Impact of Controlled-Release Urea on Upland Maize in Yunnan

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Controlled-release urea (CRU) was compared against regular urea (RU) in upland (rain-fed) maize experiments designed to investigate N nutrient source, rate, time, and placement impacts on yield, agronomic traits, and nitrogen use efficiency (NUE). **Yield under CRU was 6 to 20% higher** than that achieved with RU. In turn, NUE was 5 to 17% above that achieved with RU.

Rational application of N fertilizer is one of most important best management practices (BMPs) to maintain optimum crop yields and to ensure environmental stewardship of applied N. Farmers in China have been continually striving for high yields, but cases of irrational fertilization are still common, especially in the case of N as evidenced by low national NUE values that are near 11 to 41% (Zhang et al. 2008). Low NUE not only wastes agriculture resources and increases costs, but it also leads to environmental pollution (Tian et al., 2007; Zhu and Sun, 2008). This issue has brought the worldwide research effort of controlled-release fertilizers into focus for China.

Controlled-Release Urea versus Regular Urea

In upland areas of Yunnan Province, rain-fed maize accounts for the largest cropped area. Common practice of N use has resulted in lower N utilization rates, leading to losses of N and environmental problems. Raising NUE via improved fertilizer sources could reduce these adverse effects and support high productivity of maize in Yunnan.

The district of Yuezhou, Yunnan has a red soil and sloping landscape that is typical for the region. Soil properties listed in **Table 1** suggests a relatively high soil fertility status. The

Table 1. Nutrient status of upland maize soils, Yunnan.

	pH	Organic matter	Total N	Alkaline hydrolyzed N	Available P	Available K
Field site		----- g/kg -----		---------- mg/kg ----------		
Yuezhou	6.6	31	1.6	162	22	138
Ciying	7.3	31	1.4	119	22	139

main cropping pattern is early maize (sown in mid April/early May) following late wheat or a legume sown after mid September. Cultivation practices that maintain surface mulch are most common in maize. Maintaining residue on the surface improves crop productivity through better water use during the seasonal drought that is characteristic to this region. However, the use of mulch can limit options for effective placement of fertilizer given the available technology. Controlled-release urea has many potential advantages for this system including ease of broadcast application, better use of time and labor, and higher NUE (Zhao et al., 2010).

This research was conducted for two years to explore the effects of CRU and RU on maize in Qujing, the main maize-producing area in Yunnan. Treatments were selected to test the impact of CRU at the traditional urea-based N rate along with reduced levels of N input (**Table 2**). An additional comparison tested the substitution of RU with CRU as a top-dressed N source. The effects of these different treatments were evaluated according to yield and agronomic traits, accumulation of N in the grain and biomass, and NUE.

Abbreviations and notes: N = nitrogen; NUE = nitrogen use efficiency; CRU = controlled-release urea; RU = regular urea. IPNI Project IPNI-2010-CHN-YN12.

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Upland maize research site in Yunnan, China.

$$\textbf{NUE (\%)} = U - Uo / F \times 100\%;$$

where U = cumulative N uptake in aboveground biomass with RU or CRU, Uo = cumulative N uptake in aboveground biomass with no RU or CRU, and F = amount of applied N.

Results

Traditional N fertilization for these upland maize fields involves a single broadcast application of RU. This research found 6 to 20% increases in maize grain yield by substituting broadcast RU with CRU (**Table 2**), which are results consistent with previous studies (Cao et al., 2009; Sun et al., 2009; Zhu et al., 2007). In the first year, only the 100% CRU treatment produced grain yields that were greater than 100% RU. In year 2, all CRU treatments performed better than 100% RU, but 75% CRU provided the best yield response, followed closely by 100% CRU. The efficiency for N use (NUE) was clearly improved by broadcasting CRU rather than RU.

Based on the grain yield data, the strategy of integrating broadcast RU with top-dressed CRU was effective at providing sufficient nutrient supply throughout the entire growing season. Previous studies (Wang et al., 2007; Zhang et al., 2010) have shown evidence of CRU alone being unable to meet the early demands of crops. Use of 40% RU (broadcast) + 60% CRU (topdressing) produced maize yields that were statistically equal to the highest grain yields produced by 100% CRU (year 1) or 75% CRU (year 2). Nutrient use efficiency in this split RU+CRU application strategy was higher than the split

Table 2. Effect of regular urea (RU) versus controlled-release urea (CRU) treatments on yield of upland maize, Yunnan.

		First year			Second year		
Treatment		N use efficiency, %	Yield, kg/ha	Yield vs. 100% RU, %	N use efficiency, %	Yield, kg/ha	Yield vs. 100% RU, %
Check		-	8,480 d*	-8	-	8,480 e	-16
Broadcast	Topdressing						
100% RU	-	26 d	9,260 bcd	-	22 c	10,050 d	-
100% CRU	-	38 b	10,710 a	16	33 b	11,690 ab	16
40% RU	60% RU	31 c	9,820 abc	6	30 b	11,300 abc	12
40% RU	60% CRU	36 b	10,400 ab	12	31 b	11,380 ab	13
75% RU	-	26 d	8,970 cd	-3	34 b	11,120 bc	11
75% CRU	-	43 a	10,090 abc	9	45 a	12,000 a	20
50% RU	-	27 d	9,360 bcd	1	34 b	10,570 cd	5
50% CRU	-	37 b	9,800 abc	6	46 a	11,150 bc	11

*Numbers followed by the same letter in columns are not significantly different at $p = 0.05$
Experiments used 20 m^2 plots. Maize variety in the first year was Qidan 2 grown at 63,000 plants/ha; second year - Ludan 12 and 60,000 plants/ha. The full rates were 210-68-63 kg N-P_2O_5-K_2O/ha in the first year and 240-120-75 kg/ha in the second year. The CRU source was from Agrium Advanced Technologies™ containing 43% N. All treatments were provided with balanced rates of P and K using single superphosphate and KCl.

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CRU significantly increased NUE. NUE under the single broadcast of RU was 26 to 27%, which compares to 36 to 43% for CRU.

TAKE IT TO THE FIELD

CRU can be used in rain-fed maize to reduce labor cost and increase yield and nutrient use efficiency.

RU treatment (40% broadcast + 60% topdressed) in year 1, but no difference in NUE was observed between these two treatments in year 2. The split application of RU could also be a good fertilizer management strategy to adopt over time since it shows signs of higher yields and NUE compared to a single, early broadcast application of RU. However, the advantages would need to be greater than the costs associated with the extra labor and time demanded by multiple applications.

Conclusion

Application of CRU brought higher maize yields and NUE, reduced nutrient loss, saved labor, and reduced the potential environmental footprint associated with excess N losses. While the rates of N used in this study were far in excess of realistic crop requirements, CRU was confirmed as an effective source and should be a recommended management practice.

The optimum application rate for CRU should be a reflection of the soil and growing environment. In this research the optimum RU rate was 50% of the full rate. Controlled-release urea produced higher yields, and the optimum rate varied between 50 to 75% of the full CRU rate or the traditional RU rate. While the study clearly shows that traditional N rates used in the region are far in excess of crop requirements, CRU proved to be an efficient source of fertilizer N, enabling lower N rates without a loss of production. BC

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The mention of any trade name does not necessarily imply any endorsement.

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