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Capturing the Genetic Protein Potential in Winter Wheat

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Introduction

Montana wheat producers are interested in high protein varieties to take advantage of premium price opportunities. Unfortunately, if yield increases, the protein level typically decreases and visa versa. ‘McGuire’ is an MSU released variety developed as a high protein winter wheat. An optimum fertility program coupled with late season applications of N fertilizer can boost protein in spring wheat grain. Nitrogen (N) is a building block of protein, and sufficient N must be obtained from the soil and other sources in order to produce high protein grain.

Tindall and others in Idaho found that spring wheat producers in the PNW frequently apply topdress N to increase grain protein content. However, these late N applications are often made with little knowledge regarding the potential of obtaining significant increases in yield or grain protein content. Applying excessive amounts of N fertilizer reduces fertilizer use efficiency, and increases nitrate leaching potential. Consequently, there is a need for a simple diagnostic method for evaluating the likelihood of a profitable response to topdressed N. Similarly in Montana, "most often, producers are not able to document the effectiveness of late-season N and take it on faith that the extra effort represents ‘dollars well spent’." Irrigated spring wheat studies have shown an increase in protein of 0.5 to 2.0 percentage points, when initial N was optimal for yield (Fertilizer Facts 11).

One method of evaluating the protein response likelihood of topdress N is to measure total Kjeldahl nitrogen (TKN or total plant N) in flag leaves at heading. As the crop matures, N decreases in the flag leaf and accumulates in the grain. When levels are deficient, topdress N applications result in a substantial increase in grain protein. SPAD meter (chlorophyll) readings can also be used to determine whether plant N levels are deficient, since chlorophyll is an N-based compound.

Each wheat variety has a different genetic yield and protein potential. Some varieties are developed for insect resistance or high yield, for example. McGuire was developed as a high protein winter wheat. A study was undertaken to investigate the responsiveness of new and standard winter wheat varieties to N application.

Methodology

The study was conducted for two years at the Post Farm outside Bozeman at Montana State University (high rainfall), and at the Central Agricultural Research Center at Moccasin (dryland). Judith and McGuire winter wheat varieties were used. A randomized strip split-plot design was used in the study, an exception being one site year where the two varieties were not randomized. Urea was applied (0, 30, 60 and 90 lbs N/a) in early spring when wheat broke dormancy. Plots were split, and randomized halves received 30 lbs of additional N/a topdress at tillering. At heading, measurements were taken for flag leaf TKN, and SPAD meter (chlorophyll level). At harvest, yield, and grain protein were measured (test weight had no differences, data not reported).

Results and Discussion

At the Post Farm, pre-plant soil N was 171 lbs N/a for the 1997 harvest year, and 210 lbs N/a for 1998. An additional 37 lbs N/a was added before seeding. Estimates of soil N at the Moccasin sites were lower, 125 lbs N/a in 1997 and

35 lbs N/a in 1998. The growing conditions were characterized as good at the Post Farm, and more typical for dryland Montana producers at Moccasin.

Yield Response to Early Spring N

At Moccasin, both Judith and McGuire showed increasing yields due to early spring N (Table 1). Averaged over treatments (at the Moccasin sites), Judith's yield was 10.5 bu/a greater than McGuire's.

To minimize the impact of site and year variability in comparing grain yield, the yield values from the four site years were normalized by dividing each yield value by the greatest yield value in its site year and variety (Figure 1). Crops grown at the high rainfall, N-rich Post Farm, understandably, had little relationship with early spring N treatments (not presented), but at the dryland site, typical yield response curves were observed.

Grain Protein Response to Early Spring N

Similar to the yield response, Judith and McGuire at Moccasin showed increasing grain protein due to early spring N (Table 1). McGuire harvested grain averaged 1.8% higher protein than Judith. On average, about 20 lbs N/a was required to increase grain protein by 1% (22.5 lbs N for

Table 1. Yield and grain protein response of Judith and McGuire winter wheat to early spring and topdress N at both locations averaged over two years.

