Long-term On-farm Demonstrations in the Central Pampas of Argentina: A Case Study

By Hugo Ghio, Vicente Gudelj, Gabriel Espoturno, Mauricio Boll, Juan Bencardini, and Fernando García

The Pampas region includes most of the annual cropping area of Argentina, with almost 30 million ha of cropped land. Cropping is relatively recent, with a history of 100 to 120 years for the oldest fields. Low fertilizer use and continuous nutrient removal, with increasing crop yields in recent years, has resulted in deficiencies of N, P, and S in most of the region. Under these circumstances, research has shown that nutrient application rates close to crop removal could be an alternative to sustain the trend in increasing yields while reducing depletion of soil nutrients.

In 1998 and 1999, two long-term on-farm demonstrations under continuous no-tillage were established at two farms located in southeastern Cordoba Province in the central Pampas of Argentina. The objective of these demonstrations is to evaluate the impact of various fertilization treatments on i) crop yields, ii) soil nutrient balances, and iii) soil chemical, physical and biological properties. In this article, we briefly discuss crop yield responses and trends, soil nutrient balances, and some soil properties.

One demonstration was established at Los Chañaritos farm in 1998 on a Typic Argiudoll with approximately 10 years of continuous cropping after the last pasture. In 1999, a second demonstration was established at the Don Osvaldo farm on a similar soil, but with more than 30 years since the last pasture. The Don Osvaldo site is considered under a degraded soil condition, while the Los Chañaritos site is considered as a typical soil condition for highly productive soils of the area. Results of chemical analyses carried out at the establishment of the demonstrations are shown in **Table 1**.

Table 1. Soil chemical properties of the A horizon (0 to 18 cm) at the establishment of the field demonstrations.

Depth, cm	Organic matter, %	Bray P-1, mg/kg	Exchangeable K, mg/kg	pH 1:2.5	EC mmhos/cm
-------- Los Chañaritos --------					
0-5	3.5	24	1,059	6.2	0.17
5-18	2.9	11	795	6.3	0.10
-------- Don Osvaldo --------					
0-5	2.9	14	949	6.1	0.10
5-18	2.2	5	659	6.2	0.06

At both sites, the crop rotation was wheat/doublecropped soybeans-corn. At Don Osvaldo, corn had been cropped in odd years and wheat/soybean in even years, and at Los Chañaritos, corn was planted in even years and wheat/soybean in odd years. The information reported in this article includes six corn seasons and five wheat/soybean seasons at Los Chañaritos, and five corn and wheat/soybean seasons at Don Osvaldo.

Both field demonstrations included similar fertilization treatments aimed at evaluating selected N, P, and S combinations at sufficiency and removal rates. An extra treatment included the application of micronutrients (Zn, B, and Cu). The treatments evaluated and their nutrient rates are indicated in **Table 2**. The treatments were arranged in strips of 30 m by 200 m without replication. Crop management at both sites followed normal best management practices for high yielding crops in the area. All operations were performed using farm equipment.

Abbreviations and notes for this article: N = nitrogen; P = phosphorus; S = sulfur; K = potassium; B = boron; C = carbon; Cu = copper; Zn = zinc.

Editor's note: As a leading famer, Hugo Ghio has intensified grain production in the Pampas by adjusting fertilization management in sustainable rotations under no-tillage, following the 4R stewardship concept. He states: "We doubled our crop yields just by applying the right rate and source of nutrients at the right place and time for each crop and field situation... it is as if we doubled the area that we crop."

Table 2. Treatments and nutrient rates applied at both field demonstrations from 1998/1999 to 2006/07.

Treatment	Check	Ss[1]	Ns	NPs	NPSs	NPSr[1]	NPSr+M[1]
Nutrient	----------	----------	----------	kg/ha	----------	----------	----------
N	0	0-34[2]	60-113	70-83	70-108	85-232	86-232
P	0	0	0	11-30	11-30	27-64	23-64
S	0	12-24	0	0	9-24	11-30	11-30
K	0	0	0	0	0	0	0-13
Mg	0	0	0	0	0	0	0-30
Zn	0	0	0	0	0	0	0.4-8
B	0	0	0	0	0	0	0-1
Cu	0	0	0	0	0	0	0-5

[1]s stands for sufficiency rate, r for removal rate, M for micronutrients.
[2]N was applied only in the first year in this treatment since ammonium nitrosulfate (26-0-0-14S) was used as S source.

Soybean at Don Osvaldo 2006/07; Check at left, NPSr at right.

