Soil Testing and Balanced Fertilization Perform Critical Roles in a High-Priced Market

By Fernando O. García

High fertilizer prices have raised many questions from farmers and agronomists regarding fertilizer management. Best management practices (BMPs) for fertilizer use provide adequate responses for these questions. This article discusses the situation for field crops in the Pampas region of Argentina.

The most commonly deficient nutrients for field crops of the Argentine Pampas are N, P, and S. Current FBMPs on applying the right rate indicate that N and P recommendations on wheat and maize, as well as P recommendations for soybeans, should be based on soil test levels of soil NO_3-N (0 to 60 cm) and soil Bray P-1 (0 to 20 cm) at planting.

Determining the Right Rate of N

For N in corn, if a field has soil NO_3-N availability (0 to 60 cm) of 70 kg/ha, and a potential corn grain yield of 10 to 11 Mg/ha, the N recommended rate would be 100 kg N/ha to increase yield by 2.7 t/ha (**Figure 1**).

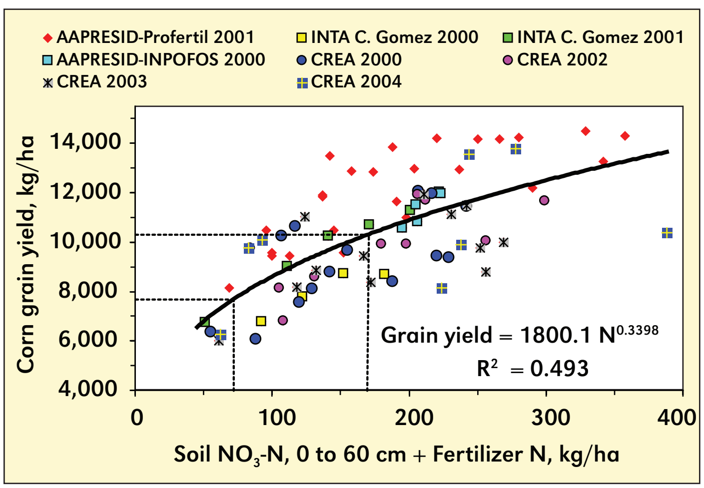

Figure 1. Corn grain yield as a function of soil N availability, soil NO_3-N (0 to 60 cm) + fertilizer N, at planting time in field experiments of the northern Pampas of Argentina carried out by several groups between 2000 and 2004.

Table 1 shows the economic results of N fertilization under this situation, with a net benefit of US$233/ ha, an increased return to the investment, and a decrease in cost of production of 6.9 US$/t of corn produced. Similarly, soil NO_3-N at planting (0 to 60 cm) can be used to guide N fertilizer rate decisions for wheat.

Table 1 Economic analysis of N fertilization in a corn field with a soil NO_3-N availability (0 to 60 cm) of 70 kg/ha at planting.

Treatment	Corn yield, t/ha	Total cost, US$/ha	Net income, US$/ha	Net margin, US$/ha	Return to investment, US$/US$	Cost per ton, US$/t
Check	7.8	647	1,115	468	1.7	82.9
N	10.5	799	1,500	701	1.9	76.0

Assumed prices: US$150/t corn; US$1.2 per kg N.

Determining the Right Rate of P

Higher fertilizer P/grain price ratios result in a need to reevaluate critical levels for P response and fertilizer P rates. Right rates of P fertilization would be determined through FBMPs such as soil testing. **Figure 2** indicates that, under current fertilizer P and wheat prices (US$180/t wheat; US$5.9/kg P) and ignoring any residual value of the P applied, responses to P application in wheat would be profitable in the short-term for soils with Bray P-1 levels of 13 mg/kg or lower.

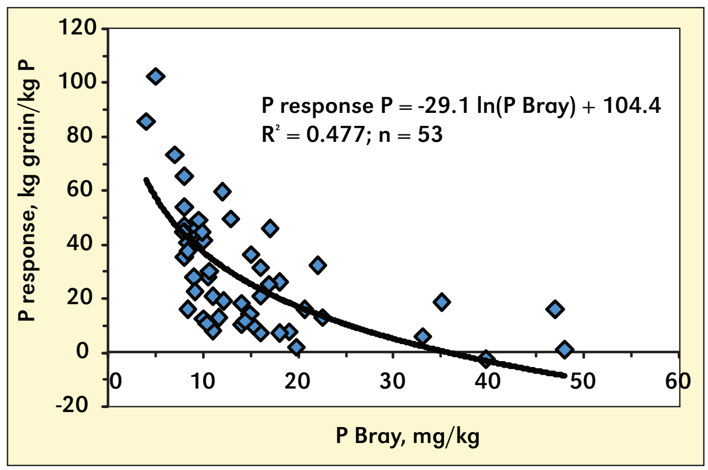

Figure 2. Wheat response to P, expressed as kg grain per kg applied P, as a function of soil Bray P-1 in 53 field experiments carried out by several authors from 1998 to 2007 in the Pampas region of Argentina.

