RESEARCH PROJECT TITLE: Site-Specific N Management for Direct-Seed Cropping Systems

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INTERIM REPORT

PROJECT OBJECTIVES: (1) Measure and predict site-specific variables required for making N management decisions on research conducted at the 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.

KEY WORDS: Nitrogen, Precision Farming, Direct-Seed

STATEMENT OF PROBLEM: Cropping systems with inefficient N use are under increased scrutiny as N movement beyond agroecosystem boundaries results in degradation of air (Mosier et al., 1996) and water (Huggins et al., 2001) at watershed and global scales (Tilman et al., 2001) and as producers seek greater efficiencies in N use to reduce external farm inputs and costs. Tailoring N management to site-specific conditions could improve N use efficiency; however, successful implementation of site-specific N management has proven elusive as virtually every factor used to support N management decisions (i.e. crop yield, N availability, N uptake efficiency and losses) has substantial spatial and temporal variability (Pan et al., 1997). The large variation in within-field conditions suggests a large potential to significantly improve N use efficiency; however, characterization and prediction of crop performance and N-related processes is required if N management decisions are to be tailored to site-specific requirements.

ZONE OF INTEREST: High and intermediate precipitation, Palouse region of WA and ID

ABSTRACT OF RESEARCH FINDINGS: 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. Uniform versus precision N management in hard red winter wheat showed in 2005 that similar yield and protein goals were met with 18% less applied N in the field-scale precision N treatment and with greater N use efficiency than was achieved with uniform N management. Results for hard red spring wheat were of less magnitude.

RESULTS AND INTERPRETATION: The research project is pursuing two strategies to develop decision support tools for precision N management (Fig.1). The first strategy relies on historic yield and protein data and empirical models to generate site-specific decision support. The second approach integrates process-oriented modeling to generate similar products. It is expected that these two approaches will be integrated at the grower level.

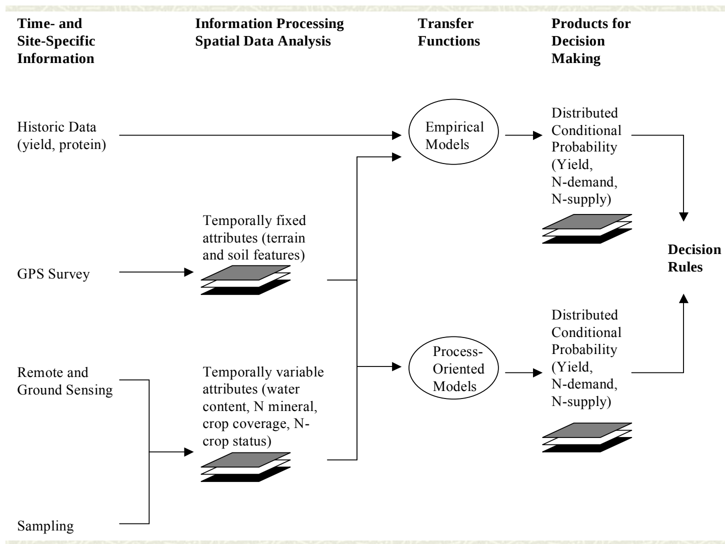

Figure 1. Conceptual strategy for developing precision N management decision rules.

Testing of precision technologies: Technologies required for growers to adopt decision rules include on-combine yield and protein monitors, variable rate application 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. Hand samples collected at 130 geo-referenced points were analyzed for grain yield and protein. Although interactions of slope affected yield monitor data (Fig. 2), overall comparisons with hand samples showed comparable results (Figure 3).

