Fertilizer best management practices in South America's agricultural systems

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Introduction

South America has a great diversity of agricultural systems. To date no government of any country has endorsed or forced on the farming sector a multidisciplinary system that involves a set of practices that guarantees profitability and/or a neutral environmental impact.

The following is a summary of the current situation regarding fertilizer nutrient use in the major agricultural systems of most South American countries, with particular reference to the commercial production sectors of Brazil and Argentina (FAO, 2003, 2004).

Status of crop production and output target

In general, the agriculture of the region may be divided into two categories:

- An export-oriented commercial sector that aims for maximum economic yields. However, the Mercosur soybean – corn based systems have little in common with the fruit and vegetable systems of the Andean countries, regarding the use of fertilizer nutrients, although both are export-oriented. There are some systems that are a mixture of these two categories - the following discussion concerns the predominant systems.
- Subsistence farming is very common in all South American countries. Due to inequality in the distribution of wealth, there are areas with considerable poverty. A common feature shared by all the countries is that a large number of tenant farmers account for a small proportion of the agricultural land (Figure 1). As regards nutrient management, a common factor of this small-holder sector is, in general, the absence of the use of any fertilizer, apart from manures and/or organic wastes.

Although none of the governments of the region enforce any particular practice concerning the use of nutrients, in many countries and regions within the countries, there are several examples of ecologically-oriented agriculture, which involve control over farm practices through certifying organizations. The period of time over which much land in South America has been cultivated is relatively short. In consequence, in many areas, the nutrient content of soils is high enough for the application fertilizers not to be necessary. The relative absence of pressure from pests and diseases in these relatively unspoiled environments permits an efficient organic agriculture. A large proportion of these organically grown products is exported to Europe and North America.

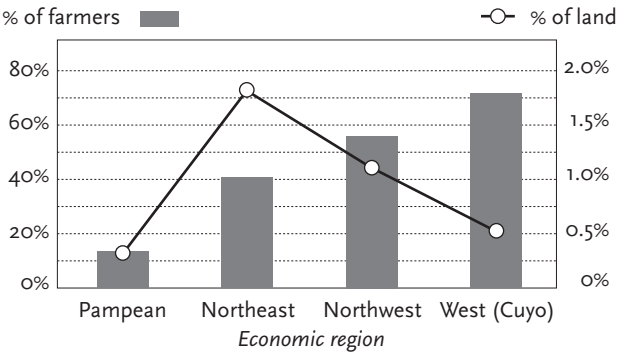


Figure 1. Proportion of smallholders and share of the total agriculture land in the four agro-economic regions of Argentina. The smallholder class comprises farmers who own less than 25 hectares.

The organic farming systems are strictly monitored in accordance with the principles of the International Federation of Organic Agriculture Movements (IFOAM) and related organizations. They can be said to prescribe the fertilizer best management practices (FBMPs) practices that have to be followed.

The most notable characteristic of this mega region is the importance of agriculture in the national economy. The importance of the agricultural sector to the national economy can be measured either in terms of its contribution to the gross domestic product (GDP) or by the proportion of the population employed in agriculture, when compared with other countries with an important agricultural sector (Table 1).

Table 1. Proportion of GDP and employment accounted for by the agricultural sectors of two groups of countries (CIA, 2007).

South America	Ag GDP (%)	Ag labor force (%)	OECD countries	Ag GDP (%)	Ag labor force (%)
Venezuela	3.7	13	Australia	3.8	3.6
Mexico	3.9	18	Canada	2.3	2
Chile	5.9	13.6	France	2.2	4.1
Brazil	8.0	20	Greece	5.1	12
Uruguay	9.3	14	Israel	2.6	1.8
Argentina	9.5	22	Russia	5.3	10.8
Colombia	12.0	22.7	South Africa	2.6	30
Paraguay	22.4	45	USA	0.9	0.7
Average	*9.3*	*21*	*Average*	*3.1*	*8.1*

In addition, many countries are among the world's top producers or exporters of cereals and oil crops (Brazil and Argentina), fruits (Chile), flowers (Colombia, Ecuador), vegetables (Mexico, Costa Rica) or industrial products such as coffee or cotton (Brazil). The production of these crops is usually highly integrated with agribusiness chains.

