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Predicting Spring Wheat Yield and Protein Response to Nitrogen

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Information for determining nitrogen (N) fertilizer recommendations for spring wheat is needed with recent variety improvements, grain protein expectations of 14% or greater, increasing fertilizer costs, and associated crop management decisions. Consequently, a spring wheat N management research project was initiated to determine spring wheat yield and protein response to N fertilizer and relevant N soil tests, and prepare yield and protein prediction models or equations using appropriate soil tests.

Thirty-four locations representing the growing seasons of 1986, 1987, 1989, 1990, and 1993 through 1996 were selected for multiple regression analysis. Regression equations provide a means to input site-specific factors and develop a unique recommendation. Selection criteria were: representative soils, recommended spring wheat cultivar, adequate fertility program, no yield limiting factors, and soil nitrate-N (0-3 ft depth) and organic matter (OM) soil tests. Dependent variables (what you are trying to predict) used in the regression analysis included grain yield, grain protein content, and grain protein yield (grain yield in lbs/a multiplied by protein content divided by 100). Independent variables (what you input to characterize the specific site) were N (soil nitrate-N in 0-3 ft of soil measured in the spring plus fertilizer-N), and OM. Data were organized into three sets based on the highest yield of each location: grain yields less than 40 bu/a (14 locations), between 40 and 60 bu/a (19 locations), and greater than 60 bu/a (11 locations).

The regression analysis resulted in working equations in the following yield levels: grain yield less than 36 bu/a, between 36 and 56 bu/a, and greater than 56 bu/a. The equations, based on available N are summarized in Table 1.

Table 1. Summary of Spring Wheat Regression Equations

No.	Equation*	Adjusted R^2
	Low Yield Potential (< 36 bu/a)	
1	Yield = 21.0 + 0.18 N - 0.00051 N^2	0.45
2	Protein = 10.2 + 0.043 N - 0.00011 N^2	0.42
3	Protein Yield = 121.5 + 2.1 N - 0.0053 N^2	0.62
	Medium Yield Potential (36 to 56 bu/a)	
4	Yield = 24.4 + 0.36 N - 0.00113 N^2	0.45
5	Protein = 9.9 + 0.021 N	0.42
6	Protein Yield = 134.6 + 2.84 N - 0.0065 N^2	0.61
	High Yield Potential (> 56 bu/a)	
7	Yield = 30.2 + 0.31 N - 0.0003 N^2	0.70
8	Protein = 9.2 + 0.014 N	0.45
9	Protein Yield = 180 + 1.92 N	0.76

*Yield = Grain yield in bu/a.
Protein = Grain protein in percent.
Protein Yield = Protein yield in lbs/a
N = Fertilizer N + Soil Nitrate-N (0-3 ft depth) in lbs N/a

Nitrogen is a significant component of all equations. OM improved the prediction for only yield (high yield potential: Yield = 5.6 + 0.35 N - 0.0005 N^2 + 10.2 OM, R^2 = 0.81), protein (low yield potential: Protein = 8.1 + 0.046 N - 0.00011 N^2 + 0.83 OM, R^2 = 0.55), and protein yield (low and high yield potentials)(low yield potential: Protein yield = 72.1 + 2.1 N - 0.0053 N^2 + 20.3 OM, R^2 = 0.067; high yield potentials: Protein Yield = -35.3 + 2.90 N - 0.0030 N^2 + 71.3 OM, R^2 = 0.82) while no improvement was found by including the interaction of N and OM. In a general sense, with high yield potential soils, one percent OM equates to 10 bu/a.

Producers have several options in using the equations, depending upon their tools available for data management. Since the equations in each category were developed from data representing a wide range of environments, specific yield goals are not necessary. Growers can organize production fields into a low, medium, or high category based on expected grain yield remembering that managing nutrients is a direct exercise in balancing the soil nutrient level with the anticipated available water, provided other yield-limiting factors are not present.

Grain yield, grain protein, and protein yield versus fertilizer plus nitrate-N equations are presented in Fig. 1, 2 and 3, respectively (equation numbers are in parenthesis from Table 1). The amount of N to produce 14% protein spring wheat (solving equations 2, 5, and 8 for Protein = 14) would be 116 lbs for yields < 36 bu/a, 195 lbs for yields between 36 and 56 bu/a, and 343 lbs for yields > 56 bu/a. By inputting these N rates into the respective yield equations (1, 4, and 7), 35, 53, and 101 bu/a would be produced. Finally, by dividing the N required to produce 14% spring wheat by the expected yield, the amount of lbs N/bu can be calculated (3.3 lbs N/bu for yields < 36 bu/a, 3.7 lbs N/bu for yields between 36 and 56 bu/a, and 3.4 lbs N/bu for yields > 56 bu/a). Consequently, the "rule of thumb" of 3 lbs N/bu for producing 14% spring wheat is reasonable.

