Evaluation of late season application of foliar nitrogen's impact of grain yield and milling qualities.

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A result from the 2010 hard red winter wheat harvest was an increase of discussions on protein values across the southern great plains. The crop garnered relatively low protein values for several reasons many of which were directly related to the weather patterns and environmental conditions. The question that many in industry and production were asking was whether protein levels could be economically increased. It has been documented that late season nitrogen (N) applications, pre and post anthesis, can indeed increase protein, a practice that is common in the production of spring wheat. Woolfolk et al., (2002) reported that when UAN and ammonium sulfate was applied to winter wheat pre and post flowering grain N concentration was increased. Agricultural producers are regularly presented with a multitude of products that boast improved yields, protein, or efficiency. One such product is the low-salt, controlled release, specialty N fertilizer. Many of these are sold to be applied at flag leaf with a fungicide in efforts to increase yield but are used elsewhere to increase grain protein. The work performed by Woolfolk did not evaluate N applications prior to pre-anthesis nor did the experiment evaluate N rates as low as what is being recommended. The Woolfolk paper showed increased protein values using traditional fertilizer sources with minimal to no tissue damage; however, treatments were applied in the cool of the morning to ensure minimum burn. This is not practical on a large scale, and reduced leaf burn is one of the selling points of the low-salt products. In addition there has been a great deal of discussion as of recent about the functionality of the additional N present in the grain as a result of post-anthesis applications.

This trial evaluated the use of foliar N applications on winter wheat at two stages, flag leaf and post-flowering using both a traditional and specialty source. Nitrogen rate will also be evaluated to determine impact of N rate on yield and quality. This is important as Woolfolk et al., (2002) reported linear response to N rate up to 34 kg N ha^{-1} and most low salt N fertilizers are not being recommended at rates more than 18 L ha^{-1} or 7.6 kg N ha^{-1}. Liquid UAN will be used as the traditional N source, a caveat however that is both N sources were applied mixed with water to achieve a flow rate of 93.8 L/ha. This was done in an effort to reduce the potential for tissue damage when the N is applied mid-day. The low-salt product used will be a controlled release liquid fertilizer produced for agricultural use that only contains N and is readily available in Oklahoma, in this case, CoRoN 25-0-0.

The trials were established at two locations Lahoma and LCB, and consisted of 14 treatments arranged in a RCBD, Table 1 shows treatment structure. Duster and Okfield were the varieties planted at Lahoma and LCB respectively. At harvest a sub-sample of grain was collected from each plot and sent to the USDA ARS Baking and Milling Lab in Manhattan KS for evaluation of treatment impact on quality.

Treatment	Rate (kg N ha)	Source	Timing
1	Check	Unfertilized Check	
2	Rec Fert $		
3	6.7	UAN	Flag Leaf
4	13.4	UAN	Flag Leaf
5	26.8	UAN	Flag Leaf
6	6.7	CoRoN	Flag Leaf
7	13.4	CoRoN	Flag Leaf
8	26.8	CoRoN	Flag Leaf
9	6.7	UAN	Post Anthesis
10	13.4	UAN	Post Anthesis
11	26.8	UAN	Post Anthesis
12	6.7	CoRoN	Post Anthesis
13	13.4	CoRoN	Post Anthesis
14	26.8	CoRoN	Post Anthesis

Table 1. Treatment Structure for the Impact of Foliar N on Baking and Milling Qualities of Hard Red Winter Wheat. $ Standard Fertility is based on yield goal recommendations and soil test results. The yield goal N rates at Lahoma and LCB waer 112 kg N ha^{-1} and 84 kg N ha^{-1} respectively.

The central great plains experienced a once in a life time weather pattern during the 2010-2011 cropping season. Even though the trial locations witnessed extreme heat and extended periods without rain yields obtained were better than regional averages. Yield levels and quality results differed across locations with just a single year of data no conclusions can be drawn however patterns did develop. Due to site differences each will be discussed independently.