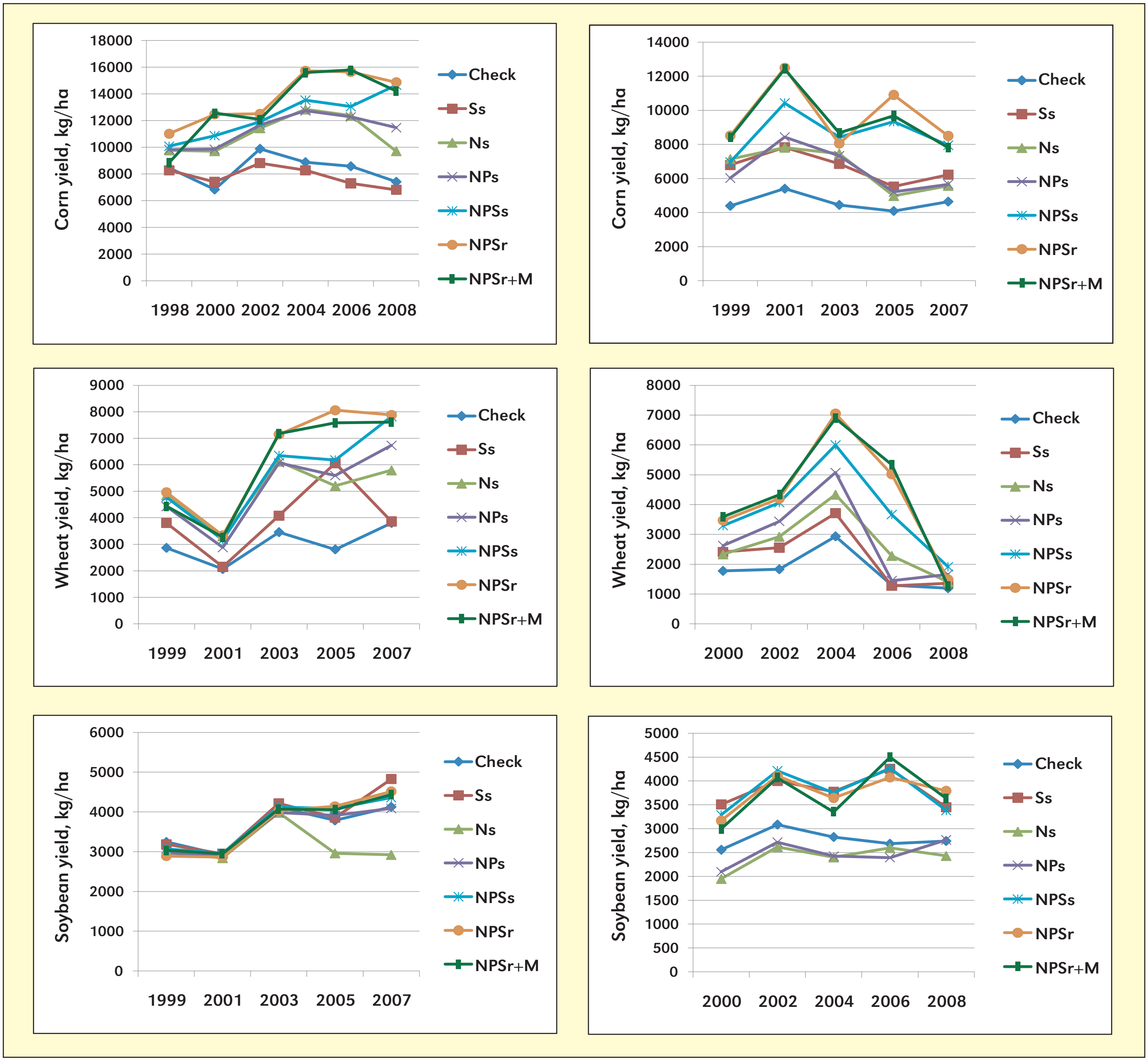

Figure 1. Grain yields of corn, wheat, and doublecropped soybean between 1998 and 2008 at Los Chañaritos (left column) and Don Osvaldo (right column).

In general, crop yields were usually higher at Los Chañaritos than at Don Osvaldo **(Figure 1)**. This could be attributed to weather differences among cropping seasons, and a better soil condition at the establishment of the demonstration at Los Chañaritos than at Don Osvaldo.

Corn and wheat responded to the application of N, P, and

Corn during the 2005/06 season at Don Osvaldo; from left to right, the treatments are: Check, NPSs, and NPSr.

