MONTANA

On-the-Go Grain Protein Sensing Is Near

Does It Have a Future in Precision Nitrogen Management for Wheat?

By Richard Engel, Dan Long and Gregg Carlson

Technologies that apply different fertilizer rates to precisely defined areas of fields are currently available using variable rate fertilizer applicators and the global positioning system (GPS). However, an efficient and easy to interpret method for prescribing fertilizer nutrients is not in place. Methods that use intensive grid soil sampling are not practical for many operations in the semi-arid Great Plains. The cost and effort needed to obtain soil samples can be high when contrasted to potential economic benefit to the grower.

Adoption of site-specific nutrient management for dryland wheat production will require development of new methods for characterizing nitrogen (N) fertility across farm landscapes. Grain protein mapping may be one of those methods.

In the near future, it should be possible to develop detailed protein maps of grain fields. Milestone Technologies of Idaho is currently developing an on-the-go protein sensor for combines. The sensor uses multi-spectral optics to measure protein content in wheat to within 0.5 percent as grain travels through the auger. A recent bench-top test of this device indicated the protein measurements were consistent with laboratory analyses performed by a near-infrared transmittance (**Figure 1**). This on-the-go grain protein sensor, when integrated with GPS hardware, will enable the development of protein maps for farm fields with similar resolution to current yield maps.

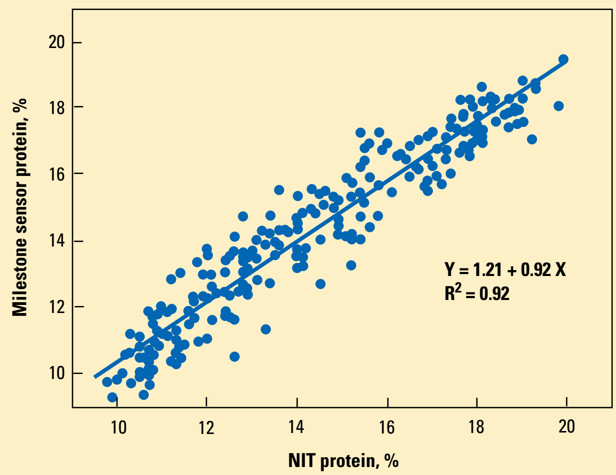


Figure 1. A bench-top test of the Milestone protein sensor on 240 spring wheat samples showed that grain protein estimates correlated well with near-infrared transmittance (NIT) analysis.

On-the-go grain protein sensing may be a significant development in precision N management efforts for wheat. Grain protein concentrations in wheat are highly correlated with N fertility and available water. If a consistent relationship can be found between yield (expressed in relative terms) and grain protein, then on-the-go protein sensing could provide a method for indexing N fertility across field landscapes. This could be used to help evaluate the success of a grower's N fertility program, direct future soil sampling efforts, and prescribe future N fertilizer rates.

Grain Yield – Protein Relationships for Spring Wheat

Studies in Montana are currently in progress to determine whether a consistent relationship can be found between yield and protein in four spring wheat cultivars. The study is being conducted under an N fertility and water gradient. The water gradient is created with a solid-set irrigation sprinkler system that supplements rainfall with irrigation to achieve the desired water level. The water regimes are designed to simulate three water environments: (1) a low water regime where wheat is under water stress