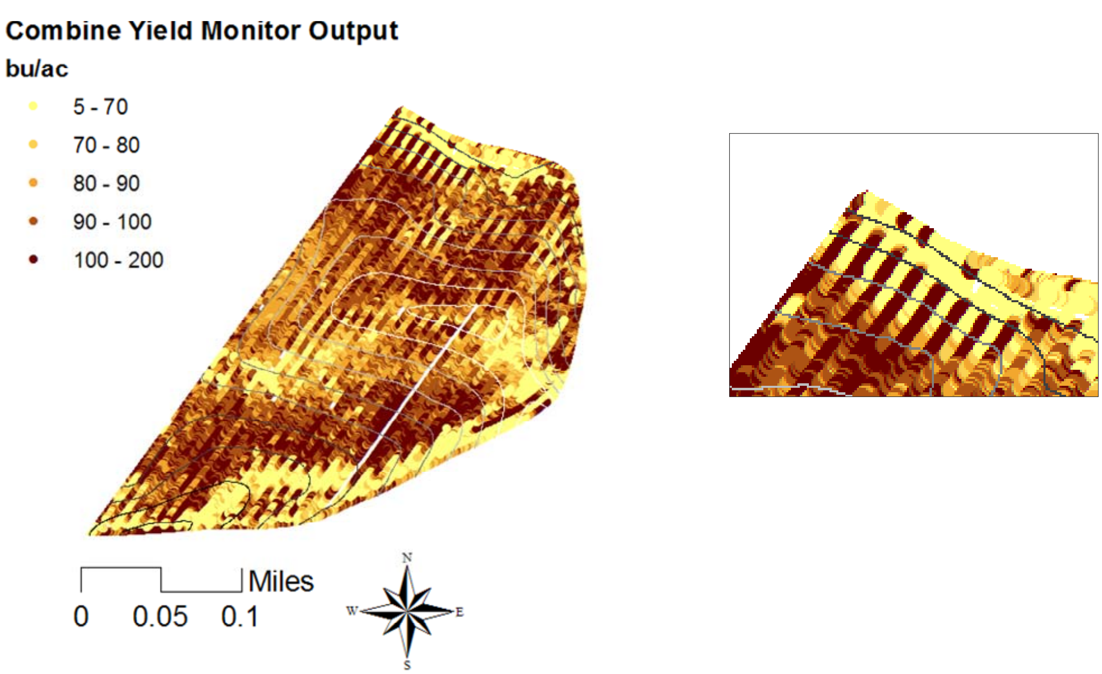

Figure 2. Yield monitor output for the Cook Agronomy Farm showing affects of slope (field striping).

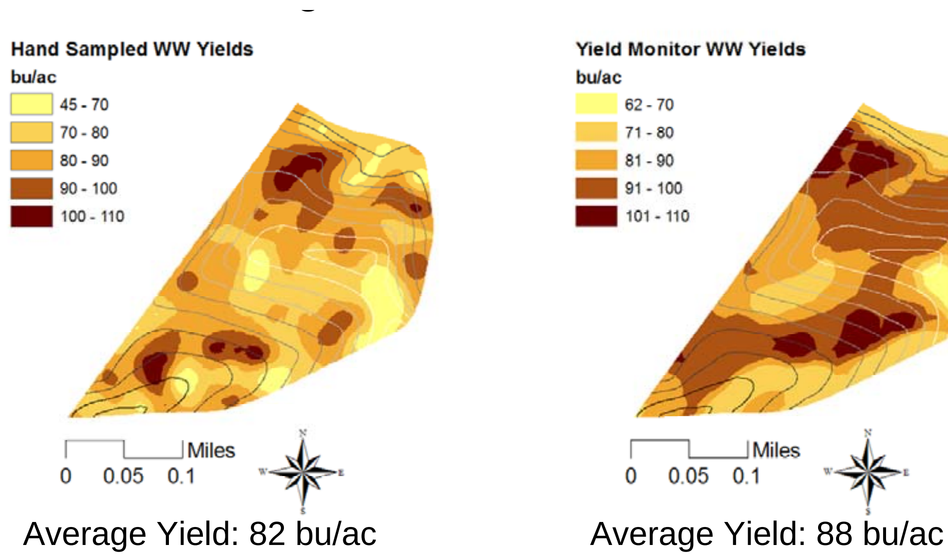

Figure 3. Comparison of hand samples versus yield monitor data for hard red winter wheat.

