Connecting Crop Nutrient Use Efficiency to Future Soil Productivity

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Argentina has seen significant change in its grain crop production over the past 25 years. Global demand for food, feed, fiber, and biofuels since the 1990s has driven a strong (3.7 times) increase in grain production. However, this growth has been mainly achieved by the country's expansion of planted area (especially soybean) rather than yield improvement (**Figure 1**).

Fertilizer use in Argentina has been low historically, but it has increased sharply from 360,000 t in 1993 to 3.6 million (M) t in 2017 (**Figure 2**). The trends show a steady increase up to 2007, followed by a slow down between 2008 and 2015, and then an apparent recovery in 2016-17. This evolution in fertilizer consumption has been related to area expansion, fertilizer and grain prices, and also governmental policies. Field crop fertilization (i.e., soybean, maize, wheat, sunflower, barley, and sorghum) accounts for about 80% of Argentina's total fertilizer use—the current average is 75 kg fertilizer product per ha.

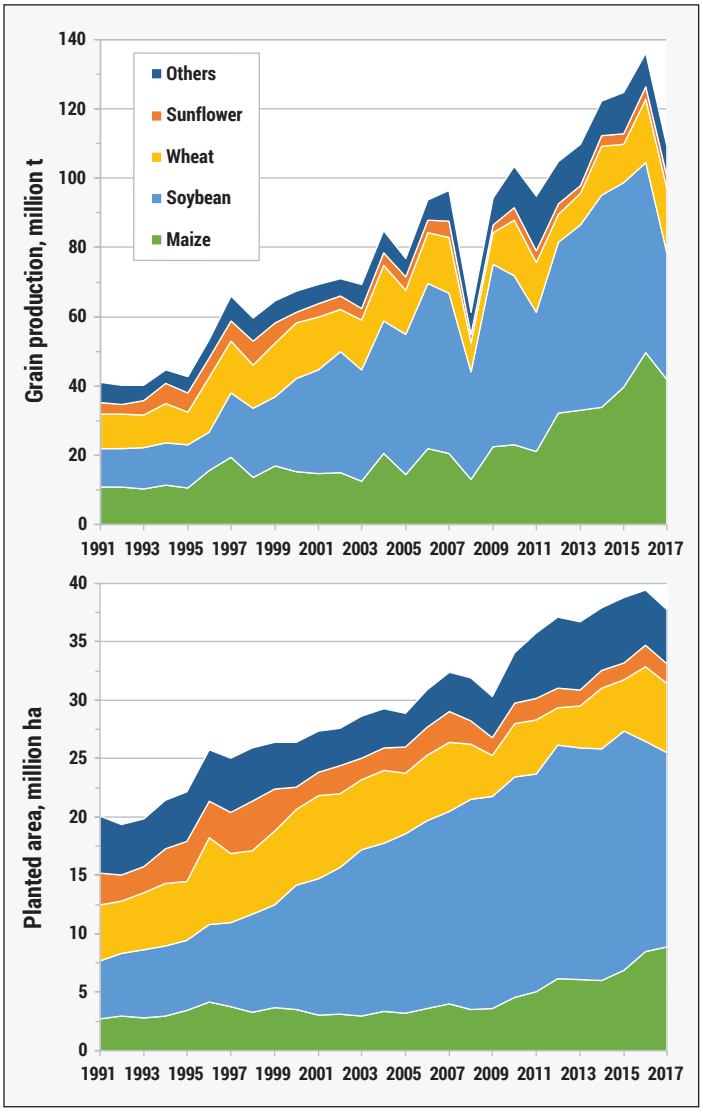

Figure 1. Grain production (top) and area planted (bottom) in Argentina (1991 to 2017). FAOSTAT-MinAgro.

