Spatial Optimization of Nitrogen Application for Wheat

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Introduction

Nitrogen (N) availability to crop plants in any given year is influenced by soil properties, topography, weather conditions, weed densities and management. Site-specific (SS) technologies may allow improved prediction of crop response to N application and thus increased N use efficiency.

Nitrogen fertilization has been shown to influence both grain yield and protein content, so to fertilize most efficiently throughout the field, both measures of output must be spatially considered. Our objectives were to develop tools that allow producers to more effectively maximize their return on fertilizer investment with SS application technology.

Methods

We used SS data collected for several crop years (2006-2012) on a dryland wheat farm from three different 100+ acre fields near Sun River. Data consisted of SS measurements of wheat grain yield and protein content as response variables and N application rate, weed density, elevation, grain moisture, soil electric conductivity (SEC), and topographic wetness index (TWI, based on slope and 'flow accumulation'; Sorenson et al. 2006) as explanatory variables. The cell size was 59 x 59 feet. Wheat grain yield, protein content, N application rate, weed density, and grain moisture were collected annually. The other explanatory variables were collected once in 2006.

A mixed effects linear model was selected to best predict grain yield and protein content. An optimization model created within the R statistical software package (R Core Team 2012) was used to optimize N rates and maximize net returns (NRs; $/acre).

Results

The specific NR benefits and N savings with SS management were field and year specific, and depended mainly on the magnitude of variability within a field (Figure 1a and c), on the quality of the input data (e.g. yield and protein monitor calibration frequency) and on the accuracy of the prediction models (Figure 1b and d). Prediction accuracy increased as more years were included. The use of SS technology enabled the application of N fertilizer to be spatially optimized for maximum NRs (Figure 2 and 3), in response to the spatial variability of wheat grain yield and protein. On average, during the 7 years studied, the fields obtained a NR increase of $21.70/acre (0.73 to $86.90/acre) using the optimization model. On some fields the model recommended to apply up to 76 lb N/acre more than the farmer applied, yet in others it recommended up to 170 lb N/acre less. The average N savings was 36 lb N/acre.

Fertilizer Facts

- Site-specific technologies are capable of maximizing net revenue and N use efficiency.
- The prescriptive N rate map for maximizing NRs will vary depending on the grain prices, protein premiums, and fertilizer prices in addition to the weather/climate of the year.

Acknowledgement

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Fertilizer Facts

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Reference

Sorenson, R., U. Zinko, and J. Seibert. 2006. On the calculation of the topographic wetness index: evaluation of different methods based on field observations. Hydrology and Earth System Sciences. 10:101-112.

