SLOW RELEASE NITROGEN FOR IRRIGATED HARD RED SPRING WHEAT YIELD AND PROTEIN

B. D. Brown
University of Idaho, Parma Research and Extension Center

ABSTRACT

Producing furrow irrigated hard red wheat with acceptable protein is challenging because of limited nitrogen (N) management options for increasing protein. Slow release N fertilizers, such as polymer coated ureas, have the potential to improve N use efficiency in furrow irrigated hard wheat by avoiding the effects of excessive early season N, yet providing N later in the season for protein enhancement. A three year study (2005-2007) was conducted at Parma, ID, to evaluate different N rates (120, 180, and 240 lb/A) of ESN polymer coated urea and dry urea preplant N sources for furrow irrigated hard red spring wheat (variety WB 936). Grain yield decreased in the absence of lodging with both preplant N sources when applied N exceeded 120 lb/A in 2005, possibly due to exacerbated stripe rust. With no stripe rust in the following years, yield increased more with ESN N than with urea N, unless the urea N was split applied. Protein content in ESN fertilized wheat was often higher than with preplant urea, and matched the protein of wheat top-dressed with 60 lb urea N/A at heading in five of six N rate comparisons, differing no more than 0.3% protein lower or higher from split urea. Apparent N recovery (ANR) ranged from 6.5 to 9.9% higher for preplant ESN at the 120 lb N rate, and 11.5 to 14.9% higher at the 180 lb N rate. Slow release N proved an effective preplant N source under the conditions of this study, which included a minimum of 75 lb N/A of preplant residual N.

INTRODUCTION

Producing high yielding irrigated hard spring wheat with acceptable protein has been challenging for producers despite their efforts to manage available N for protein enhancement. Both higher fertilizer N rates and split applications are used by growers, but even these measures often result in protein concentrations that result in low protein price discounts. Furrow irrigated producers are especially frustrated because late season top-dressed fertilizer N does not appear to be used as effectively by the plant for protein enhancement as the N which can be fully incorporated with overhead sprinkler irrigation.

Furthermore, to avoid later application costs, some producers will attempt to provide all of the N that is necessary for both yield and protein in a single preplant application, which increases the risk of lodging and lower yields from excessive N during vegetative growth. A preplant broadcast fertilizer N that could match or increase the effectiveness of later top-dressed N could (1) reduce application costs, and (2) reduce N losses from volatilization, leaching, and denitrification.

Broadcast and incorporated polymer coated urea may have potential for delaying early season N availability, yet provide adequate late season N for yield and protein enhancement. ESN is a polymer coated urea currently marketed for grain crops in the Midwest. The diffusion of water through the polymer coating is temperature dependent. Water passing through the polymer solubilizes the urea core, enabling it to diffuse into soil where it can be used by plants.

The objective of this study was to evaluate ESN as a preplant broadcast and incorporated N source for furrow irrigated hard red spring wheat.

METHODS

A research trial conducted on a silt loam for three years (2005-07) at the Parma R & E Center involved preplant urea and ESN N sources evaluated at various N rates (120, 180 , and 240 lb/A) for their effectiveness in furrow irrigated hard red spring wheat. Increasing amounts of ESN substitution for urea were included at the 180 N rate and a split application of urea (60% of the total applied at heading) was also evaluated at the two highest N rates. Treatments were arranged in a randomized complete block with four replications and are shown in Table 1.

The previous crop that received 50 lb N/A preplant was dry beans. Preplant nitrate-N in the first foot in these trials measured 35 ppm in 2005, 21 ppm in 2006, and 22 ppm in 2007. Preplant fertilizer treatments were applied March 30, 2005, February 21, 2006, March 7, 2007, and incorporated with a Triple K narrow spring toothed harrow. Subsequent rainfall after the incorporation occurred 4 days later in 2005 (0.27”), 8 days later in 2006 (0.26”), and 34 days later in 2007 (0.21”). Jerome hard red spring wheat was planted March 30, 2005, February 28, 2006, and March 7, 2007. Jerome was chosen in part because of its high yield potential and a tendency to have lower protein. The trials were furrow irrigated as needed, and harvested August 5, 2005, July 27, 2006, and August 1, 2007.

Chlorophyll meter (SPAD) readings were collected just prior to the top-dressed urea N application. Plant heights, yield, test weight, and protein were measured. Total grain protein N was calculated from the grain yield and protein data. Apparent N recovery was calculated in 2006 and 2007 based on the difference in grain N of fertilized and unfertilized wheat relative to the N applied.

