Polymer-Coated Urea Application Timings, Nitrogen Rates, and Blending Ratios Affect Corn Production

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Introduction

Degradation of Great Lakes Basin water quality, increasingly unpredictable spring weather conditions, and escalating fertilizer prices have placed greater emphasis on improving management of soil nitrogen (N) fertilizer through strategies that more closely synchronize N availability with peak corn (Zea mays L.) N demand. Enhanced efficiency fertilizer sources including polymer-coated urea (PCU) limit the amount of N available for microbial transformation after application potentially reducing environmental N losses. Scientific validation of the application timings, blending ratios, and N rates of PCU and readily soluble N sources is critical for developing environmentally-focused yet productive approaches to nutrient management.

The objectives of this study were to evaluate the corn response to 1) three N application timings, 2) two N rates, and 3) five N blending ratios of PCU and a readily soluble N fertilizer in corn fertilizer programs involving one N application.

Materials and Methods

- Field study initiated spring 2011 on a Capac loam (fine, loamy, mixed, active, mesic Aquic Glossudalf) with 0 to 3% slope
- Conventional tillage, CC rotation, 2.4% O.M., 7.6 pH, 59 ppm P, and 115 ppm K
- Study arranged as 3 x 2 x 5 factorial design with three replications, a non-treated control, and 4.6 m x 12.2 m plots
  - 3 application timings (early pre-plant [2-4 weeks] incorporated, at-plant incorporated, and sidedress V4 surface application)
  - 2 N fertilizer rates (84 and 168 kg N ha^{-1})
  - 5 PCU:urea percentage blending ratios (100:0, 75:25, 50:50, 25:75, and 0:100)
- Corn (DeKalb 46-61) seeded in 76-cm rows at 79,000 seeds ha^{-1}
- PCU was ESN (Agrium Advanced Technology, Denver, CO)
- Grain yields determined with a small-plot combine and adjusted to 150 g kg^{-1} moisture before analysis
- Data measureables included: chlorophyll meter reading (R1), leaf firing, stalk nitrate analysis, grain moisture, grain test weight, grain yield, whole plant sampling at physiological maturity for total biomass and total N analysis of vegetation, cob, and grain from 3 blending ratios
- Plot Details: PPI N appl.: 5/5/11
  At plant N appl.: 5/24/11
  Sidedress N appl.: 6/20/11
  Planting date: 5/24/11
  Harvest: 10/27/11
  PSNT: 30 kg N per ha^{-1}

- **All treatments below applied at both 84 and 168 kg N per hectare**

N Timing	Blend Ratio (ESN:Urea)
Pre-plant (Incorp)	100:0
(2-4 weeks prior)	75:25
	50:50
	25:75
	0:100
At Plant (Incorp)	100:0
	75:25
	50:50
	25:75
	0:100
Sidedress V4 (Surface)	100:0
	75:25
	50:50
	25:75
	0:100

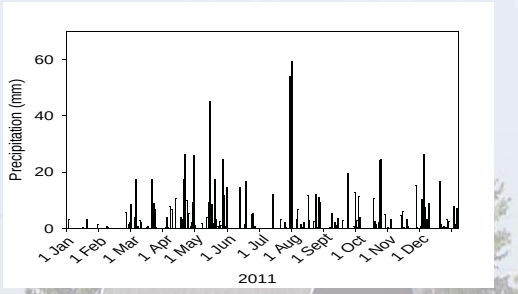

Figure 1. Daily precipitation data at the MSU Agronomy Farm, East Lansing, MI, 2011.

Table 1. Application timing by blend ratio interaction on corn grain yield analyzed at 150 g kg^{-1} moisture in 2011. Grain yields were averaged across application rates of 84 and 168 kg N ha^{-1}.

Appl. Timing	Blend Ratio (ESN:Urea) 100:0	75:25	50:50	25:75	0:100
	-------Corn Grain Yield (Mg ha^{-1})-------				
Pre-plant	9.2	9.7	9.0	8.7	8.3
At-plant	9.8	9.4	9.7	11.0	10.8
Sidedress	10.0	10.0	9.6	9.8	8.9
LSD (0.05)			1.2		

Table 2. Application timing by blend ratio interaction on corn total vegetative N uptake (excluding cob and grain) in 2011. Nitrogen uptake was averaged across N application rates of 84 and 168 kg N ha^{-1}. Asterisks (*) indicate greatest yield within individual application timings.