The importance of agriculture is overwhelming in many rural regions, even if this is not well reflected in the statistics. Vast sectors of the economy of small towns or villages that are not involved directly in agriculture could not exist without it.

Nutrient management, recycling and budgets

South American countries rarely offer agricultural subsidies such as those accorded in many OECD countries. In most cases, fertilizer use is determined more by economic considerations. In this context, commercial sector farmers naturally aim for maximum economic yield and try to avoid the misuse and excessive use of fertilizers.

One exception as regards subsidies is Chile that reimburses farmers for expenditure on liming and on fertilizer use in certain cases that fall within the «Green Box» framework, i.e. agricultural support measures that do not distort trade.

However, nutrient imbalances do occur due either to excessive or to inadequate application of certain nutrients or, most commonly, due to the insufficient restitution of nutrients or low fertilizer rates. The absence or low application of P was very common for many years in Argentina, partly due to an unfavorable price ratio between P fertilizer and grain. This situation lasted for many years and ultimately resulted in serious imbalances as nutrients removed in the exported grain were not replaced (Figure 2). This situation is changing, with a steady trend towards increasing N and P rates, as a result of successful educational programs.

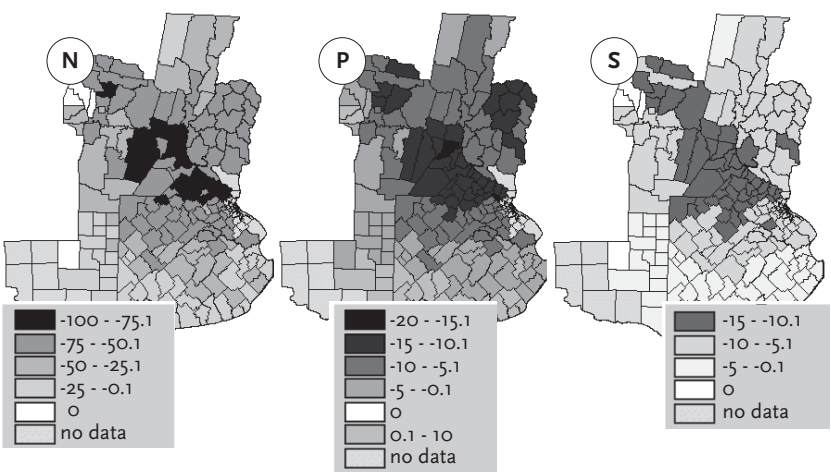


Figure 2. Estimated balances of nitrogen (N), phosphorus (P) and sulfur (S) in Pampean region counties. The balances were estimated as the difference between removal in grain and fertilizer application in soybean, wheat, corn and sunflower (Garcia, 2006).

The over-application of K sometimes occurs where blanket recommendations for K fertilization are implemented. For example, tropical weathered soils in Brazil require high applications of K fertilizers, usually in NPK blends. Good management and recycling of cover crops improves the retention of K in the plant and soil system, reducing the need for the application of K in the fertilization program. If this is not taken into account, there is an over-application of K relative to the quantities removed in the harvested crop.

The over-application of N with an adverse effect on the environment is rare, but it sometimes occurs. It can occur, for example, in areas around cities where vegetable farms are concentrated. The production systems are intensive and a negative environmental impact may occur due to excessive fertilizer use, mainly of N.

South America's farmers seldom recycle nutrients in their agriculture wastes. In the agribusiness chain, there is little coordination between the production of organic wastes, originating from livestock or crops, and their application on field crops. Producers recycle only a small proportion of manures and/or of treated organic wastes of urban origin.

In Argentina, according to a national agricultural survey (INDEC, 2003), in the four major corn provinces, only 0.5% of the area with corn received organic manures, the highest rate of application being Entre Ríos with application on 2.4% of the area. Approximately 15% of US farmers apply different organic manures in conjunction with commercial fertilizers. The proportion reaches up to 30% of the farms in the Lake States region, where there is a more intensive use of manures from dairy farms.