Preliminary analyses of on-combine grain protein monitoring using a Zeltex unit looked promising (Figure 4). Within-field grain protein patterns were similar between hand samples and monitor data.

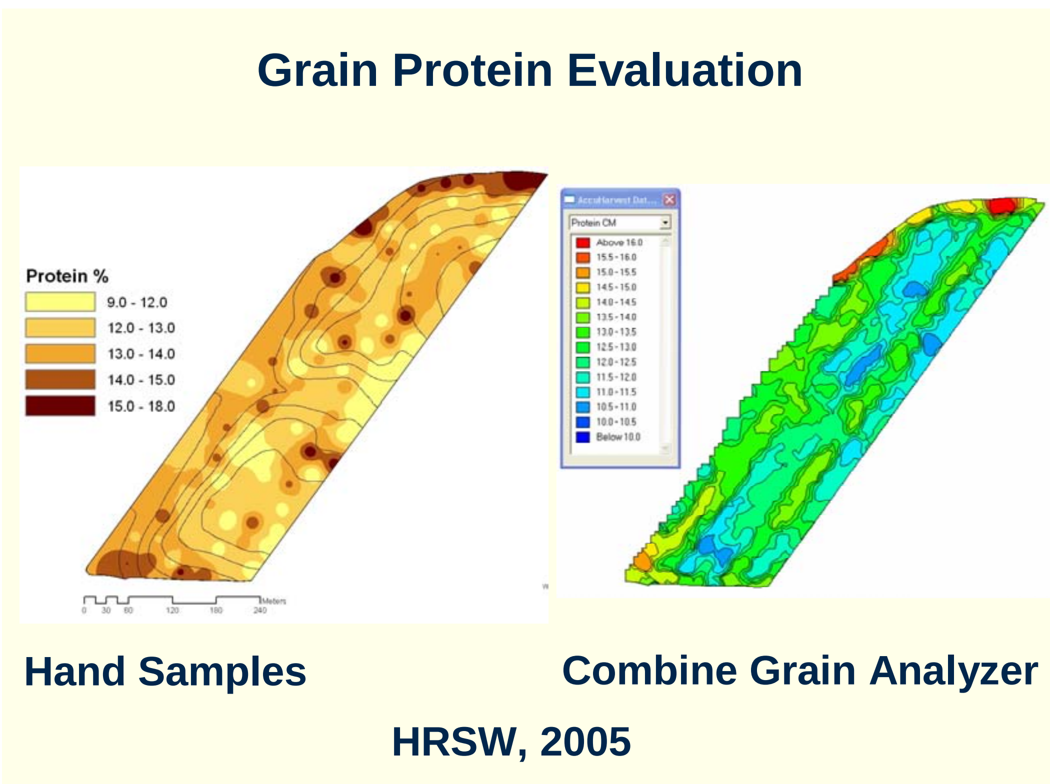

Figure 4. Comparison of hand samples and combine grain analyzer for grain protein of hard red spring wheat.

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 6).

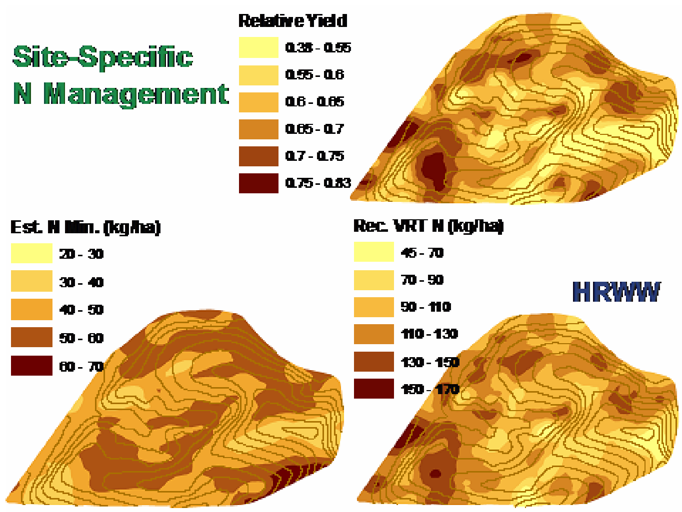

Figure 6. Relative yield, estimated N mineralization and recommended variable N fertilizer application for hard red winter wheat at the Cook Agronomy Farm.

