WHEAT CROP SENSING IN SPRING: ON-FARM COMPARISON OF UNIFORM N-RATE, ON-THE-GO, AND PRIOR SCANNING, 2012.

Ole Wendroth - Department of Plant and Soil Sciences
University of Kentucky, Lexington, KY 40546
PH: (859) 257-4768; Email: owendroth@uky.edu

WHAT WE LEARN FROM OUR EXPERIMENTS:

1. In this year with mild weather during winter, applying Nitrogen fertilizer between 39 lbs N/ac and 60 lbs N/ac for the first split did not cause a systematic yield difference as long as the second split added up to a total of amount of 112 lbs N/ac.
2. The effect of different N application rates for the first split was not reflected in NDVI measurements until a month after N application.
3. A fixed calibration function for the GreenSeeker improved yield slightly compared to uniform rate. A flexible calibration function that would require scanning in a pass prior to the second N application improved yield compared to fixed calibration.
4. Spatial yield variability is tremendous, obscures yield response to fertilizer rate and deserves more attention. Understanding the impact of surface topography and pedology on growing conditions is a key to effective and environmentally sustainable nutrient and crop management.

INTRODUCTION

During several years of experiments, we applied the GreenSeeker sensor in order to quantify technical characteristics and its usefulness for determining nitrogen deficiency situations in winter wheat. During these experiments nitrogen supply situations were imposed in a farmer's field that ranged between excessive and deficient supply. At a spatial resolution and data aggregation over an area of approximately 12 by 12 feet or larger an obvious spatial relationship between sensor signal (e.g., NDVI) and winter wheat grain yield existed. Lack of knowledge still exists how to convert the NDVI reading into a nitrogen fertilizer recommendation. Moreover, the response of yield to nitrogen is not uniform in a farmer's field. Results from our group and other scientists in South America have shown that a prescription function relating the N rate to NDVI should be kept flexible and be adapted to local soil or growing conditions. Moreover, to improve the site-specific N application, the behavior of NDVI across the entire field should be known before defining a prescription. This means an extra pass over the field, and the implications of on-the-go and a priori scanning are discussed here briefly:

A problem associated with on-the-go sensing is the fact that it would have to be based on two calibration spots, one having received no N fertilizer at all, and the other having received the full rate already at the first split. Scanning these two plots with the GreenSeeker and using the results for calibration can cause problems caused be soil variability and spatially differing residual amounts of nitrogen in the soil. In other words, it has to be questioned whether two calibration spots are representative for the entire field and would support a valid site specific prescription function.

Scanning the entire field prior to the second N fertilization split means an extra pass, which implies effort and time necessary for obtaining data. On the other hand, if the scanning could occur together with herbicide application prior to the second split anyway, no extra pass would be necessary. The advantage of the scanning before the fertilizer application means that the entire range of NDVI data would be known before, knowledge on field spatial variability can be included in the derivation of a fertilizer prescription. The N application would be more flexible inasmuch as it would not have to be based on one uniform response and calibration but on several prescription functions specifically derived for different zones in the field.

The objective of this project was to investigate four strips each 120 feet wide and 1380 feet long with regard to

- NDVI and grain yield under usual uniform nitrogen fertilizer application rate, while the first split is between 39 and 60 lbs N/ac and the second split compensates for a total of 112 lbs N/ac. Is there a timing effect?
- NDVI and grain yield simulating on-the-go site-specific sensor-derived N-fertilizer application based on a uniform prescription relationship between NDVI and nitrogen need,
- NDVI scanning prior to fertilizer application and using two different response functions.

RESULTS AND DISCUSSION

In Fig. 1, the spatially varying nitrogen rate is shown for the first split applied on February 09 in the 1380-ft.-long field divided in 14 plots. It is obvious that the rates were distributed in a cyclic pattern. A few days prior to the second split, NDVI was measured and data are shown in Fig. 1. From the results presented in Fig. 1 we learn, that in some zones, the NDVI follows the nitrogen application pattern, but some other zones do not show this relationship. Especially in the middle part of the field (bottom graph), we see a strong relationship between 0 and 500 ft., and between 900 and 1380 ft. distance, however, the zone from 500 to 900 ft. behaves different.