Appl. Timing	Blend Ratio (ESN:Urea) 100:0	50:50	0:100
	-------Veg. N Uptake (kg N ha^{-1})-------		
Pre-plant	21.7*	17.4	16.4
At-plant	17.0	28.7	24.5*
Sidedress	20.3*	23.1	23.9
LSD (0.05)		7.8	

Table 3. Nitrogen rate by blend ratio interaction on corn R1 chlorophyll meter readings and stalk nitrate analysis in 2011. Chlorophyll contents and stalk nitrate analysis were averaged across three application timings of pre-plant, at-plant, and sidedress.

N Rate and Blend Ratio	SPAD R1 7/27/11	Stalk Nitrate (ppm)
84 kg N		
100:0 (ESN:Urea)	40.7	1.1
75:25	40.4	
50:50	40.2	3.1
25:75	39.6	
0:100	41.2	12.4
168 kg N		
100:0 (ESN:Urea)	41.5	8.1
75:25	42.5	
50:50	43.5	33.7
25:75	44.0	
0:100	42.6	5.7
Control	36.7	0.0
	LSD (0.10) = 1.7	LSD (0.05) = 20.6

Table 4. Application timing by blend ratio interaction on corn nitrogen use efficiency in 2011. Nitrogen use efficiency was averaged across application rates of 84 and 168 kg N ha^{-1}.

Appl. Timing	Blend Ratio (ESN:Urea) 100:0	75:25	50:50	25:75	0:100
	-------- NUE† (Mg grain kg N^{-1}) --------				
Pre-plant	0.57	0.61	0.54	0.46	0.46
At-plant	0.67	0.63	0.68	0.88	0.82
Sidedress	0.76	0.72	0.64	0.67	0.55
LSD (0.05)			0.18		

† Nitrogen Use Efficiency (NUE) defined as the difference between grain yield for individual treatment and the grain yield of the control treatment (no N applied) divided by the rate of applied N fertilizer.

Table 5. Application timing by N rate interaction on corn nitrogen use efficiency in 2011. Nitrogen use efficiency was averaged across all five ESN:urea blending ratios.

Appl. Timing	N Rate (kg N ha^{-1}) 84	168
	---- NUE† (Mg grain kg N^{-1}) ----	
Pre-plant	0.53	0.53
At-plant	0.87	0.61
Sidedress	0.79	0.54
LSD (0.05)	0.12	

† Nitrogen Use Efficiency (NUE) defined as the difference between grain yield for individual treatment and the grain yield of the control treatment (no N applied) divided by the rate of applied N fertilizer.

Preliminary Results and Discussion

- March through Sept. 2011 precipitation was 706 mm with 21 rainfall events of 13 mm or greater occurring during this time period (Fig. 1). April and May rainfall were 135 and 152 mm, respectively, with an additional 165 mm occurring over a 3-day period in July. Pre-plant and at-plant N applications were separated by 102 mm of rainfall.

- Under the moderately wet 2011 growing conditions, yield benefits for applying a blend of PCU and urea compared to only PCU or urea were greatest when blends were applied as pre-plant (75% PCU) or at-plant (25% PCU) single N application timings. PCU's ability to reduce N loss for surface applications of N resulted in greater yields with PCU included in the sidedress N blending ratio (Table 1).

- Moist growing conditions throughout the season likely resulted in N losses as evidenced by lower rates of total vegetative N uptake (Table 2) and reduced stalk nitrate accumulation (Table 3). Increasing total vegetative N uptake did not consistently improve corn yield (Table 2).

- Application timing and blend ratio interactions on NUE paralleled corn yield results (Table 4). At the lower total N rate of 84 kg N ha-1, at-plant and sidedress N applications maintained significantly greater NUE (Table 5). Application timing had no effect on NUE at 168 kg N ha-1.

- PCU and urea blend ratio main effects and blend ratio by application timing interactions were not significant for any of the following: total biomass produced for vegetation , grain, or cob; total N concentrations in vegetation, grain, or cob; total N uptake for cob or grain;