NITROGEN MANAGEMEMT IN DRYLAND WINTER WHEAT TO IMPROVE GRAIN YIELD AND PROTEIN

Deepak Ghimire* and Bijesh Maharjan
University of Nebraska-Lincoln, Lincoln, NE
*deepak@huksers.unl.edu, Tel: (402)853-9527

ABSTRACT

Maximizing the yield along with adequate protein content in winter wheat is an emerging challenge for dryland wheat producers. Proper nitrogen (N) management with optimization of fertilizer application rate and timing might be a potential strategy to improve grain yield and protein. The objective of the study was to evaluate the effects of different N rates and application timing on grain yield and protein content of hard red winter wheat in Nebraska. Field study was carried out at four locations across the state in a split-plot design with six N rates and three application timings. The results showed that N rates had significant effect on grain yield and protein content at all locations except for grain yield at one of the locations. Regression analysis showed that the grain yield response and grain protein response to fertilizer N was closely described by significant linear regression equations at two out of three locations. Further, the results revealed that application timing of fertilizer N had no significant effect on grain yield or protein at two out of three locations. The presented results from the first year of the study suggest a potential gain in grain yield and protein with a relatively higher N fertilizer rates.

INTRODUCTION

Hard red winter (HRW) wheat (*Triticum aestivum* L.) is an important class of wheat in terms of production and market. HRW wheat accounts for almost 40% of the total wheat production in United States (Tilley et al. 2012). Moderately high protein content (11-12%) in HRW wheat makes it well suited for preparation of wide range of flour based products (Gibson and Newsham, 2018). Moreover, the grain protein is used as a criteria to determine the price of wheat grains in market. Wheat producers lose income as a discount kicks at protein levels below 10%-11% depending on the elevator.

Despite high yields in the 2016 Nebraska wheat crop, low protein levels caused an estimated $2.3 million to $9.6 million loss in income (personal communication, grain elevator personnel). Similar low protein issues persisted in 2017. Improving the yield along with adequate protein content is an emerging challenge for dryland wheat producers. Among many potential factors, soil nitrogen (N) is probably the most central factor that affected protein (Zorb et al. 2018). Previous studies have reported that optimizing fertilizer N application rate and time may potentially contribute to an increased yield along with desirable protein level (Ma et al., 2019; Abedi et al., 2011; Bole and Dubetz, 1986). Therefore, further investigation about the effect of soil N on wheat grain yield and protein content is imperative. A two-year study was started in fall of 2018 at four different locations in Nebraska with an objective to evaluate effects of the combination of different rates and application timing of N on grain yield and quality of HRW wheat.

MATERIALS AND METHODS

Field study was carried out at four different research stations located across Nebraska (Mead, Grant, Sidney and Scottsbluff) in 2018/19. The wheat plots at Scottsbluff were damaged by hail and therefore no data presented. At all locations, the experimental layout was split plot randomized complete block design with four replications. The main plot factor was wheat variety (Ruth and Freeman). The sub plot factor was combination of: Three fertilizer N application timing - 100% in fall, 100% in spring and Split (30% in fall and 70% in spring) and six N rate (0, 25%, 50%, 75%, 100% and 125% of recommended N rate). The recommended N rate was 80 lbs acre^{-1} at Mead and 60 lbs acre^{-1} at other three locations.

Ammonium nitrate (34-0-0) was used as fertilizer and was surface broadcasted by hand in the plots. The fall application of N was done at around two weeks after planting and the spring application was done at around Feeks-5 stage of wheat. The average yield per plot was recorded by the harvest-master during harvest and was adjusted to 12% moisture. The protein analysis of whole grains was carried out using DA 7250™ NIR analyzer (Perten Instruments) and reported on dry basis. Pre-plant and post-harvest soil sampling was done at three different soil depths (0-8, 8-24 and 24-48 inches) to account for residual soil N.

Effects of variety, N rate and application timing on yield and protein was determined using Proc Mixed in SAS (SAS Institute, Cary, NC) with N rate and N timing as the fixed effects and block and all interactions of block with other terms as random effects (Little et al. 2006). Comparisons of the means was conducted by comparing differences in least-square means in SAS. Differences were considered as significantly different at $P < 0.05$. Regression relationship between N rate and yield and N rate and protein was analyzed in MS Excel.

RESULTS AND DISCUSSION

The mean values of grain yield and protein for different treatment factors are presented in Table 1. No significant interactions between the treatments was observed.

