

The Effects of in-Furrow Application of Urea and Urea Based Slow Release Nitrogen Products on Stand Establishment and Crop Performance of Spring Wheat

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Applying fertilizer under the soil surface at planting saves time and eliminates the need for tillage for the sake of incorporating. This preserves moisture and residue. Putting the fertilizer directly in the seedbed with the planter has its own advantages over banding. Without the drag of additional equipment for banding, putting fertilizer down the tube saves fuel. It also decreases soil disturbance, thereby preserving moisture and residue even more. The challenge with this method is avoiding a substantial reduction in stand due to the damage that urea causes when it comes in close contact with the seed (Figure 1). Despite this challenge, there is substantial interest in using this method and some farmers have reported positive outcomes with it. Environmentally Smart Nitrogen (ESN) is a slow-release nitrogen fertilizer product made of polymer-coated urea granules. It has been shown to be a good alternative to uncoated urea when it comes to in-furrow N application. The safety of urea and ESN application was found to be affected by soil type, width of seedbed and the width of rows. Current guidelines suggest that ESN can be applied at three times the safe rate of urea for a given crop and soil type. For a loam soil that would mean up to 30 lbs N as urea with the seed and up to 90 lbs N as ESN.



Figure 1. The effect of N-rates and ESN to urea blending ratios on wheat stand establishment

A trial with spring wheat was set up in Carrington which ran from 2013 to 2015. The primary goal of this trial was to test the recommendations using different N-rates and ESN:urea blending ratios.

Pushing the limits

Some treatments in 2013 were meant to push the boundaries of current recommendations. In 2013, there were three treatments with a side-dress component. Most notable of them was a treatment where 90 lbs N was applied as urea in-furrow with 45 lbs N top-dressed as urea. In this treatment the 90 lbs of urea applied with the seed was so damaging to the stand that the plots did not recover. The average yield was only 14.2 bu/A.

The other two side-dress treatments were 90 lbs N as 50:50 ESN:urea applied at planting and as side-dress (180 lbs N total) and a treatment with 45 lbs N as 50:50 ESN:urea applied at planting and as side-dress (90 lbs N total). The yield and protein from these treatments were not significantly different from their respective counterparts without the side-dress application.

In 2013, there was an additional rate of a 113 lbs N representing the 125 percent optimum N-rate at three blending ratios. It was found that the yields from this treatment were the same or lower than the yields from the 90 lb N rates.

In 2013, there were two fall broadcast applications. Urea and ESN were broadcast applied at 90 lbs/A in the fall. The yields from these treatments were not significantly different from each other but they were lower than the 45 lb N spring in-furrow treatments, due to the loss of nitrogen. In 2014 and 2015 the fall broadcast treatments were replaced by spring broadcast treatments to improve nitrogen use efficiency.

Main treatments (2013-2015): ESN and ESN:Urea blends

There were 10 treatments maintained through all three years (Table 1). Within those treatments, there were three different N rates applied with the seed (45, 68 and 90 lbs N). N applied at 90 lbs represented the 100 percent optimum rate for spring wheat for the site in 2013. The 68 lbs N was 75 percent of the optimum rate and 45 lbs N was 50 percent of the optimum rate. These N rates were maintained regardless of soil levels in the next two years because the primary objective was to review application from a seed safety point of view. This allowed comparison of crop performance based on the amounts that were applied and not based on total available nitrogen. Due to the price difference between ESN and urea, blending ESN with urea at different ratios was also evaluated at three ratios for each nitrogen rate. The ratios were 100 percent ESN, 75:25 percent ESN:urea and 50:50 percent ESN:urea applied in-furrow. In 2014 and 2015 these treatments were also compared with Agrotain-treated urea in-furrow and the spring broadcast application of urea, ESN and Agrotain-treated urea.

Table 1. Main treatments. These were repeated in all site-years.