		Moccasin Sites				Post Farm Sites			
		Judith		McGuire		Judith		McGuire	
Early Spring N	Topdress N	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein
--lbs N/a--	--lbs N/a--	-bu/a-	--%--	-bu/a-	--%--	-bu/a-	--%--	-bu/a-	--%--
0	0	37.6	7.6	28.2	9.0	86.8	12.4	74.3	15.3
0	30	52.4	8.9	44.8	10.4	94.1	12.3	76.1	15.4
30	0	53.0	8.8	43.4	10.4	92.1	12.2	74.5	15.1
30	30	60.9	10.1	53.3	12.2	90.3	12.4	79.0	15.3
60	0	62.9	10.4	52.8	12.1	89.3	12.5	76.2	14.8
60	30	66.5	11.7	54.4	13.5	91.1	12.6	80.2	15.3
90	0	70.7	11.5	57.6	13.7	95.3	12.5	79.1	15.4
90	30	71.6	12.8	57.0	14.7	91.9	12.5	76.1	15.2

Judith and 20 lbs N for McGuire).

Similar to the yield data, to minimize the impact of site and year variability in comparing grain protein, the protein values from the four site years were normalized by dividing each protein value by the greatest protein value in its site year and variety. Normalized data showed strong linear responses to early spring N (Figure 2). At the dryer, less nutrient rich Moccasin sites, a much stronger response to early spring N was observed. Judith and McGuire were similar in this response.

Relationship of Grain Protein and Flag Leaf TKN

Flag leaf TKN is a key diagnostic measure of N status, and can indicate the likelihood of additional N increasing grain protein. Inherent in winter wheat production is increased variability compared to spring wheat, as there are two growing seasons and a dormant period. This can increase the benefit of late season topdress, as many of the problems facing winter wheat occur prior to heading. A reasonably strong relationship between flag leaf TKN and grain protein (Figure 3) was observed. The line for McGuire has a steeper slope than that for Judith, demonstrating its greater potential for translocation of plant N (i.e., flag leaf N) into grain protein. For each 0.1% increase in flag leaf TKN, Judith and McGuire increased protein by 0.26% and 0.55%, respectively.

Relationship of Topdress to Grain Protein and Flag Leaf TKN

In general, topdress fertilizer increased grain protein at harvest (Table 1). Moccasin was the site with consistent protein responses. Judith increased 1.3% for each increment of early spring N. McGuire's response peaked with the first 30 lbs N/a increment and then declined with higher initial N. Overall, McGuire's response to topdress was greater than Judith's by 0.13 percentage points.

Fairly strong relationships, shown in Figure 4, were found betweenflag leaf TKN and grain protein increase due to topdress N (Judith, R^2 = 0.55; McGuire, R^2 = 0.67). The steeper slope for McGuire (Figure 4) demonstrates its genetic predisposition to respond well with increased protein to fertilizer N.

One aspect that should be pointed out is the curious intersection at 4.2% flag leaf TKN between Judith and McGuire. Our previous work with irrigated spring wheat found a threshold value at this same point. This previous study (summarized in Fertilizer Facts 12) found that if flag leaf TKN was below this value, N application often increased grain protein. Our data is much more limited in scope, but the similarity to our past research is striking.

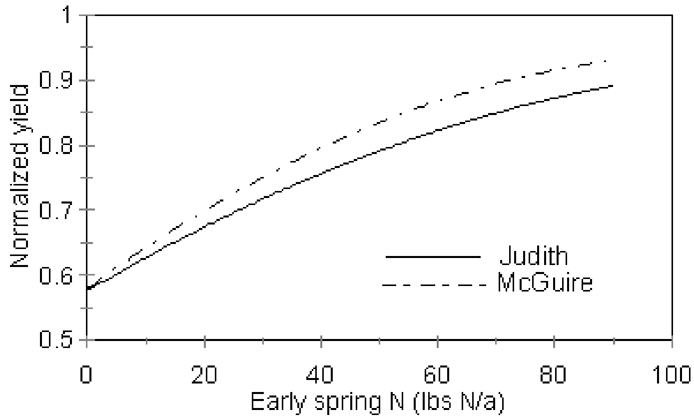
Fertilizer Facts:

Variety selection and optimum management practices must be integrated for good production enterprises

McGuire winter wheat is more responsive to early season and late season applied N compared to a standard variety, Judith.