Table 1: Effect of variety, N rates and application timing on grain yield and protein

Treatments		***Yield (bu acre^{-1})***			***Grain Protein (%, dry basis)***		
		Grant	Mead	Sidney	Grant	Mead	Sidney
Variety	Ruth	94.22^{a}	61.5^{b}	38.17^{b}	10.98^{a}	12.58^{a}	11.28^{a}
	Freeman	95.03^{a}	71.3^{a}	44.14^{a}	10.64^{a}	12.29^{a}	10.93^{b}
N Rate	0%	87.35^{d}	67.7^{a}	30.94^{d}	10.36^{cd}	11.60^{c}	11.05^{b}
	25%	91.85^{c}	67.3^{a}	33.84^{d}	10.17^{d}	12.18^{b}	11.05^{b}
	50%	92.47^{c}	66.9^{a}	39.49^{c}	10.72^{bc}	12.25^{b}	10.95^{b}
	75%	96.79^{b}	67.6^{a}	42.21^{c}	10.82^{b}	12.41^{b}	10.98^{b}
	100%	96.76^{b}	64.1^{a}	47.91^{b}	11.26^{a}	12.95^{a}	11.19^{ab}
	125%	102.54^{a}	65.0^{a}	52.51^{a}	11.51^{a}	13.21^{a}	11.43^{a}
Application timing	Fall	92.34^{b}	66.5^{a}	41.56^{a}	10.75^{a}	12.29^{a}	11.08^{a}
	Split	95.81^{a}	67.2^{a}	42.08^{a}	10.80^{a}	12.41^{a}	11.21^{a}
	Spring	95.73^{a}	65.5^{a}	39.81^{a}	10.87^{a}	12.60^{a}	11.04^{a}

Values in the same treatment fraction followed by different letter denotes significant differences at $P<0.05$ for the given location in column

Grain yield response to N fertilizer rate and application timing

The results showed that N rates had significant effect on grain yield at Grant and Sidney but a non-significant effect at Mead (Table 1). At Grant and Sidney, all the N applied plots had significantly higher yields compared to the control plots. Regression analysis results showed that the grain yield response to fertilizer N was closely described by significant linear regression equations ($r^2 = 0.9399$, $p < 0.01$ and $r^2 = 0.9915$, $p < 0.0001$ at Grant and Sidney, respectively) (Figure 1 & 2) where yield increased with the increasing N rates. The wet spring this year could have resulted in good grain yield across N treatments. The availability of water during critical growth stages has shown to enhance the N use efficiency in wheat (Ma et al., 2019). Similar results of yield improvement with N fertilization have been reported in previous studies (Bhatta et al., 2017; De Silva et al., 2018).

The indifferent yield among N treatments at Mead might be because of Fusarium Head Blight (FHB), among other factors. Severe infestation of FHB was reported around the study location. Lemmens et al (2003) have reported that the severity of FHB could be higher in wheat fertilized with higher N rates and thereby potentially reducing the yield.