Trt no.	N-rate (lbs/A)	ESN to urea
1	0	
2	45	100% ESN
3		75:25 ESN:urea
4		50:50 ESN:urea
5	68	100% ESN
6		75:25 ESN:urea
7		50:50 ESN:urea
8	90	100% ESN
9		75:25 ESN:urea
10		50:50 ESN:urea

To assess seedling damage and recovery, stand counts were taken two weeks after planting and at mid-season between tillering and heading. Spikes were also counted near harvest. Mid-season stand counts were taken by counting every stem instead of counting individual plants. This stand count showed better correlation with yield than the pre-tillering stand count, suggesting that some of the plots recovered from seedling damage because surviving plants produced more tillers.

The effect of blending urea with ESN varied throughout the years (Figure 2 and 3). In 2013 the stand was especially harshly affected by seed damage from urea, which caused significant reduction in the yield as well (Figure 2). The plots receiving 100 percent ESN with the seed did not suffer a great reduction in stand. In 2014 there was no significant difference between the yields and stand counts for the different blending ratios (Figure 2). Stand counts were reduced at higher N rates. In spite of this, grain yield increased with nitrogen rates regardless of ESN to urea blending ratio. Mid-season stand counts showed that the plots recovered through tillering.

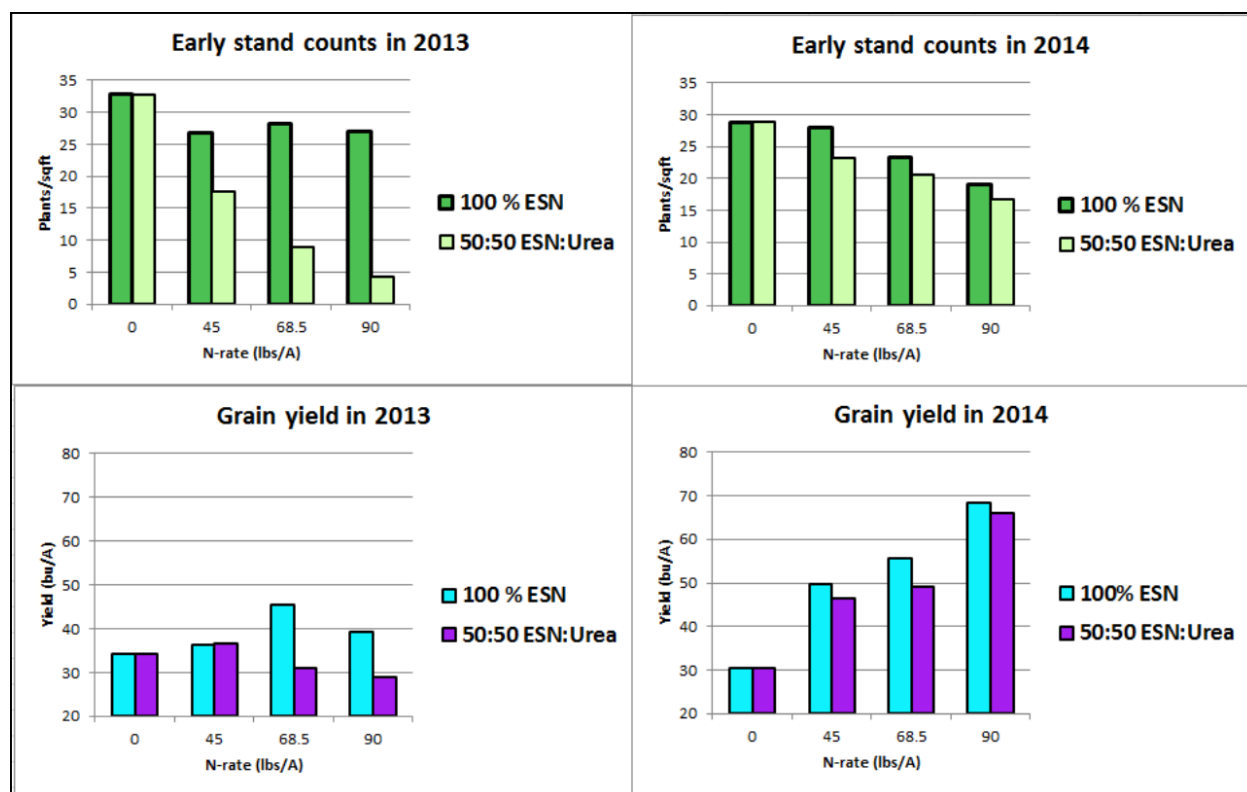


Figure 2. A comparison of early stand counts and grain yields of four nitrogen rates and two ESN:urea blending ratios in 2013 and 2014.

