Fertilizers to Sustain Production of 100 Million Metric Tons of Grain

By F.O. García, G. Oliverio, F. Segovia, and G. López

Argentina is anticipating a large increase in its grain production potential. It is clear that improved soil nutrient balance is a key to sustaining this goal.

Sustainable productivity in our agricultural ecosystems is an important objective for the 21st century. Sufficient attention to crop and soil management details such as control of weeds, insects, diseases, and soil erosion, along with adequate crop rotation, soil organic matter balance, and nutrient supply are critical components of sustainability. Adequate crop nutrient supply is possible only in soils of optimum fertility. Most of the grain production regions of Argentina...the Pampas and the extra-Pampas areas...were developed under high native soil fertility. However, negative soil nutrient balances (nutrient removal exceeding nutrient application) during 100 years of cropping history have resulted in general deterioration of fertility levels (Andriulo et al., 1996; García, 2001). Sustained, high yield agricultural production can be assured once these negative balances are addressed. Crop fertilization is the main tool available.

Nitrogen (N), phosphorus (P), and in recent years, sulfur (S) are the nutrients of most concern in the Pampas and other grain-production regions. Deficiencies and responses to other nutrients such as potassium (K), magnesium (Mg), and micronutrients are reported for specific crops and areas. Grain production in Argentina, especially for soybeans, has sharply increased in the last decade (**Figure 1**). A report from Fundación Producir Conservando has projected a potential production of 100 million metric tons (M t) of grain for 2010/11 (Oliverio and López, 2002). This increase is projected from further expansion of planted area as well as average yield improvements for the major grain crops.

This article summarizes and discusses the results of a subsequent projection by Fundación Producir Conservando (Olivero et al., 2004), which estimates fertilizer consumption based on improved soil nutrient balances for the goal of 100 M t grain production. The full report is available at >www.producirconservando.org.ar<.

Fertilizer consumption in Argentina has steadily increased since the early 1990s at a rate of 146,000 t/year (**Figure 2**). Despite this trend, the overall nutrient balance is still very negative (**Figure 3a**). In the four major grain crops, removal to application ratios for N, P, K, and S are heavily weighted toward depletion at: 3 to 5, 2 to 2.5, 50 to 100, and 10 to 100, respectively. The 2010/11 projection by Olivero et al. considers a set of improved rates of replenishment for soil N, P, and S removed by soybean, wheat, corn, and sunflower. These replenishment rates were established for each county, or department, according to present soil nutrient availability. In highly fertile soils, the replenishment rates were usually lower than 100%, allowing for a decrease in soil nutrient availability

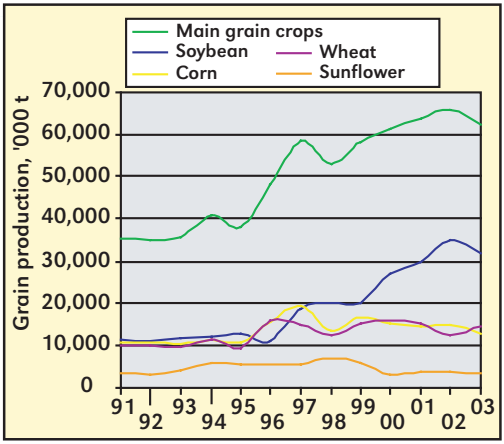

Figure1. Evolution of corn, wheat, soybean, and sunflower production in Argentina, 1991-2003. Source: SAGPyA.

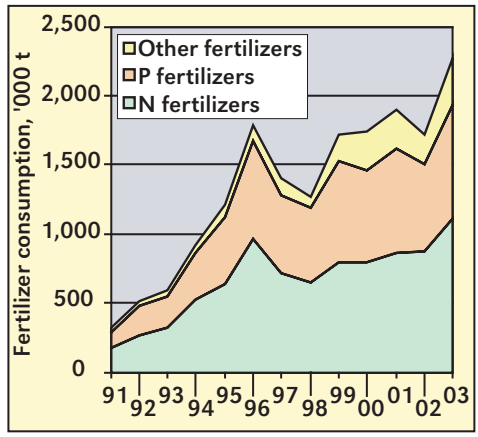

Figure 2. Evolution of consumption of N, P, and other fertilizers in Argentina, 1991-2003. Adapted from data of SAGPyA and Fundación Producir Conservando.

from a negative nutrient balance. In all cases, crop- and county-specific replenishment rates were set higher than current estimates. Phosphorus replenishment rates were set above 100% for wheat and corn in order to account for P removed by double-cropped soybeans, a portion of the rotation that traditionally relies on residual soil P.