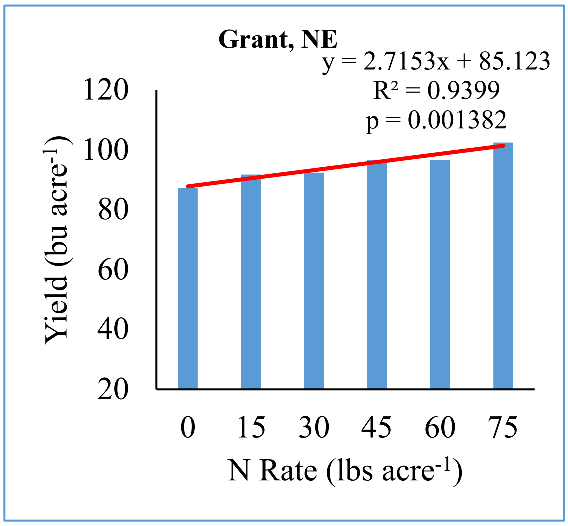

Fig. 1: Grain yield as affected by N rates

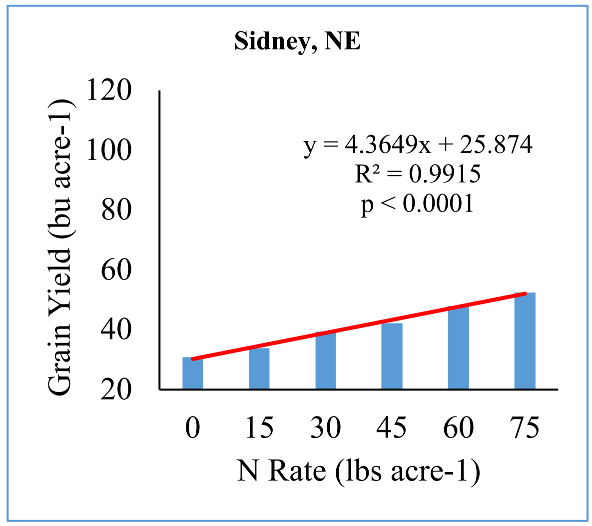

Fig. 2: Grain yield as affected by N rates

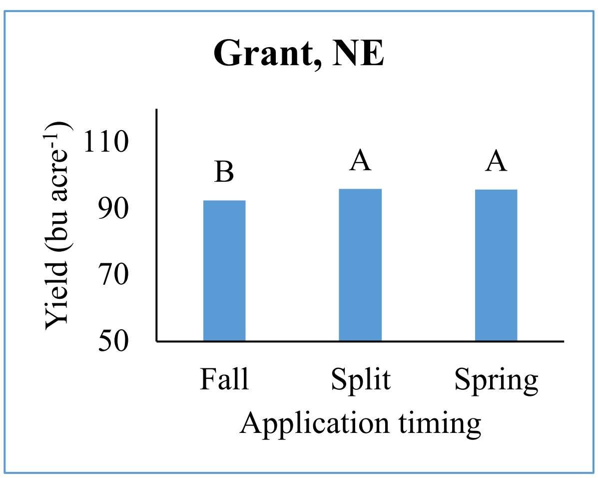

Fig. 3: Grain yield as affected by application time

Further, the results showed that N fertilizer application timing had no significant effect on the grain yield except for Grant (Table 1). At Grant, the split and spring N applied plots were found to have significantly higher yield compared to the plots with N applied in fall (Figure 3). Most of the N uptake by wheat occurs during stem elongation and N application prior to this stage has higher loss potential (Zebarth et al., 2007). This might have resulted in lower yield for fall N applied plots at Grant.

Grain protein response to N fertilizer rate and application timing

The results revealed that N rates had significant effect on grain protein at all locations (Table 1). Results of linear regression analysis showed that the grain protein response to fertilizer N was closely described by significant linear regression equations at Mead ($r^2 = 0.9492$, $p < 0.001$) and Grant ($r^2 = 0.9051$, $p < 0.01$) (Figure 4 & 5). The plots applied with higher N had greater protein compared to low or no N applied plots. However, the highest protein level was always below 12% at Grant and Sidney. In contrast, higher grain protein levels (>12 %) were achieved at all N applied plots at Mead with the highest (13.21%) in plot applied with 100 lbs N $acre^{-1}$.