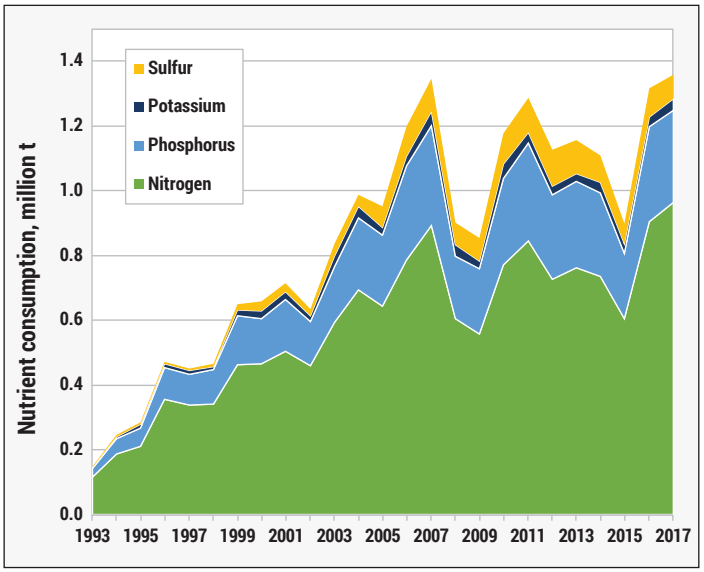

Figure 2. Fertilizer consumption in Argentina (1993 to 2017). MinAgro and Fertilizar Civil Association.

This significant growth in fertilizer use has improved nutrient budgets for field crops somewhat, but they are still far from reaching levels considered sustainable. Removal of N, P, K, and S by grains from 1990 to 2016 was estimated at 26.6, 7.7, 18.6, and 4.1 M t, respectively. During this same time period, the application of N, P, K, and S in these crops amounted to only 40%, 48%, <1%, and 26% of these nutrient removals.

Values for the nutrient use efficiency index referred to as partial nutrient balance (PNB, removal-to-use ratio) also

SUMMARY

Trends over the past 25 years indicate that Argentina's growth in its grain crop productivity has largely been supported by the depletion of the extensive fertility of its Pampean soils. Long-term research provides insight into sustainable nutrient management strategies ready for wide-scale adoption.

KEYWORDS:

Bray P; organic matter; nutrient use; sustainability; on-farm experiments.

ABBREVIATIONS AND NOTES:

N = nitrogen; P = phosphorus; K = potassium; S = sulfur; Grains included soybean and sunflower, as well as cereals (wheat, maize, sorghum and barley).

IPNI Project ARG-12

http://doi.org/10.24047/BC10248

Table 1. Accumulated grain yield and net profit after 12 years of experimentation at five field experiments in the central Pampas. Source: CREA Southern Santa Fe-IPNI-Nutrien Ag Solutions.

Site	Crop rotation	Accumulated grain yield, kg/ha		
		Check	NPS	US$/ha/yr
Balducchi	Maize-Wheat/Double-cropped soybean	57,670	127,750	370
San Alfredo		91,130	143,125	210
La Blanca	Maize-Soybean-Wheat/Double-cropped soybean	73,505	109,750	160
La Hansa		54,220	93,925	180
Lambare		88,640	112,075	80

Check = zero application; NPS = N at 90 to 175 kg/ha for maize or wheat, depending on crop yield; and P and S rates as crop removal plus 5 to 10%.

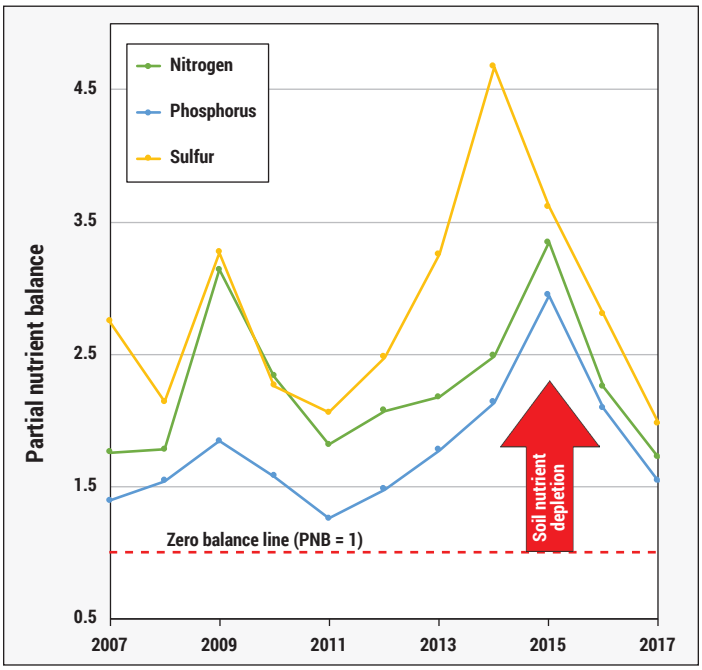

Figure 3. Partial nutrient balance of N, P, and S, for the main grain crops of Argentina (2007 to 2017). Note: For PNB of N, 60% of total soybean N uptake was attributed to biological N fixation.

