The Effect of Delaying Preflood-Nitrogen Fertilization on Grain Yield of Flood-Irrigated Rice


ABSTRACT

Preflood application of urea-nitrogen (N) to a dry soil is challenging in some years due to frequent rainfall during late May and early June. Our objective was to evaluate how delaying the preflood, urea-N application on a very-short-season cultivar influenced grain yield response to N rate. Clearfield 111 rice was fertilized with a single, preflood application of 0, 40, 80, 120, and 160 lb urea-N/acre on four different dates (4 June, 12 June, 18 June, and 27 June). Rice grain yield for the 4, 18, and 27 June fertilization dates increased quadratically as N rate increased and the 12 June fertilization date yield response was positive and linear. The results suggest that the preflood urea-N can be delayed for several weeks without reducing grain yield assuming that urea-N losses were similar among N application times. The results are tenuous because the conditions under which urea-N was applied differed and may have led to different amounts of N loss.

INTRODUCTION

Rice (Oryza sativa L) uptake of preflood-applied, urea-N fertilizer is very efficient when done properly. Proper application includes the use of an effective urease inhibitor, application to a dry soil, and rapid incorporation by flooding. Unfortunately, in some years, application of the preflood urea-N to a dry soil is challenging due to frequent rainfall during late May and early June. This was the situation that occurred in 2014. Weather records for 25 May to 12 June show 8 (of 19) days of measurable rainfall totaling 5.4 inches at the University of Arkansas System Division of Agriculture’s Pine Tree Research Station (PTRS) and 10 days of rainfall totaling 7.9 inches at
the Rohwer Research Station. Currently, the recommendation is to wait a reasonable amount of time for the soil to dry before applying preflood N. However when a dry soil for urea-N application cannot be achieved, growers are encouraged to apply the urease inhibitor-treated urea to the moist soil surface and if possible allow the soil to dry for 2 days before flooding. Ammonia loss from the urea during the 2-day drying time is delayed by the urease inhibitor and the drying allows urea to be incorporated below the soil surface when the flood is applied. The DD50 guideline for the absolute deadline for applying the preflood N was established in the early 1990s with longer season cultivars and needs to be reevaluated since the duration of the vegetative growth stage of many existing cultivars and hybrids has been reduced. Our objective was to evaluate how delaying the preflood, urea-N application on a very-short-season cultivar influenced grain yield response to N rate.

PROCEDURES

The experiment was conducted at the PTRS on a Calhoun silt loam that was previously seeded to soybean and fallowed in 2013 due to a stand failure. The N-STaR value of 6, 18-inch deep composite soil samples for the field averaged 70 ppm (standard deviation = 10 ppm) and recommended an N rate of 160 lb N/acre. Composite 4-inch deep soil samples showed soil chemical property means of 7.8 pH, 35 ppm P (Mehlich-3), and 80 ppm K (Mehlich-3). A blanket application of 80 lb K₂O/acre was applied after rice emergence.

Rice (CruiserMaxx-treated CL111) was seeded (90 lb/acre) on 23 April in four adjacent areas that were each separated by a levee to represent four different N fertilization and flood times of rice that was planted on the same date. Individual plots consisted of 9, 16-ft long rows spaced 7.5 inches apart and were surrounded by a 2.5-ft wide plant-free alley. Rice was fertilized preflood with single applications of 0, 40, 80, 120, and 160 lb urea-N/acre on four different dates (4 June, 12 June, 18 June, and 27 June). Note that the first N application date was delayed by one week waiting for dry soil conditions. All urea-N fertilizer was treated with the labeled rate of a urease inhibitor (3 qt Agrotain Ultra/ton urea, 26.7% a.i.). At maturity, 8 of the 9 rows in each plot were harvested with a plot combine, grain moisture and weight was recorded, and rice grain moisture was adjusted to 12% for final yield calculations.