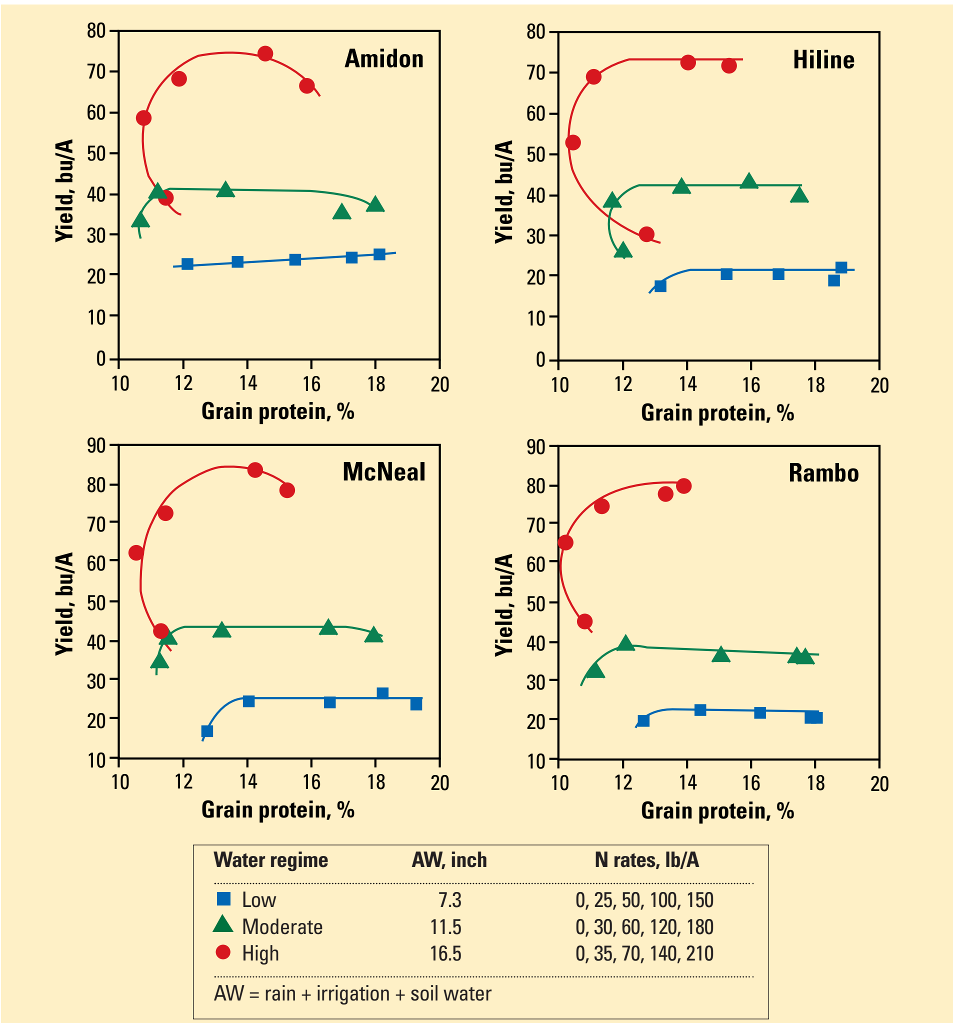


Figure 2. Yield vs. grain protein for four spring wheat cultivars grown under three water regimes. Havre, Montana. 1996.

during vegetative, reproductive, and grain-fill periods; (2) a moderate water regime where wheat is under minimal stress during vegetative and reproductive stages, then stressed during grain-fill; (3) a high water regime where wheat is grown under minimal water stress through most of the growing season.

Grain yield vs. protein curves (**Figure 2**) for the Amidon, Hiline, McNeal, and Rambo spring wheat cultivars illustrate this relationship changes with water. Under drought stress conditions the first increments of applied N produce small increases in yield and protein. Thereafter, protein increases without a corresponding increase in yield, producing a flat curve. As moisture improves, the curves become more "C-shaped." Large increases in yield are observed from applied N. However, protein first decreases then increases as N nutrition improves. This drop in protein with applied N is referred to as the "Steenbjerg effect" and occurs when crop growth is stimulated more than N uptake.

Grain Protein an Indicator of Nitrogen Nutrition

Expressing yield in relative terms, or a percent of the maximum, can normalize the relationships in **Figure 2**. Maximum yield (100 percent) is defined as the average of yields not significantly (.05 level) different than the highest yielding cultivar x water regime treatment. When relative yield is plotted against grain protein (**Figure 3**) two things become evident. First, yield levels for most of the data-points are less than the maximum at protein concentrations below 13.4 percent. Second, where protein concentrations are greater than or equal to 13.4 percent, yield is near the maximum. The implications are that grain protein concentrations provide a method for segregating wheat that is N-deficient from wheat that is N-adequate. This approach appears to be consistent across a wide range of water regimes.