On the other hand, South American farmers are more efficient in their use of mineral N fertilizers than farmers in the United States or the European Union. A large proportion of farmers match demand with supply. Table 2 compares the proportion of farmers in the United States and in Argentina employing practices that influence N use efficiency. Probably due partly to cropping practices, N rates are lower and partial N efficiency is higher in Argentina and Brazil than in certain other cereal producing countries (Table 3).

Table 2. A comparison of N application practices between farmers of Argentina and of the United States in the core states of each country (Christiansen, 2002; Fertilizar 2002-2006).

Nitrogen application practice		USA	Argentina
		% farmers	
Timing	Proportion before planting	41	9
Method	Side dressing, broadcast	60	33
N balance	Negative	21	85

Table 3. Partial factor productivity of N in representative corn growing production areas of major corn exporting countries (Melgar, 2006).

	Corn exports	Average yield in representative states/provinces	Average N rate in representative states/provinces	Partial factor productivity
	million t/yr	t/ha	kg N/ha	kg grain/kg N
USA	46.45	9.15	157.0	58.4
Argentina	10.65	7.16	58.1	123.4
Brazil	2.17	4.88	48.0	101.7
China	7.81	5.04	197.9	26.1
France	7.54	8.29	163.3	50.8

There are large differences between the two groups concerning the adoption of precision agriculture technologies, especially regarding the adoption of variable application techniques. However, this situation may change fairly quickly since the transfer of technology is rapid with globalization and associated advances such as speed information exchange and cost contraction as technological breakthroughs are increasingly adopted. Among the factors that will favor the adoption of precision agriculture by local farmers are:

- Producers cultivate large tracts of land, with a relatively high capital/worker ratio;
- A high level of education of large farmers and of crop consultants;
- Availability of technology from North America and Europe, plus local developments;
- Large farmers must rely on more information;
- Ease of sharing data, analyzing problems and searching solutions through farmer groups.

On the other hand, some factors that could delay the adoption of these techniques are:

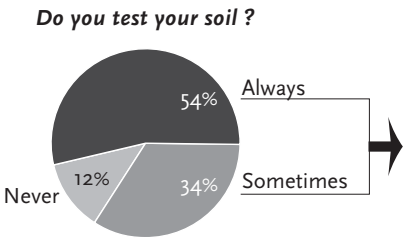
- The higher cost of investment in hardware and software, and the lack of credit;
- Greater production risks due to sudden changes in the tax structure, insurance, etc.;
- A lower soil variability as a result of the shorter period of agricultural practices compared with the northern hemisphere and, thus, a lower accumulated effect of the use of fertilizer or amendments;
- A generalized use of harvest contractors, which can make it difficult to collect quality data.

Fertilizer recommendations

Along with the major advances in the agricultural sectors of South America since the 1960s, most countries developed national institutions for agricultural research. These institutes covered most aspects of crop production and soil fertility management, and relevant information was accumulated systematically over time. Blanket fertilizer recommendations were generated for almost all crops and systems while, at the same time, field trials provided data on which fertilizer recommendations could be based. The extent and dissemination of this information varied between the countries.

The soil types are responsible for large differences in fertilizer practices in tropical regions. This is well illustrated in the cases of Argentina and Brazil. In Brazil, development was not possible without previous liming and generous P and K fertilization. In Argentina, Chile and Uruguay to some extent, the widespread use of fertilizers was delayed until well into the 1980s. Fertilization was a pre-condition for agricultural development in many countries with tropical soils, and this led to major progress in the management of fertilizers.

Today, most systems make an extensive use of soil testing as a tool for making site-specific fertilizer recommendations. A recent survey, conducted among 800 farmers in the main producing provinces of Argentina, revealed that soil test results guide fertilizer use in half of the area sown with corn or wheat, and in 20 % of the soybean areas. Figure 3 shows the overall results in terms of use, timing and frequency (Fertilizar, 1999-2006).



When do you make soil test ?	
Before sowing	68%
Next to fertilization	28%
Other moments	4%

With what frequency do you make it ?	
Once a year	59%
Once every two years	35%
Others	6%

Base: farmers answering always and sometimes

Figure 3. Use of soil tests as primary tool for fertilizer assessment by Argentina's Pampean farmers. Survey of 800 respondents in the core grain producing regions (Fertilizar, 2006).

