Polycoated Urea to Enhance Fertilizer N Utilization Efficiency
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Research Question

1) Evaluate, compare, and contrast the fertilizer N utilization of polycoated urea and straight urea by hard red spring wheat.
2) Determine if hard red spring wheat varieties that vary in their grain yield and protein potential respond differently to the two sources of N.

Results

At the soft dough growth stage there was no differential effects of spring wheat variety or N source on total biomass and N accumulation at either experimental site (Table 1). Total biomass accumulation had a curvilinear response to increasing N rates (Figure 1). Maximum biomass accumulation occurred with 60 to 90 lbs N/A at both sites. There tended to be slightly greater biomass at Site C than Site R, which was probably due to the nearly 2 weeks earlier planting at Site C. Total N accumulation increased throughout the range of increasing N rates with no difference between sites (Figure 2). Though the plant continued to accumulate N as N application increased, the biomass potential was apparently limited by something other than N.

Grain yield and protein followed expected patterns with respect to differences between the two spring wheat varieties. Knudson had greater grain yield and lower grain protein than Alsen. The interaction between varieties and N rates was not significant at either site (Table 1). Thus the grain yield and protein response to N rates was similar for the two varieties. At both sites, maximum grain yield occurred between 90 to 120 lbs applied N/A (Figure 3). However, grain protein increased throughout the range of applied N rates (Figure 4).

Interactions between N rates and N sources were not significant for grain yield at either site or grain protein at site R (Table 1). At site C, there was a significant interaction between these factors for grain protein. Nevertheless, visual evaluation of grain yield (Figure 5) and protein (Figure 6) response to N rates of both N sources were similar at both experimental sites. Urea produced greater grain yields than ESN regardless of N rate (Figure 5). However, ESN produced greater grain protein concentration than urea regardless of N rates (Figure 6). Interestingly, protein differences between the two N sources increased as N rate increased, this interaction was significant only at Site C, while at the same time grain yield differences tended to decline at higher N rates.

Materials and Methods

Two field experiments were established near the University of Minnesota’s Northwest Research and Outreach Center (NWROC) near Crookston, Minnesota; one 5 miles west of NWROC (Site R) and the other 7 miles south of NWROC (Site C). Soils at Site C and Site R were a Bearden silty clay loam and Bearden-Colvin Complex, respectively. Official taxonomy of Beardon soil is fine-silty, mixed, superactive, Frigid Aeric Calciaquoll and of Colvin soil is fine-silty, mixed, superactive, Frigid Typic Calciaquoll. Treatment and experimental designs at both locations were a 2 (N sources) by 2 (wheat varieties) by 6 (N rates) factorial in a randomized complete block design.

Two N sources, urea and Environmentally Safe Nitrogen (ESN™), were broadcast over assigned plots in the spring of 2008. After tillage with a field cultivator to incorporate fertilizer and prepare a seed bed, two hard red spring wheat varieties, Alsen and Knudson, were planted. Nitrogen fertilizer was applied at six N rates equivalent to 0, 30, 60, 90, 120, and 150 lbs. N/A. Fertilizer was applied just previous to wheat planting on April 9 at Site C and April 7 at Site R. Both sites had adequate soil test P levels so no P fertilizer was applied.

Individual plot sizes were five feet wide, 10 seed rows separated by six inches, and either 22 feet long (Site C) or 25 ft long (Site R). A bare gap of about one foot existed between each plot. Replications or blocks were separated by ten feet alleys to accommodate herbicide and fungicide applications and plant sampling. Herbicides and fungicides were applied as need and recommended. At the soft dough growth stage, whole plants were sampled from three feet of the fourth seed row by clipping at the soil surface, drying, and processing to determine total
biodiversity and total N accumulation. At grain maturity, the entire plot was harvested with a small plot grain combine. Grain was initially dried then weighed for yield and a subsample was used to determine test weight and grain protein using NIR technology.

Statistical analysis was done using SAS 9.1 and the Proc Mixed procedure with slice analysis and targeted single degree contrasts where appropriate. Regression used in each figure was determined from the contrast analysis.

**Related Research**

Many attempts have been made, or are currently being made, to improve fertilizer N utilization efficiency in wheat production. Raun et al. (2001) has shown that winter wheat canopy light reflectance in the spring after dormancy is broken can be used to predict the yield potential. Fertilizer N is then applied in the spring to meet that yield potential. The yield potential is based on the growth of the winter wheat crop the previous fall and after growth resumes in the spring. In northwest Minnesota, Sims (2007) attempted to correlate spring wheat yield and protein with canopy light reflectance readings throughout the growing season. He found the canopy light reflectance relationship to yield and protein were different between two spring wheat varieties and that it was not able to distinguish treatments that differed by 7 to 10 bushel A-1. One reason for the difference in results between the two research projects might the actually growing season of the two crops. Spring wheat production in northwest Minnesota is approximately a 90-day growing season, planting to harvest, compared to 90+ days from dormancy to harvest in winter wheat production.

Other research has attempted to use split applications of fertilizer N to increase utilization efficiency. This management strategy applied some fertilizer N, if necessary, as preplant then applied the additional fertilizer N at or soon after tillering.

