Adapting Controlled-Release Urea to Sugarcane Production in Southern China

By Liuqiang Zhou, Jinsheng Huang, Yan Zeng, Hongwei Tan, Xiaojun Zhu, and Shihua Tu

Blending controlled-release urea (CRU) with regular urea raised the profitability of cane production over two years compared to urea alone.

Crop N demand at early growth stages was met by urea while CRU ensured sustained N supply at later growth stages.

Sugarcane's single season growing period of 8 to 12 months or more in southwest China produces a huge amount of biomass with millable cane yields up to 150 t/ha. The crop requires a large quantity of nutrients, especially N and K, to achieve the region's high yields. In practice, farmers usually split N fertilizers into three to four timings: at planting, seedling and/or tillering, and grand growth (occurring approximately 120 days after planting) stages. Manual fertilizer application in the sugarcane fields during the humid hot summer is not only a hard job but also time consuming and expensive, especially at the grand growth stage when fertilizer application is very difficult. Controlled-release urea is considered as an ideal alternative N source to crops with long growing periods, like sugarcane. Earlier studies have shown that use of CRU not only increases crop yields, but also reduces the required number of split applications, and improves N use efficiency (Haderlein et al., 2001; Geng et al., 2015).

The objectives of this study were to define optimal rates and blends of CRU used in combination with regular urea (RU) for sugarcane, and to evaluate its influence on cane yield and economic returns. The two-year experiment consisted of nine treatments, including three N rates, three blends of CRU+RU, and two application timings of RU (**Table 1**). Phosphate fertilizer (fused Ca-Mg phosphate, 150 kg P_2O_5/ha) was applied once basally and K fertilizer (potassium chloride, 375 kg K_2O/ha) was split (60:40) between a basal application and during seedling growth. In the planted cane (first crop season), basal fertilizers were applied in the seed furrow and side-dressings were banded between rows. In the ratoon crop (second season), all the fertilizers were banded into soil.

Table 1. Nitrogen application rates and timings for sugarcane field experiments in Guangxi.

	N rate, kg/ha			
Treatment	Total	CRU[1]	RU	N fertilizer timings
No N (CK)	0	0	0	-
RU (2)[2]	330	0	330	Basal, seedling, grand growth
RU (1)	330	0	330	Basal, grand growth
CRU (1)	330	330	0	Basal, grand growth
CRU @ 80% N rate (1)	264	264	0	Basal, grand growth
CRU @ 70% N rate (1)	231	231	0	Basal, grand growth
CRU+RU (60:40) (1)	330	198	132	Basal, grand growth
CRU+RU (80:20) (1)	330	264	66	Basal, grand growth
CRU+RU (60:40) @ 80% N rate (1)	264	211	53	Basal, grand growth

[1]RU = Regular Urea; CRU = Controlled-Release Urea. The CRU source was from Agrium Advanced Technologies™ containing 43% N.
[2]Numbers in the parentheses refer to the number of side-dressings.

Table 2. Sugarcane yields as affected by different treatments in 2013 to 2014.

	-------- 2013 --------		-------- 2014 --------	
Treatment	Yield, t/ha	±% vs RU (2)	Yield, t/ha	±% vs RU (2)
No N (CK)	62 d[2]	-42	75 d	-45
RU (2)[1]	110 b	2.8	141 ab	3.4
RU (1)	107 b	-	136 b	-
CRU (1)	116 a	8.2	145 a	6.5
CRU @ 80% N rate (1)	104 b	-2.6	138 b	1.2
CRU @ 70% N rate (1)	98 c	-8.1	132 c	-3.1
CRU+RU (60:40) (1)	118 a	10	148 a	8.2
CRU+RU (80:20) (1)	116 a	8.6	146 a	7.1
CRU+RU (60:40) @ 80% N rate (1)	106 b	-0.6	139 ab	2.1

[1]Numbers in the parentheses refer to the number of side-dressings.
[2]Values in each column followed by different letters are statistically different at $p = 0.05$.

Yield and Yield Components

Nitrogen is a vital nutrient in sugarcane production as cane yield was reduced by more than 40% when it was omitted (**Table 2**). In the first year, the 100% N rate treatments using CRU or CRU+RU produced significantly higher cane yields than RU alone. Cane yields were significantly lower with a decrease in CRU rates. The CRU-containing treatments produced similar effects in the second year. The CRU+RU blends (60:40 and 80:20) and 100% CRU treatment achieved the highest (statistically equal) cane yields during the 2-yr period.

The CRU+RU blends might be particularly useful in sugarcane areas where limited soil moisture is available at early growth stages. Earlier studies have highlighted better performance of blends of CRU with RU as compared to CRU alone (You et al., 2008). Any yield advantage in using CRU+RU

Abbreviations and notes: N = nitrogen; P = phosphorus; K = potassium; Ca = calcium; Mg = magnesium. IPNI Project CHN-GX14

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Guangxi produces over 60% of China's sugarcane with a planting area of 1.1 million (M) ha and an annual cane production of 78 M t. Sugarcane production is the primary income source for Guangxi's farmers.

blends could be attributed to a combination of immediate N release from RU that meets crop demand at earlier growth stages, and a sustained supply of N from CRU for later growth stages. Data presented in **Table 2** implies that the currently recommended N rate is optimal, and use of CRU alone or in combination with RU is preferred on this medium fertility soil.

