Advances in the Use of Remote Sensors in Argentinean Agriculture

By Ricardo Melchiori

Research on the use of remote sensors to improve N use efficiency (NUE) in Argentina has shown important advances in integrating efforts among different organizations and companies. Variable rate management based on remote sensing would be an option to improve NUE under high yielding sustainable cropping systems.

Despite the great amount of data and information developed on N management for grain crops, worldwide NUE has been estimated at only 33% (Raun and Johnson, 1999). The need for NUE improvement promotes the continuous development of knowledge and field experiments, and the evaluation of new technologies, such as those associated with precision agriculture.

In Argentina, INTA (the national institute of agricultural technology), AAPRESID (the no-till farmers' association), and Profertil (a fertilizer company) developed a joint project that has been conducted since 2002 to promote the development and dissemination of sustainable N management technologies with emphasis on the improvement of NUE through remote sensing techniques.

Several researchers have shown that crop N deficiencies could be detected by remote sensors. However, stage of development, crop cover, accumulated biomass and nutritional status, and other factors affect the spectral response of the crops and the capacity for detecting N deficiencies. Strategies based on remote sensing require the availability of technologies to detect the deficiencies and the development of diagnostic methods and prescriptions to eliminate the N stress. It is also necessary to know how much and under which conditions the potential crop yield is affected, and how the environment might affect the response to N in late applications.

The author is shown taking measurements of NDVI in a corn (maize) crop at Paraná (Entre Rios).

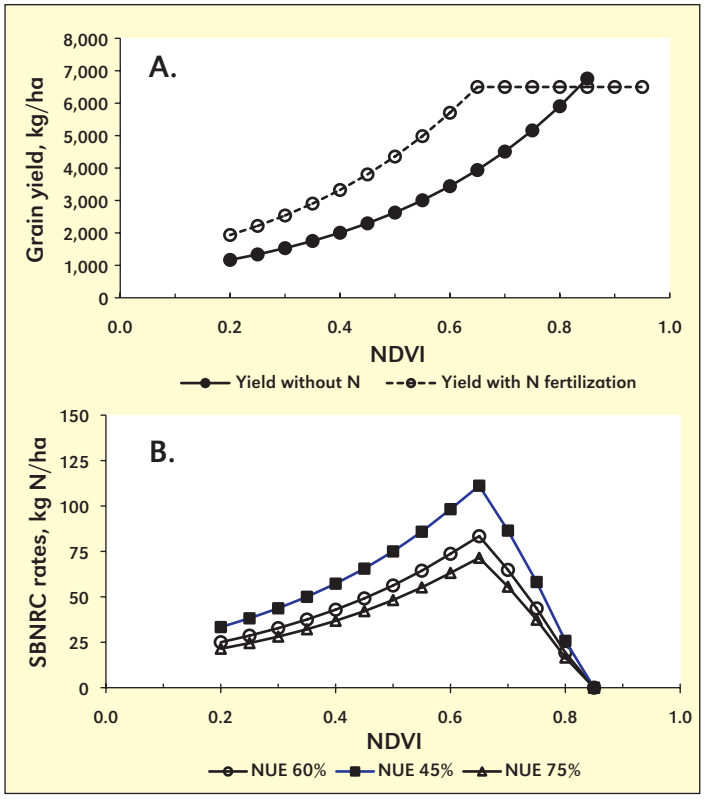

Figure 1. A) Theoretical recommendation model as function of the NDVI (Yield without/N: Yield without applied N; Yield with/N: Estimated yield with N fertilization.

B) N rate estimated for the relationships in (A) and three levels of NUE (NUE = 45, 60, and 75%).

Abbreviations and notes: N = nitrogen.

Current collaborative research in Argentina has proposed to: 1) develop and validate local procedures of diagnosis and recommendation of N fertilization based on remote sensing, and 2) evaluate N application timing to optimize the detection capacity of the N stress improving NUE. Results of this research have been published in Melchiori et al. (2004, 2005, 2006, 2007, and 2008a). This article summarizes the current knowledge gained during this project.