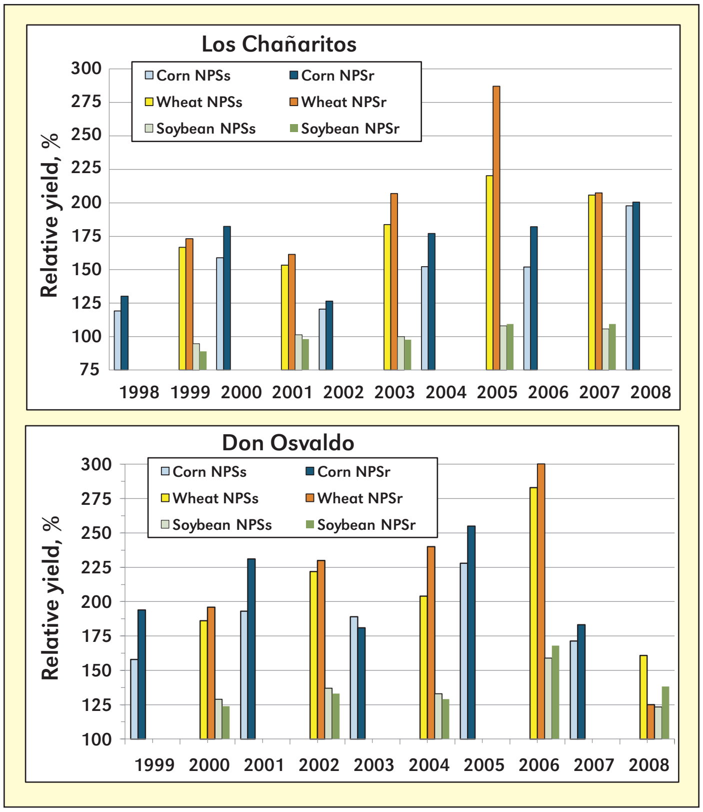

Figure 2. Relative grain yield of NPSs and NPSr treatments with respect to the Check treatment for corn, wheat, and doublecropped soybean between 1998 and 2008 at Los Chañaritos (top chart) and Don Osvaldo (bottom chart).

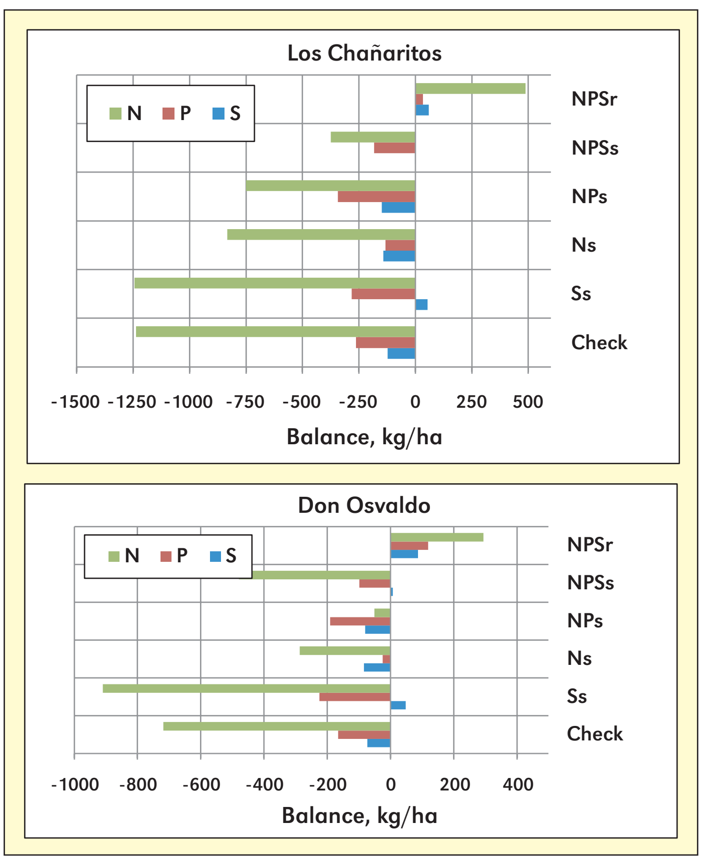

Figure 3. Nutrient balances for the seven treatments at the end of the 2008/09 cropping season at Los Chañaritos (top chart) and Don Osvaldo (bottom chart).

Table 3. Soil organic matter, Bray-1 P, and pH (0 to 18 cm) at Los Chañaritos on August 2004 (after the first six cropping seasons).