With a few exceptions, farmers in all the countries and in the regions within each country have access to public or private soil testing services. Education is the main limiting factor preventing the better use of this technology and deriving greater benefits from soil testing in making fertilizer recommendations.

Brazil has a network for monitoring the quality of soil testing throughout the country. At present, there are five quality programs for soil analysis in Brazil (Bernardi and Silva, 2001). Embrapa coordinates the "Analysis Quality of Laboratories of the Soil Fertility Program" - PAQLF. This program was established in 1992. The participation of the laboratories is voluntary. Nationwide, more than 80 soil fertility laboratories in 23 Brazilian states participate in the program. Initially, the objective of PAQLF was to permit evaluation and correction of the analytical quality of the participating laboratories. In 1998, with the adoption of more rigorous quality standards, the program also provided certification of the satisfactory performance of the participants, which could be presented to their customers. However, there are no programs of this type in the other countries of the region, where there are serious discrepancies between the soil tests and technologies used in the different laboratories.

There are substantial differences between Brazil and Argentina, for example, regarding the criteria for interpreting soil tests and making fertilizer recommendations. Due to the major soil types that are characteristic of each country, in Brazil, the predominant criterion is cationic saturation while, in Argentina, nutrient sufficiency is the predominant criterion for farmers and consultants. Environmental differences also result in large differences in the need for liming. The Mollisols and Alfisols are much more resilient to changes in soil fertility parameters due to misuse of fertilizers or imbalances than are Ultisols and Oxisols.

Fertilizer availability

Fertilizer availability is not an important limitation for South American commercial farming. However, availability and choice is often inversely related to the distance from sea ports. An inadequate road and warehouse infrastructure may make fertilizers temporarily unavailable if the requirements were not anticipated adequately.

Traditions also influence market constraints. For example, K is often poorly available for non-Pampean crops of Argentina, and fluid fertilizers such as urea ammonium nitrate (UAN) are not a common fertilizer source in Brazil. The market development of blends for many crops is much greater in Brazil than in Argentina, where the use of single product fertilizers has been historically higher.

Fertilizer use

Most countries of the region show a trend towards improvements in the balance between nutrients applied and removed, although there is considerable variation between countries. While, for example, Brazil and Chile have a longer history of fertilization and therefore, a lower imbalance, in Argentina or Bolivia, there is a large gap between the removal and the replenishment of nutrients.

One factor that is indirectly helping to improve nutrient balances is the strong adoption of the "no-till" system in most field crop production systems of the region. Figure 4 shows the development of this system in Brazil, but the same exponential pattern can be observed elsewhere. No-till systems stress the need for better N use efficiency and proper P and K placement. In turn, this results in more stable production due to a better soil-water relationship and, hence, higher yields and nutrient requirements.

Nutrient balances show a rather positive trend in spite of economic constraints. In fact, for some time, the nutrient balance in Brazil has been positive for all nutrients except N (Yamada and Lopes, 1998). Recent estimates indicate positive balances even for N (Yamada, personal communication). The better knowledge of farmers and professional consultants provide responses to many of the economic pressures placed on modern agriculture (Figure 5).

As yet, little consumer concern about agricultural products has been observed, except perhaps from large urban groups. The demand for higher quality vegetables and fruits is, however, growing as a result of awareness about nutrition and quality. In consequence, the variety and quality of fruits and vegetables offered to consumer on the markets of large cities, with their high purchasing power, are much greater compared with small villages or towns.

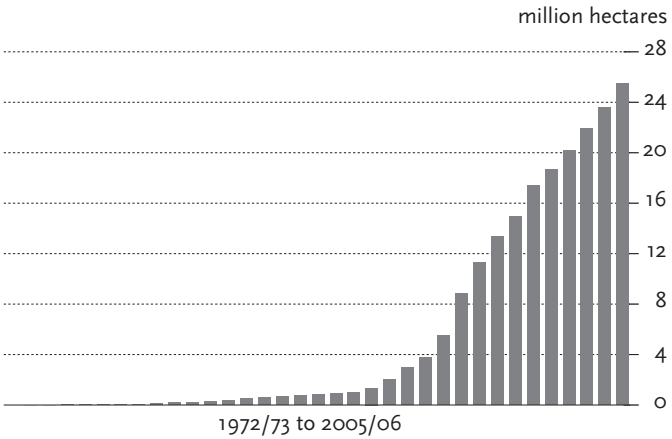


Figure 4. Development of no-till agriculture in Brazil (FEBRADPD, 2007).

