Can a Soil Mineralization Test Improve Wheat and Corn Nitrogen Diagnosis?

By Nahuel Reussi Calvo, Hector E. Echeverría, Hernan Sainz Rozas, Angel Berardo, and Natalia Diovisalvi

A network of field studies determined that the traditional method for predicting soil N availability ...a pre-plant nitrate test ... can be combined with an indicator of soil N mineralization capacity to significantly improve the diagnosis for soil N availability for both wheat and corn.

The process of mineralization is a major source of available N for crops, particularly in soils with high OM content. Mineralization usually satisfies 30% and 60% of the N demand of wheat and corn grown in the southern region of Buenos Aires Province. However, soil N mineralization potential is site-specific. A simple and reliable way to estimate this potential in the region is the laboratory soil test known as *Nan*, which stands for *anaerobically incubated N*. This technique consists of measuring NH_4^+-N released during a 7 day, 40°C anaerobic incubation of surface soil (0 to 20 cm sample depth). The Nan test is closely correlated to potentially mineralizable N determined by long-term aerobic incubations (Soon et al., 2007), and it is sensitive to changes in management practices and tillage systems (Genovese et al., 2009). Moreover, the short period of time required to perform the Nan test represents an advantage over other methodologies that estimate N mineralization, which makes it useful as a routine method in soil testing laboratories.

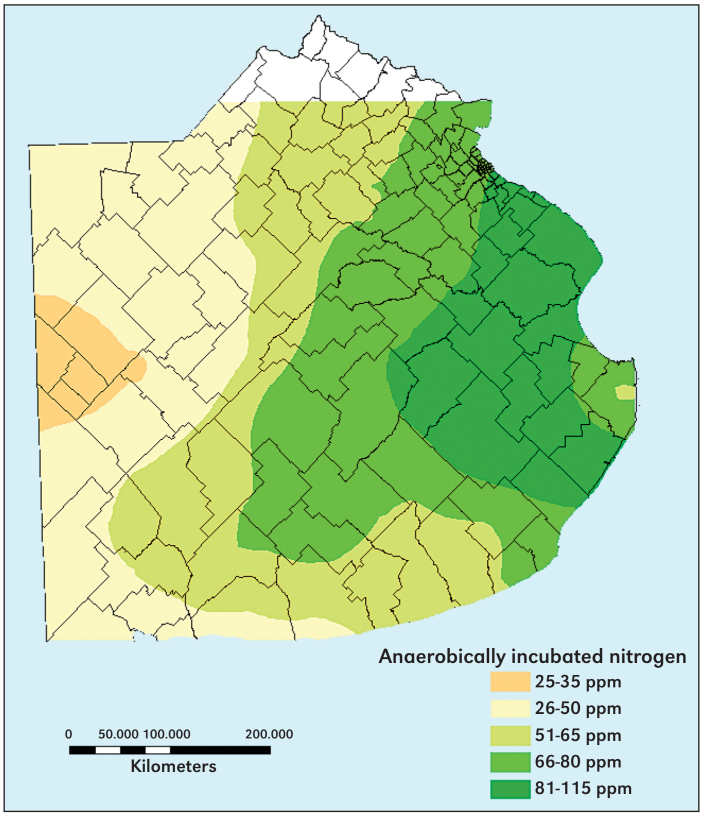

Figure 1. Average levels of anaerobically incubated N (Nan) in the surface layer (0 to 20 cm) of soil (3,240 samples) in the Buenos Aires Province, Argentina.

Response to N (on left) in an environment with low soil N mineralization as determined by the Nan diagnostic test.

In a soil survey in the Buenos Aires Province, Reussi Calvo et al. (2011) determined values of Nan ranging from 25 to 115 mg/kg. These values varied with location and tended to decrease from east to west (**Figure 1**). This change in Nan is evidence of different soil N mineralization potential within the area that should be considered when adjusting the rate of N application (Sainz Rozas et al., 2008; Reussi Calvo et al., 2013a). This particular pattern of N mineralization potential may reflect agricultural history, management practices, and climatic conditions (Genovese et al., 2009).

Today, the most widely used N diagnostic method for wheat and corn in Argentina is a NO_3^--N soil test of top 60 cm of the soil profile taken at planting time (Sainz Rozas et al, 2008; Barbieri et al, 2009). Different thresholds for N availability (soil + fertilizer) have been proposed, which vary by region, tillage system, and yield goal (Barbieri et al., 2009). However, this simplified model does not consider the direct contribution of soil N mineralization. Only 38 to 54% of the variation in crop yield is explained by NO_3^--N (0 to 60 cm) availability at planting time (Sainz Rozas et al, 2008; Barbieri et al., 2009).