Treatment	Organic matter, %	Bray-1 P, mg/kg	pH, 1:2.5
Check	3.1	8	6.4
NPSs	3.3	18	6.3
NPSr	3.1	21	6.2

S at both sites, with the highest yields for the NPSr treatment. For soybean, the treatments without S resulted in the lowest grain yields at Don Osvaldo. At Los Chañaritos, differences in soybean yields were observed only in the last seasons (2005/2006 and 2007/2008), with the lowest yield for the N treatment. No responses were observed with application of Mg, Zn, B, and/or Cu (NPSr vs. NPSr+M treatments).

In general, grain yields of the fertilized treatments tended to increase while the Check treatments maintained similar grain yields along the years **(Figure 1)**. At both field sites, the relative grain yield differences between the Check and the NPSs and NPSr treatments, and between both NPS treatments, have increased through the seasons **(Figure 2)**. This improvement in grain yields, by maintaining or building-up soil fertility, would also provide for a better soil condition by supplying more C through greater crop residue production and root growth and development, and, thus, a greater microbial population growth and activity.

Soybean at Don Osvaldo 2006/07, showing response to S. NPs treatment is in the foreground and NPSs treatment in the background.

Nutrient balances were estimated as the difference between nutrient removal by the grain and fertilizer nutrient application. For soybean, it was considered that 50% of grain N removal is provided by biological N fixation. Thus, the corresponding amount was subtracted from the grain N removal. The S balances were positive for the Ss, NPSs, and NPSr treatments at both sites, indicating that S rates have been overestimated **(Figure 3)**. At both sites, N and P balances were positive for the NPSr treatments. Regular NPS rates used by farmers in the region, equivalent to those of treatments NPSs or NPs, would result in soil N and P negative balances of 28 to 83 and 3 to 18 kg/ha per cropping season, respectively. These negative balances have resulted in widespread and severe

NPS deficiencies in most of the fields under annual cropping in the Pampas.

The differences in P balances among the Check, NPSs, and NPSr treatments might explain the differences on soil Bray-1 P (0 to 18 cm) determined on August 2004 at Los Chañaritos **(Table 3)**. No major differences among these treatments were observed for soil organic matter and pH. Soil organic matter was slightly higher for NPSs than for the Check or NPSr. Soil pH tended to decrease as fertilizer rates increased for NPSs and NPSr, compared to the Check.

In summary, NPS applications at grain removal rates resulted in high crop yields while maintaining or improving soil nutrient balances and, thus, soil fertility conditions. Further evaluations of specific soil properties and a longer evaluation period are needed to confirm the conclusions of the first 10 years of these on-farm demonstrations. On-farm testing would contribute to a more rapid and widespread adoption of crop and soil nutrient management guidelines developed at research centers. BC

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From left, Dr. García and Dr. Paul Fixen of IPNI are shown with Mr. Gudelj, Mr. Ghio, and Mr. Boll at the corn demonstration at Don Osvaldo.

Wheat at Los Chañaritos 2007/08; check plot at the left and NPSr at right.

Conversion Factors for U.S. System and Metric Units

Because of the diverse readership of *Better Crops with Plant Food*, units of measure are given in U.S. system standards in some articles and in metric units in others…depending on the method commonly used in the region where the information originates. For example, an article reporting on corn yields in Illinois would use units of pounds per acre (lb/A) for fertilizer rates and bushels (bu) for yields; an article on rice production in Southeast Asia would use kilograms (kg), hectares (ha), and other metric units.

Several factors are available to quickly convert units from either system to units more familiar to individual readers. Following are some examples which will be useful in relation to various articles in this issue of *Better Crops with Plant Food*.

To convert Col. 1 into Col. 2, multiply by:	Column 1	Column 2	To convert Col. 2 into Col. 1, multiply by:
	Length		
0.621	kilometer, km	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
0.394	centimeter, cm	inch, in.	2.54
	Area		
2.471	hectare, ha	acre, A	0.405
	Volume		
1.057	liter, L	quart (liquid), qt	0.946
	Mass		
1.102	tonne[1] (metric, 1,000 kg)	short ton (U.S. 2,000 lb)	0.9072
0.035	gram, g	ounce	28.35
	Yield or Rate		
0.446	tonne/ha	ton/A	2.242
0.891	kg/ha	lb/A	1.12
0.159	kg/ha	bu/A, corn (grain)	62.7
0.149	kg/ha	bu/A, wheat or soybeans	67.2

[1]The spelling as "tonne" indicates metric ton (1,000 kg). Spelling as "ton" indicates the U.S. short ton (2,000 lb). When used as a unit of measure, tonne or ton may be abbreviated, as in 9 t/ha. A metric expression assumes t=tonne; a U.S. expression assumes t=ton.