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 7.) 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.

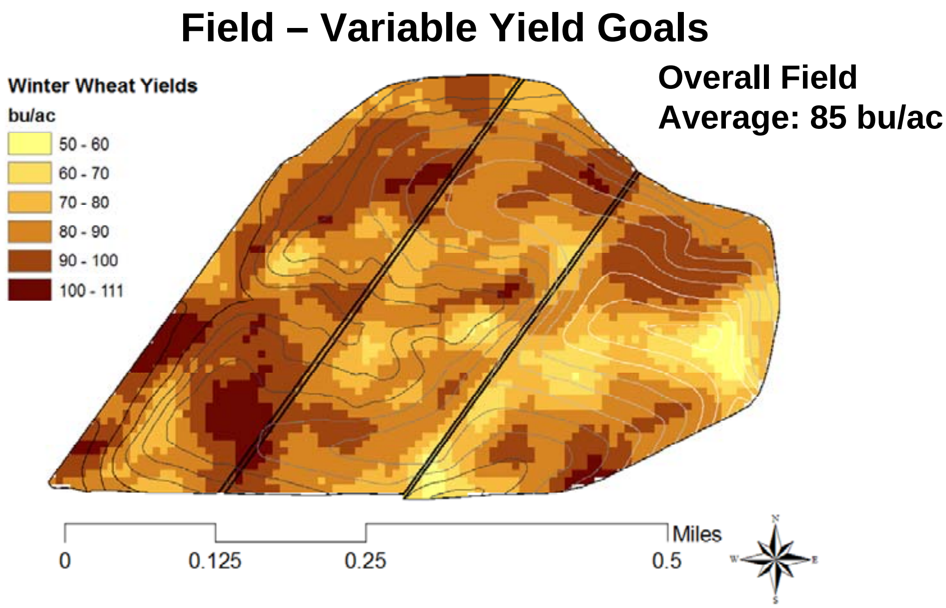

Figure 7. Field distributed yield goals for hard red winter wheat based on relative yield map and overall historic yield of 85 bu/ac.

Estimates of N mineralization were based on 369 geo-referenced soil samples analyzed for organic matter (Figure 6). This amount of detailed information is likely 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.

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. In 2005, results for hard red winter wheat showed a distinct advantage for precision N management (Table 1). Similar yield and grain protein were achieved with 18% less applied N. This primarily occurred as N rates were adjusted downward following less than normal precipitation during the winter of 2005. Wheat yields, however, were fairly typical as above normal rainfall occurred in late spring and early summer. The N balance efficiency (Ng/Nf) is a measure of N removal in harvested grain divided by fertilizer N input. Values above 1 for Ng/Nf of PAN in 2005 indicate that soil and fertilizer sources of N were important for meeting crop requirements. In 2006, winter precipitation was more normal and N rates were actually increased in high producing areas of the field to meet the expected demand. The range of N applied in the PAN treatment was 77 to over 300 lbs N/ac. Summer heat stress, however, limited yield and areas where high rates of N were applied for PAN did not respond to added N. Currently, we are considering an upper bound on N application rates may be more appropriate with soil derived N supplying more or less N to meet crop demands under variable spring and summer conditions. Hard red spring wheat has been more of a challenge for PAN.

Results for 2005 and 2006 both show slight reductions in applied N while similar grain yield and protein levels were obtained (Table 2).