Nan Experiments in Wheat

The contribution of Nan to N fertilization diagnose in wheat (**Figure 2**) was evaluated in southern Buenos Aires (Balcarce region) for a 5 year period at 28 sites. Soil OM content varied from 4.4 to 6.8 %, while Nan varied from 34 to 94 mg/kg and the availability of NO_3^--N varied between 39 and 130 kg N/ha. These values are strong indicators of a significant difference in soil N mineralization potential (Reussi Calvo et al., 2013a).

Only 24% of the yield variability in the control plots (CY) was explained by the soil NO_3^--N test (**Table 1**), which high-

Abbreviations and notes: N = nitrogen; NH_4^+ = ammonium; NO_3^- = nitrate; OM = organic matter; ppm = parts per million; RY = relative yield.

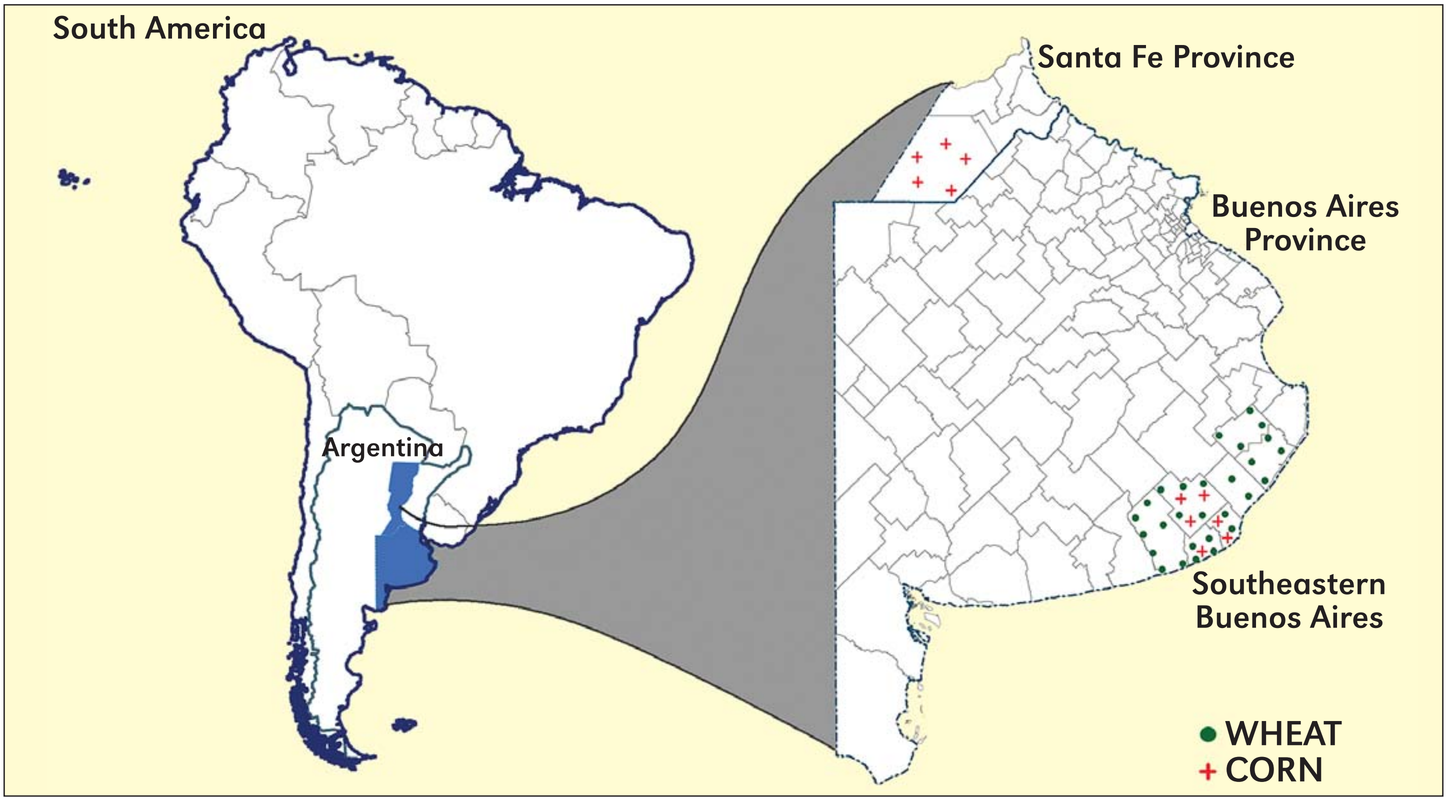

Figure 2. Location of experiments for wheat and corn in Santa Fe and Buenos Airies, Argentina.

lights the limitations of using this single variable for soil N diagnosis in wheat. Nan concentration had a greater impact on the CY than did NO_3^--N content, as it explained 41% of yield variability (**Table 1**). When NO_3^--N availability and Nan were combined the estimation of CY was improved significantly (**Table 1** and **Figure 3a**).