RESULTS

Grain yields differed appreciably in the three years of study. Yields were limited in 2005 by stripe rust (*Puccinia striiformis*) and possibly by a later planting date than in 2006 and 2007. Stripe rust occurred only in 2005, and lodging only in 2006, which did not appear to affect yield.

Yields with broadcast preplant urea and ESN were significantly reduced with higher N in 2005, although there was no lodging. It’s possible that high N concentrations in the soil exacerbated stripe rust severity, but that was not obvious from visual inspection. Yield was significantly higher with ESN than with preplant urea.

The yield response to higher N in 2006 differed between the two N sources. Yield at the 120 rate did not differ significantly for the two N sources. Yield with preplant urea was unaffected by N rates above 120 lb/A, but yield with ESN increased. In all years, the more ESN was substituted for urea, yield tended to increase at the 180 lb N/A rate.. Delaying the application of 60 lb of urea N until heading ameliorated some of the excessive preplant urea N effects in some years.

Protein in 2005 ranged from 13.9 to 14.9%, with N rates of 120 to 240 lb N/A, in 2006 from 11.2 to 13.1%, and from 13.4 to 15.8% in 2007. The results in 2006 show the difficulty in producing high yields of furrow irrigated hard wheat with acceptable protein despite higher N rates than are required to maximize yield. Higher protein in 2007 than in 2006 may have been due to 17 ppm more nitrate-N (NO_3-N) in the 12-24” depth in 2007.

Protein increased with higher N rates in all years, and split urea protein was consistently higher than preplant urea protein. Protein tended to be higher the greater the substitution of preplant ESN for urea, especially in 2006. While protein for the two preplant N sources did not differ in 2005, protein was consistently higher for preplant ESN in 2006, and at the highest N rate in 2007.

Table 1. Jerome hard red spring wheat response to preplant conventional urea and slow release N fertilization. Parma, 2005.

Total N applied	Preplant Urea N	Preplant ESN N	Late Urea N	Yield	Protein	Test weight	Height	SPAD	Grain N
	------------lb/A------------			bu/A	%	lb/bu	in		lb/A
120									
	120	--	--	84	13.9	61.7	34	49.1	125
	--	120	--	92	14.0	61.6	34	51.7	137
180									
	180	--	--	82	14.2	60.5	34	51.4	124
	120	60	--	82	14.3	60.7	33	52.2	125
	60	120	--	84	14.4	60.8	34	51.9	128
	--	180	--	87	14.4	61.2	34	50.4	132
	120	--	60	83	14.6	60.4	34	48.7	128
240									
	240	--	--	73	14.6	60.5	33	52.9	112
	--	240	--	83	14.6	60.5	33	51.3	128
	180	--	60	79	14.9	60.3	33	52.2	125
CV				8	1.9	0.7	3.3	5.2	7.6
$LSD_{.10}$				8	0.3	0.5	1.3	3.2	11.6

Table 2. Jerome hard red spring wheat response to preplant conventional urea and ESN slow release N fertilization. Parma, 2006.

Total N applied	Preplant Urea N	Preplant ESN N	Late Urea N	Yield	Protein	Test weight	Height	Lodged	SPAD	Grain N	ANR
	------------lb/A------------			bu/A	%	lb/bu	In	%		lb/A	%
0	--	--	--	79.2	8.9	61.2	32.9	0	44.1	74.9	--
120											
	120			113.8	11.2	62.0	36.8	8	52.2	135.6	50.6
	--	120	--	116.6	11.6	62.5	36.2	0	53.1	143.4	57.1
180											
	180	--	--	118.8	11.7	62.0	36.2	10	55.0	147.3	40.2
	120	60	--	121.2	12.2	62.4	37.8	10	54.5	156.4	45.3
	60	120	--	124.3	12.3	62.4	37.1	28	53.0	161.9	48.3
	--	180	--	129.1	12.7	62.4	37.3	38	54.9	174.0	55.1
	120	--	60	125.8	12.7	62.3	37.3	65	55.9	169.4	52.5
240											
	240	--	--	116.6	12.5	62.2	37.4	18	54.3	155.2	33.5
	--	240	--	125.2	13.0	62.2	37.4	55	55.5	172.6	40.7
	180	--	60	122.5	13.1	62.1	37.3	53	56.2	170.5	39.8
CV				4.5	3.8	0.4	2.7	112	3.8	3.0	--
$LSD_{.10}$				6.4	0.43	0.4	1.2	35	2.4	10.5	--

Table 3. Jerome hard red spring wheat response to preplant conventional urea and ESN slow release N fertilization. Parma, 2007.