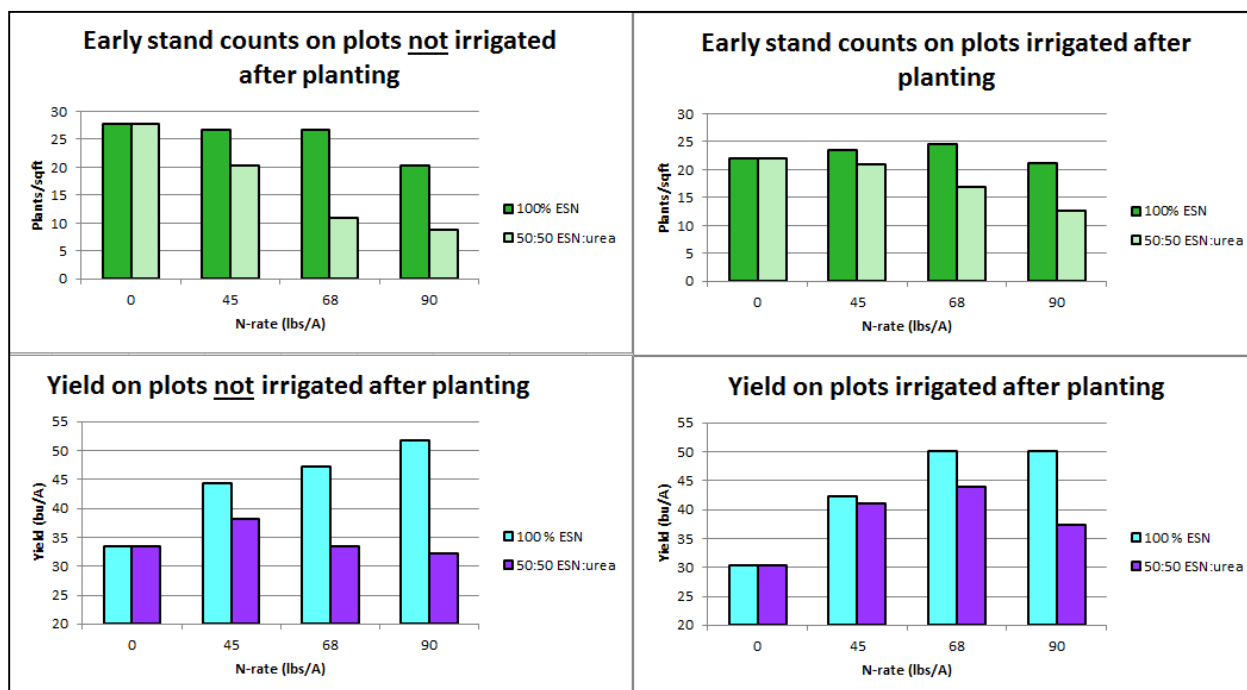


Figure 3. A comparison of early stand counts and grain yields of four nitrogen rates and two ESN:urea blending ratios between the two sites of 2015 distinguished by irrigation timing.

Does it help if we get rain shortly after planting?

The difference in the outcomes of 2013 and 2014 was likely due to environmental factors. It was postulated that the length of time that passed between planting and the first rainfall event could have had a major effect. In 2013 it rained 0.27 inches three days after planting and 0.13 inches the day after that. In 2014 it rained 0.37 inches less than half a day after planting and 0.24 the day after that. The rainfall could have made a big difference in how much damage the urea was able to cause to the seeds. For this reason, in 2015 we introduced the effect of irrigation timing. The trial was duplicated on two sites right next to each other. Both were under irrigation throughout the season. The only difference between them was that one of the sites received 0.5 inch of water within an hour of planting and the other did not. The next rain event happened seven days after planting at 0.15 inches. We expected that the initial shot of 0.5 inch of water would mitigate the damage caused by plain urea compared to the site that was left dry. On the graphs we can see that this was true to some extent (Figure 3). However, unlike in 2014, blending urea with ESN came with a yield penalty even on the side irrigated after planting, suggesting that proximity to a rainfall event at planting alone does not determine the extent to which plots would be damaged by plain urea. In 2013, the weather was hot and dry year with a late start. Conditions were generally not favorable for wheat. In contrast, 2014 was a great year for spring wheat with a cool summer and lots of rain when it mattered. Spring wheat yields were generally higher than average for that year.