Other points that should be considered before making any decision on P fertilization include: i) P balances and effects on soil test levels for the next years, ii) effects on the response to N or S applications and their use efficiency, and iii) the economic return on investments in land, seed, herbicides, and other inputs because of potentially lower yields.

Table 2 shows the impact of 6 years of continuous P fertilization at removal + 10% P rates in soils of low to medium soil Bray P-1 (average of 11 mg/kg Bray P-1) at the Nutrition Network of CREA Southern Santa Fe. The P fertilization resulted in gross

Abbreviations and notes for this article: N = nitrogen; NO_3^- = nitrate; P = phosphorus: S = sulfur.

Table 2. Gross margin and soil Bray P-1 changes from P application at removal + 10% P rates in 6 years of a wheat/soybean-corn rotation in the central Pampas of Argentina. Data from Nutrition Network CREA Southern Santa Fe (Garcia et al., 2006).

Total P applied[1]	Cost of applied P[2]	Gross income[3]	Gross margin	Soil Bray P-1 change[4]	Gross income from soil Bray P-1 change[5]	Total gross margin [6]
kg P/ha	US$/ha	US$/ha	US$/ha	ppm P	US$/ha	US$/ha
193	1,247	1,417	170	+13.4	394	564

[1]P applied along three rotations cycles in the NPS treatment. [2]Considering P cost of 5.9 US$/kg and application costs. [3]Gross income estimated from the differences in grain yields between NPS and NS treatments along the 6 years of experimentation; prices assumed were: US$150/t corn; US$180/t wheat; US$250/t soybean; US$1.2/kg N; US$5.9/kg P; and US$1.7/kg S. [4]Difference in soil Bray P-1 (0 to 20 cm) between NPS and NS treatments at the end of the 6 years. [5]Estimated value of the soil Bray P-1 change considering a requirement of 6 kg P to increase 1 mg/kg soil Bray P-1. [6]Sum of gross margin because of grain yield increase and gross margin because of soil Bray P-1 change.

Table 3. Wheat grain yields, net margin, return to investment, and cost per Mg of wheat produced at different soil Bray P-1 levels with and without P application for the southeastern area of the Pampas. Elaborated from data of Berardo et al. (1999).

Bray P-1, mg/kg	Treatment	Wheat grain yield, kg/ha	Net margin, US$/ha	Return to investment, US$/US1$	Cost per Mg, US$/t
	Check	3,291	260	0.93	169
<5	+P1	5,173	422	1.18	133
	Check	3,648	315	1.03	152
5-10	+P	5,259	435	1.2	131
	Check	4,044	377	1.14	137
10-15	+P	5,354	450	1.22	128
	Check	4,440	439	1.25	125
15-20	+P	5,449	465	1.24	126
	Check	4,836	501	1.36	115
20-25	+P	5,544	480	1.26	124
	Check	5,232	563	1.47	106
>25	+P	5,639	495	1.28	122

[1]Rate of 22 kg P/ha. Assumed prices: US$180/t wheat;US$5.9/kg P.

margins of 170 US$/ha in 6 years, and an average increase in soil Bray P-1 of 13.4 mg/kg. Considering that 6 kg/ha of P would be required to increase Bray P-1 by 1 mg/kg, the change in soil Bray P-1 represents a gross income of 394 US$/ha, increasing the total gross margin (grain yield + soil Bray P-1) to 564 US$/ha. These results emphasize the importance of considering not only the short-term profits, but also the long-term effects of P fertilization on soil P balances and cropping system sustainability.

Adequate P fertilization improves use efficiency of other nutrients such as N and S in corn and wheat, and S in soybean. **Figure 3** shows the improvement in N use efficiency (NUE) in wheat with adequate P application. NUE increased by 27% and 36% in field trials carried out at the beginning of the 1980s and in the last 10 years, respectively. Seven soybean field trials in the northern Pampas have shown average S use efficiencies of 22 and 27 kg soybean per kg applied S, without and with P application, respectively.

Economic analysis of grain production and response to fertilization should include not only the net profit, but also other economic indicators such as return per investment and cost per Mg of grain produced. Return to investment would be defined as the relationship of the gross income respect to the gross costs, including land, capital, and labor, this is the return to the whole investment not just the fertilizer cost. Research carried out at the southern Pampas on wheat (Berardo et al., 1999), indicates that the greatest wheat grain yield, net margin, and return to investment and the lowest cost per Mg were obtained at soil Bray P-1 levels above 25 mg/kg, emphasizing the importance of high Bray P levels for getting high yields and profits (**Table 3**). Thus, getting high soil P levels would be a goal for the

Response to balanced fertilization in maize at the Nutrition Network CREA Southern Santa Fe: NPS treatment to the left and check at right.