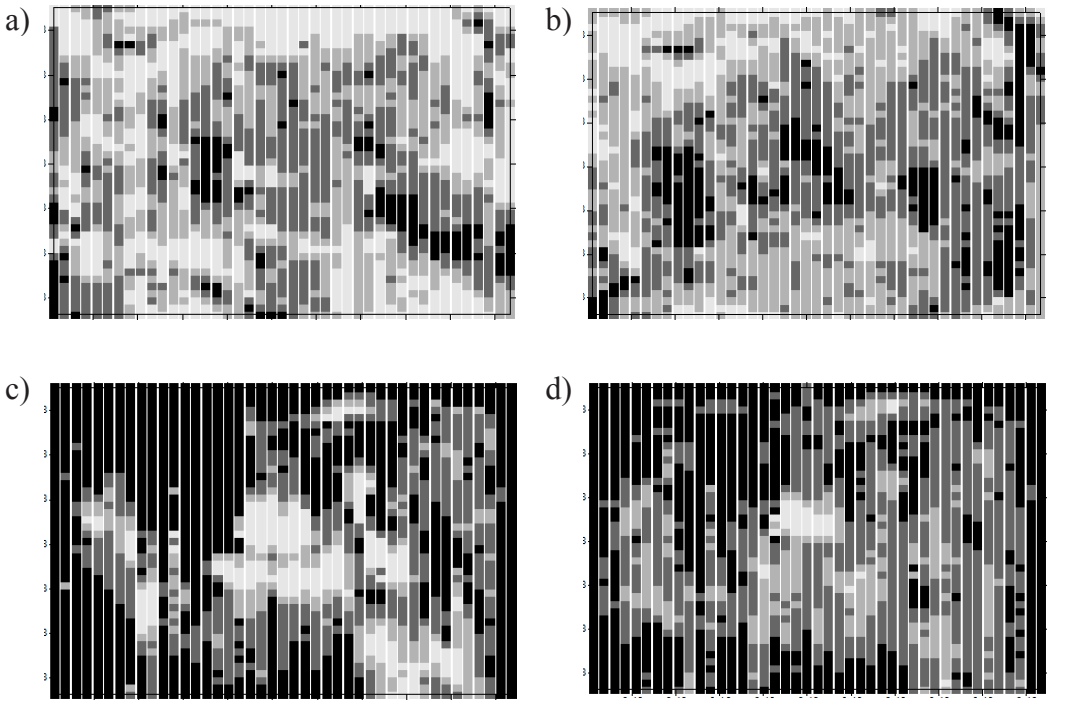

Figure 1. a) Measured and b) predicted grain yield (bu/acre; R^2 = 0.53), and c) measured and d) predicted grain protein content (%; R^2 = 0.72) maps for one of the studied fields (2010.) Yield and protein were predicted based on N application rate, elevation, soil electric conductivity, topographic wetness index, and grain moisture.

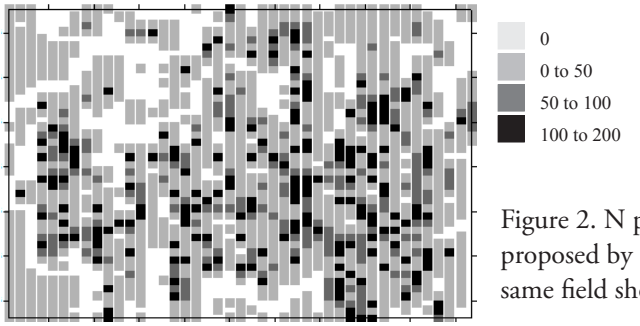

Figure 2. N prescription map (lb N/acre) proposed by the optimization model for the same field shown in Figure 1.

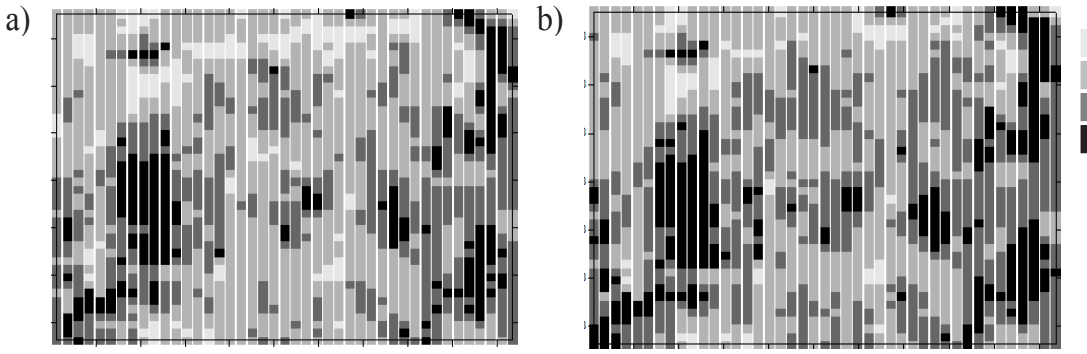

Figure 3. Distribution of NR ($/acre) for the same field shown in previous figures, a) with the farmer's N rate and b) with the optimized SS N rate application.

Edited by Clain Jones, Extension Soil Fertility Specialist, and Kathrin Olson-Rutz, Research Associate