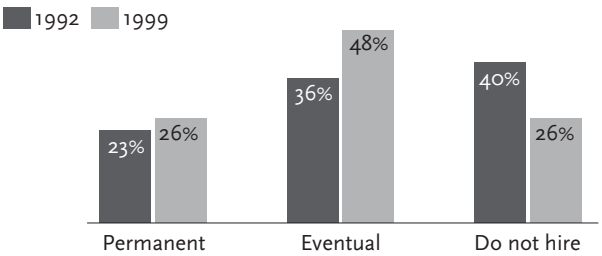


Figure 5. Changes in the frequency of consultation of professional advisory services by Argentinean farmers (White, 2000).

Fertilizer advisory services

National agricultural research institutes were established in South American countries around the end of the 1950s and during the 1960s, with basic and applied research, plus an extension service covering many fields of agronomic science and technology. The institutes included several experimental stations and extension agencies in the different areas of the countries.

These institutes are the main agencies of technology transfer, in the fields of soil management, soil fertility and fertilizer application. Over time, many of these pioneer public institutions were accompanied by private institutions and NGOs. Farmer organizations in Argentina (AAPRESID, AACREA), foundations in Brazil (MT, Agroceres) were major players in transmitting information. In addition, several agricultural universities, although not playing a central role in extension as is the case with the land-grant system

in the United States, provide soil testing services to farmers along with recommendations, in most countries of the region.

A special mention needs to be made of industry organizations such as Fertilizar in Argentina and ANDA in Brazil (Asociación Civil Fertilizar, 2007; Associação Nacional para Difusão de Adubos, 2007). Both originated as a result of a demand and were mandated with the transfer of information to farmers on the best use of fertilizers and liming. They received immediate support from public and governmental sectors in order to offset the indiscriminate exploitation of soil nutrients resulting from the large removal of plant nutrients exported with grains, not compensated with their restitution.

After 40 years of activity, having achieved unqualified success in its original mission, ANDA is targeting other, equally important activities. Its main objectives are now to diffuse information on the correct use of mineral fertilizers and to safeguard the image of the fertilizer products and the industry. The Association is the official fertilizer sector representative in dealings with authorities, with a focus on:

- Defending the sector's interests in the development of legislation governing the production, commercialization and use of fertilizers;
- Assisting in the development of policies and regulations concerning mineral fertilizer producers.

Recently a new fertilizer association was formed in Colombia, with the same mission as the industry associations in other countries (Asociación Colombiana de Fertilizantes, 2007).

Legislation

Regulatory norms concerning fertilizers are currently being considered, especially in the framework of Mercosur or the Andean Community.

Unlike the situation in certain other countries, in view of the free enterprise nature of the business, governments do not intervene on price issues. Farmers are free to use whatever fertilizers wish, regardless of the environmental and quality impact.

However, governmental agencies control the quality of imported products. This may impact favorably on the environment by controlling contaminants in fertilizers (Gov. Brazil, 2006), but there is no regulatory intervention on the use of fertilizers in any country.

Conclusion

In the context of a professional agriculture without subsidies, economic rationality helps to prevent the misuse of fertilizer, but ignorance or unfavorable/favorable price ratios of grain to fertilizer can lead to serious imbalances, threatening the sustainability of agriculture.

The issue of FBMPs developed with the consensus of all the stakeholders and adequately promoted could be adopted easily by the farming sector in South American countries, providing the practices are economically sound and the goal of attaining higher yields is not jeopardized.

Environmental awareness is certainly a topical subject. However, a major ecological impact of agriculture does not come from the misuse of fertilizers but rather from deforestation, erosion and inadequate soil conservation.

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