Table 3. Millable cane numbers and single cane weight as affected by different treatments in 2013 to 2015.

	--------- 2013 ---------		--------- 2014 ---------	
Treatment	Millable cane, no./ha	Cane weight, kg/cane	Millable cane, no./ha	Cane weight, kg/cane
No N (CK)	45,000 c[2]	1.39 d	64,670 bc	1.19 f
RU (2)[1]	57,560 a	1.91 bc	77,780 a	1.85 d
RU (1)	57,000 a	1.88 c	74,670 b	1.86 d
CRU (1)	57,560 a	2.01 ab	78,670 a	1.91 b
CRU @ 80% N rate (1)	54,670 ab	1.90 c	75,670 b	1.84 e
CRU @ 70% N rate (1)	52,890 b	1.86 c	72,450 c	1.84 e
CRU+RU (60:40) (1)	57,780 a	2.04 a	79,340 a	1.94 a
CRU+RU (80:20) (1)	57,670 a	2.01 ab	77,890 a	1.97 a
CRU+RU (60:40) @ 80% N rate (1)	55,560 ab	1.91 bc	76,340 ab	1.89 c

[1]Numbers in the parentheses refer to the number of side-dressings.
[2]Values in each column followed by different letters are statistically different at $p = 0.05$.

Among the agronomic traits investigated such as plant height, cane diameter, number of millable canes and single cane weight, only the latter two were significantly correlated to cane yields. Higher millable canes were generated in the ratoon cane season than in the planted cane season (**Table 3**). No differences in millable canes were observed amongst the highest-yielding treatments. Single cane weight was negatively correlated with millable cane number (i.e., the higher number of millable canes, the lower the single cane weight). Thus, single cane weight was considerably lower in the second year. The two CRU+RU blends produced the highest single cane weight in both years, implying that a blend of CRU+RU in proper proportions can be the best choice for sugarcane production.

Economic Returns

Economic returns corresponded well with cane yields (**Table 4**). The CRU+RU blends (60:40 and 80:20) and the 100% CRU treatment produced net incomes that were US$644, $521, and $467/ha higher than the RU (1) treat-

TAKE IT TO THE FIELD

Mix CRU and RU in the right proportion for sustained nutrition of sugarcane to generate high yield and profitability.

ment in year 1, and $587, $471, and $400/ha higher in year 2, respectively. This further confirms that application of CRU to sugarcane is cost effective, and use of CRU blends with RU may be more profitable than applying CRU alone.

Summary

Applications of CRU can reduce the frequency of N fertilizer applications when compared to RU management, and can significantly increase sugarcane yields in both the planted and the ratoon cane seasons. The blended treatments of CRU+RU (60:40 and 80:20) and 100% CRU produced the highest cane yields over the 2-yr period. This yield advantage is attributed to the increased number of millable canes and single cane weight. The three CRU treatments produced higher net incomes than the RU (1), suggesting that CRU would be a preferred source of N for sugarcane, and blends of CRU+RU in appropriate proportions might be more effective than CRU alone when used in similar growing conditions.

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Table 4. Economic returns of different treatments.

Treatment	Net income[2], US$/ha 2013	2014
No N (CK)	2,028	2,667
RU (2)[1]	4,568	5,836
RU (1)	4,597	5,787
CRU (1)	5,064	6,187
CRU @ 80% N rate (1)	4,352	5,833
CRU @ 70% N rate (1)	3,988	5,523
CRU+RU (60:40) (1)	5,241	6,374
CRU+RU (80:20) (1)	5,118	6,258
CRU+RU (60:40) @ 80% N rate (1)	4,512	5,918

[1]Numbers in the parentheses refer to the number of side-dressings.
[2]Net income refers to the values after deducting the total cost including fertilizers (CRU prices have exceeded RU by US$154 to US$200/t), pesticides, labors for fertilizer and pesticide applications, irrigation, and harvest.

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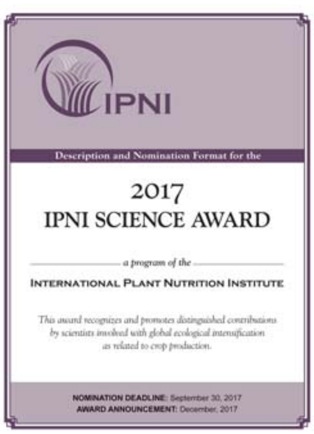
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Dr. Ismail Cakmak (right) receives 2016 IPNI Science Award from Dr. Terry Roberts, President IPNI.

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