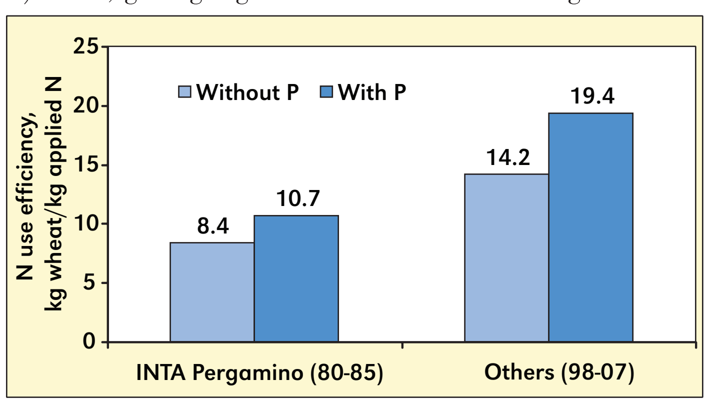

Figure 3. Nitrogen use efficiency in wheat with or without P application for trials carried out by EEA INTA Pergamino (Buenos Aires, Argentina) between 1980 and 1985, and by several other groups in the Pampas region of Argentina between 1998 and 2007.

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Table 1. Estimated margins (total revenue minus operating expenses) for years 2005 through 2008 for irrigated durum wheat, southern Alberta.

Crop year	Nutrients: N 120 lb/A	P_2O_5 55 lb/A	K_2O 10 lb/A	Expected yield, bu/A	Market price, $/bu	Gross revenue, $/A	Fertilizer cost, $/A	Operating cost, $/A	Margin, $/A
	--------- Price, $/lb		---------						
2005	0.40	0.30	0.15	90	$4.27	$384.30	$66.00	$229.00	$155.30
2006	0.45	0.38	0.15	90	$4.27	$384.30	$76.40	$233.40	$150.90
2007	0.60	0.70	0.15	90	$6.40	$576.00	$112.00	$300.00	$276.00
2008	0.90	1.00	0.59	90	$9.00	$810.00	$168.90	$353.90	$456.10

fertilizer prices change.

An excellent example of a crop planning tool used with farm customers was developed by Keith Mills, a CCA working for a retail grain and crop input company in Western Canada. He works with farm customers growing crops under both irrigated and rain-fed conditions in southern Alberta. His easy-to-use Basic Crop Planner is a spreadsheet program he uses with customers to estimate potential returns per acre for a number of different crops. His customers often use this tool to help them decide which crops to grow if they are considering changes in their crop rotations. The grower can quickly calculate margins per acre by entering realistic crop yields for their farm along with current area prices for crop inputs, including fertilizers, and prices expected for harvested crops.

Keith Mills emphasizes that the yield and input price estimates entered need to be realistic for the area. The Basic Crop Planner is based on variable crop inputs and expected crop yields and current market prices, and doesn't include fixed costs as this can vary greatly from farm to farm depending on specific land ownership and rental conditions. Mills updates his crop planner each year with average crop prices and input costs for the area where he works. It can be modified by an individual customer especially for expected crop yields depending on specific field conditions, and if an alternate source for crop inputs at different prices is found.

It is interesting to compare information from a number of years for a specific crop and see how changes in crop input prices or operating costs and grain prices affect margin returns per acre. This growing season (2008) some farm customers were considering reducing their rates of fertilizer solely because of increases in fertilizer prices. However, when they saw what the margins were using current fertilizer and crop prices, fertilizer rates have in most cases remained similar to recent years and margins have increased. An example in **Table 1** shows estimated returns over the years 2005, 2006, 2007, and 2008 for irrigated durum wheat.

Operating costs have increased and fertilizer inputs have increased more compared to most other crop inputs, such as herbicides and fuel. The fertilizer costs as a percentage of operating costs are 29%, 33%, 37%, and 48%, respectively for the years 2005, 2006, 2007, and 2008. For example, if the years 2006 and 2008 are compared, fertilizer costs increased 121%, but margins increased 202%. Between the 2 years, every extra $1.00 of investment in fertilizer has been offset by $2.49 in increased margin per acre.

Fertilizer rates have remained similar over the past 4 years even though the portion of the operating costs from fertilizers has increased. Fortunately for growers, the return on fertilizer expenditures remains very positive and optimum economic fertilizer rates have remained similar to rates before the increases in both grain and fertilizer prices. BC

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long-term P management.

In a short-term analysis of P fertilization, it improved net margin at soil Bray P-1 levels below 15 to 20 mg/kg, and return to investment and cost per Mg grain at soil Bray P-1 levels lower or equal to 10 to 15 mg/kg (**Table 3**). The highest grain yields obtained at these experiments were 5.7 Mg/ha, and the rate used provides enough P to replenish the P extracted in wheat crops of up to 6 Mg/ha. Thus, soil testing and adequate P rates provided for high yields, economic profit, and neutral to positive soil P balances. Fertilizer P rates would be increased at lower soil Bray P-1 levels (i.e. less than 10 mg/kg) to improve Bray P-1 status of these soils.

Conclusions

- Balanced fertilization…NPS for this region…results in higher use efficiency of all the resources and inputs implied in grain production.
- Soil testing is a key BMP in defining the right rate of N and P for field crops of the Pampas of Argentina.
- Applying BMPs for fertilizer allows the objectives of productivity, profitability, sustainability, and a healthy environment to be achieved. BC

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