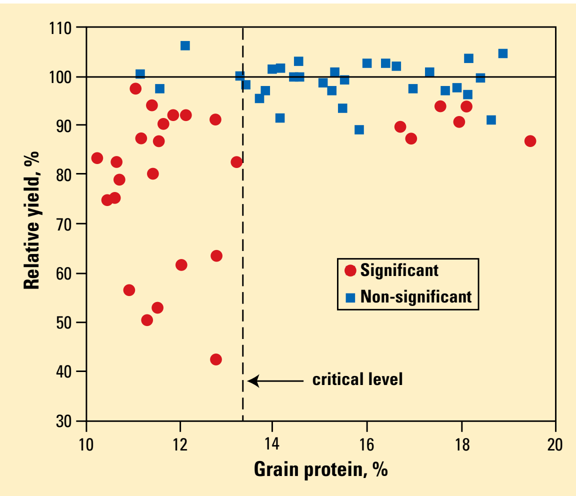


Figure 3. Relative yield vs. grain protein relationships for spring wheat grown under a wide range of N and water regimes reveal a 13.4 percent critical protein level. Protein levels below the critical level were usually significantly below the maximum yield (0.05 level) . Protein levels at or above the critical level were generally associated with maximum yield. Havre, Montana. 1996.

Application in Precision Nitrogen Management

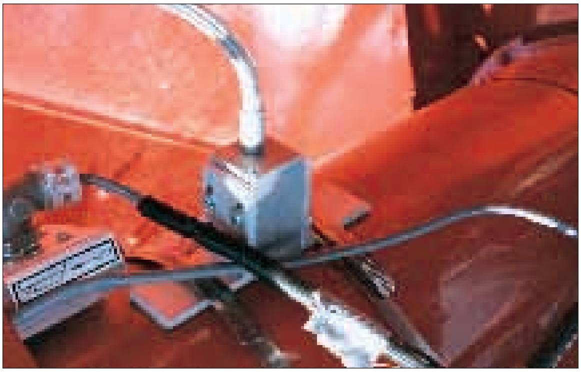
Development of on-the-go protein sensors for combines and protein mapping will make it possible to identify areas within a field (or entire field sites) where the current N fertility program is either insufficient or adequate for maximum yield. The quantity and spatial distribution of N removed from a field could be used as a basis for future N fertility programs using variable rate application technologies. For areas of the field where N fertility is adequate based on grain protein concentrations,

This sensor uses multi-spectral optics to measure protein content in wheat during harvest. (Source: Milestone Technologies, Inc.)

future N recommendations might use a maintenance approach to nutrient management. Under this scenario N is applied at a rate equal to its removal. For example, by mathematically combining the results from protein and yield (expressed in pounds of grain per acre) maps, via the equation below, we can estimate N removal from a field site.

$$\text{N removed in wheat} = \frac{(\text{yield x \% protein})}{5.7 \times 100}$$

In areas of the field where N fertility is insufficient, a build approach to N management would be required. The quantity of N required under this scenario could be estimated by soil testing and from models that relate grain protein to available N (soil + fertilizer N). Results from our spring wheat N fertility-water gradient studies indicate that more N is required to increase protein under wet conditions than under drought. Application of these models would require an estimate of available water (soil moisture + growing season precipitation) conditions for the field site where N deficiency exists.



The sensor is shown here mounted on a combine during protein and moisture testing.

Looking Ahead

The ability to accurately map N fertility across field landscapes at low cost has been a barrier to adoption of site-specific N management. With on-the-go grain protein sensing, producers will be able to map in great detail areas in their fields where current N fertility programs are either insufficient or adequate for maximum production. This capability could speed adoption of site-specific nutrient management and variable-rate fertilizer application services in regions of the Great Plains where this practice is not being utilized. BC

Dr. Engel is an Associate Professor of Soil Science with Montana State University, Department of Plant, Soil, and Environmental Science, Bozeman, MT 59717-3120. Dr. Long is Assistant Professor, Site-Specific Management, and Dr. Carlson is Associate Professor of Agronomy, both located at Montana State University–Northern Agriculture Research Center, Havre, MT 59501.