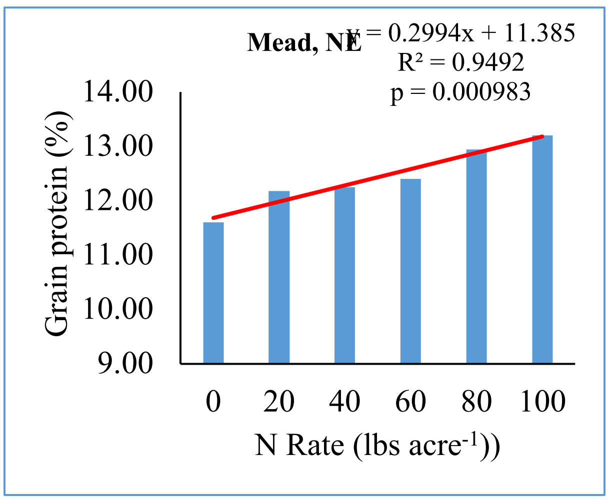

Fig. 4: Grain protein as affected by N rates

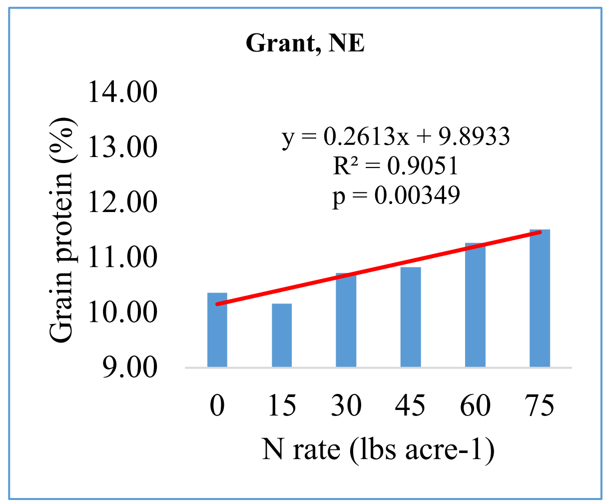

Fig. 5: Grain protein as affected by N rates

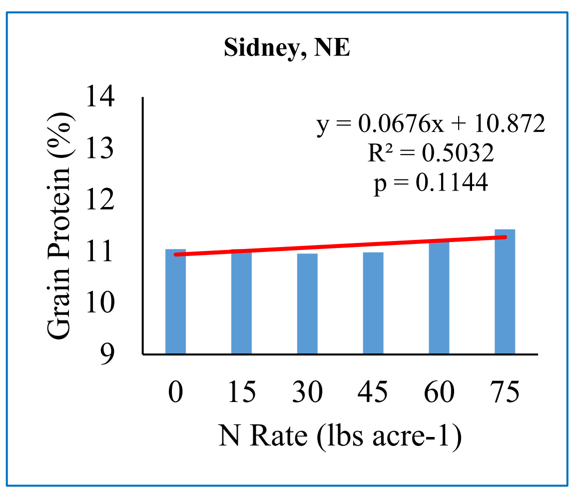

Fig. 5: Grain protein as affected by N rates

No significant difference was observed in grain protein among the N fertilizer application timing at all locations. In contrast, studies (Zebarth et al., 2007; Weber et al., 2008)) have reported an increase in grain protein with delayed fertilizer N application. The currently study considered Feeks-5 as the late N application time while the fore-mentioned researches have considered N application at more later stages which might be the reason for the contrasting results.

SUMMARY

As indicated by the results, the grain yield and protein content of hard red winter wheat is likely to be improved by the application of optimum nitrogen rates. However, the application timing showed limited response on grain yield and protein. These results justify for further investigation in coming years to get a clear picture of the N treatment effects on wheat yield and protein.

REFERENCES

Abedi, T., A. Alemzadeh, and S.A. Kazemeini. 2011. Wheat yield and grain protein response to nitrogen amount and timing. Aus. J. Crop Sci. 5 (3): 330-336

Bhatta, M., K.M. Eskridge, D.J. Rose, D.K. Santra, P.S. Baenziger, et al. 2017. Seeding Rate, Genotype, and Topdressed Nitrogen Effects on Yield and Agronomic Characteristics of Winter Wheat. Crop Science 57(2): 951–963. doi: 10.2135/cropsci2016.02.0103.

Bole, J.B., and S. Dubetz. 1986. Effect of irrigation and nitrogen fertilizer on the yield and protein content of soft white spring wheat. Can. J. Plant Sci. 66(2): 281–289. doi: 10.4141/cjps86-041.

De Silva, S.H.N.P., T. Takahashi, and K. Okada. 2018. Controlling Yield and Grain Protein Content of Wheat in Japan through Pre-Anthesis Nitrogen Application to Maximize Producers' Profit. JARQ 52(3): 205–217. doi: 10.6090/jarq.52.205.

Gibson, M., and P. Newsham. 2018. Bread. Food Science and the Culinary Arts. Elsevier. p. 121–131

Lemmens, M., K. Haim, H. Lew, and P. Ruckenbauer. 2004. The Effect of Nitrogen Fertilization on *Fusarium* Head Blight Development and Deoxynivalenol Contamination in Wheat: Impact of Nitrogen Fertilization. Journal of Phytopathology 152(1): 1–8. doi: 10.1046/j.1439-0434.2003.00791.x.

Tilley, M., Y.R. Chen, and R.A. Miller. 2012. Wheat breeding and quality evaluation in the US. Breadmaking. Elsevier. p. 216–236

Weber, E.A., S. Graeff, W.-D. Koller, W. Hermann, N. Merkt, et al. 2008. Impact of nitrogen amount and timing on the potential of acrylamide formation in winter wheat (Triticum aestivum L.). Field Crops Research 106(1): 44–52. doi: 10.1016/j.fcr.2007.10.011.

Zebarth, B.J., E.J. Botha, and H. Rees. 2007. Rate and time of fertilizer nitrogen application on yield, protein and apparent efficiency of fertilizer nitrogen use of spring wheat. Can. J. Plant Sci. 87(4): 709–718. doi: 10.4141/CJPS06001.

Zörb, C., U. Ludewig, and M.J. Hawkesford. 2018. Perspective on Wheat Yield and Quality with Reduced Nitrogen Supply. Trends in Plant Science 23(11): 1029–1037. doi: 10.1016/j.tplants.2018.08.012.