Lahoma

The Lahoma location had been fallowed the previous season which helps explains the extremely high yields compared to the rest of the region. At this location treatment mean yields ranged from 4000-5400 kg ha^{-1}. However there was a great deal of variation across treatments so no significant difference was seen in yields. The coefficient of variation of the yields was 18. No main effects or interactions were significant. Analysis of protein showed no significant difference in protein values across treatments. All treatments receiving foliar N has protein values greater than both the check and standard fertility treatments. The treatments receiving 13.4 kg N ha^{-1} post-anthesis achieved the highest protein values. There was a significant rate*time interaction at p of .095. Yield and Protein results shown in Figure 1.

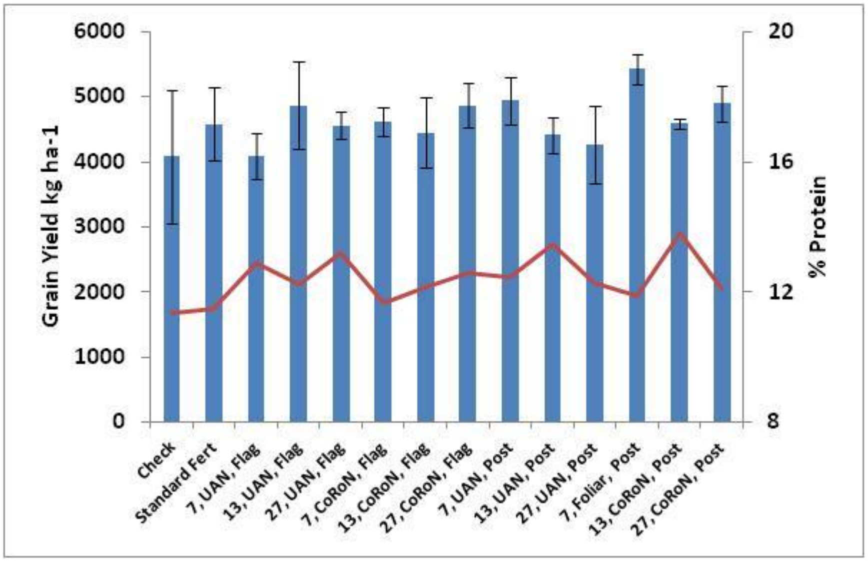

Figure 1. Grain yield (kg ha^{-1}) and protein percentage results from the Lahoma, OK location. Error bars represent standard error of each treatment. Treatment titles shown as nitrogen rate in kg N ha^{-1}, nitrogen source, and application timing.

Mixing tolerance is a ranked value with a score from 0-6, values above 3 are preferred. The results from the Lahoma wheat samples showed significant difference across treatments. Three treatments fell below the industry preference, 27 kg N ha^{-1} CoRoN post-anthesis, 13 kg N ha^{-1} CoRoN flag leaf, and the check. The treatments receiving 13.4 kg N ha^{-1} post-anthesis and the 7 kg N ha^{-1} UAN at flag leaf had the highest mixing tolerance scores, Figure 2. Source was significant at .0013, with UAN at 3.67 and CoRoN at 2.94. Also rate*time interaction was significant at .0091.

