PRECISION N MANAGEMENT: FIELD-SCALE APPLICATION OF N EFFICIENCY INDICES IN WHEAT

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ABSTRACT

Preliminary evaluation of precision agricultural technologies showed that on-combine grain yield and protein monitors show promise as useful tools to characterize site-specific variations in crop performance. Variable rate applicators were shown to be proficient at achieving targeted site-specific application goals. First year comparisons of uniform versus precision N management in hard red winter wheat showed that similar yield and protein goals were met with 20% less applied N in the field-scale precision N treatment and greater N use efficiency than was achieved with uniform N management.

INTRODUCTION

Spatial variation in yield and protein across fields is well documented for dryland wheat producing regions of the PNW (Fiez et al., 1995). Large within-field variation in wheat performance arises from landscape and soil attributes that produce complex spatial and temporal variations in available water, organic matter and rooting depth (Busacca and Montgomery, 1992). Current N management recommendations for dryland wheat in the Inland Pacific Northwest (PNW), however, were largely developed on a regional scale for the uniform, whole-field application of N (Leggett, 1959). Tailoring N management prescriptions to site- and time-specific conditions could substantially improve N use efficiency (NUE). However, despite the availability of precision agricultural technologies there are currently no N management recommendations for the region and little grower adoption. The major barrier to adoption of precision technologies for N management has been the lack of their integration into a grower-oriented monitoring, application and evaluation system that assesses tradeoffs and optimizes the economic and environmental performance of N use.

Research objectives are to: (1) measure and predict site-specific variables required for making N management decisions on research conducted at the Washington State University (WSU) Cook Agronomy Farm; and, (2) test and evaluate site- and time-specific N management decisions as compared to uniform N management at the WSU Cook Agronomy Farm.

METHODS

The research in progress is being conducted at the WSU Cook Agronomy Farm (CAF) located within 6 miles of Pullman WA (annual average of 545 mm precipitation). The 57-ha (140 acre) research farm is dedicated to direct-seed, cropping systems research and has soils and landscapes representative of the dryland annual cropping area of eastern Washington and northern Idaho). Spatial data currently used to assess the potential for precision N management are: (1) digital elevation model (DEM) created using a survey grade global positioning system; (2) determination of terrain attributes based on DEM; (3) ground sensing of apparent electrical conductivity (EC_a) using electromagnetic induction (EM-38, Geonics, Inc.); (4) establishment of a nonaligned, randomized grid sampling design with 369 geo-referenced points over 37 ha (92 acres); (5) detailed morphological descriptions of soil horizonation and features and baseline soil characterization (0-1.5 m) at 183 geo-referenced points; (6) hand samples of crop yield and aboveground biomass on 2-m^2 areas at geo-referenced sample locations; (7) N analysis of grain and straw to determine aboveground N uptake and grain protein; (8) soil sampling (1-1.5 m) prior to spring planting of wheat and following harvest for analysis of soil water and mineral N; (9) use of no-till drill-mounted variable rate applicator for N fertilizer (UAN) at planting; (10) use of combine-mounted yield monitor and grain analyzer (for protein); and (11) estimates of NUE over the grid sampling design (369 points) for hard red spring wheat (1999), spring barley (2000), hard red spring wheat, hard red winter wheat, and four additional alternative crops (2001 through 2006).

RESULTS AND DISCUSSION

Testing of precision technologies: Technologies that may be useful for growers to adopt decision rules include on-combine yield and protein monitors, variable rate application controllers, and geo-referencing (GPS) equipment. Both on-combine yield and protein sensors were mounted with GPS on a JD 6622 during the 2005 harvest of hard red spring wheat and winter wheat at the WSU Cook agronomy farm. Although interactions of slope affected yield monitor data (Fig. 1), overall comparisons with hand samples showed comparable results (Figure 2).