Theoretically, this would reduce potential N losses in the soil environment during the time when the wheat crop was establishing itself and would apply the necessary fertilizer N at a time when rapid growth and high N demand were just starting. Two issues have been raised with this strategy. One, is a second trip through the field is necessary to apply the in-season fertilizer N and two, soil moisture conditions must be adequate to activate and carry the fertilizer N into the crop root zone before potential volatilization losses occur. Timing of applying the fertilizer N and getting it into position of availability for the growing spring wheat crop is critical. Twenty-one site years of spring wheat research from northwest Minnesota in the 1990s clearly showed that most effective fertilizer N strategy was to preplant apply sufficient fertilizer N (J.A. Lamb and G.W. Rehm, personal communications). In these trials, spring wheat grain yield and protein with split fertilizer N applications did not exceed those achieved with adequate preplant fertilizer N applications.

Fertilizer N use research often finds 50 to 60% of the fertilizer N applied is harvested in the crop it is applied to (Hauck, 1985). It is also not unusual for total N budgets to not be able to account for 20 to 30% of the fertilizer N applied. It is assumed that this unaccounted for N is lost from the system via ammonia volatilization, nitrate leaching below the root and sampling zone, and/or nitrous oxide loss from nitrate denitrification. Nitrogen accounted for, but not harvested in the crop, may be found as residual inorganic N or as organic N. In the latter case, subsequent crops will harvest some of this fertilizer N. The longer the fertilizer N is exposed to the soil environment the greater the chances that it will be diverted from crop utilization. World wide, fertilizer N utilization in wheat is about 30% (Raun et al. 2001). Theoretically, the closer the fertilizer N availability is timed with the crop requirements, the higher the likelihood to increase the fertilizer N utilization efficiency.

Tisdale et al., (1993) wrote that the ideal fertilizer N source would be capable of releasing N over an extended period of time and in accordance with crop needs. Technology exists to delay or slow the release of available N by developing N products with low water solubility, modifying water soluble N sources to delay the release of N, and chemicals to control the hydrolysis of urea and conversion of ammonium to nitrate (Hauck, 1985). In recent decades coated urea N sources have been developed to slow the release, availability, and potential losses of N. Sulfur coated urea (SCU) is probably the most well known and has been available for sometime. In this case, imperfections in the sulfur coating allow water to migrate through the coating, dissolve the urea granule, and the liquid N to migrate to the soil environment (Hauck, 1985).

Allen (1984) reported that increasing temperature also increased the release of N from SCU suggesting
some biodegradation of the sulfur coating enhancing the N release. There is also a tendency for the sulfur coating to rupture under dry conditions, thus exposing the urea-N to the soil environment under less than ideal conditions. Sometimes a sealant is applied the SCU (Sartain, 2007). Microbial decomposition of the sealant will expose the sulfur coating imperfections and allow water migration. Since microbial activity and decomposition is temperature related, the release of coated N will correspond to warmer temperatures when crop growth is being stimulated. Other coated urea sources may use different coatings, but the temperature related microbial decomposition process is similar. Once the coating is decomposed, the urea granule is exposed to the soil environment like straight urea. The slow release component is based on differences in decomposition among the various coated granules applied. These N sources tend to be very expensive and have been primarily used in high value or ornamental crops. More recent technology applies a poly material as a coating to the urea granule. The polycoating does not require microbial decomposition, but uses osmosis and diffusion to release the N. Water is drawn to and diffuses through the polycoating, dissolves the urea granule, and the liquid N diffuses back through the coating into the soil environment. The slow release is based on the diffusion process which is affected by several factors, but perhaps the most important is temperature. As temperature increases, diffusion increases.

The release of the polycoated N will be based the rate of diffusion and the ability to draw water into and through the coating. The cost of these polycoated urea N sources seems to add about $0.10 per pound of N applied. At today’s high N prices this proportional cost is less than it would have been 5 years ago and places this material in a price range more amenable for spring wheat production.

Research has clearly shown that applying sufficient fertilizer N prior to planting spring wheat in northwest Minnesota is the most effective overall management practice. Yet, the desire to improve fertilizer N utilization is more important at today’s high fertilizer N prices. Can best fertilizer N management practices and the potential benefits of polycoated urea improve fertilizer N utilization be combined? The polycoated urea would be more expensive than straight urea, but a single preplant application of fertilizer would eliminate the need and risks associated with in-season split applications.

Preliminary data suggests that under adequate growing conditions, it may not only be possible, but the improved utilization more than paid for the extra cost of the polycoated urea.
Figure 3. Grain yield response, averaged over N sources, of two spring wheat varieties to applied N rates at two experimental sites.

Figure 4. Grain protein response, averaged over N sources, of two spring wheat varieties to applied N rates at two experimental sites.
Figure 5. Grain yield response, averaged over spring wheat varieties, to applied N rates of two N sources at two experimental sites.

Figure 6. Grain yield response, averaged over spring wheat varieties, to applied N rates of two N sources at two experimental sites.