Local Data Improves Sensor-Based Nitrogen Recommendations

By Olga Walsh, Robin Christiaens and Arjun Pandey

Sensor-based technologies facilitate assessment of crop nutrient status and account for spatial and temporal variability. This enables fertilizer rate adjustment according to site-specific conditions. Research in Montana shows that nitrogen (N) fertilization algorithms developed in other regions need adjustment using Montana data, for use in Montana.

Crop sensor-based systems with developed algorithms for making mid-season fertilizer N recommendations are commercially available to producers in some parts of the world. Although there is growing interest in these technologies by grain producers in Montana, use is limited by the lack of local research under Montana's semiarid conditions. A field study was carried out at two locations in 2011 and three locations in 2012 in north west Montana: the two dryland sites at the Western Triangle Agricultural Research Center (WATARC) and the Martin farm (Martin) near Conrad, MT, and one irrigated site at the Western Agricultural Research Center (WARC) near Corvallis, MT. The spring wheat variety Choteau was grown at all sites. The objectives of this research were: 1) to evaluate two optical sensors – GreenSeeker© (model 505) and Pocket Sensor (a prototype GreenSeeker Handheld Crop Sensor), 2) to assess whether the algorithms developed in other regions can be successfully utilized under Montana conditions, and 3) determine whether sensor-based recommendations need to be adjusted depending on what N fertilizer source (liquid UAN), or granular urea is used.

Table 1. Prescribed top-dress N rate (lb N/A) using NDVI sensors, by research site and year.

Treatment	Pre-plant N rate, lb N/A	Top-dress N source	Year: 2011 WTARC	2011 WARC	2012 WTARC	2012 WARC	2012 Martin
1	0	-	-	-	-	-	-
2	220	-	-	-	-	-	-
3	20	Urea	18	26	13	99	16
4	40	Urea	18	6	13	99	16
5	60	Urea	18	13	13	99	0
6	80	Urea	9	19	24	99	17
7	20	UAN	27	26	20	99	14
8	40	UAN	18	6	13	87	14
9	60	UAN	9	6	17	99	19
10	80	UAN	9	15	17	87	5

Table 2. Grain yield by preplant N and top-dress N at WTARC and WARC, 2011; and WTARC, WARC, and Martin, 2012.

Treatment	Preplant N rate, lb N/A	Top-dress N source	Mean spring wheat grain yield, bu/A: 2011 WTARC	2011 WARC	2012 WTARC	2012 WARC	2012 Martin
1	0	-	13.8 f	30.4 e	70.5 d	58.5 f	28.3 c
2	220	Urea	39.6 a	55.6 abc	73.9 d	83.0 e	30.6 bc
3	20	Urea	22.8 e	41.5 d	80.0 c	85.4 de	33.3 ab
4	40	Urea	23.1 e	51.0 bc	86.3 a	88.3 bcde	33.3 ab
5	60	Urea	27.7 cd	57.6 ab	85.7 abc	95.8 abc	34.5 ab
6	80	Urea	32.1 b	59.3 a	87.7 a	87.9 cde	35.3 a
7	20	UAN	21.6 e	48.5 cd	80.4 bc	92.7 abcd	33.3 ab
8	40	UAN	24.4 de	52.3 abc	82.6 abc	94.6 abcd	34.4 ab
9	60	UAN	29.5 bc	50.1 bc	82.5 abc	97.7 ab	33.0 ab
10	80	UAN	32.3 b	53.5 abc	86.0 ab	97.9 a	33.8 ab

Means in the same column followed by the same letter are not significantly different, $p < 0.05$.

The experimental design included ten treatments, an unfertilized check treatment (0 lb N/A), a non-limiting N-rich reference treatment (220 lb N/A), and four pre-plant N application treatment rates of 20, 40, 60, and 80 lb N/A applied as broadcasted granular urea. The pre-plant N application treatments were repeated twice, once for in-crop application of UAN and another for granular urea. Individual plot size was 5' x 25' and each treatment was replicated four times. Wheat crop reflectance measurements – Normalized Difference Vegetative Index (NDVI) from each plot were collected at Feekes 5 growth stage. The Feekes 5, early jointing (beginning of stem elongation, prior to first visible node) has been identified in a course of multiple field studies as the most appropriate sensing time for wheat because it provides reliable prediction of both N uptake and biomass. The two GreenSeeker crop sensors (Trimble Navigation Ltd., Sunnyvale, CA) were used to collect the NDVI measurements. According to treatment structure, top-dress N fertilizer was applied as broadcast urea, or as surface applied UAN (using a backpack sprayer with a fan nozzle). Top-dress N recommendations were generated using algorithms experimentally developed for spring wheat: 1. Spring Wheat (Canada), 2. Spring Wheat (US/Canada/Mexico), and 3. Generalized Algorithm. The algorithms are available at: http://www.soiltesting.okstate.edu/SBNRC/SBNRC.php. The Spring Wheat (Canada) and Generalized algorithms did not prescribe any top-dress N fertilizer to be applied at any of the experimental sites in both growing seasons. The top-dress rates prescribed by the Spring Wheat (US/Canada/Mexico) algorithm ranged from of 0 lb N/A to 99 lb N/A depending on the NDVI values measured. The prescribed N rates were applied to experimental plots (**Table 1**), and harvested grain yields were measured at crop maturity (**Table 2**).

