Post Anthesis Nitrogen Application on Wheat to Enhance Protein

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High protein premiums are often offered for spring wheat when an above average winter wheat yield is expected. To try to capitalize on the projected premiums, farmers may try to enhance the protein content of their spring wheat kernels with a late-season application of nitrogen.

Overview of past research at the CREC

Research into using foliar application of nitrogen post-anthesis has been ongoing intermittently for nearly 30 years at the CREC. Various rates, timings, application volumes and even the use of adjuvants were explored. Many of the trial years also replicated the treatments on several varieties which were chosen as representatives of certain yield and protein content characteristics. The one universal aspect of these trials was the foliar application of 28% UAN immediately or shortly after anthesis with the goal of enhancing protein content.

Between 1988 and 1991, Blaine Schatz and Greg Endres assessed the nitrogen rate to use to give the most optimal protein boost. Their work was summarized by Dr. Dave Franzen in an Extension publication titled "Post-anthesis N application studies North Dakota, region and elsewhere," https://**www.ndsu.edu**/fileadmin/**soils**/pdfs/**postanthesis**compilation.pdf. In their research Schatz and Endres used 0, 15, 30, 45 and 60 lbs N/ac foliar treatments right after anthesis. The application volume was 20 gal/ac for each treatment which means that the 60 lb N was pure 28% UAN, the 45 lb N treatment was at 3:1 UAN to water ratio, the 30 lb treatment was 1 to 1 and the 15 lb treatment was 1 to 3. The 30 lb treatment proved to be the most beneficial in this scenario. Protein increased 1.25% with the 30 lb treatment on average between the 6 site-years of the study. Protein increase above that nitrogen rate was not consistent. The same publication by Dr. Franzen also describes the results of a survey done in 1993 by Blaine Schatz and Greg Endres involving 27 farmers that used post-anthesis nitrogen application that year. Amongst the responders the average yield difference from their application was +0.2 bu/ac and the average protein difference was +0.7%. A more detailed description of both the survey respondents' application rates and methods, and the summarized data and methodology of the trials conducted by Schatz and Endres, can be found in the aforementioned Extension bulletin.

In 2012 Blaine Schatz conducted a trial to assess whether a late post-anthesis treatment would still be beneficial. The report on that trial can be found in the 2012 Annual Report of the Carrington Research Extension Center under the title "Influence of a "late" post-anthesis nitrogen on spring wheat performance." In that trial, 28% UAN was applied at the early- to medium-dough stage, past the immediate post-anthesis stage that is normally recommended for such application. Four different varieties were used in this study and it was found that despite the delay, the treatment still increased protein content for all of them. The average increase across varieties was 1.1%. The application mix was roughly a 4:3 UAN:water ratio.

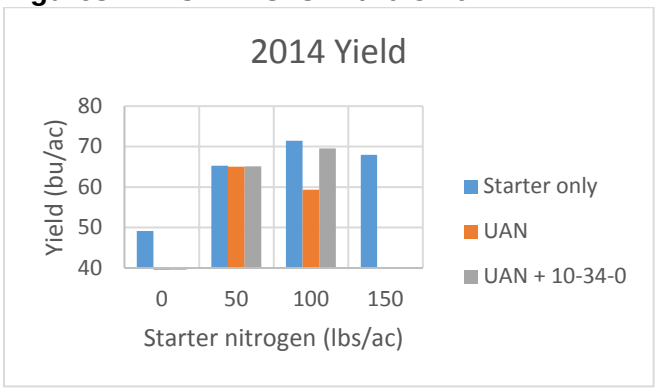
In 2016 there was an article published in the American Journal of Plant Sciences by Joel Ransom, Senay Simsek, Blaine Schatz, Eric Eriksmoen, Grant Mehring and Itai Mutukwa with the title "Effect of a post-anthesis foliar application of nitrogen on grain protein and milling and baking quality of spring wheat"(http://dx.doi.org/10.4236/ajps.2016.717218). This research article was the product of collaboration between the Carrington and Minot RECs as well as the Department of Plant Sciences at NDSU in Fargo. The aim of this study was to compare the post-anthesis foliar application to the same amount of extra nitrogen added as a starter. The other objective was to assess whether baking quality would be affected by the post-anthesis treatment. This study used sites from Carrington, Minot and Prosper between 2011 and 2013. Treatments were 75% optimal N-rate, 75% optimal N-rate plus 30 lbs N per acre at planting, 75% optimal N-rate plus 30 lbs N per acre applied post anthesis with a foliar

