A Tool to Determine Economically Optimum Nitrogen Rates for Small Grains

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Introduction

Fluctuating and sometimes high nitrogen (N) fertilizer costs and small grain prices have made it very difficult to determine the economically optimum N rate (EONR). MSU fertilizer guidelines (EB 161) and most crop adviser recommendations are based on a constant lb N per bu (lb N/bu), yet this approach does not take into account fertilizer costs, grain prices, or organic matter (O.M.) content and thus likely does not optimize economic return. Therefore, there is a need for the development of economic models in Montana to determine the EONR for small grains.

Methods

Nitrogen yield response curve data for spring wheat, winter wheat, and barley were compiled from Agricultural Research Center annual reports and personnel. These data were for both on- and off-station plot studies. There were a total of 128 spring wheat (1993-2006), 350 winter wheat (1970-2006), and 491 barley data points (1981-2006), with a majority of the data collected in the Golden Triangle. The vast majority of the studies were conducted on fallow dryland sites; data from both irrigated fields and recrop situations were excluded from further analysis due to small sample size.

The barley data was largely from a study evaluating seeding rate, applied N, and applied sulfur (S). Because S is rarely added to barley fields, and S can increase grain protein, only data from the 0 S treatment were included. The final data sets consisted of at least 96 data points for each crop.

Yield models were developed that included maximum yield (or yield potential) for each trial, total available N, and O.M.. All models shown here use standard English units (e.g. bu/ac, lb N/ac).

The best fitting yield model equation was a "quadratic-plateau" model. This has the form:

$$\text{Yield} = a*\text{TUN} - (a^2/(4*\text{YP}))*\text{TUN}^2 \text{ when TUN} < \text{YMN}$$

$$\text{Yield} = \text{YP when TUN} \geq \text{YMN}$$

Where TUN = total useable N (soil N to 3 ft. + fertilizer N + c*O.M.), c is a constant, YP is yield potential, and YMN (yield maximizing N) is the TUN where peak yield is achieved.

An optimizing routine was used to find the best fitting coefficients for these equations for each crop. Models were also developed for protein and plump, yet in the interest of space are not shown here.

Net marginal return was calculated as the difference between grain revenue and N fertilizer cost. For wheat, grain revenue included protein discounts or premiums and for barley it was assumed that if plump was too low (<75 - 80%) or protein too high (>13.0 - 13.5%), that revenue would be based on the feed barley rather than the malt barley price.

Results

The values of "a" in the yield model were determined to be 0.55, 0.58, and 1.34 for spring wheat, winter wheat, and barley, respectively. A higher number means that it takes less N to grow a bushel of that crop, in agreement with what is known about N responses between wheat and barley. The values of "c" were found to be 27.4, 14.8, and 8.5 for spring wheat, winter wheat, and barley respectively, suggesting that O.M. is more important for increasing spring wheat yield, than for increasing either winter wheat or barley yield. The r^2-values for the three yield models were 0.92, 0.92, and 0.89, respectively.

Net marginal returns and EONR are highly affected by spring wheat grain price and N fertilizer cost (Figure 1). For example, if wheat is $9/bu, the protein discount is 16¢/0.25% protein,

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Urea costs $450/ton, and the yield potential is 50 bu/ac, the model predicts an EONR of approximately 170 lb available N/ac or 3.4 lb N/bu. However, at $5/bu wheat and $850/ton urea, the model predicts an EONR of 125 lb N/ac or 2.5 lb N/bu. These values will change if O.M., protein discount, or yield potential changes. For example, at $7/bu spring wheat and $550/ton urea, the EONRs are 120 and 210 lb available N/ac for a 50 bu/ac yield potential at protein discounts of 8¢ and 24¢/0.25%, respectively (Figure 2).

The models are online at: http://www.montana.edu/softwaredownloads/cropdownloads.html. Figure 3 shows a screen shot of the net revenue estimate for the spring wheat online model. The input values can be easily changed by moving a "slider", causing the net revenue graph to change instantaneously.

Fertilizer Facts:

- The economically optimum N rate (EONR) can be determined using the economic model.
- The EONR can be substantially different depending on fertilizer price, grain price, and protein discount.
- Models for spring wheat, winter wheat, and barley are online, and are also "slider" driven, making them user-friendly.