A strong linear relationship was observed between NDVI values obtained with GreenSeeker and with Pocket Sensor

Abbreviations and Notes: UAN = urea ammonium nitrate

Obtaining spring wheat reflectance measurements (Left: Robin Christiaens, Research Associate using GreenSeeker Sensor, and Right: Jeff Jerome, Research Assistant using Pocket Sensor), Western Triangle Agricultural Research Center, Conrad, MT, Spring 2012.

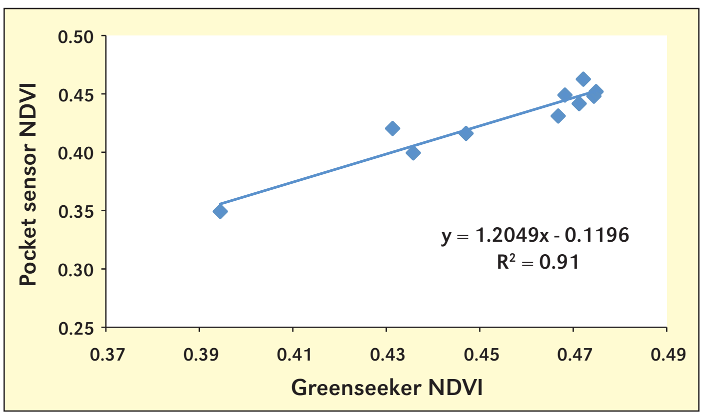

Figure 1. Relationship between GreenSeeker NDVI and Pocket Sensor NDVI, WTARC and WARC, 2011; and WTARC, WARC, and Martin, 2012. NDVI values are averaged by treatment over all five site-years.

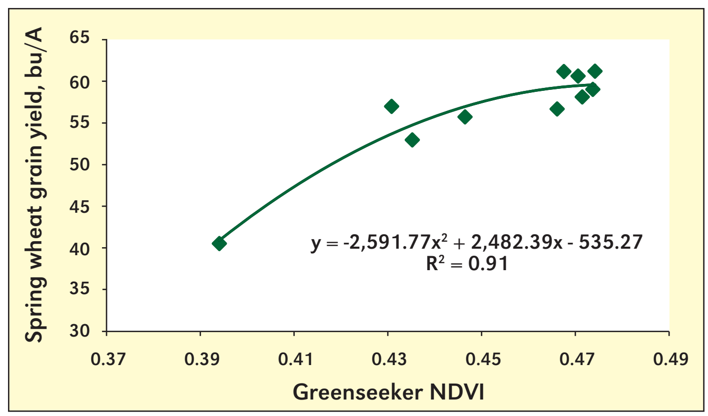

Figure 2. Relationship between mean GreenSeeker NDVI values and mean spring wheat grain yields (averaged over site-years) at WTARC and WARC, 2011; and at WTARC, WARC, and Martin, 2012.

(R^2=0.91) (**Figure 1**). GreenSeeker and Pocket Sensor NDVI readings predicted 91% and 96% of variation in spring wheat grain yields respectively across site-years ($R^2 = 0.91$ and 0.96) (**Figures 2 and 3**). In both growing season, the rates generated by the USA/Canada/Mexico Algorithm were not appropriate for grain yield optimization. For example, much higher top-dress N rates were prescribed for the irrigated site (WARC) compared to those for the dryland sites WTARC and Martin. This makes sense since the expected yield potential at the irrigated site was much greater. On the other hand, grain yields obtained at WTARC were just as high as at WARC, indicating that the yield potential was either underestimated at WTARC or overestimated at WARC. This puts forward a question of whether there is a need for two separate algorithms, one developed for dryland spring wheat, and another for irrigated spring wheat production systems. At Martin in 2012, a strong relationship between NDVI and grain yield was observed, indicating that

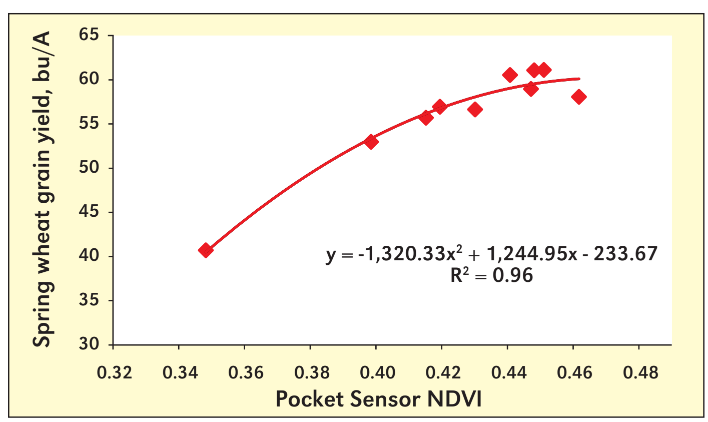

Figure 3. Relationship between mean Pocket Sensor NDVI values and mean spring wheat grain yields (averaged over site-years) at WTARC and WARC, 2011; and at WTARC, WARC, and Martin, 2012.

