Fertilizer Facts: February 1997, Number 12

Flag Leaf Diagnosis of Grain Protein Response to Late-Season N Application in Irrigated Spring Wheat

Mal Westcott, Joyce Eckhoff, Rick Engel, Jeff Jacobsen, Grant Jackson, and Bob Stougaard
Western Ag Research Center, Eastern Ag Research Center, Land Resources & Environ. Science Dept., Land Resources & Environ. Science Dept., Western Triangle Ag Research Center and Northwestern Ag Research Center, Montana State University

Irrigated spring wheat grain protein is consistently increased by 0.5 to 2% with the application of late-season N when early-season N fertility is optimum for grain yield potential. An effective and efficient approach to N fertilization for yield and protein is to make an early-season N application targeted for a yield potential in consideration of soil analysis, followed with an application at heading to increase grain protein.

In practice, irrigated spring wheat growers cannot always ensure that early-season N is optimum for grain yield. Uncertainty in soil N availability, climatic conditions, irrigation practices, etc., may result in N fertility that is short or in excess of optimum. These factors make it difficult for growers to determine if grain protein responses to late-season N will be realized. A method for assessing crop N status late in the season may help in predicting the effectiveness of late-season N.

We wanted to determine if diagnosis of N content in the flag leaf, the uppermost leaf on the wheat stem at heading, is a reliable predictor of grain protein response to late-season N application. Two methods were compared: 1) laboratory analysis of dried leaf material for total N concentration, and 2) measurement of leaf "greenness" with the portable, hand-held SPAD chlorophyll meter, an indirect determination of N content in plant tissue.

Irrigated spring wheat studies were conducted in 1994 and 1995 at six locations across the state: the Eastern (Sidney), Northwestern (Kalispell), Southern (Huntley), Western (Corvallis), and Western Triangle (Conrad) Agricultural Research Centers and at the Post Farm in Bozeman. Three hard red spring wheat varieties (Len, Newana, and Hi-Line) were fertilized with four rates of early-season granular urea (46-0-0) designed to provide a broad range of N fertility conditions at each site. Maximum rates ranged from 150 to 300 lbs N/a. Flag leaves from the fertilized plots were sampled at heading and measured for "greenness" with the SPAD meter in the field and for total N in the laboratory. Plots were then split in half with one half receiving an additional 40 lbs N/a as granular urea and the other half receiving no additional N. Comparisons were made in grain protein level between these two halves of each plot to determine protein increase due to late-season N application. Results are reported as averages across the three varieties, since effects were consistent across varieties.

Flag Leaf N Diagnosis

Grain protein in 1994 was increased by late-season N application where flag leaf N concentration (FLN) was below a threshold value of 4.3% (Fig. 1). The magnitude of grain protein response was proportional to the degree of FLN deficiency below this threshold value. For example, grain protein was increased by nearly 0.7% at 4.3% FLN, and 1.8% at 4% FLN. This response was consistent across locations and with a high degree of correlation.

A similar FLN threshold value of 4.2% was found in 1995 consistent across four of the six locations (Conrad, Corvallis, Huntley, and Sidney), though the magnitude of grain protein response to late-season N was not as great as in 1994 (Fig. 2). It is apparent that a FLN threshold value of 4.2 to 4.3% is useful for predicting whether grain protein will respond to late-season N applications, but FLN analysis is not useful for predicting the magnitude of response.

The two sites that did not agree with the correlation in Fig.2 were Bozeman and Kalispell. At Bozeman, the grain was planted very late due to cold, wet spring conditions that year, and the effects on crop development led to very high levels of FLN at time of sampling. At Kalispell, an unusual grain yield response to late-season N application occurred. These two cases serve as examples where growing conditions make predictability of grain protein responses difficult and underline the importance of individual grower knowledge of special conditions in making decisions on late-season N application.

Flag Leaf SPAD Meter Diagnosis

The SPAD meter readings of flag leaves were well-correlated with FLN levels at individual sites in both years of the study, but the nature of the correlation differed among locations (data not shown). This makes it difficult to identify a critical SPAD level that is applicable to protein responses at many locations. However, it is possible to account for the differences in locations by "normalizing" the SPAD levels. This is done by comparing all readings at a site to the highest level at that site; i.e. comparison to the "greenest" plants.

Figure 3 shows the correlation between grain protein response and "normalized" SPAD (NSPAD) levels across all locations in 1994. Protein responses occurred when NSPAD levels were below 0.93 at heading; i.e. below 93% of maximum for the given location. An increase of 1% in grain protein was realized at a 0.89 NSPAD level.

Similarly, a good correlation was found at four of the six sites in 1995 (Bozeman, Conrad, Corvallis, and Huntley). Protein responses occurred when NSPAD was below 0.95 this year, with an increase of 1% where NSPAD was 0.92. The poor correlations at the Kalispell and Sidney sites again underscore the role that specific conditions may play; the Sidney site was on a field where no crop responses to early-season N occurred, and the Kalispell site elicited the unusual yield responses mentioned above.