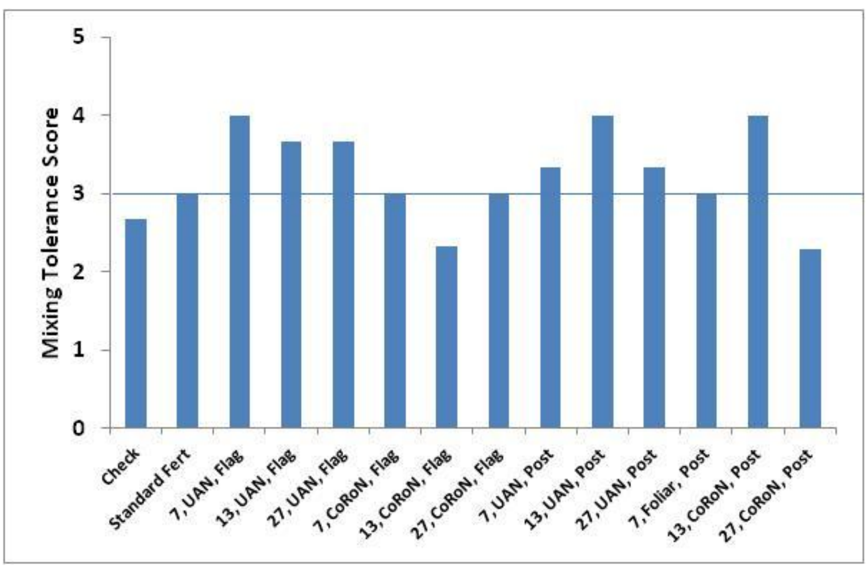

Figure 2. Mixing Tolerance Score results from the grain collected at the Lahoma Ok, location. Hard winter wheat quality targets committee recommends a target value of 3 or greater. The blue horizontal line shows the recommended level. Treatment titles shown as nitrogen rate in kg N ha^{-1}, nitrogen source, and application timing.

The Hard Winter Wheat Quality Targets Committee gives a recommended target Loaf Volume of 850 cc or greater. At the Lahoma location only one treatment yielded a loaf volume sufficient to meet the committee's recommendation, 13 kg N ha^{-1} CoRoN applied post anthesis, Figure 3. There was no significant main effect or interactions with the Loaf Volume data from Lahoma.

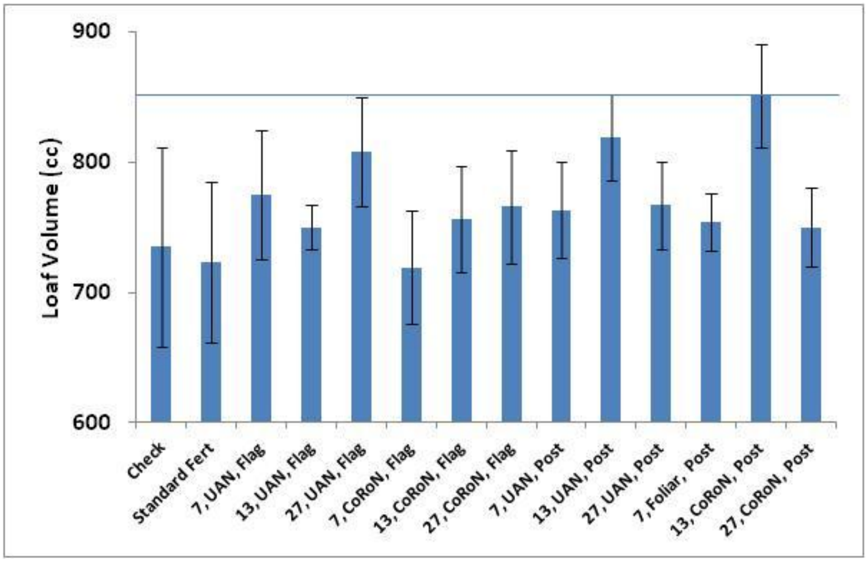

Figure 3. Loaf Volume, measured in cc, results from the grain collected at the Lahoma Ok, location. Error bars represent standard error of each treatment. Hard winter wheat quality targets committee recommends a target value of 850cc or greater. The blue horizontal line shows the recommended level. Treatment titles shown as nitrogen rate in kg N ha^{-1}, nitrogen source, and application timing.

Lake Carl Blackwell (LCB)

The LCB location is located near Stillwater and sets on a lower class of soils that will typically have lower yields than the Lahoma site. The 2011 harvest resulted in a range of yields from 1700 to 2200 kg ha^{-1}. There was no significant difference in yields across treatments however the check and standard fertility treatments did result in the lowest yields Figure 4. The protein data from LCB showed results of which could be considered expected. Standard fertility significantly increased protein above the check while all foliar N treatments increased protein above the level of the standard practice. Five of the six treatments with the highest protein levels were the foliar applications made at post anthesis. The treatment of 27 kg N ha^{-1} UAN post-anthesis resulted in a 1% increase in protein over the standard fertility treatment. Time as a main effect was significant at a .101.