the sensors performed well in terms of identifying the differences in yield potential among the treatments. The top-dress N rates prescribed at this site-year did not optimize yields. A top-dress rate of 16 lb N/A was generated for Treatment 3, that received 20 lb N/A pre-plant application, compared to a top-dress rate of 17 lb N/A for treatment 6 that received 80 lb N/A pre-plant N application. Treatment 6 was one of the highest yielding treatments (**Table 1**).

Results indicated that both sensors performed well and were useful in predicting mid-season spring wheat grain yield potential. In addition, algorithms developed in other regions did not provide the appropriate top-dress N rates for Montana spring wheat varieties and growing conditions. Lastly, because there were no substantial differences in grain yields associated with top-dress fertilizer N source (urea vs. UAN) at any of 5 site-years, fertilizer rates do not need to be adjusted based on N fertilizer source, urea or UAN.

Currently, additional research is being conducted statewide in Montana to develop improved sensor-based N optimization algorithms for both spring wheat and winter wheat varieties for Montana growing conditions. BC

Acknowledgements

Funding for this research the Montana Fertilizer tax Advisory Committee. Use of the Martin Farm research site, Mr. Linsey Martin, Penroy, MT.

Dr. Walsh (e-mail: olga.walsh@montana.edu) is an Assistant Professor, Soil Nutrient Management, Mr. Christiaens (e-mail: robin.christiaens@montana.edu) and Mr. Pandey (e-mail: arjun.pandey@msu.montana.edu) are Research Associates, Western Triangle Agricultural Research Center, Montana State University.

Fertilizing Crops to Improve Human Health

The importance of fertilizer in boosting agricultural production is well known. It is estimated that at least half of the world's population now depends on fertilizer inputs for growing their food supply. The tremendous increase in agricultural productivity during the last 50 years has contributed to the goal of global food security and raising standards of living.

However, large areas of the world suffer from chronic hunger and still require additional support to overcome persistent shortages. Over 30 million people die each year of malnutrition, making it by far the leading cause of death globally.

In addition to an adequate amount of food (calories), it is also necessary to have adequate nutrition (vitamins and minerals). The Green Revolution focused on boosting the yields of staple cereal crops (such as rice and wheat), but not on the micronutrient-rich crops (such as beans and vegetables). Additionally, plant-breeding efforts tend to focus on traits such as high yields and pest resistance more than the crop nutritional content for human diets.

Trace elements in crops reflect the soil properties the plants are grown on. Crop fertilization with appropriate micronutrients offers a simple and cost effective method of improving the nutritional value of food, especially in regions where pernicious malnutrition has had devastating impacts.

Biofortification of food by using micronutrient-fortified fertilizer can improve the nutritional content of the staple foods that people already eat. This simple technique provides a relatively inexpensive and long-term means of delivering micronutrients to people in need. In some areas, micronutrient fertilizers may also increase crop yields.

This scientific publication covers other important health aspects related to fertilizer practices such as:

- Proper fertilizer management can increase the health-promoting properties (phytonutrients) of many fruit and vegetables.
- Damage done by plant diseases and pests are reduced through proper plant nutrition. Careful fertilization can improve the quantity, quality, and safety of food crops.
- A scientific review concludes that there is no evidence that organically grown crops are of superior quality. However, supplying appropriate plant nutrients in mineral form enables improvement of crop quality compared with nutrient-deficient crops.
- Calcium (Ca), magnesium (Mg), and potassium (K) are essential for humans. Properly fertilized legumes (beans) and nuts are good sources of Ca. Leafy green vegetables and legumes are rich sources of Mg. Fruits and vegetables are important sources of K. A nutrient-rich soil provides the source of these elements for crops.
- Nutrient management influences the protein, carbohydrate, and oil composition of plants. Fertilizing for optimal yields does not differ greatly from fertilizing for optimum quality for most of the world's major food crops.
- A variety of health-promoting plant substances are enhanced with proper fertilization, such as flavonoids in apples, lycopene in tomatoes, isoflavones in soybeans, sulfur-compounds in plants such as cabbage and broccoli as examples.
- Global food security remains one of the great challenges of the century. Proper plant nutrition (using both inorganic and organic sources) will play a central role in efforts to produce an adequate supply of nutritious food. BC

IPNI and partners have recently published a comprehensive scientific review on this topic with 11 chapters (290 pages) written by global experts. Details on obtaining this publication either in hard copy format or as a free download are available at: http://info.ipni.net/FCIHH