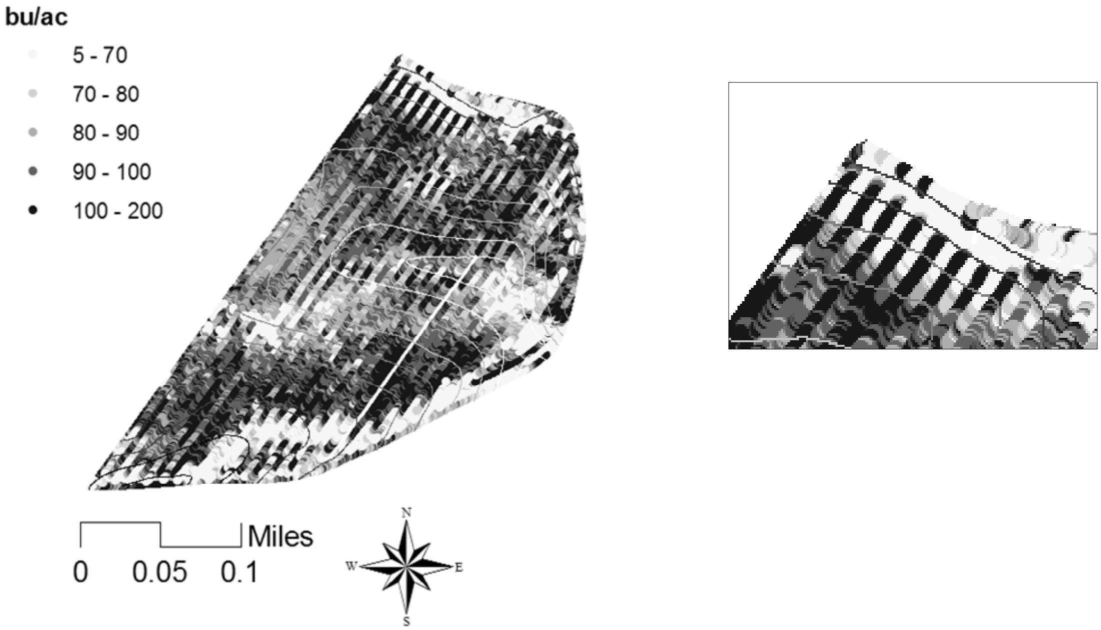
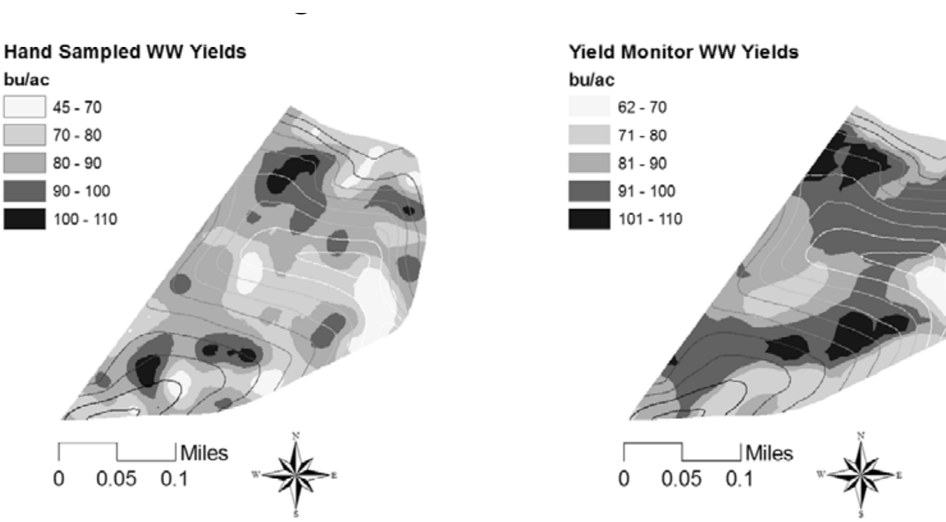


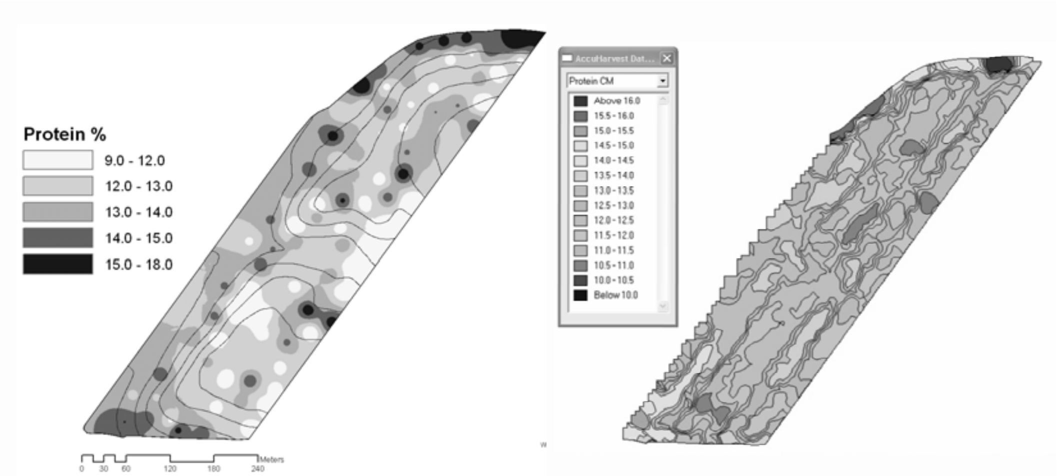
Figure 1. Combine yield monitor output for the Cook Agronomy Farm showing affects of slope (field striping).