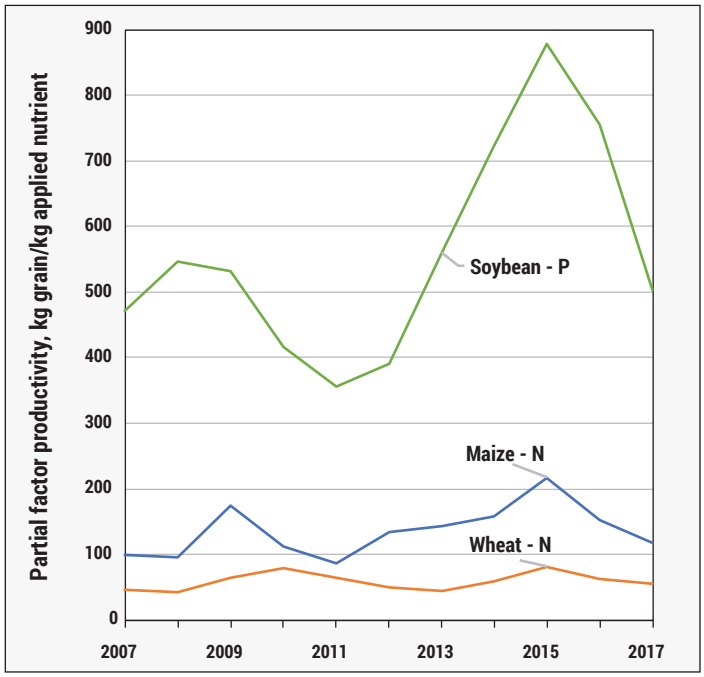

Figure 4. Partial factor productivity of N (maize and wheat), and P (soybean) in Argentina (2007 to 2017).

point to soil nutrient depletion for grains grown between 2007 and 2017, when periods of lower fertilizer use (**Figure 2**) correspond to more intensive removal (**Figure 3**). Partial factor productivity (PFP, grain yield/unit of applied nutrient) values averaged 156 and 74 kg grain per kg N applied in maize and wheat, respectively; and 695, 386, and 265 kg grain/kg P applied in maize, soybean, and wheat, respectively (**Figure 4**).

Net removal of N and P (as well as K and S) with harvested grain comes at the expense of various pools of soil nutrients and a net mineralization of soil organic matter. Accordingly, soil survey maps (**Figure 5**) provide the evidence of progressive deterioration in soil fertility with losses of 30 to 50% for native soil organic matter, and the spread of soils testing low in Bray P (Sainz Rozas, et al. 2011).

All this evidence suggests a need for profitable nutrient application rates that can sustain high crop yields and soil productivity. Long-term on-farm research in the central Pampas by CREA Southern Santa Fe (a farmer´s organization), has shown grain yield increases with balanced NPS fertilization of 27 to 120%, depending on the initial fertility condition of each site (**Table 1**). These responses generated system-sustaining gains between US$80 and US$370/ha/yr. Moreover, balanced NPS fertilization has increased soil organic C by 7%, soil glomalin concentration (indicator of microbial activity) by 23%, and soil microbial respiration by 50% (Ferreras, et al. 2018).

Conclusion

Continued development and implementation of adequate and balanced nutrient management practices will be key for Argentinean to sustain its extensive grain crop production systems. **BC**

Acknowledgement

Summary of the paper presented at the XXVI World Congress of Soil Science. IUSS-SLCS-SBCS. Rio de Janeiro, Brazil, 12-17 August 2018.

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References

Ferreras, L. et al. 2018. Better Crops 102(1): 18-20. http://doi.org/10.24047/BC102118

Sainz Rozas, H. et al. 2011. Fertility Symposium. Rosario, May 2011. IPNI-Fertilizar AC. Available at http://lacs.ipni.net/article/LACS-1018.