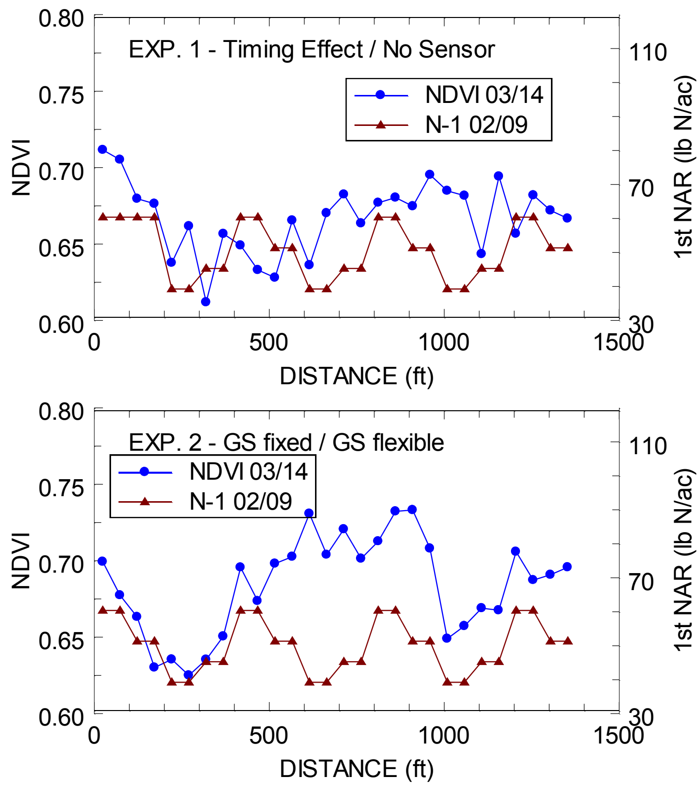

Figure 1. The red triangles show the spatial variation of nitrogen application rate (NAR) and the NDVI measured several days before the second split. The blue symbols display the NDVI measured along both strips.

The strip shown in the upper part of Fig. 1 (Experiment 1) was used for a uniform application not based on sensors but based on a total N-rate of 112 lbs N/ac while the second split compensated for whatever amount was missing from the first split to reach the 112 lbs. N/ac. The bottom part of Fig. 1 (Experiment 2) represents the part of the field that was used for a sensor-based N-rate derived from a uniform or a flexible prescription approach. Each of the 14 plots was divided into one uniform and one flexible prescription zone.

In Fig. 2, NDVI results and the N application procedure of experiment 2 are described: The applied N-rate for the first split is plotted as bullets versus the NDVI measurements known from Fig. 1 (bottom). The minimum N-rate ($N2_{min}$) for the second split was assigned to the maximum NDVI, and the maximum N-rate ($N2_{max}$) for the second split was applied for the minimum NDVI. The green line in the upper part of Fig. 2 denotes the uniform prescription function used for half of the area in each plot. In the bottom part of Fig. 2, more flexibility was allowed for the prescription because two functions were used for that experimental strip. Hence, half of each plot along the Experiment 2 strip was managed with uniform prescription, the other half with flexible prescription.

