Nitrogen Release from Polymer-Coated Urea via a Buried-Bag Technique

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Introduction

Rice grown in direct-seeded delayed-flood production systems relies heavily on aerial application of N fertilizer with N fertilizer and application expenses representing one of the single largest variable costs for rice production in Arkansas. Ground equipment use is limited following rice seeding due to construction of irrigation levees for efficient management of irrigation water, pest control, optimizing stand establishment, and eventually for flooding rice fields to optimize N fertilizer use efficiency.

The costs associated with aerial application of N fertilizers are high. For example, the charge for aerial application of fertilizer in Arkansas averages \$0.11 kg fertilizer ha^{-1} with a minimum charge of \$12.33 ha^{-1} if $\leq$ 112 kg fertilizer is applied. For a cultivar requiring 168 kg N ha^{-1}, the seasonal aerial application costs for preflood and midseason N total \$40.22 ha^{-1}, which is about 23% of the total seasonal N fertilizer and application costs (calculation based on \$0.79 kg urea-N^{-1}; USDA-NASS, 2005). In contrast, the cost of custom application of fertilizer with ground equipment remains the same regardless of the fertilizer rate (typical cost is \$12.35 ha^{-1}). Estimates from the USDA-NASS (2007) indicate that 60 to 68% of the Arkansas rice hectarage receives P and K fertilizer. The ability to blend N fertilizer with P and K for preplant application with ground equipment would significantly reduce application costs associated with N fertilization, if custom applicators fees with ground equipment remain independent of fertilizer application rate.

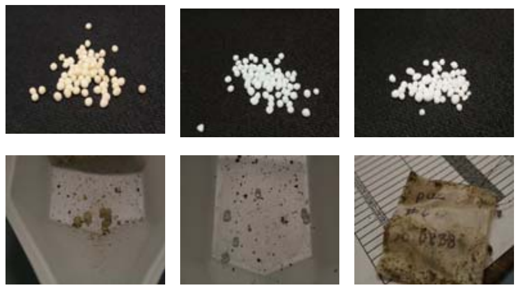
The availability of a slow-release N fertilizer suitable for preplant application to drill-seeded rice would offer growers an alternative and possibly less costly N-fertilization method.

The primary research objective was to determine the N release characteristics of several polymer-coated urea fertilizers to determine if the N release matches the N uptake characteristics of direct-seeded, delayed-flood rice production practices in Arkansas.

Materials and Methods

- Two Field Incubations (2007):
  - Pine Tree Branch Station (PTBS), Calhoun silt loam .
  - Rice Research Ext. Center (RREC), Dewitt silt loam.
- 'Francis' rice seeded at both locations.
- Two N-fertilizer sources:
  - Environmentally Smart Nitrogen (ESN 44% N)
  - Duration-5 (D5 43% N)`
- Placed in mesh bags and buried immediately following rice seeding.
  - Each bag contained 38 to 44 mg N.
  - Unearthed at 10 d after burial, and every 10 d thereafter until 60 d.
  - Transported on ice and refrigerated until analysis (combustion).
- Two Lab Incubations:
  - Calhoun silt loam (PTBS).
  - Incubated at 20 and 25ºC , 25 % gravimetric water content.
- Placed in mesh bags and buried in jars containing 400 g soil.
  - Each bag contained 38 to 44 mg N.
  - Unearthed at 5 d after burial and every 5 d thereafter until 40 d.
- Replicate data was analyzed using regression analysis.

Pic 1. D5 (top left), ESN (top middle), and urea (top right) before burial. Bottom left and middle represent D5 and ESN, respectively for sampling times at 20 d after burial. (Bottom right) buried bag that contained prills.



Results

Nitrogen Release Characteristics of ESN

- For all sites ESN fertilizer-N remaining in the prills declined in a non-linear fashion (quadratic), with both linear and quadratic regression coefficients depending upon both N source and sample time (Table 1).
- Ten d after burial 54 to 100% of the fertilizer N remained in ESN prills depending upon incubation. In contrast, 40 d after burial 4 to 29% of the fertilizer-N remained in the prills (Fig 1).
- The N release pattern of ESN from the laboratory incubation at 20 ºC was significantly different than all other incubations.
- ESN-N release from field incubations was statistically similar among sites, with N release rates proceeding faster at RREC.
- ESN-N release measured in the laboratory incubation at 25 ºC was statistically similar to both field incubations.