Though the SPAD meter approach has the advantage of immediate diagnosis at time of sampling, practical use requires that any field to be tested needs a reference plot against which to compare readings. This plot should be fertilized at a rate well over optimum for yield. Protein responses will be expected where NSPAD levels are below 0.93 to 0.95 at heading (93 to 95% of the reference plot).

Dryland wheat producers need to remember that responses to late-season N will depend on timely rainfall to ensure incorporation of applied materials and efficient use by the crop. Irrigated producers should fertigate or time irrigation to occur shortly after application.

Fertilizer Facts:

- Irrigated spring wheat grain protein will be increased by N applications at heading where flag leaf N is below 4.2 to 4.3%.
- Use of the SPAD meter for diagnosis of the likelihood of protein response requires that meter readings be "normalized" by comparison to a well-fertilized reference plot in the same field.
- Irrigated spring wheat grain protein is expected to respond to late-season N where normalized SPAD level are 0.93 to 0.95 (93 to 95% of the reference plot) at heading.

- Flag leaf analysis is reliable in predicting the likelihood of a grain protein response to late-season N application, but is not useful in predicting the magnitude of the response nor the final grain protein level.

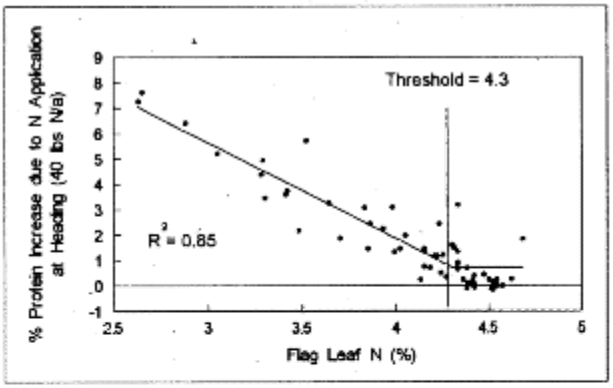

Figure 1. Relationship between the protein response to N topdressed at heading and flag leaf N in irrigated spring wheat in 1994.

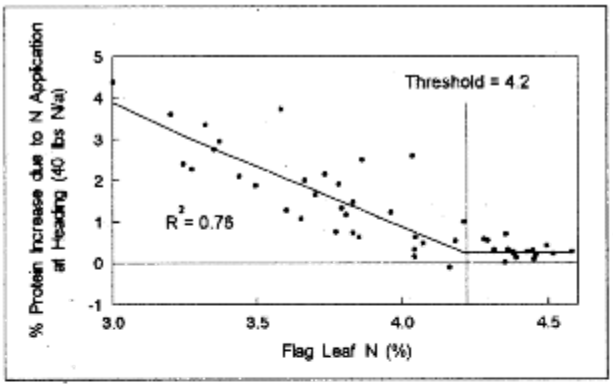

Figure 2. Relationship between the protein response to N topdressed at heading and flag leaf N in irrigated spring wheat in 1995.

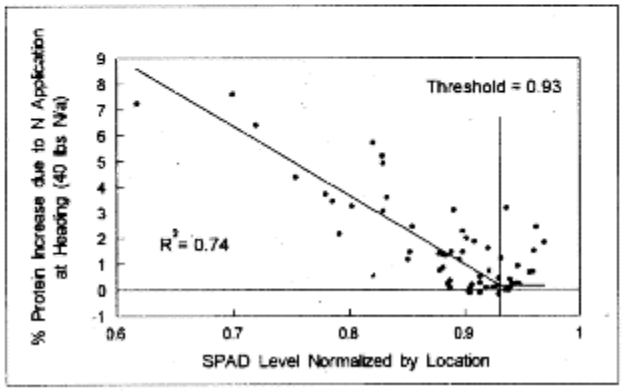

Figure 3. Relationship between the protein response to N topdressed at heading and SPAD meter readings in irrigated spring wheat in 1994.

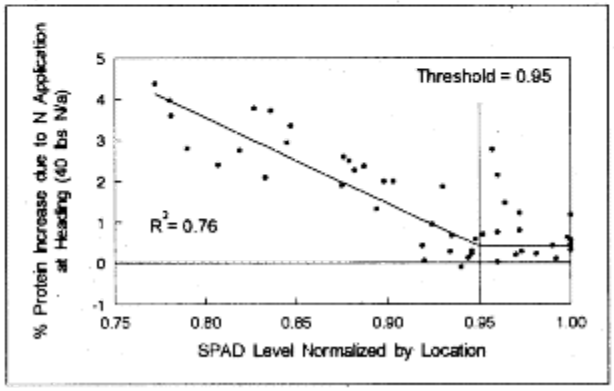

Fig. 4. Relationship between the protein response to N topdressed at heading and SPAD meter readings in irrigated spring wheat in 1995.