Year	N Mgmt.	Yield bu/ac	Protein %	Applied N lb/ac	Ng/Nf
2005	Uniform	92	12.2	141	0.72
2005	PAN	91	11.8	116	1.29
2006	Uniform	83	12.0	197	0.47
2006	PAN	81	12.2	212	0.47

Table 1. Comparisons of uniformly applied N (primarily fall applied with spring topdress) or split between fall and spring with the precision applied N (PAN) that included a fall N application based on historic yields coupled with variable topdress-applied N in the spring dependent on an updated yield potential that considers winter precipitation. Ng equals the N exported in the harvested grain, Nf equals applied N, and Ng/Nf is a measure of N use efficiency.

Year	N Mgmt.	Yield bu/ac	Protein %	Applied N lb/ac	Ng/Nf
2005	Control	53	10.4	0	n.a.
2005	Spring	62	12.7	137	0.53
2005	Split	62	12.6	136	0.52
2005	PAN	64	12.5	131	0.57
2006	Control	50	11.5	0	n.a.
2006	Spring	51	14.8	178	0.39
2006	Split	54	14.3	177	0.40
2006	PAN	51	13.5	159	0.41

Table 2. Comparisons of control (0 applied N), all spring uniform and split fall (80 lbs N/ac)-spring applied N, and variable rate N (PAN) where 80 lbs N/ac were applied in the fall and N was applied according to variable yield goals in the spring during planting. Ng equals the N exported in the harvested grain, Nf equals applied N, and Ng/Nf is a measure of N use efficiency.

IMPACTS OF RESEARCH: Two growers in WA field testing on-combine monitors of grain protein during the 2006 harvest season and tested various stratigies for variable rate applications for wheat in 2007. In 2006 and 2007, Dr. Huggins was invited to present this research at the PNDSA Direct-Seed Conf., the Western Society of Agronomy Meetings in Salt Lake City, the PNW Precision Ag. Conf. and the International Precision Ag. Conference that was held in St. Paul, MN.

INTERACTION (COOPERATION) WITH OTHER SCIENTISTS CONDUCTING RELATED ACTIVITY: Cooperative research initiated with Dr. Dan Long, USDA-ARS Pendleton, OR. Research involves testing of on-combine monitors of grain protein and factors influencing yield, protein and N use efficiency of wheat.

PUBLICATIONS AND PRESENTATIONS:

Presentations:

1. Nitrogen Fertilizer Recovery in No-Tillage Wheat: Influence of Previous Crop, Terrain and Application Method. International Annual Meetings American Society of Agronomy, Nov. 6-10, 2005, Salt Lake City, UT.
2. Temporal Stability of Field-Scale Crop Performance in a Mediterranean Climate. International Annual Meetings American Society of Agronomy, Nov. 6-10, 2005, Salt Lake City, UT.
3. Field-Scale Variation in Nitrogen Use Efficiency and the Agronomic Performance of Wheat. Precision Agriculture Day, Jan. 12, 2006, Dayton, WA.
4. Nitrogen Index Assessment. Special presentation at NRCS national meeting on developing N loss Indices, March 9, 2006, Denver, CO.
5. Agroecosystem Design and Evaluation: A Tale of Two Research Farms. Special presentation for USDA-ARS Northern Great Plains Research Station, April 18, 2006, Mandan, ND.
6. Beyond Replicated Design. Invited Earth Day presentation, May 2, 2006, Champaign-Irbana, IL.
7. Field-Scale Variation of NUE and Classification of N Indices for Evaluating Wheat Performance. Eighth International Conference on Precision Agriculture. July 23-26, 2006, Minneapolis, MN.

Abstracts:

1. Nitrogen Fertilizer Recovery in No-Tillage Wheat: Influence of Previous Crop, Terrain and Application Method. Huggins, D.R., A.R. Kemanian, J.L. Smith and C.O. Stockle. Abstracts 2005 International Annual Meetings American Society of Agronomy, Nov. 6-10, Salt Lake City, UT
2. Temporal Stability of Field-Scale Crop Performance in a Mediterranean Climate. Huggins, D.R., R.E. Rossi and A.R. Kemanian. Abstracts 2005 International Annual Meetings American Society of Agronomy, Nov. 6-10, Salt Lake City, UT
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