Total N applied	Preplant Urea N	Preplant ESN N	Late Urea N	Yield	Protein	Test weight	Height	Lodged	SPAD	Grain N	ANR
	------------lb/A------------			bu/A	%	lb/bu	in	%		lb/A	%
0	--	--	--	87.0	11.7	60.8	32.0	0	43.1	108.1	--
120	--	--	--								
	120			119.4	13.4	61.8	34.9	0	50.7	169.6	51.3
	--	120	--	123.7	13.8	62.7	34.3	0	46.8	181.5	61.2
180											
	180	--	--	120.6	14.8	61.6	34.4	0	50.9	188.8	44.8
	120	60	--	122.0	14.9	62.1	33.3	0	50.8	192.6	46.9
	60	120	--	124.4	14.8	62.5	33.9	0	51.2	195.4	48.5
	--	180	--	131.2	15.0	62.3	33.5	0	50.6	209.5	56.3
	120	--	60	127.9	15.2	61.8	35.0	0	50.8	205.5	54.1
240											
	240	--	--	127.2	15.0	61.7	33.3	0	51.2	203.1	39.6
	--	240	--	127.7	15.8	61.9	35.6	0	51.4	213.7	44.0
	180	--	60	125.6	15.5	61.4	32.5	0	50.9	206.4	41.0
CV				5.1	3.0	1.1	5.1	--	3.8	6.0	--
$LSD_{.10}$				7.5	0.5	0.8	2.0	--	2.3	13.5	--

Preplant ESN protein averaged 0.17% lower than with split urea N over three years, but differed significantly in only one of six comparisons.

Total grain N content per acre also differed appreciably in the three years, and depended primarily on yield. Grain N ranged from 112 to 137 lb/A in 2005, and was highest at the lowest N rate due to higher yields. Grain N ranged from 136 to 174 lb/A in 2006, and from 170 to 214 lb/A in 2007 for the same treatments, but unlike 2005, were highest with the highest preplant N rate. In most comparisons, grain N with preplant ESN was greater than with preplant urea, and was consistently as high as with split applied urea.

Including a control in 2006 and 2007 enabled calculation of apparent N recovery (ANR). The ANR in harvested grain of that applied in both years decreased as N rates increased. ANR of preplant N ranged from highs of 50.6% and 51.3% with preplant urea and 57.1% and 61.2% with preplant ESN for the 120 lb N rate, to only 33.4% and 39.6% with urea and 40.7% and 44.0% with ESN at the 240 lb N rate. Recovery estimates are conservative as they don't include N contents of chaff and stubble. The split urea treatment improved the ANR over that with all preplant urea, primarily due to higher yields.

SPAD (define) readings (heading) and plant heights (dough stage) for the two preplant N sources did not differ significantly except for 2007, when SPAD readings at heading were lower for ESN at the 120 lb N/A rate. Test weight decreased with higher N in all years, and was occasionally higher with ESN. Lodging in 2006 increased with higher N, especially for treatments providing higher N during later growth stages, but these were also the most productive treatments. Lodging was greater with preplant ESN than preplant urea.

In summary, preplant urea N was less effective in most years compared to preplant slow release N, especially at higher N rates. The influence of stripe rust on the N response in 2005 can not be ruled out. Greater losses of preplant urea N from leaching or volatilization (NH_3 from soil, denitrification, NH_3 from plants) more likely explain the yield response in other years. Volatile losses from urea N that are more dependent on the rate applied are more consistent with the 2006 results of a limited yield response and low protein. There appear to have been significant N losses in 2006 from early season available N. Physiologic N imbalance or inefficiency also can not be ruled out. This study was unable to document the mechanism responsible for the poorer performance of preplant urea, but it appears to be related to the increased availability of N during early growth. Regardless of the mechanism, preplant slow release N was significantly more effective than urea under the furrow irrigated conditions of these three field trials.

The delayed release of N from ESN was not a limiting factor for yield in these trials, as preplant residual N was likely sufficient for early vegetative growth N requirements. The results may differ under more limiting early season N conditions. Further study is merited on preplant slow release N for producing high yielding furrow irrigated hard wheat with acceptable protein.

ACKNOWLEDGEMENTS

This study was made possible in part by funding from Agrium. We are also thankful for the protein analyses provided by the UI Aberdeen Wheat Quality Laboratory. The assistance of Vernon Booth with field sampling, and the farm crew at Parma was also appreciated.