Flag leaf TKN provides a good diagnostic tool for determining the likelihood of a grain protein response.

SPAD meter readings were not a reliable tool to predict protein response in winter wheat.



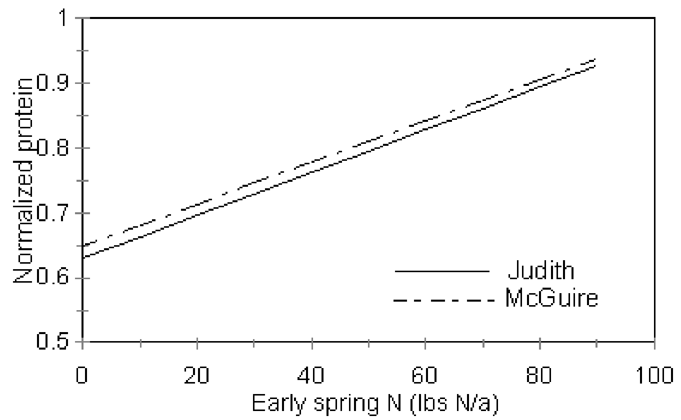
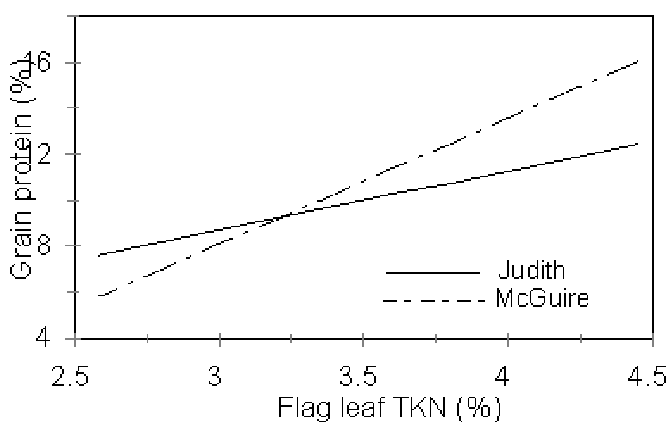


Figure 1. Yield response of Judith and McGuire winter wheat to early season N at Moccasin sites. Judith: $y = 0.58 + 0.0053x - 0.00002x^2$, $R^2 = 0.77$; McGuire: $y = 0.58 + 0.0066x - 0.00003x^2$, $R^2 = 0.65$.

Figure 2. Protein response of McGuire and Judith winter wheat to early season N at Moccasin sites. Judith: $y = 0.0033 x + 0.63$; $R^2 = 0.78$, McGuire: $y = 0.0032 x + 0.65$; $R^2 = 0.79$.



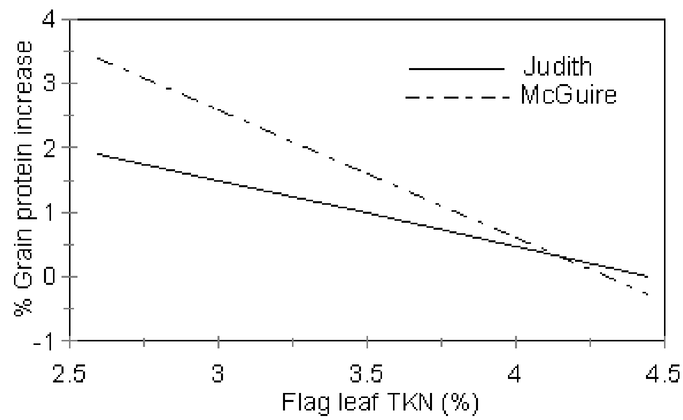


Figure 3. Relationship between flag leaf TKN at heading and grain protein from Moccasin and Post Farm over two years. Judith: $y = 0.89 + 2.6 x$, $R^2 = 0.51$; McGuire: $y = -8.4 + 5.5 x$, $R^2 = 0.61$.

Figure 4. Relationship between flag leaf TKN at heading and average grain protein from all four site years. Judith: $y = 4.6 -1.0 x$, $R^2 = 0.55$; McGuire: $y = 8.5 - 2.0 x$, $R^2 = 0.67$.

Edited by Jeff Jacobsen, Extension Soil Scientist