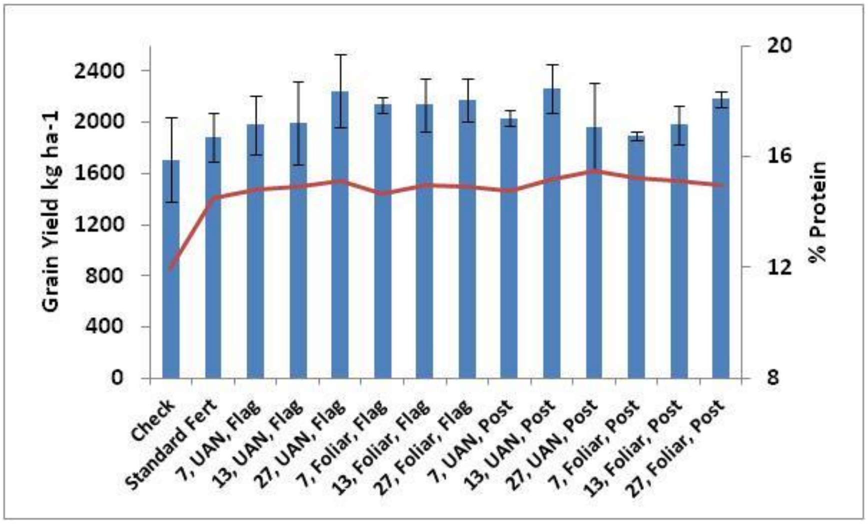

Figure 4. Grain yield and protein percentage results from the LCB, OK location. Error bars represent standard error of each treatment. Treatment titles shown as nitrogen rate in kg N ha^{-1}, nitrogen source, and application timing.

While protein levels at LCB where quite good, 14.5 to 15.5 %, all of the treatments yielded a below par mixing tolerance with scores ranging from 1.3 to 2.0. Neither significant differences nor trends were found across the mixing tolerance data.

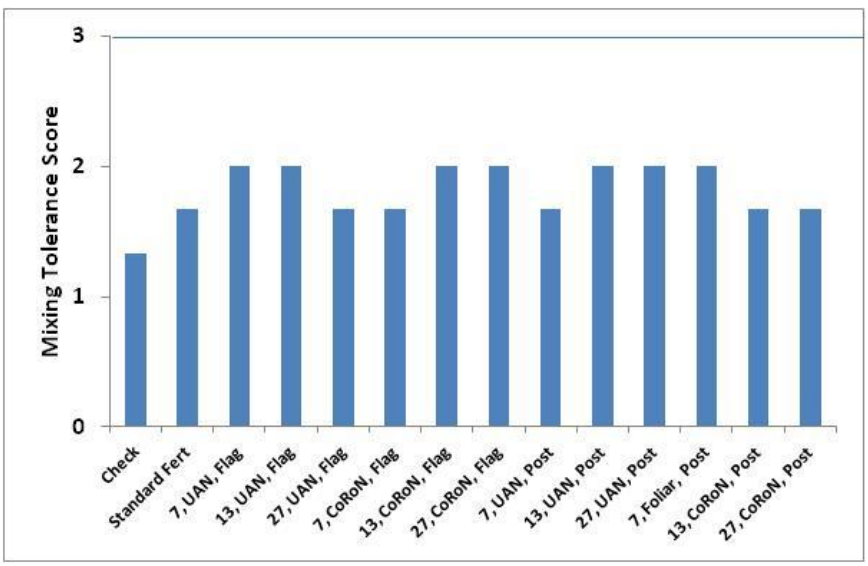

Figure 5. Mixing Tolerance Score results from the grain collected at the Lahoma Ok, location. Hard winter wheat quality targets committee recommends a target value of 3 for greater. The blue horizontal line shows the recommended level. Treatment titles shown as nitrogen rate in kg N ha^{-1}, nitrogen source, and application timing.