Pre-plant NO_3^--N content was not a good predictor of N exported in grain. However, when Nan was incorporated into the model, the estimation was improved from 11 to 58% (**Table 1** and **Figure 3b**).

Nan Experiments in Corn

Nan's contribution to the N diagnosis in corn was evaluated for six years at 14 sites within the provinces of Santa Fe and Buenos Aires (**Figure 2**). In these respective regions, the

Table 1. Models to estimate the yield (kg/ha) in control plots and the N exported in wheat grain, and the relative yield (%) of corn at planting and six-leaf (V6). Sources: Reussi Calvo et al., 2013a; Sainz Rozas et al. (2008).

Models for wheat (n = 28)	Adjusted r^2
Control yield = 3,609+ 18.810 x NO_3–N	0.24
Control yield = -1,555+ 80.732 x NO_3–N- 0.38 x (NO_3–N)^2 + 47.423 x *Nan*	0.66
Grain N = 57.8+ 0.172 x NO_3–N	0.11
Grain N = 19.1+ 0.134 x NO_3–N + 0.662 x *Nan*	0.58
Models for corn (n = 26)	**Adjusted r^2**
Relative yield at planting = 61.7+ NO_3–N x 0.234	0.37
Relative yield at planting = 53.8+ NO_3–N x 0.182 + 0.213 x *Nan*	0.57
Relative yield at V6 = 41.9 + NO_3–N x 0.653	0.56
Relative yield at V6 = 41.5 + NO_3–N x 0.492 + 0.193 x *Nan*	0.73

Nan = anaerobic N (mg/kg, 0 to 20 cm).
For wheat and corn, NO_3^--N at planting is kg/ha, at 0 to 60 cm.
For corn, NO_3^--N at V6 is kg/ha, at 0 to 30 cm.

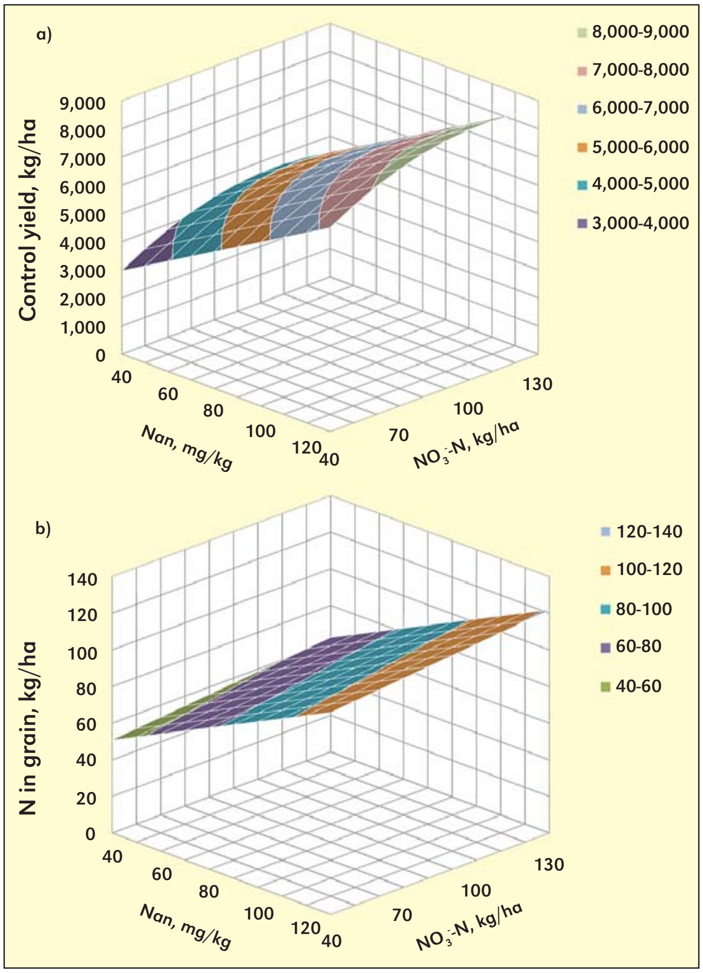

Figure 3. Contribution of Nan and preplant NO_3^--N to the yield (a) and N exported in wheat grain (b). Adapted from Reussi Calvo et al. (2013a).

