Post-harvest Evaluation of N Management for Winter Wheat using Grain Protein

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Introduction

Nitrogen is the nutrient most often limiting winter wheat yields in Montana. Since the soils of this region were first cultivated (late 1800's) there has been a depletion of indigenous N reserves due to declining organic matter, crop removal, and erosion. This depletion has been further exacerbated by introduction of new cultivars and improved cultural practices to conserve water (reduced tillage) and control weeds that have resulted in increased yields and plant N requirements. Historically, soil testing has been viewed as the single best approach for diagnosing potential nutrient deficiencies, including nitrogen. However, more recently, agronomists in neighboring regions including Colorado, North Dakota, Oregon, and Saskatchewan have promoted the idea of using grain protein as a biological index of nitrogen sufficiency or deficiency. This approach is based on their finding that a consistent relationship existed between yield (expressed in relative terms) and grain protein in wheat, and that from this relationship a critical protein level could be established for partitioning wheat yields into N deficient and N sufficient categories. In Montana, this idea was evaluated in spring wheat and reported in Fertilizer Fact Sheet #14. This report summarizes the results of a similar study conducted with winter wheat. The objective was to determine whether a consistent relationship exists between yield and grain protein in winter wheat; and to determine if a critical level could be established for diagnosing N nutrition (deficient vs. adequate).

Methods

Field studies were conducted over 2 seasons on winter wheat (2000-2001) on the property of the Northern Agricultural Research Center, near Havre, Montana. Pre-plant soil NO_3-N test levels were 17, and 22 lbs/a (0-24 inch depth) in 2000, and 2001, respectively. A solid-set irrigation system was used to create three distinct water environments (low, moderate, and high) according to the following scheduling scheme. In the low water regime, wheat was grown under dryland conditions, except for a single irrigation shortly after crop emergence (approximately 1.5 to 2.5 inches for stand establishment). In the moderate regime, wheat received a single irrigation after crop emergence, plus two irrigation events during the vegetative growth period (late-tillering and heading). In the high water regime, wheat received irrigation as in the moderate regime, plus irrigation during grain-fill. Within each water regime four winter wheat varieties (CDC Kestrel, Erhardt, Rampart, McGuire) were seeded in factorial combination with five N fertilizer levels. The N fertilizer rates were designed to provide a wide range of N fertilizer conditions across the site.

Results

Wheat responded to the water gradient from irrigation and the N gradient from fertilizer by producing a wide range of grain yield and protein levels across the study site. Rampart winter wheat grain yield ranged from 11 to 83 bu/a (Figure 1) and grain protein concentrations varied from 9 to 19%. This variation in yield and protein was indicative of the ranges observed in the other cultivars tested (data not shown). Grain yield levels were normalized across the water regimes by expressing the yield of the N deficient wheat in "relative terms", or as a percentage of the highest yielding N rate treatment(s) for each cultivar x water regime combination. The relationship between relative yield and grain protein is expressed in Figure 2. Several things are evident in this figure. If protein in winter wheat exceeded 12.5%, yield seldom suffered from inadequate N nutrition. For example, protein exceeded 12.5% in 52 episodes (cultivar x water regime) in this study. In 49 of these instances. yield was not significantly reduced by inadequate N. Conversely, if protein was ≤ 12.5%, yield frequently (50 of 63 episodes) suffered from inadequate N nutrition.

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 of protein histories for their fields. Hence, grain protein provides a useful qualitative indicator of a grower's N fertilizer program when contrasted with an established critical level (12.5%). Growers with a history of low protein winter wheat, i.e. below the critical level, can use protein analyses to estimate if their fields are in need of additional fertilizer. How much

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additional fertilizer might have been needed can be estimated thru an examination of the relationship between grain protein and available N (Figure 3). In this study we found that wheat protein concentrations increased 1% with approximately 22 lbs/a and 33 lbs/a of additional N under low to moderate rain conditions (<10 inches growing season precipitation) and