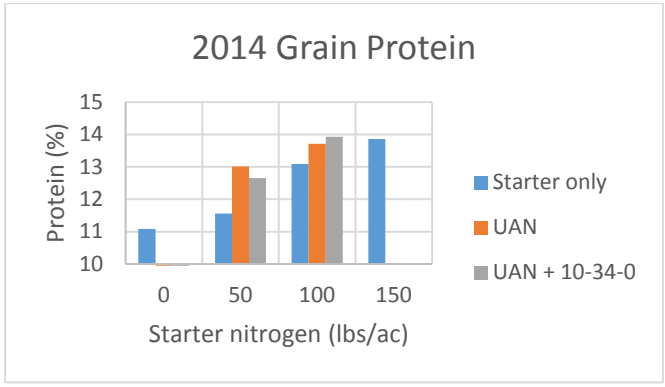
application of 1:1 28% UAN and water mix. Four varieties were used, but there was no variety interaction with the fertility treatments for yield or protein. This means that even though the varieties differed from each other in yield and protein content, there were no statistical differences between the nitrogen treatments. Protein content was consistently higher for the post-anthesis treatment compared to when the same additional rate was applied at planting. The milling and baking quality results showed that the increase in protein achieved by post-anthesis treatment yields similar grain quality as a wheat crop of the same protein content fertilized only at planting. This article however cautions farmers that the practice is likely to be profitable only under certain circumstances and market conditions.

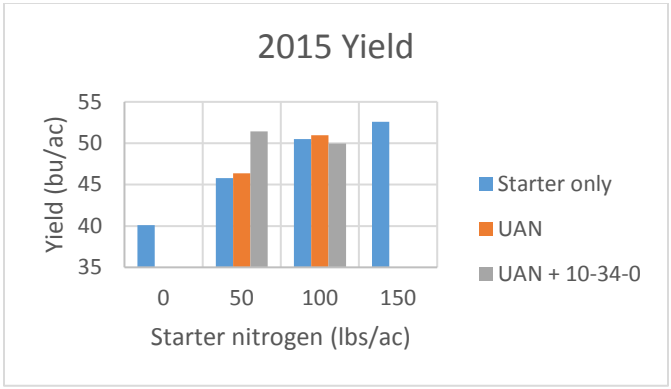
Recent Research

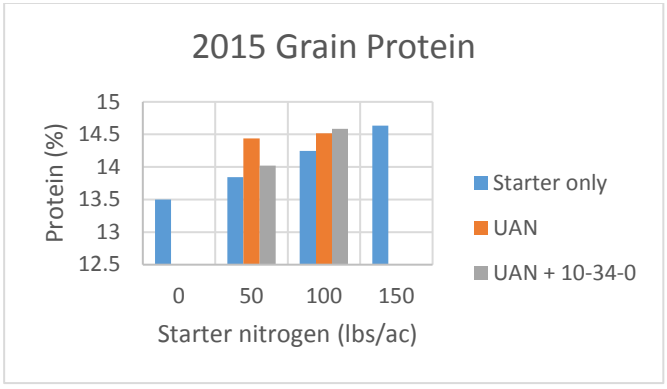
The CREC has continued with the post-anthesis nitrogen application trials. Following are results from the 2014, 2015 and 2017 trial years.

Figures 1-4. UAN vs. UAN/10-34-0 mix.









In 2014 and 2015 we compared foliar application of a mix of UAN and 10-34-0 with the intention of assessing whether including phosphorus in the post-anthesis treatment would provide any added benefits.

A single rate of 30 lbs N/ac was applied at the milk stage to plots treated with different rates of starter nitrogen in the form of urea. Liquid fertilizers were diluted to a 1:3 fertilizer to water ratio. The variety Briggs was used and the trial was under irrigation.