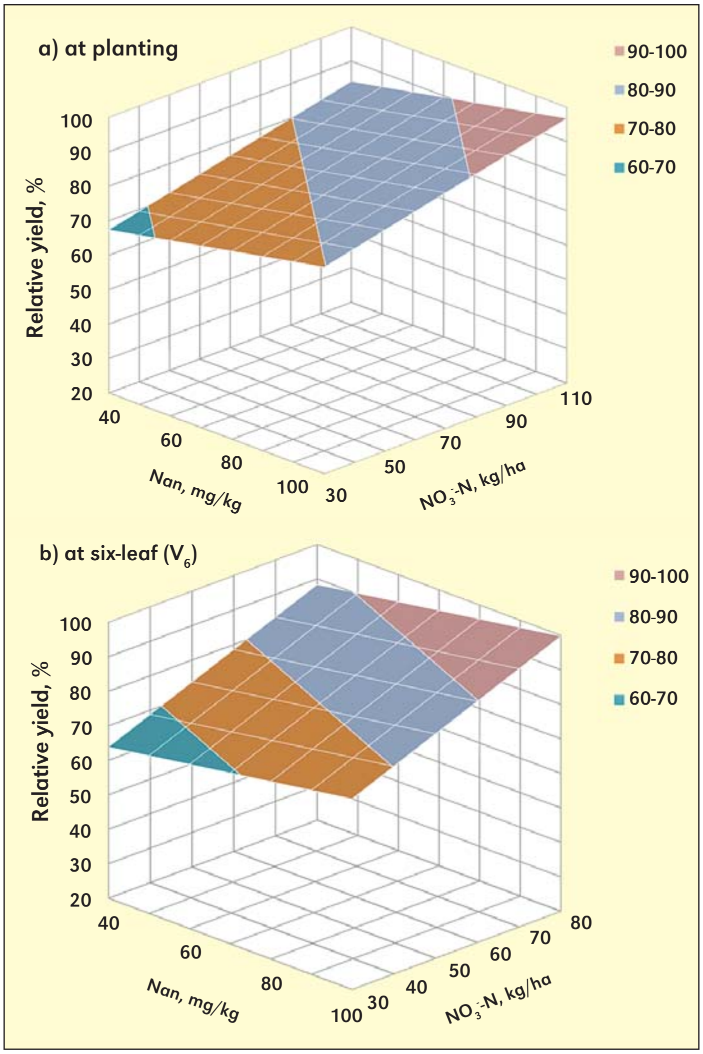

Figure 4. Contribution of Nan and NO_3^--N content to the relative performance of corn sampled at planting (a) and at six-leaf (V_6) stage (b). Adapted from Sainz Rozas et al. (2008).

soil NO_3^--N test already explained 53% and 45% of the crop yield variability (Reussi Calvo et al., 2013b). When Nan was included in the model the predictor improved by 5% in Santa Fe and 16% in Balcarce. The larger contribution of Nan to corn yield estimation in Balcarce is explained by the region's lower temperatures and higher OM contents, which would limit the overall predictive capability of the soil NO_3^--N test that is performed at planting.

Nitrogen response in an environment with low Nan. From left to right 0, 100, 200, and 300 kg N/ha.

A network of 26 experiments conducted in the southern Pampas (Sainz Rozas et al., 2008) determined that the combined measurement of soil NO_3^--N content with Nan improved the estimation of N availability at planting and V6 (**Table 1**). Furthermore, Nan has a greater partial contribution to the RY sampling at V6 than at planting (**Table 1**; **Figure 4a** and **4b**). The use of NO_3^--N at planting or V6 may be a relatively reliable methodology for predicting corn response to N fertilization in the Pampas. However, the predictive value is increased when Nan is incorporated for N diagnosis. BC

Dr. Reussi Calvo is with FERTILAB Soil Testing and Unidad Integrada INTA-FCA Balcarce (e-mail: nreussicalvo@laboratoriofertilab.com.ar). Mr. Echeverria and Dr. Sainz Rozas are with Unidad Integrada INTA-FCA Balcarce, Mr. Berardo and Mrs. Diovisalvi are with FERTILAB Soil Testing.

References

Barbieri, P.A., H.E. Echeverría, and H.R. Sainz Rozas. 2009. Cien. Suelo 27:115-125.

Genovese, F., H.E. Echeverría, G.A. Studdert, and H. Sainz Rozas. 2009. Cien. Suelo 27:225-236.

Reussi Calvo, N.I., H. Sainz Rozas, H.E. Echeverría, and A. Berardo. 2013a. Agron. J. 105:321-328.

Reussi Calvo, N., H. Saiz Rozas, A. Berardo, H.E. Echeverría, and N. Diovisalvi. 2013b. Simposio de Fertilidad. 22 y 23 de Mayo, Rosario, Santa Fé, Argentina. 269-272.

Sainz Rozas, H., P. Calviño, H.E. Echeverría, M. Redolatti, and P. Barbieri. 2008. Agron. J. 100:1020-1025.

Soon, Y.K., A. Haq, and M.A. Arshad. 2007. Com. Soil Sci. Plant Anal. 38:2029-2043.