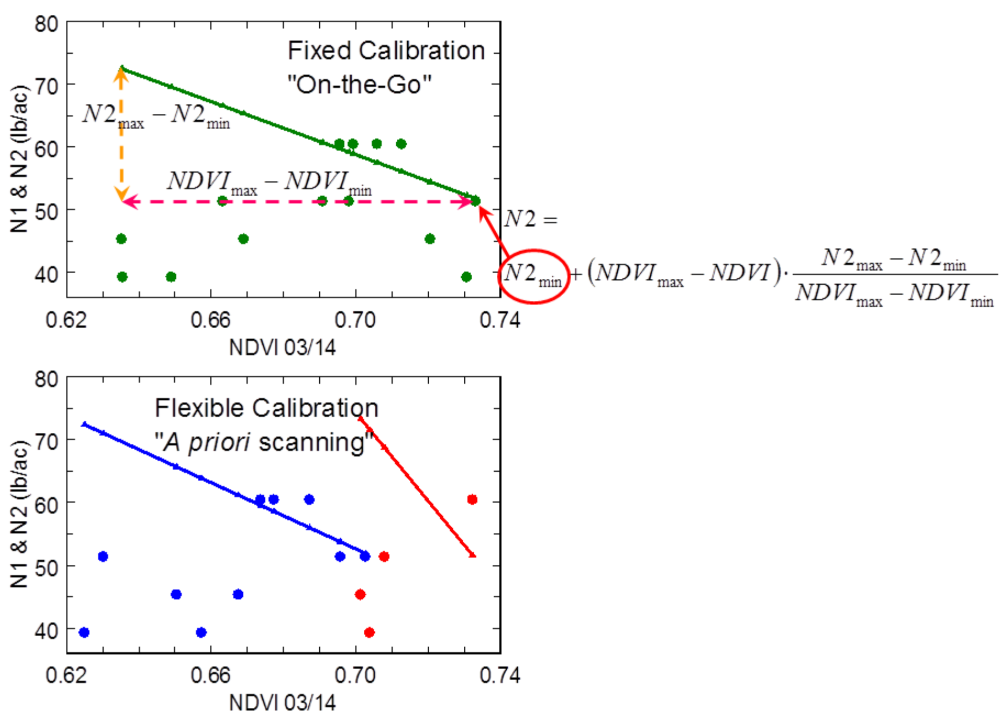

Figure 2. Fixed calibration (upper part) and flexible calibration (lower part) functions for the NDVI-N-prescription relationship. $NDVI_{max}$ and $NDVI_{min}$ denote the maximum and minimum NDVI obtained as the range of NDVI measurements.

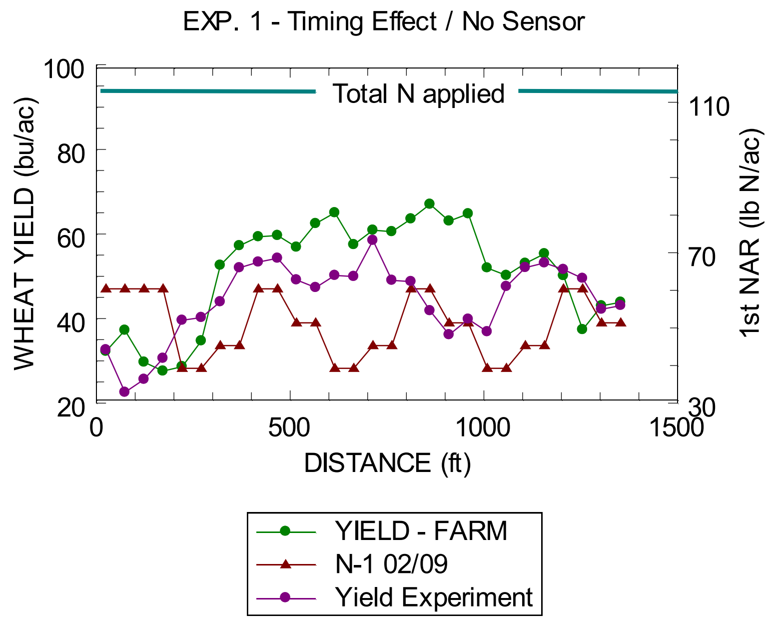

Figure 3. Wheat yield observed under the farmer's uniform nitrogen management and in the adjacent experimental strip with the N1 and N2 adding up to a uniform total rate.

