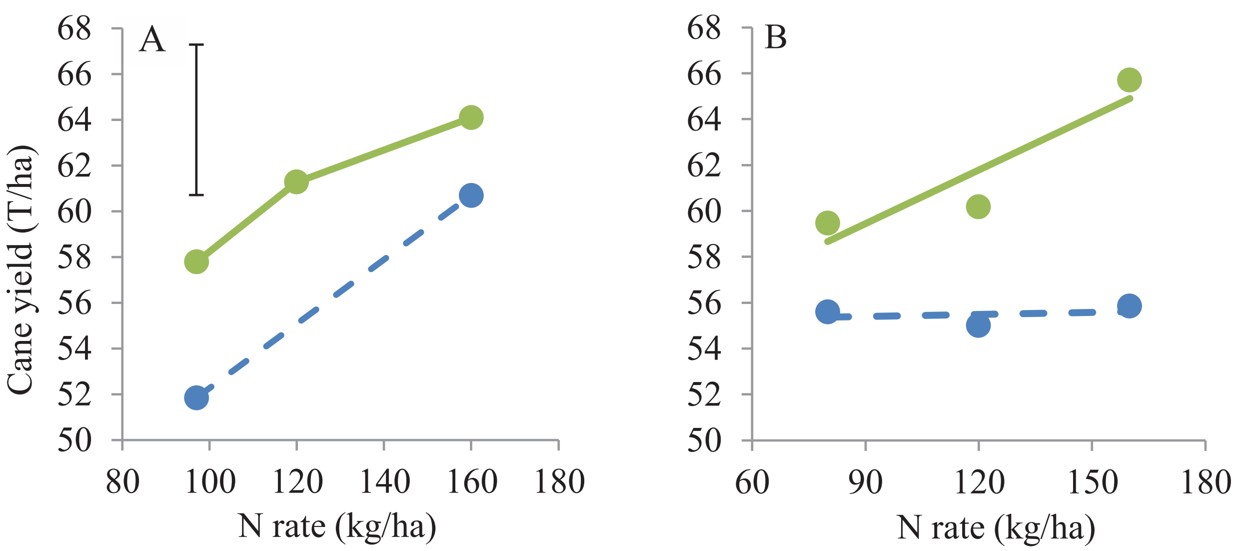


Figure 3. Effect of Agrocote® ( ), urea (, dashed) and N rate on cane yield grown on clay (A) and solodic (B) soils. Error bar is Fisher's protected LSD 5%.



increased cane yield by 5 and 6 t/ha on clay and solodic soils respectively (Figure 1). Sugar yield was also significantly ($P \leq 0.05$) increased by Agrocote® averaged across both soil types (Figure 2).

Rate response curves were used to compare the relative efficiencies of controlled release N and urea. Yield responses on both soil types showed that the lowest rate of Agrocote® produced cane yields that were not significantly different to 160 kg urea-N (Figure 3).

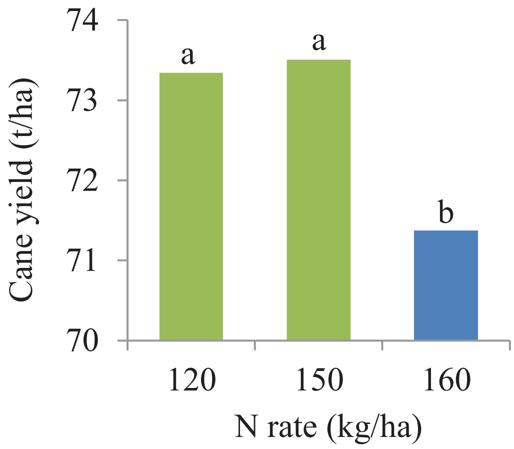
There was no N response to urea on the solodic soil but there was a significant ($P \leq 0.05$) yield response to Agrocote-N; at 160 kg N/ha Agrocote increased cane yield by 10 t/ha above that measured with urea-N. On the solodic soil, 80 kg N/ha as Agrocote produced numerically higher but statistically equivalent cane yields to 160 kg urea-N (Figure 3). These results show that controlled release fertilisers have the potential to improve N-use efficiency in sugarcane grown in the wet tropics.Reducing the uncoated urea rate significantly ($P \leq 0.05$) reduced cane yield on the clay soil.