The treatments consisted of two rates of starter N in the form of urea, 50 and 100 lbs N/ac which either did or did not receive a post-anthesis treatment. The post-anthesis treatment was applied either in the form of 28% UAN or as a 1:1 nitrogen ratio of UAN and ammonium polyphosphate (APP) (10-34-0). There was also a check with no nitrogen applied and a set of plots that received 150 lbs N/ac at

planting but no foliar treatment. This was done to observe where treatments would fall within that year's nitrogen response curve.

The UAN-APP mix did not have protein and yield results consistently different from UAN applied by itself, suggesting that there is neither any benefit nor any damage caused by applying this mixture versus using only UAN.

Protein increased with the foliar treatments for both years and for both the 50 and the 100 lb N rates. Averaged for the two years, protein increased by 1% for the 50 lb starter N rate when foliar was applied and 0.45% for the 100 lb N rate. Yield increased with starter nitrogen rates up to the 100 lb N rate in 2014 and up to the 150 lb N rate in 2015.

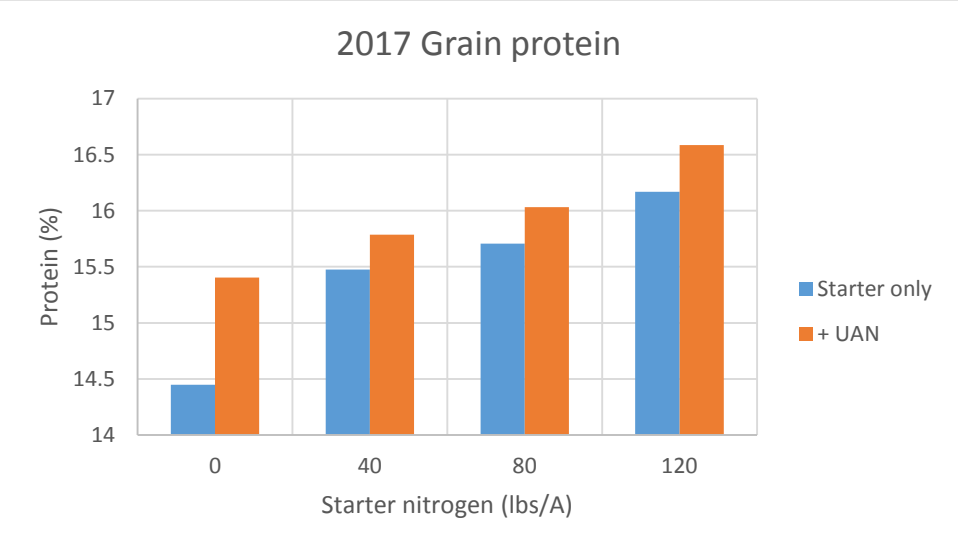


Figure 5. Protein boost despite no yield response to nitrogen.

In 2017, 30 lbs nitrogen was foliar applied to plots treated with 0, 40, 80 or 120 lbs nitrogen at planting. Results were compared to plots that only received the starter rates. Nitrogen application did not have an effect on yield this year, possibly due to a large rate of mineralization early in the season when moist soil conditions coupled with unusually warm temperatures. By the time of advanced tillering it was apparent that based on NDVI readings, which are an indicator of plant vigor, that there would be no yield response. Despite that, protein increased with starter nitrogen rates both with and without post-anthesis treatment, and the post-anthesis application of nitrogen consistently yielded higher amounts of protein than plots receiving the same rate of starter but no foliar nitrogen. Foliar application produced 1% more protein when no starter nitrogen was applied, 0.3% at 40 lbs N, 0.3% at 80 lbs N and 0.4% at the 120 lb starter N rate.

Future research

Looking at the last two decades of research at the CREC, we can confidently say that foliar applying 30 lbs of nitrogen per acre to spring wheat shortly after anthesis is a reliable way of increasing grain protein. The question is whether the expected gain in protein would translate to an increase in profit. Economics would depend on market conditions and also on the crop's potential for protein production in a given year. For this reason, staff at the CREC are looking into integrating the use of an unmanned aerial system for predicting yield and protein response to post-anthesis nitrogen application.