Summary of main treatments

The 10 treatments were tested under varying environmental conditions. Results indicate that there was no consistent effect on grain protein from blending ratios and that protein levels responded to nitrogen rates mostly in a linear fashion.

To summarize the results of the 10 treatments from the four site years:

- The 90 lb N rate as 100 percent ESN in-furrow yielded the most in 2014 and both sites in 2015. The highest yield was at 68 lbs N as ESN in-furrow in 2013, likely because of poor yield potential for that year.
- At the 45 lb N rate, ESN can be mixed with urea up to 25 percent without yield penalty compared to 100 percent ESN.
- At higher N rates, blending urea with ESN is likely to cause yield loss compared to 100 percent ESN. ESN is generally priced \$0.20 above a pound of N from urea. Even if spring wheat were to be sold at \$4.00/bu (a conservative estimate), it would only be profitable to mix 20 lbs of urea in with ESN if the potential yield difference between 100 percent ESN and the mix was less than a bushel. Therefore, based on the fact that most site years at the 68 and 90 lb N rates the yield loss from mixing was 5 bushels or more, it may not be profitable to mix urea with ESN at those N rates in most years.
- If ESN is mixed with urea or if straight urea is applied in-furrow, getting rain shortly after planting does prevent some of the damage but is not the only factor in determining how well the crop is able to recover from stand reduction.

In-furrow vs. broadcast application

In 2014 and 2015 there were three spring broadcast fertilizer treatments. These treatments were not incorporated to assess whether a farmer who would consider seed applying fertilizer for the sake of avoiding soil disturbance could instead simply broadcast the fertilizer and leave it on the surface. The treatments were 90 lbs N as urea, 90 lbs N as ESN and 90 lbs N as Agrotain urea. Broadcast ESN and Agrotain-coated urea had yields and protein similar to the 100 percent ESN applied in-furrow at the same rate. The spring broadcast urea treatment yielded less and had lower protein than the in-furrow applied ESN at 90 lbs. This is likely due to greater nitrogen loss from plain urea than from ESN and Agrotain-coated urea.

In-furrow application of Agrotain-coated urea

Agrotain enhances nitrogen use efficiency by inhibiting the urease enzyme. This slows down the formation of ammonia which volatilizes, thereby causing nitrogen loss. Ammonia formation is also the major cause of seedling damage when urea is in contact with the seed. Agrotain is commonly used by farmers wishing to reduce nitrogen losses from urea fertilizer. In 2014 and 2015, in addition to a broadcast application, Agrotain-coated urea was applied with the seed at the previously mentioned three nitrogen rates. In 2014, similar to the ESN:urea blends, plant stands and yields were not significantly lower than the 100 percent ESN treatments and yields increased with N rates. The response in 2015 was less favorable. For the plots that did not receive irrigation right after planting yields decreased with N rates. On the plots that did receive irrigation right after planting the yields increased with N rates but were lower than the 100 percent ESN treatments at the 68 and 90 lb N rates. At the 45 lb N rate, yields of ESN and Agrotain treatments were the same on the plots irrigated right after planting, but the 45 lb N Agrotain-treated plots had slightly lower yields (-2 bu/A) than the ESN plots on the area that did not receive water after planting. From this data it looks as though applying Agrotain-treated urea with the seed is not as damaging as plain urea, but it is also less safe to apply than urea. The safe rate to apply Agrotain-treated urea with the seed is likely somewhere between the safe rate for plain urea and ESN.