Average Yield: 82 bu/ac Average Yield: 88 bu/ac

Figure 2. Comparison of hand samples *versus* yield monitor data for hard red winter wheat.

Preliminary analyses of on-combine grain protein monitoring using a Zeltex unit looked promising (Figure 3). Within-field grain protein patterns were similar between hand samples and monitor data.



Hand Samples **Combine Grain Analyzer**

Figure 3. Comparison of hand samples and combine grain analyzer for grain protein of hard red spring wheat over 12-ha field (2005 data).

Variable rate fertilizer application equipment was tested for capabilities of achieving targeted N rates across the field (Fig. 4). Dry fertilizer applications were made with a Midtech unit coupled with a Barber spreader while liquid applications were made with the same Midtech unit attached to a Great Plains direct-seed drill. The liquid system was able to achieve target N levels with more accuracy.

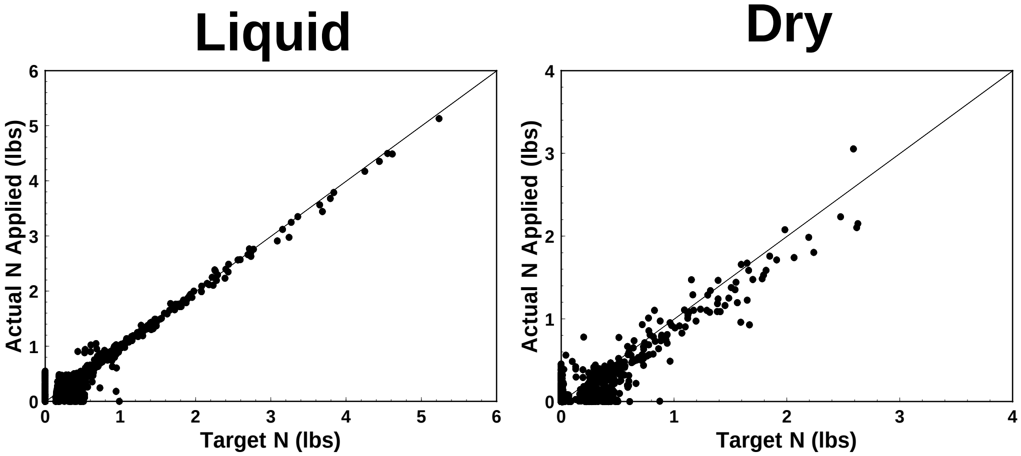


Figure 4. Target *versus* actual amounts of applied N for dry and liquid systems.

Preliminary results of testing precision technologies indicate that although not perfect these technologies will likely prove to be useful for precision N management. Further field testing is needed particularly with the on-combine grain protein sensor.

Decision Rule Development: Our development of precision N management strategies requires evaluation of grain yield and protein goals as well as N use efficiency (NUE) goals. Evaluation of yield, protein and NUE will result in definition of an N requirement as well as aid overall development of strategies to effectively vary N applications at different times and field locations during the course of cereal crop management. During the 2005 and 2006 season, variable rate and timing of N were tested and compared to uniform N applications at the Cook Agronomy Farm. The precision N management treatments were derived from historic relative yields for all crops grown from 1999 through 2004 (Figure 5).

Relative crop yields were used to define yield goals across the landscape. Additional research is currently being conducted to evaluate the stability of yield goals across a given field over time. Once relative yields are defined, historic yields for a field can be used to distribute the yield variability across the field. For example, if the average field yield for hard red winter wheat is 85 bu/ac, the relative yield map can be used to distribute this overall historic yield across the field (Figure 6.) The average hard red winter wheat yield for the field is 85 bu/ac, however, the range in yield varies from 50 to over 100 bu/ac. The site-specific yield values then serve as the yield goals for a given location. Estimates of N mineralization were based on 369 geo-referenced soil samples analyzed for organic matter (Figure 6). This amount of detailed information is cost-prohibitive, however, preliminary data show that soil organic matter levels are related to historic crop yields and we are examining the use of relative yields to predict soil mineralization from organic matter.