Table 1 provides site-specific examples of the nutrient replenishment rates used in the projection. **Table 2** shows national averages for main grain crops in 2002/03 and those projected for 2010/11.

As a result of the projections, total fertilizer consumption estimated at 2.3 M t in 2003 would increase by 120% to almost 5.1 M t by 2011. Cereal and oil crops would account for 4 M t, whereas other crops (fruits, vegetables, forages, and others) would account for 1.1 M t. The estimation by Olivero et al. considered only increases for N, P, and S. Thus, if

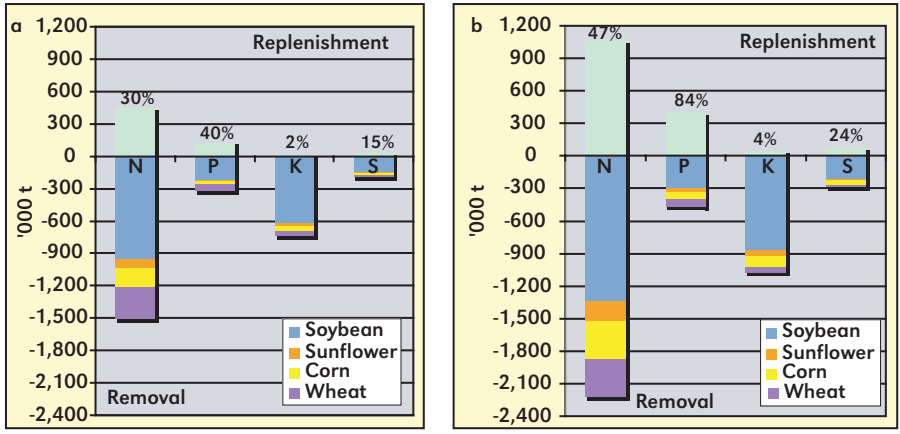

Figure 3. Nutrient removal and replenishment in the four major grain crops of Argentina estimated for the 2003/04 season (a) and projected for the 2010/11 season (b). The estimate for N removed by soybeans was reduced by 50% considering N supplied by biological N fixation. Adapted from data of SAGPyA and Fundación Producir Conservando.

Table 1. Percentage of replenishment of N, P, and S used to estimate potential nutrient needs in some counties of Argentina (Oliverio et al., 2004).

County/Department	Province	Replenishment, % N	P	S
Bahía Blanca	Buenos Aires	75	100	60
Cap. Sarmiento	Buenos Aires	88	100	60
Gral. Alvarado	Buenos Aires	63	100	40
Gualeguay	Entre Ríos	88	100	40
Marcos Juarez	Córdoba	88	100	60
25 de Mayo	Buenos Aires	75	100	60
Venado Tuerto	Santa Fe	88	100	60

the potential increase for K fertilizer consumption is also included, fertilizer consumption by 2011 would equal 5.3 M t. Based on the proposed nutrient replenishment rates, a marked improvement in the removal to application ratios is expected , with values equal to: 2.1, 1.2, 22.8, and 4.2 for N, P, K, and S, respectively (**Figure 3b**).

Most of the increase would be attributed to P fertilizers. Since soybeans will continue as the main crop, future increases in N application would be much less pronounced compared to P. The expansion of soybean monoculture raises concern not only because of the deficit in soil N replacement, but also because of low carbon (C) inputs (i.e. organic matter) to the soil. Grasses as cover crops and a higher proportion of corn and wheat in the rotation would increase N fertilizer demand, but could also help to improve soil C and N balances. Crop-pasture rotations, historically the main rotation in the Pampas, are another possibility to improve soil organic matter balances and soil C and N.

Table 2. Percentage of replenishment of N, P, and S in corn, soybean, sunflower, and wheat estimated for 2002/03 and projected for 2010/11 (Oliverio et al., 2004).

Crop	Year	Replenishment, % N	P	S
Corn	2002/03	55	103	3
	2010/11	74	138	25
Soybean	2002/03	0	19	5
	2010/11	0	54	24
Sunflower	2002/03	4	37	3
	2010/11	99	100	25
Wheat	2002/03	77	190	0
	2010/11	77	190	25

Field research has provided strong support for the adoption of balanced fertilization programs, not only because of the agronomic and economic results, but also because of the possibility of providing a better soil nutrient balance. Besides general responses to N, P, and S, responses to other nutrients such as boron (B), chloride (Cl), and zinc (Zn) have been reported. BC

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