Development and Local Adjustments for the Use of Algorithms Based on Remote Sensing

The project in Argentina has followed the model developed by Oklahoma State University (OSU), described by Raun et al. (2005). Briefly, the method obtains predictive equations of crop yield as a function of the normalized difference vegetation index (NDVI). Algorithms predict N response at the projected yield level, and estimate the N rate required for a given NUE from the difference between yield estimations for the unfertilized and fertilized crop. **Figure 1A** and **Figure 1B** illustrate the theoretical recommendation model for wheat where the crop yield and the N response are estimated from NDVI determinations at specific crop growth stages (V10-12 in maize, or 1st-2nd node in wheat) in high-N reference plots

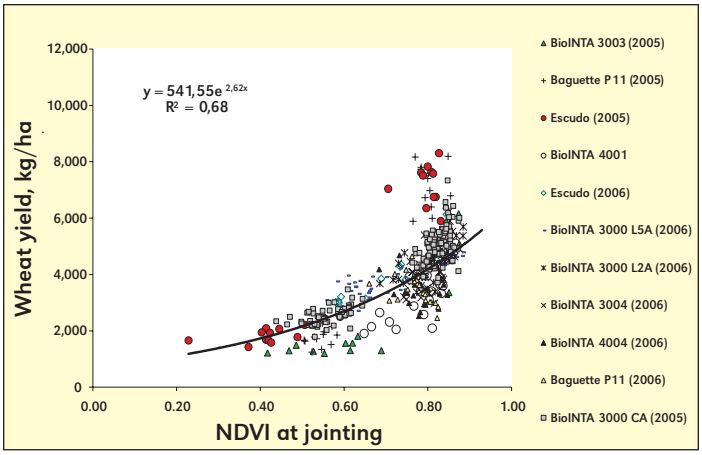

Figure 2. Wheat yield as a function of NDVI determined at beginning of the booting period with a GreenSeeker optical sensor. Data include results of several experiments with several varieties grown under differing water and N availability regimes.

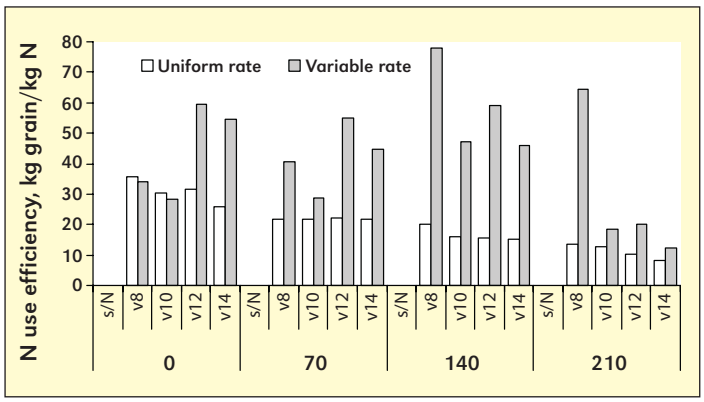

Figure 3. Nitrogen use efficiency (NUE) in maize following N fertilization between V8 and V14 using two strategies of recommendation: uniform rate vs. variable rate based on the use of remote sensors, at varying N rates applied at planting (0, 70, 140, and 210 kg N/ha) (averages 2002-2008).

and in the field of interest. The model restricts expected grain yield and NUE to pre-determined limits.

Local results in wheat crops growing under contrasting site conditions provided verification of these relationships and resulted in predictive yield models specific to Argentinean growing conditions. **Figure 2** shows, as example, the relationship between NDVI determinations with a GreenSeeker sensor and wheat grain yields at INTA Parana (Entre Rios province). This type of dataset was also developed for maize and subsequently generated equations were integrated into the library, available at: >http://www.soiltesting.oksate.edu/sbnrc/sbnrc.php<

Summary of Maize and Wheat Evaluations

The development of the model for maize required the evaluation of late-season N applications. Results from studies conducted in the USA have shown adequate N responses with N applications from growth stages V6 to V14 (Scharf et al., 2002; Randall et al., 2003). An extended N application period makes it possible to synchronize N availability with crop N demand, thus decreasing the risk in decision-making as many factors defining crop yield are already set. Although

The author (right) and Agustin Bianchini of AAPRESID check NDVI readings in maize, using a GreenSeeker sensor.

results have been encouraging (Melchiori et al. 2004, 2005, and 2006), it should be noted that row spacing of 52 cm (an expanding practice for maize in Argentina) will be necessary for the normal transit of machinery at later growth stages and that adoption of these late applications would also depend on the probability of precipitation immediately after.

Average results for seven growing seasons at Paraná (2002-2008), show that maize yield responses to late-season N applications are possible. Average N responses were similar with uniform N rates and variable-rate application using remote sensors, but the total N amount applied using the remote sensing-based model was lower, thus, improving NUE **(Figure 3)**.

In wheat, work included the development of the predictive equations relating crop yield and NDVI, as well as the evaluation of the effects of cultivars, growing cycles, tillering habits, planting N rates, and water availability. All of these factors affect NDVI determinations.