Each trial (N application time) contained five N rates arranged as a randomized complete block design and four blocks. Regression analysis was performed using replicate data with the MIXED procedure of SAS v. 9.4 (SAS Institute, Inc., Cary, N.C.) using a model that contained the intercept term (N application time) and the linear and quadratic terms of N rate. The full model was run, the most complex non-significant (*P > 0.15*) term was deleted (if needed), and the simplified model was run again until the simplest final model with significant terms was derived. Predicted yield comparisons among N application times were made using the LSMEANS statement at preflood-N rates of 0, 120, and 160 lb urea-N/acre with differences interpreted as significant at the 95% level.
RESULTS AND DISCUSSION

Rice grain yield for the 4, 18, and 27 June fertilization dates increased quadratically as N rate increased and the rice yield response for the 12 June fertilization date was positive and linear (Table 1 and Fig. 1). For the three N fertilization dates that produced a quadratic relationship, the preflood-N rate predicted to produce maximal yield for CL111 was 173 lb urea-N/acre for 4 June, 150 lb urea-N/acre for 18 June, and 177 lb urea-N/acre for 27 June. The predicted yields within each of the examined N rates (120 and 160 lb urea-N/acre) were similar among the three dates showing quadratic relationships and greater than the predicted yield from the 12 June urea-N application date. Grain yield of rice receiving no-N fertilizer increased numerically and sometimes significantly as the permanent flood was delayed and followed the statistical order of: 4 June < 12 June = 18 June < 27 June (Table 1).

The soil moisture and weather conditions in which the urea-N was applied varied somewhat among the four application dates. For the N applications on 4 and 12 June, the soil was moist from rains that had occurred 2 days before the N was applied (0.33 inches on 2 June and 2.5 inches on 8 to 10 June). The plots were flooded 2 days following the urea-N application. Rain (0.37 inch) also occurred on 12 June after the urea-N was applied. The 18 and 27 June N applications were applied to dry soil. Thus, the N applications on 4 and 12 June were made under less than ideal situations which may have led to some N loss and thus some yield loss. Based on the yield results, a substantial amount of urea-N was lost from the 12 June application. Rice heading was delayed by delaying the preflood-N rate. Rice that was fertilized with 160 lb N/acre on 4 and 12 June reached 100% heading within 2 days of each other, which was 7 to 11 days earlier than 100% heading of rice fertilized on 18 and 27 June, respectively.

SIGNIFICANCE OF FINDINGS

The results from research with CL111 in 2014 suggest that the preflood N can be delayed for several weeks without reducing grain yield assuming that urea-N losses were similar among N application times. The results are tenuous because the conditions under which urea-N was applied differed and may have led to different amounts of N loss. Additional research is warranted to confirm that these results are consistent across soils under uniform (e.g., dry) soil conditions and rice genotypes.

ACKNOWLEDGMENTS

Research was funded by a grant from the Rice Check-off Program administered by the Arkansas Rice Research and Promotion Board and the University of Arkansas System Division of Agriculture.
Table 1. Regression coefficients and P-values for grain yield of CL111 rice planted on the same day and fertilized with preflood urea-N on four different dates during 2014 at the University of Arkansas System Division of Agriculture’s Pine Tree Research Station.

<table>
<thead>
<tr>
<th>Preflood-N date</th>
<th>Intercept(^c) (SE(^b))</th>
<th>Linear (SE(^b))</th>
<th>Quadratic (SE(^b))</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 June</td>
<td>69 (±5) c</td>
<td>1.415 (±0.134)</td>
<td>-0.00409 (±0.00080)</td>
</tr>
<tr>
<td>12 June</td>
<td>84 (±5) b</td>
<td>0.545 (±0.134)</td>
<td>0.00023 (±0.00080)(^d)</td>
</tr>
<tr>
<td>18 June</td>
<td>88 (±5) b</td>
<td>1.383 (±0.134)</td>
<td>-0.00461 (±0.00080)</td>
</tr>
<tr>
<td>27 June</td>
<td>103 (±5) a</td>
<td>1.004 (±0.134)</td>
<td>-0.00283 (±0.00080)</td>
</tr>
</tbody>
</table>

\(^a\) Coefficients for the equation \(y = a + bx + cx^2\) where \(y = \) grain yield (bu/acre); \(a = \) intercept; \(b = \) linear coefficient; \(c = \) quadratic coefficient; and \(x = \) preflood-N rate (lb urea-N/acre).

\(^b\) SE = standard error. All coefficients are significantly \((P < 0.05)\) different than zero, unless noted.

\(^c\) Intercept values followed by different lowercase letters indicate statistical differences among values for rice receiving no N fertilizer.

\(^d\) Coefficient not different than zero.

Fig. 1. Grain yield response to preflood urea-N rate at four different N application dates for CL111 rice that was seeded on the same date in a trial conducted during 2014 at the University of Arkansas System Division of Agriculture’s Pine Tree Research Station. Regression coefficients are listed in Table 1.