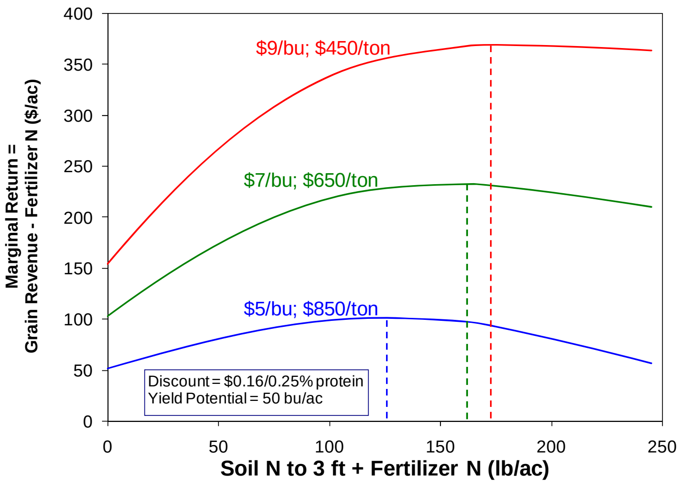

Figure 1. Effect of available N and price:cost ratios on marginal return assuming O.M. = 2%, a protein discount of 16¢/0.25% and a yield potential of 50 bu/ac. Dashed lines show EONRs.

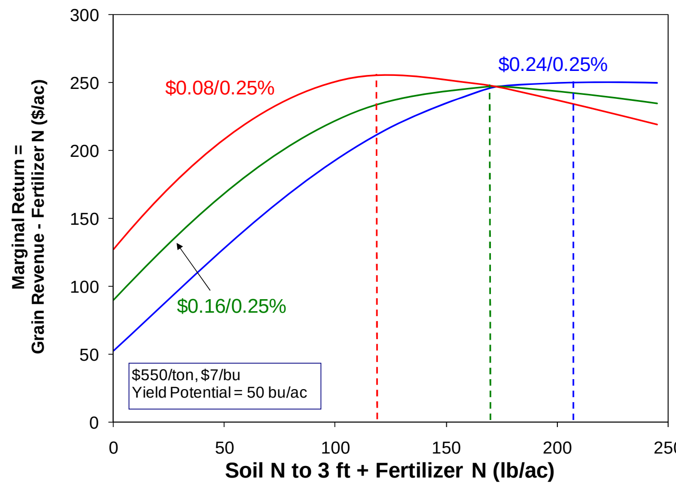

Figure 2. Effect of available N and protein discount on marginal return assuming O.M. = 2%, $550/ton urea, $7/bu wheat, and a yield potential of 50 bu/ac. Dashed lines show EONRs

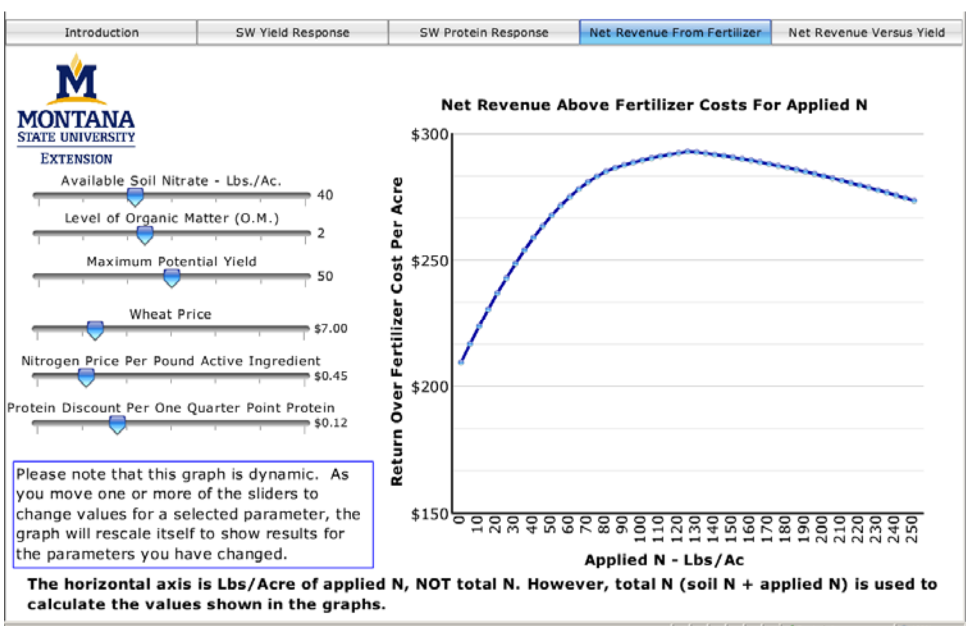

Figure 3. Online model for spring wheat showing the Net Revenue graph indicating the economically optimum level of fertilizer application.

Edited by Clain Jones, Extension Soil Fertility Specialist, and Elizabeth D'Imperio, Research Associate