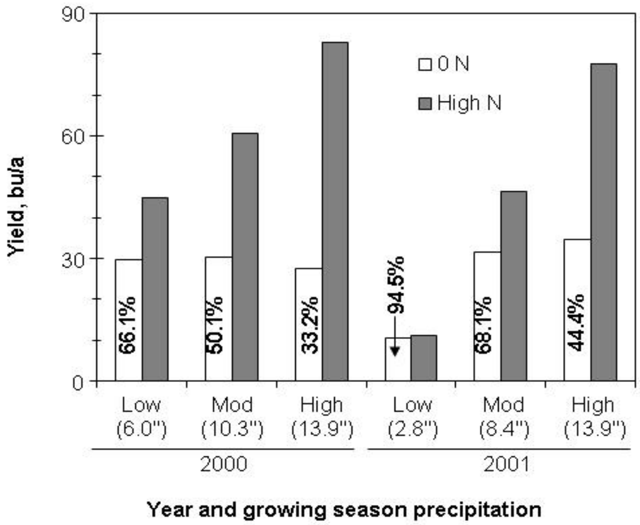

Figure 1. Grain yield of Rampart winter wheat over two growing seasons at varying levels of growing season precipitation. Numbers on 0 N bars expressed the yield as a percentage of the adjacent high N treatment.

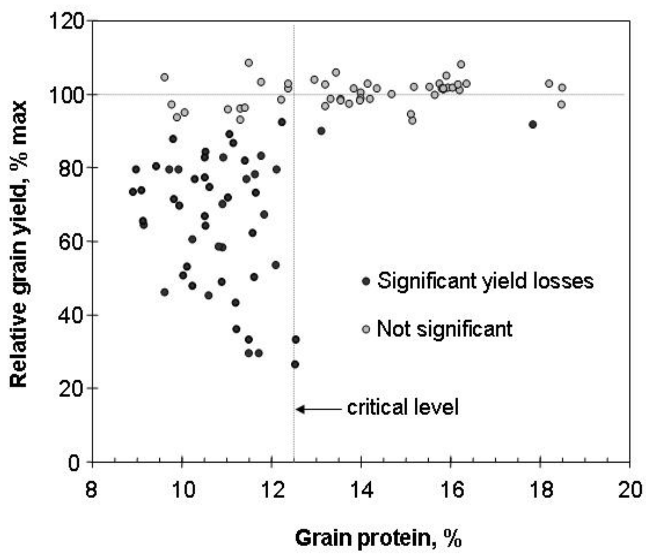

Figure 2. Relative yield vs. grain protein relationships for winter

high rain (or irrigated conditions, respectively). Hence, a grower who produced winter wheat with 11.0% protein content would have needed to add an additional 33 lbs/a of fertilizer N under low to moderate rainfall conditions, or 50 lbs/a of fertilizer N under high rainfall (or irrigated) conditions, to reach the 12.5% critical level where yield is maximized.

Fertilizer Facts:

- A winter wheat grain protein greater than 12.5% is associated with N nutrition adequacy and a protein less than 12.5% is likely associated with N deficiency.
- Winter wheat grain protein increased 1% with approximately 22 and 33 lb/a of additional N under low to moderate rain, and high rainfall conditions, respectively.

Edited by Clain Jones, Extension Soil Fertility Specialist and Evette Allison, Research Associate

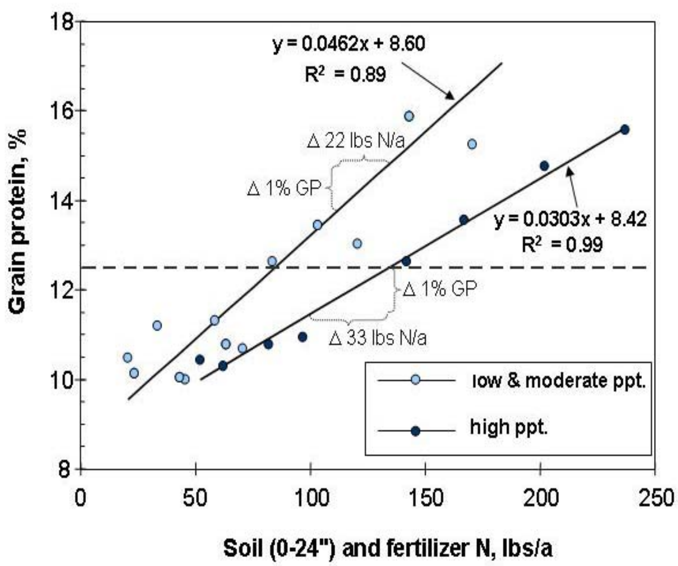

Figure 3. Winter wheat grain protein vs. available N (soil + fertilizer) relationships under low to moderate growing season precipitation (<10 inches) and high precipitation conditions (>13 inches)