Nitrogen Release Characteristics of Duration-5

- D5 fertilizer-N content declined in a non-linear (quadratic) fashion for both the 20 and 25 ºC lab incubations, but the quadratic coefficient was not different than zero for both field incubations (Table 2).
- Ten d after burial 82 to 100% of the D5-N remained in the prills depending upon incubation. In contrast, 40 d after burial 11 to 49% of the fertilizer remained in the prills (Fig 1).
- Regression coefficients for the 20ºC lab incubation estimated the largest amounts of D5-N remaining in the prills for all sampling times.
- N release from D5 among field incubations was statistically similar.
- N release measured with the laboratory incubation at 25 ºC was statistically similar to both the field incubations.

Pic 2. Polymer coated fertilizers field incubation before, during, and after burial at day zero.

Table 1. Analysis of variance p-values for percentage of fertilizer-N remaining in prills as affected by N source, site-year, sample time and their interactions for two field and lab incubations conducted in silt-loam soils.

Source of Variation	df	p-value
Intercept:		
Source (S)	1	0.0121
Siteyear (SY)	3	0.0180
Source x Siteyear	3	0.0006
Linear:		
Sample Time (ST)	1	<0.0001
ST x S	1	<0.0001
ST x SY	3	<0.0001
ST x S x SY	3	0.0013
Quadratic:		
ST x ST	1	<0.0001
ST x ST x S	1	<0.0001
ST x ST x SY	3	<0.0001
ST x ST x S x SY	3	0.0068

Fig 1. Fertilizer remaining in polymer prills after a 40 d incubation period for field incubations conducted at the Pine Tree Branch Station (PTBS) and the Rice Research Extension Center (RREC) and for lab incubations at 20 and 25ºC.

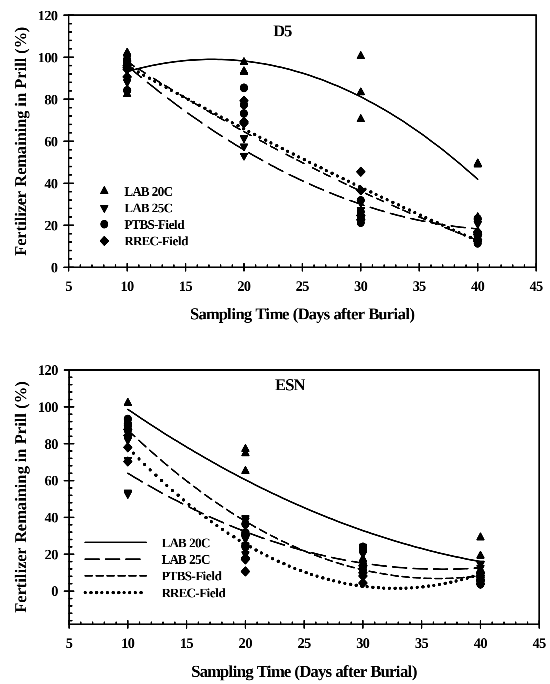


Table 2. Regression coefficients for fertilizer release measured from D5 and ESN with lab and field incubations conducted on silt-loam soils.

Incubation	Parameter Estimate		
	Intercept	Linear	Quadratic
	------------Coefficient†------------		
D5			
LAB20	65.805	3.836	-0.111
LAB25	150.314	-6.143	0.071
PTBS	136.091	-4.072	0.024‡
RREC	128.277	-3.357	0.012‡
ESN			
LAB20	147.550	-5.425	0.053‡
LAB25	110.282	-5.365	0.073
PTBS	160.103	-8.428	0.116
RREC	159.947	-9.674	0.148

† Where Y = Fertilizer-N remaining in prill (%) and x = sampling date (Days after Burial).
‡ Coefficient not different than zero.

Conclusions

- The laboratory incubation at 20ºC did not accurately describe fertilizer–N release from D5 and ESN in the field.
- Laboratory incubation at 20ºC overestimated the amount of N remaining in D5 and ESN prills when compared with field incubations.
- Fertilizer-N release from D5 and ESN estimated with the 25ºC laboratory incubation was not statistically different from release measured in the field.
- Thirty d after burial approximately 60-80% of N had been released from the ESN and D5 prills when incubated in the field or at 25ºC.
- Field incubation and yield trial data (not presented) suggest that N release from D5 and ESN is too rapid for Mid South delayed-flood rice production.
- D5 and ESN's N release characteristics suggest they do not match the N requirements for delayed -flood rice systems and would be less efficient at supplying N to the rice plant than current N fertilization practices.
- Nitrogen released from D5 and ESN between preplant N application and before the establishment of the permanent flood (≈40 d) would likely undergo nitrification and be lost via denitrification after establishment of the permanent flood.

References

USDA-NASS, 2005. Agricultural prices monthly. [On-line]. Available at http://usda.mannlib.cornell.edu/usda/current (verified 11 October 2007).

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