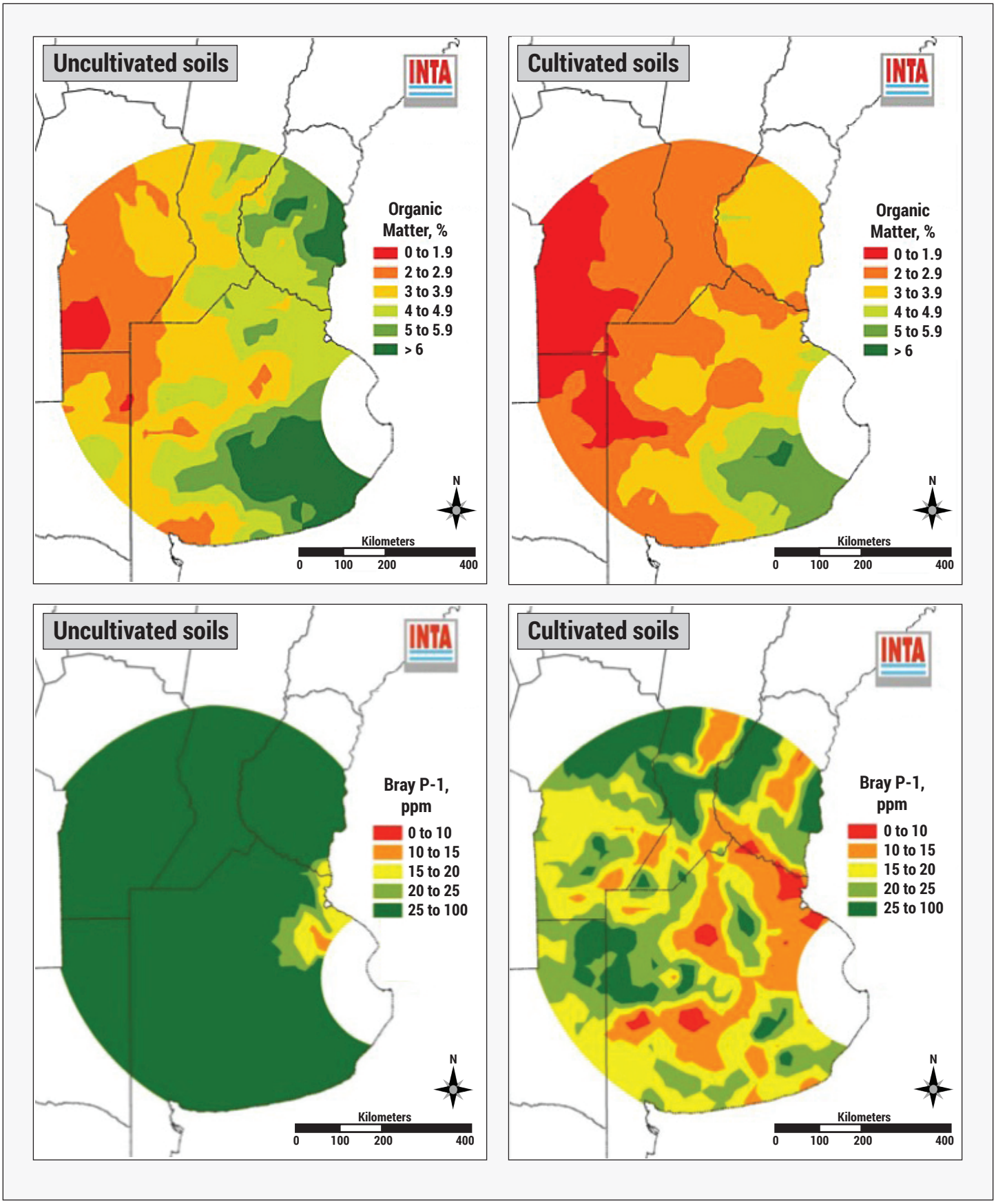

Figure 5. Soil maps comparing organic matter (top) and Bray P (bottom) in uncultivated and cultivated soils of the Pampas region of Argentina. Source: Sainz Rozas, et al. (2011) and Instituto Nacional de Tecnología Agropecuaria (INTA).