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Post-Harvest Evaluation of N Management for Spring Wheat Using Grain Protein

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Nitrogen (N) is the nutrient most often limiting spring wheat yields and protein levels in Montana and the Northern Great Plains. Since the soils of this region were first cultivated (late 1800s), occurrences of N deficiency have increased over time. This can be attributed to the depletion of indigenous soil N reserves with declining organic matter levels, crop removal, and erosion processes. In addition, variety development efforts and improved cultural practices to conserve water (reduced tillage) and control weeds have led to higher yield potentials with greater plant N requirements.

Historically, soil analysis has been used to predict potential N deficiency problems and characterize available N status. However, routine use of soil analysis by dryland wheat farmers in Montana and other Great Plains regions is very low. In an effort to promote soil N analysis, researchers in Colorado proposed the idea of using grain protein as a bioassay, or biological indicator, of soil N fertility. This approach is based on the finding that a consistent relationship existed between yield (expressed in relative terms) and grain protein in winter wheat, and that from this relationship a critical protein level (11.5%) could be established for partitioning wheat yields into N deficient and N sufficient categories.

This fact sheet summarizes the results of a spring wheat study conducted in Montana. The objective was to determine whether a consistent relationship exists between yield and grain protein in spring wheat, and to determine if a critical level could be established for diagnosing N nutrition (deficient versus adequate).

A 3-year (1996-1998) field study was conducted near Havre, Montana at the Northern Agricultural Research Center. Soil NO_3-N test levels were 8, 40, 41 lbs/a (0-24 in. depth) in 1996, 1997, and 1998, respectively. A solid-set irrigation system was used to create three distinct water environments: Low water regime — wheat was grown under dryland conditions, except for a single application shortly after crop emergence (approximately 2.5 in for stand establishment); Moderate water regime — wheat received a single application after crop emergence, plus two irrigations during the vegetative growth period (late tillering and heading); and High water regime — wheat received irrigation as in the moderate regime, plus one irrigation during grainfill (2 events in 1996, 1 event in 1997 and 1998). Within each water regime, four spring wheat varieties (Amidon, Hi-Line, McNeal, Rambo) were seeded in combinations with five N fertilizer levels (low regime: 0, 25, 50, 100, and 150 lbs N/a; moderate regime: 0, 30, 60,120, and 180 lbs N/a; high regime: 0, 35, 70, 140, and 210 lbs N/a).

Due to the water gradient from irrigation and N fertilizer application rates, a wide range of grain yield and protein levels were observed. Over the three growing seasons, grain yield and grain protein concentrations varied from 19 to 77 bu/a and 10 to 20%, respectively. Grain yield (bu/a) versus protein (%) curves for 1996 (Figure 1) illustrate how the relationship between these two measured variables change with applied water and N. Data from 1997 and 1998 is not presented, but expresses similar relationships to those in 1996. Under the highest water stress conditions (low regime), the first increments of applied N (25 lbs/a) produced small increases in grain yield and protein. Thereafter, N fertility increased protein without a corresponding increase in yield, producing a flat curve. As water increased, larger yield responses were observed from the first increment of applied N for the moderate (30 lbs N/a) and high (35 lbs N/a) regimes, respectively. As anticipated, yield increased as water availability increased. The initial increases in grain yield were sometimes accompanied by a small drop in protein concentration, before protein increased with improving N nutrition, producing a C-shaped curve or "Steenbjerg" effect. Grain yield increases with N were greater with the high water regime compared to either moderate or low regimes.