Commercially, Agrocote® will most often be applied as a component of fertiliser blends to increase the proportion of readily available N early in the season, to reduce costs to farmers and to allow the inclusion of other nutrients such as P, K and trace elements. The trial at Macknade measured crop response to blends of controlled release N and urea where 25% of the N was coated. In this trial, all controlled release treatments increased cane yield compared to uncoated urea at the $P \leq 0.1$ level of significance (Figure 3).

Yield was not significantly different at the $P \leq 0.05$ level of significance. The Agrocote® blend, applied at 120 kg N/ha produced higher cane yields than 160 kg urea ($P \leq 0.1$), which indicates that the use of a relatively small proportion of controlled release N may have beneficial effects on cane N-use efficiency (Figure 3).

Further trial work has been established in the Herbert, Burdekin and Mackay cane growing regions, during 2012–13, to quantify the efficiency of controlled release nitrogen when applied in blends.

Figure 3. Cane yield following the application of blended controlled release fertiliser (CRF) at Macknade site. Treatments were 25% CRF-N + 75% urea-N (■) and 100% urea N (■). Bars marked with the same letter are not significantly different at ($P \leq 0.1$). No significant differences at $P \leq 0.05$.



Comparisons between potassium treatments

There were no clear differences in the performance of controlled release and conventional K fertilisers. Cane and sugar yields were lowest at 50 kg K/ha, indicating that the trial sites were K responsive, but the low K rate was only supplied as controlled release so no direct comparison with uncoated KCl could be made within the responsive range (Table 4). At higher K rates there were no significant differences between uncoated or CR-KCl. CCS was not affected by either K source or rate (Table 4).

Discussion

Heavy rainfall and flooding events, such as those recorded in the Herbert during these trials, create flooding, waterlogging and water flow, all of which may trigger N-loss events and reduce the efficacy of soluble N fertilisers. Indeed, uncoated urea was significantly less effective than controlled release urea at equivalent N application rates.

Pack *et al*. (2006) found that the risk of N leaching from fertiliser was greatest early in the season immediately following application and diminished later in the season when a lower concentration of soluble N remained in the soil.

Table 4. Yield (t/ha) and CCS from cane supplied with conventional and CR KCl. Values marked with the same letter are not significantly different ($P \leq 0.05$).

Fertiliser	Rate	Cane yield	CCS	Sugar yield Agrocote® (kg N/ha)		
KCl	100	77.7	a	12.9	10.0	a
Agrocote® KCl	100	74.2	ab	13.0	9.6	b
KCl	75	73.8	ab	13.0	9.6	b
Agrocote® KCl	75	77.2	a	12.8	9.8	ab
Agrocote® KCl	50	70.1	b	12.9	9.1	c
LSD (0.05)		4.2		ns	0.4	

In this study, 400 mm of rainfall fell in November and December, within weeks of applying up to 160 kg N/ha to the trial plots. Considerable N loss from the urea plots may have occurred during this period, as uncoated urea is highly soluble and readily converted to NH_4+ and then NO_3–, which is both highly mobile and a source of oxygen for denitrifying bacteria. In commercial practice, splitting urea N applications to improve N-use efficiency would not have been possible as application equipment cannot access wet fields.

The CR coating on Agrocote® prevents the rapid dissolution of N during heavy rainfall events and inundation, conditions that were experienced during these trials. As in the trials described by Pack *et al*. (2006) and Paramasivam *et al*. (2001), Agrocote® probably increased N-use efficiency by minimising N loss by denitrification and/or physical transport processes. Further work is planned in the 2012–13 season to measure denitrification rates from cane treated with CR N.

CR K showed no significant difference in ratoon cane under a trash blanket farming system, however the use of CR K in plant cane should be investigated, especially in light of sett burn cause by the use of KCl in plant cane fertiliser mixtures.

Results from these trials have important implications for cane production and environmental stewardship in the Queensland wet tropics where nitrogen losses from agricultural soils have been linked to high N levels in surface-waters and aquifers and to the gradual degradation of the Great Barrier Reef (Hunter and Walton, 2008; Rasiah *et al.*, 2003b).

In the Herbert trials, the efficiency of CR N demonstrated that an opportunity exists for N rate reductions, which would likely lead to positive environmental outcomes. Further work is required to assess the efficacy of CR N in drier seasons, lower rainfall districts and other soil types.

Trials are continuing at these sites in the 2012–13 seasons. Additional trials have been established in the Burdekin and Mackay. The aim of these future trials is to measure N-use efficiency with CR N in other districts and in blends of CR N and uncoated urea. Measurements will be undertaken to try to quantify the fertiliser's effect on N losses via denitrification and surface runoff.

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