In reality, spring wheat is produced for its high grain protein content. Combining yield and protein into one dependent variable, protein yield, makes sense because N is vital to both yield and protein production. This calculation produces predictive equations with stronger relationships (higher R^2) than either yield or protein alone, thus decreasing the data variability when compared to yield and protein predictions individually. It is also recognized that many factors influence yield and protein of spring wheat in addition to available N. These prediction equations provide research-based guidelines. A spring wheat grower can select the appropriate protein yield equation, calculate a protein goal, solve the equation for N, subtract the nitrate-N soil test, and the result is the N fertilizer recommendation. Yield can be monitored throughout the growing season, and N increased to increase protein, if yields are predicted to be higher than the initial yield goal.

Fertilizer Facts:

- Nitrogen management is an initial component of spring wheat production.
- Producing spring wheat with 14% protein requires significantly more N than growing spring wheat for optimal yields.
- On average, 3.3 lbs N/bu is required to grow spring wheat with 14% protein regardless of yield level.
- Soil nitrate-N and, in some instances, organic matter (OM) are useful tools for making N fertilizer recommendations.

Edited by Jeff Jacobsen, Extension Soil Scientist

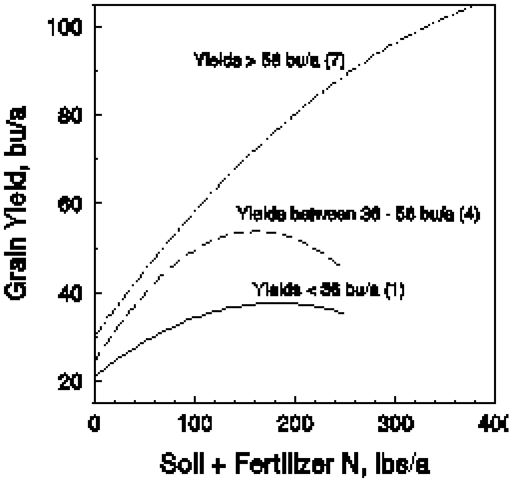

Figure 1. Effect of available N on spring wheat yield.

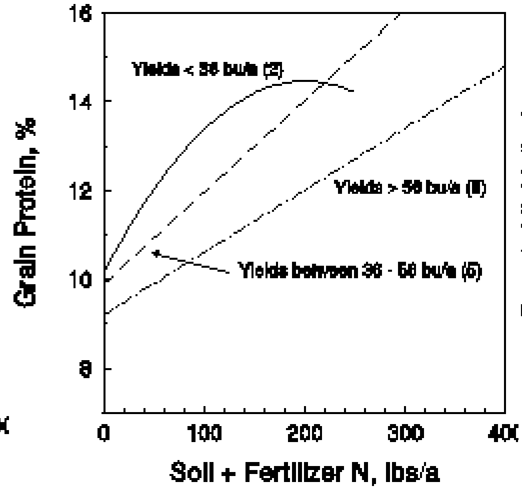

Figure 2. Effect of available N on spring wheat protein.

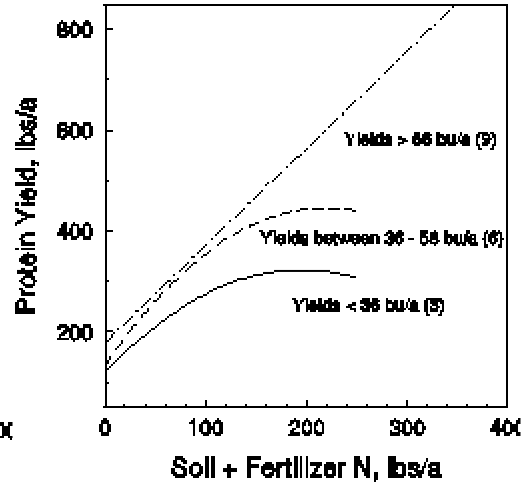

Figure 3. Effect of available N on spring wheat protein yield.