Nineteen strip field experiments were carried out from 2006 through 2008 at EEA INTA Paraná. Generally, the experiments included a strip with the N rate recommended for the field, a reference strip without N limitation, and a strip where N rate was determined using remote sensors (Melchiori et al., 2008b). In several cases, strips without N at planting and with only late N application were included. **Figure 4** shows the relationship between wheat grain yield and NDVI observed with field data and with the algorithm available at the OSU website: >http://www.soiltesting.okstate.edu<. It is quite similar to the theoretical model described in **Figure1a**.

Optimization of Variable Rate Systems

In recent years, we have started the evaluation of a variable-rate N application system (GreenSeeker RT 200, Ntech Industries, Ukiah, California, USA) in field studies. This system allows for the use of sensors on an applicator, whereby collected data are processed by a computer to prescribe N application rates and provide information for real-time variable N rate application.

Results evaluating different configurations for the number of sensor units indicate that acceptable estimations and

Wheat experimental field at EEA INTA Paraná (Entre Rios).

variability of NDVI determinations for wheat and maize are obtained with 4 to 6 sensor units for standard fertilizer applicators. Also, NDVI variability decreases as crop development progress.

Future work should be oriented to expand the evaluation of remote sensors to a wider range of environmental conditions to make N application models more robust, and to promote the development of local techniques and equipment. BC

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Dr. William Raun (OSU), Agustín Bianchini (AAPRESID) and the participants of the Precision Agriculture Project of INTA at EEA Paraná.

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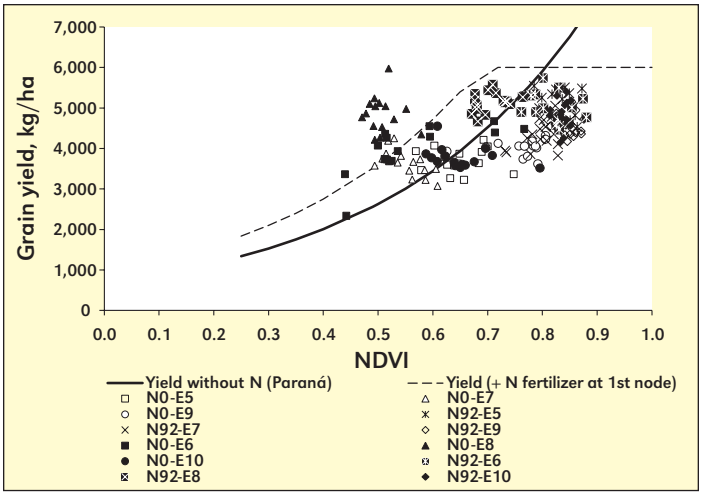

Figure 4. Wheat response to late N applications (1st node) under contrasting experimental conditions at Paraná (Entre Rios), 2006-2008.

References

Melchiori, R.J.M., O.P. Caviglia, S.M. Albarenque, N. Faccendini, and A. Bianchini, 2008a. Actas VII Congreso Nacional de Trigo.

Melchiori, Ricardo, Octavio P. Caviglia, S.M. Albarenque, Nelson Faccendini, Agustin Bianchini, and W.R. Raun. 2007. International Annual Meetings, ASA-CSSA-SSSA, Nov 4-8. New Orleans.

Melchiori, Ricardo, Pedro Barbagelata, Susana M. Albarenque, Agustin A. Bianchini, and William Raun. 2008b. Abstract submission to 9th International Conference on Precision Agriculture. Denver, Colorado. July 20-23.

Melchiori, R.J.M., O. Caviglia, and A. Bianchini. 2004. ASA-CSSA-SSSA Annual Meetings. Seattle, Washington.

Melchiori, R.J.M., O.P. Caviglia, A. Bianchini, N. Faccendini, and W. Raun. 2005. VII Congreso Nacional de Maíz. Pp. 218-220. Rosario, Argentina.

Melchiori, R.J.M., O.P. Caviglia, A. Bianchini, N. Faccendini, and W. Raun. 2006. ASA-CSSA-SSSA International Annual Meetings. Indianapolis, IN, November 12-16.

Randall, G.W., J.A. Vetsch, and J.R. Huffman. 2003. Agron. J. 95:1213-1219.

Raun, W.R. and G.V. Johnson. 1999. Agron. J. 91: 357-363.

Raun, W.R., J.B. Solie, M.L. Stone, K.L. Martin, K.W. Freeman, R.W. Mullen, H. Zhang, J.S. Schepers, and V. Jonson. 2005. Comm. in Soil Sci. and Plant Anal. 36:2759-2781.

Scharf, P.C., W.J. Wiebold, and J.A. Lory. 2002. Agron. J. 94:435-441.

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