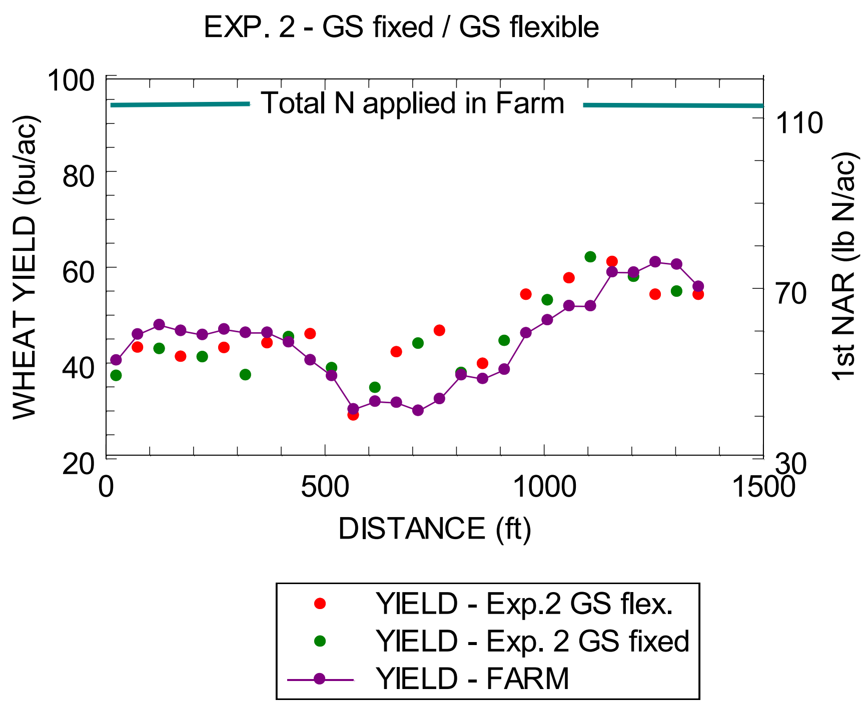

Figure 4. Wheat yield observed under the farmer's uniform nitrogen management and in the adjacent experimental strip with the fixed and the two flexible prescription functions.

The yield results of the farmer's uniform management adjacent to the fixed prescription function are shown in Fig. 3. Overall, a strong spatial variability of wheat yield was observed in both strips. The farmer's strip yielded higher on the average by 7 bu/ac. A different result was observed for the strip in Experiment 2, where half of each plot was managed according to the uniform prescription function, the other half with flexible response. Figure 4 shows that both uniform and flexible prescription yielded higher (46 bu/ac) than the farmer's strip (44.3 bu/ac) adjacent to our experimental strip. The uniform calibration yielded 44.7 bu/ac, hence yields were only slightly higher than under the farmer's uniform management. The flexible calibration yielded higher (46.9 bu/ac) than both, the uniform calibration and the farmer's uniform management.

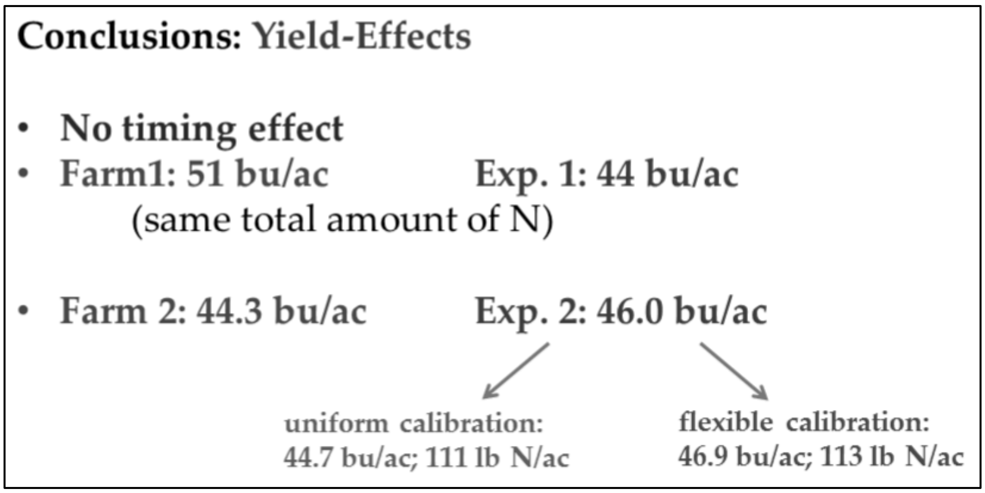

Figure 5. Summary of yield effects.

CONCLUSION

There was no obvious timing effect on yield. Hence, in this experiment and under this year's mild winter weather conditions the final yield was not obviously affected by a low or high first split as long as the total amount of 112 lbs N/ac was applied. Higher yields were obtained when the fertilizer rate was based on optical sensors, especially when a flexible prescription approach was used that would require scanning the crop prior to fertilization. It was noticeable that spatial variability of crop yield had a huge impact on yield variability and will remain in the focus of our ongoing experiments.

ACKNOWLEDGEMENTS

The farmer Trevor Gilkey has allowed us to conduct this research in his farm and we thank him for his cooperation and partnership over the years of our ongoing research. Financial support of this research through the Kentucky Small Grain Growers' Association is gratefully appreciated. Adam Hendricks (Wheattech) has produced the application prescriptions and we appreciate his help very much. We thank Jason Walton, Yang Yang and Marcela Muller for their help during the field measurement campaigns. Support from the UK Experimental Station in Princeton is thankfully acknowledged.