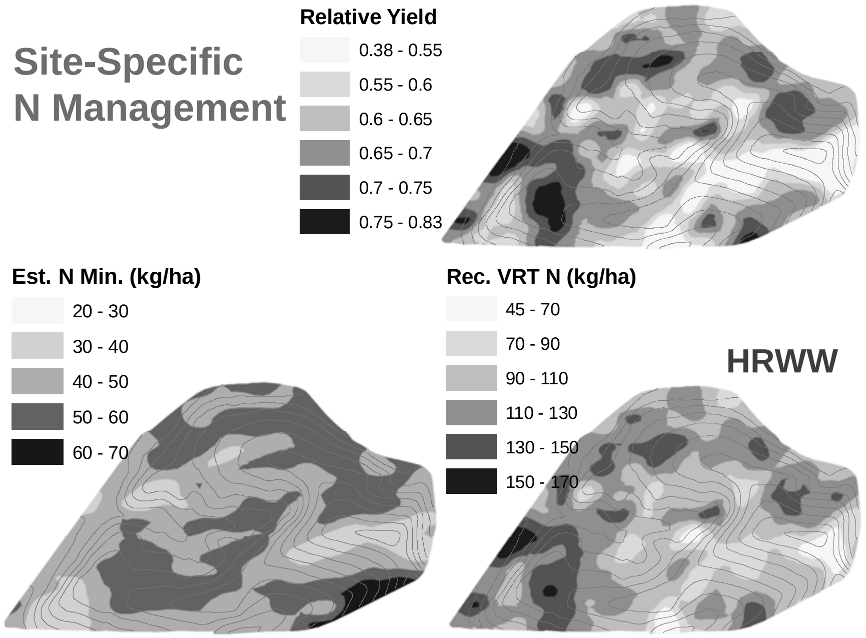


Figure 5. Relative yield, estimated N mineralization and recommended variable N fertilizer application for hard red winter wheat at the Cook Agronomy Farm.

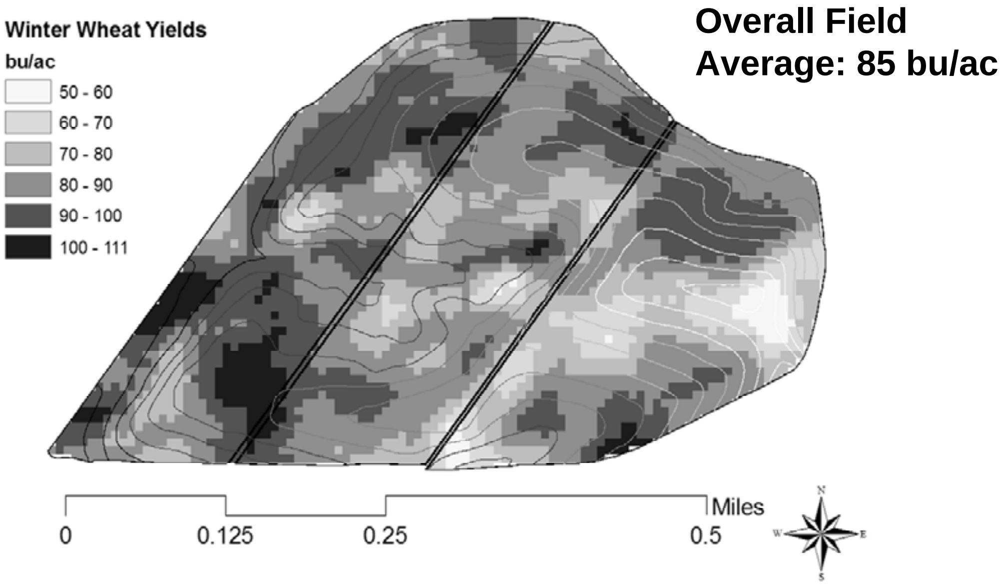


Figure 6. Field distributed yield goals for hard red winter wheat based on relative yield map and overall historic yield of 85 bu/ac.

Variable Nitrogen fertilizer rates for hard red spring and winter wheat were based on yield and protein goals and the unit N requirement defined for each (3.65 lbs N/bu for HRS and 3.0 lbs N/bu for HRW). These rates were applied and compared to uniform N applications based on the overall yield goal of the field. Results for hard red winter wheat showed a distinct advantage for the precision N management (Table 1). Although preliminary, these data show that the same yield and protein levels were achieved with a 20% reduction in applied fertilizer and a significant increase in N use efficiency. Further criteria are under development to use Gw/Nf and Ng/Nf (see Table 1 for definition of terms) as diagnostic tools to evaluate the performance of cereal crops. These efficiency ratios can be generated by growers that have a yield and protein monitor, GPS and a variable rate applicator.

Table 1. Uniform versus precision applied N (PAN) strategies for fertilization of hard red winter wheat. Gw equals the harvested grain weight; Ng equals the N weight in harvested grain. Combined with Nf (the amount of applied fertilizer) these variables were used to assess measures of N use efficiency: Gw/Nf and Ng/Nf.

	Fert N lbs/ac	Yield bu/ac	Protein %	Gw/Nf	Ng/Nf
Uniform N	**142a**	**94a**	**11.4a**	**35b**	**0.7b**
PA N	**113b**	**93a**	**11.0a**	**47a**	**0.9a**

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