As with the protein data 5 of the 6 treatments with the greatest loaf volumes included applied post anthesis. All treatments receiving fertilizer increased the volume above the recommended level of 850 cc. Additionally all treatments receiving foliar N have loaf volumes greater than the standard fertility. While there was no significant difference between the standard fertility and 27 kg N ha^{-1} UAN post-anthesis, the late application did increase volume by 55 cc.

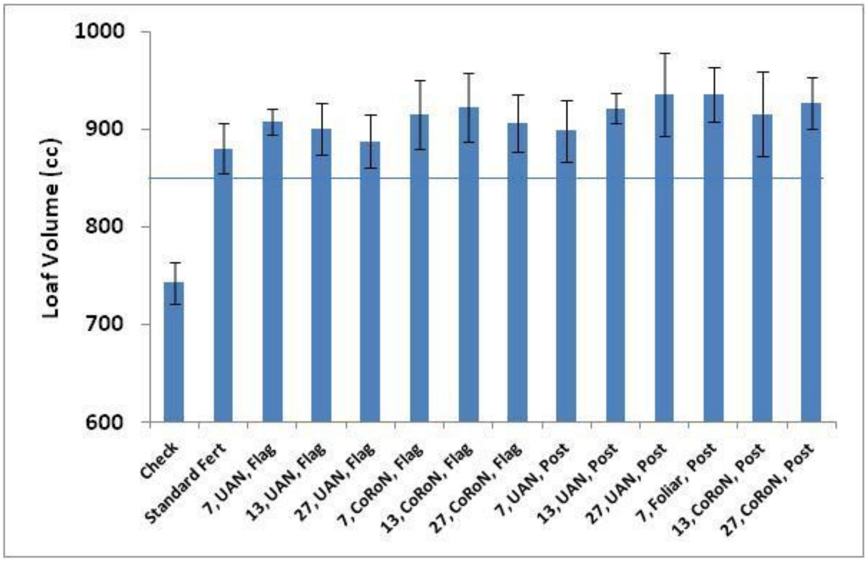

Figure 6. Loaf Volume, measured in cc, results from the grain collected at the Lahoma Ok, location. Hard winter wheat quality targets committee recommends a target value of 850cc or greater. The blue horizontal line shows the recommended level. Error bars represent standard error of each treatment. Treatment titles shown as nitrogen rate in kg N ha^{-1}, nitrogen source, and application timing.

Discussion

A note on procedures is that at both locations all foliar treatments were applied midday. On the day of application daily average temperatures ranged from 60 to 75° F with temperature at application being between 75 to 85° F. Even with the high temperatures no leaf burn was observed from any of the nitrogen applications.

Across both locations no evident trends in grain yields developed but trends where found in the grain protein results. Lack of response in yield due to late season applications of N is not unexpected, especially considering the environment. Extreme heat and drought during the spring and summer drew soil moisture from depth, likely contributing a great deal of additional NO_3 during periods of stem elongation through grain fill. The lack of consistent grain protein results from the Lahoma location tends to support this hypothesis. While there was significant difference in mixing tolerance scores across treatments at Lahoma no conclusions can be drawn on which timing rate or source may lead to an improved score above the standard fertility treatment. Loaf volume results are very positive and indicate a potential increase volume with foliar applied N. While results were not consistent across sites the data does suggest that nitrogen applied post anthesis may lead to a higher likelihood of volume increase.

As is often the case in field experiments no final conclusions can be drawn from a single years worth of data. The extremes of the past cropping season may have lent to even further complicate the results. The 2011-2012 winter wheat crop is in the ground with a good stand at both locations. The 2012 results are highly anticipated as an added year of data will likely lead to a better understanding.