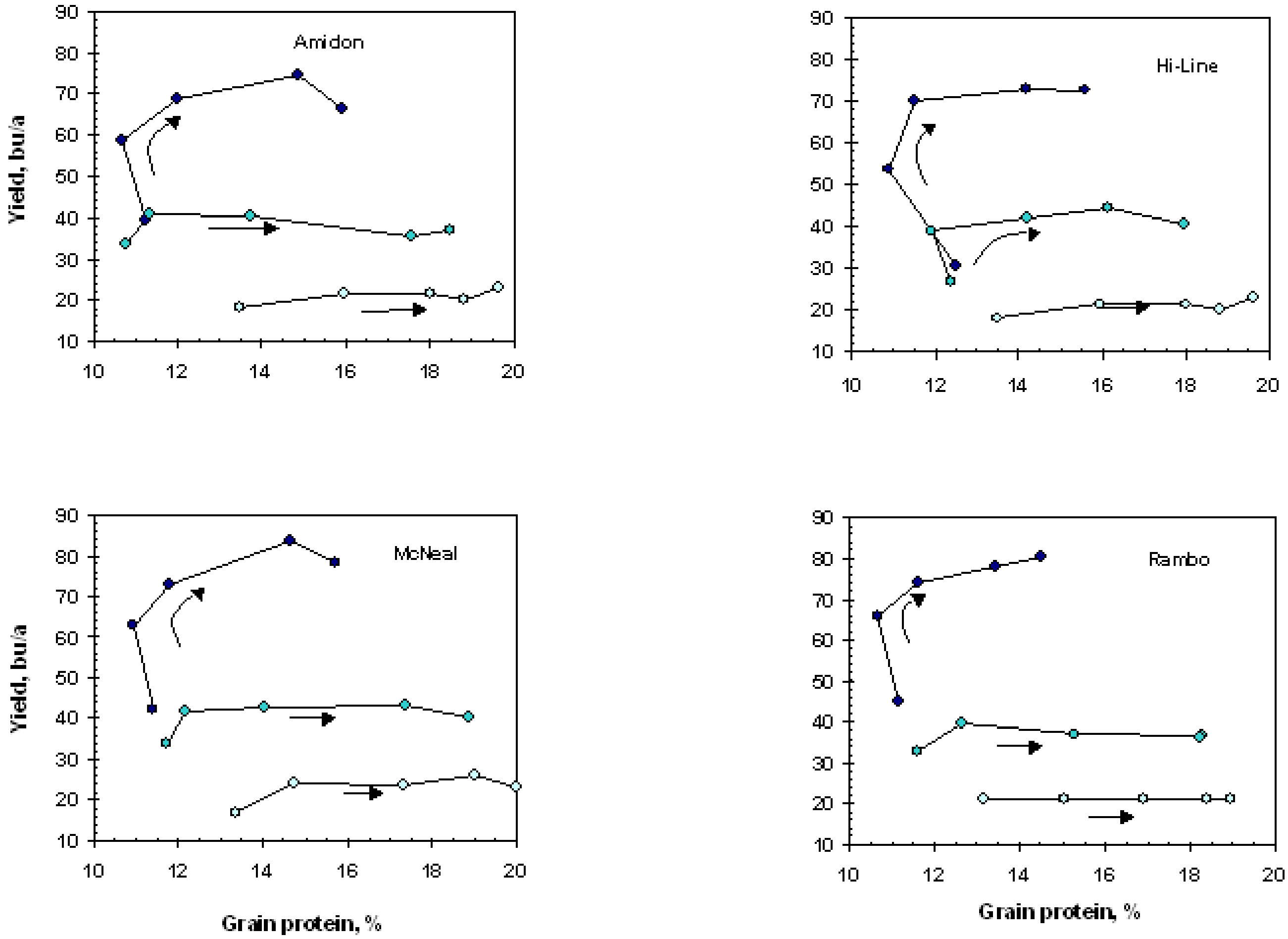
Expressing grain yield in relative terms, or as a percent of the maximum grain yield, provides a technique to include all of the relationships across the water regimes in this study. Plateau grain yield (100%) was equal to the mean grain yield of N rate(s) not significantly (0.05 level) different from the highest yielding N treatment. Scatter diagrams of relative grain yield versus grain protein (Figure 2) produced a plot similar to those presented by investigators in Colorado. Two things are evident from this scatter diagram. First, insufficient N nutrition rarely reduced grain yield where protein levels exceeded 13.2%. Out of 118 data points where protein exceeded 13.2%, grain yield was at or near the maximum in 106 cases. Second, where protein concentrations were less than 13.2%, grain yield losses due to N deficiency occurred with great frequency. Out of 62 data points where protein was less than 13.2%, grain yield was less than the maximum in 54 cases.

Although the magnitude of yield losses from N deficiency cannot be predicted from protein concentrations, there are many practical applications of this study. Most growers have excellent records (or memories) of protein histories for their fields. Grain protein levels provide a useful qualitative indicator of a grower's N fertilizer program when contrasted with an established critical level, or 13.2% for Montana hard red spring wheat. Consequently, growers with a history of low protein wheat, i.e., below the critical level, can see through protein analyses whether their fields are in need of additional fertilizer N. In addition, growers who have not recently had their soil analyzed may be more inclined to do so in their fields which produce low protein wheat.

Fertilizer Facts:

- Grain protein in spring wheat provides a post-harvest indicator of N nutrition
- Grain protein less than or equal to 13.2% is associated with yield losses due to inadequate N nutrition
- Grain protein greater than 13.2% is associated with adequate N nutrition

Edited by Jeff Jacobsen, Extension Soil Scientist



	Water regime	Rain + irrigation (in)	N fertilizer rates (lbs/a)
o	Low	7.3	0, 25, 50, 100, 150
o	Moderate	11.5	0, 30, 60, 120, 180
o	High	16.5	0, 35, 70, 140, 210

***Figure 1**. Grain yield versus protein relationships for Amidon, Hi-Line, McNeal, and Rambo spring wheat (1996). For each curve, fertilizer N rates increase in the direction of the arrows.*

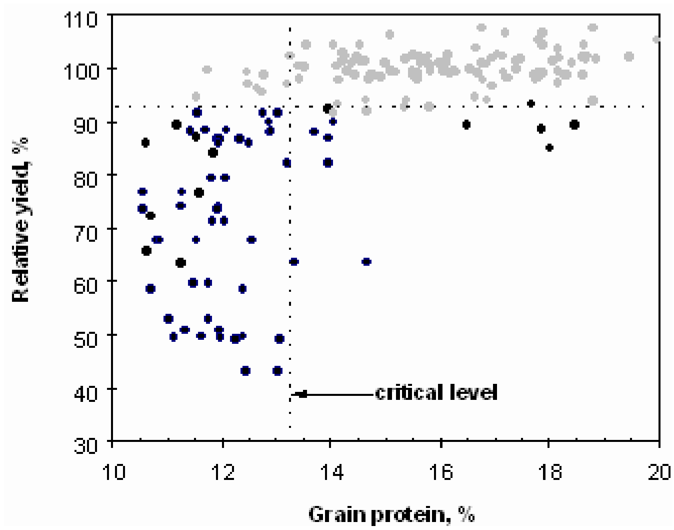


Figure 2. *Relative yield versus grain protein for spring wheat. Havre, 1996-1998. 'Dark circles' indicate yield significantly below maximum. 'Light circles' indicate yield was not reduced by N deficiency or excess.*