# Fertilizer use by crop in Brazil

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**Land and Plant Nutrition Management Service**
**Land and Water Development Division**

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# Acknowledgements

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The background photograph is from the FAO Mediabase (FAO/19379/R. Jones) and the other photographs were provided by B.E. van Wik (sugar cane) and J. Flémel (coffee). The source of these photographs is EcoPort (Portal to Ecology Management) and Pioneer.com Web site for soybean.

# Abstract

Brazil has almost 50 million hectares under annual and permanent crops, with in addition a large reserve of land with agricultural potential. Brazil is the world's largest producer of coffee, sugar cane and citrus and the second largest producer of soybeans. It has the world's second largest cattle population.

There is a close relationship between the consumption of fertilizers and crop production in Brazil. Between 1970 and 2001 agricultural production in Brazil, represented by the sixteen most important crops, increased by 3.4 times and the consumption of fertilizers increased by 4.4 times. During this period the cropped area increased only 1.5 times, rising from 36.4 million ha to 56.2 million ha.

On the one hand advanced production technologies are widely used for the production of export crops (coffee, sugar cane, citrus and soybeans). These technologies include not only appropriate rates of fertilization but also the implementation of a series of other agronomic recommendations.

On the other hand, the average yields of food crops for domestic consumption compare unfavourably with those of countries with advanced agricultural technology, although some farmers achieve yields that are substantially higher than the average. The problem of low average yields is therefore due not to a lack of agricultural technologies but to the poor implementation of these technologies, including inappropriate mineral fertilizer application. In the case of subsistence farming, which is practised in the poorer areas of the country, especially in the Northeast region, practically no mineral fertilizers are used. The use of fertilizers on food crops is constrained by their relatively low prices. The prices of rice, beans and maize, for example, fell by about 20 percent in terms of US dollars between 1993 and 2002.

Brazil is characterized by the co-existence of large estates with a large number of small farms. Almost half the 4.8 million farms are of less than 10 ha and 89 percent have less than 100 ha, occupying one fifth of the agricultural area. However, apart from sugar cane, and to a lesser extent soybean, rice and citrus, agricultural establishments possessing less than 100 ha are responsible for a substantial proportion of the agricultural production of the country.

Since the 1970s the government has promoted the settling of the Centre West region, known as the *Cerrado*, whose total area amounts to 207 million ha. This area was once considered to be marginal for agricultural production. However, today the

*Cerrado* accounts for 43 percent of the Brazilian production of beef cattle, 23 percent of the coffee, 34 percent of the rice, 59 percent of the soybeans and 29 percent of the maize. This has been made possible by research in different agronomic science disciplines, including the development of appropriate fertilization and soil amendment systems.

Another important development is that of "no-till" systems. It is estimated that no-till systems are currently applied on almost 40 percent of the grain area in Brazil, or about of 25 million hectares.

In general, the fertilizer nutrient balance in the Brazilian agriculture is unsatisfactory. The quantities of nutrients removed are higher than the quantities supplied. Thus soils are being progressively depleted of nutrients. This represents a threat to long-term agricultural sustainability. As regards the ratio between the nutrients, by international standards the use of nitrogen is low in relation to phosphate and potash. Concerning the types of fertilizers, Brazil has an unusually high proportion of nutrients, over 80 percent, applied in the form of compound fertilizers. It is also one of the few countries where the use of single superphosphate has increased in recent years, partly due to the demand for this fertilizer for use on soybeans, owing to its sulphur content.

In Chapter 10 of this publication suggestions are made concerning measures that might be taken to help to remedy certain major agricultural and social problems. The transformation of subsistence agriculture into profitable family farms is needed for the alleviation of rural poverty. However, a survey in 1995/1996 revealed that only 4.1 percent of the farmers in the Northeast region, where the largest number of small farms in the country is concentrated, had some kind of advice from the official rural extension service.

# Preface

The Food and Agriculture Organization of the United Nations (FAO) commissioned this study. It is one of a series of publications on fertilizer use on crops in different countries.

The aim of the series is to examine the agro-ecological conditions, the structure of farming, cropping patterns, the availability and use of mineral and organic plant nutrients, the economics of fertilizers, research and advisory requirements and other factors that have led to present fertilizer usage. The reports examine, country by country, the factors that will or should determine the future development of plant nutrition.

During the past two decades, increasing attention has been paid to the adverse environmental impact of both the under use and the over use of plant nutrients. The efficient use of plant nutrients, whether from mineral fertilizers or from other sources, involves the shared responsibility of many segments of society, including international organizations, governments, the fertilizer industry, agricultural research and advisory bodies, traders and farmers. The publications in the series are addressed to all these parties.

Fertilizer use is not an end in itself. Rather it is a means of achieving increased food and fibre production. Increased agricultural production and food availability can, in turn, be seen as an objective for the agricultural sector in the context of contributing to the broader macroeconomic objectives of society. A review of the options available to policy-makers is given in the FAO/IFA 1999 publication entitled *Fertilizer Strategies*.

The contents of the studies differ considerably from country to country, in view of their different structures, histories and food situation. But in each case the aim of the study is to arrive at a better understanding of the nutrition of crops in the country concerned.

# Abbreviations and symbols

| | |
|---|---|
| ABCAR | Associação Brasileira de Crédito e Assistência Rural |
| AENDA | Associação das Empresas Nacionais de Defensivos Agrícolas |
| ANDA | Associação Nacional para Difusão de Adubos |
| Embrapa | Empresa Brasileira de Pesquisa Agropecuária |
| FAO | Food and Agriculture Organization of the United Nations |
| FEBRAPDP | Federação Brasileira de Plantio Direto na Palha |
| GuiaNet | Guia Internet Brasil |
| IBGE | Instituto Brasileiro de Geografia e Estatística |
| UFLA | Universidade Federal de Lavras |
| ha | hectare |

| | |
|---|---|
| AMM | Ammonium |
| AN | Ammonium nitrate |
| AS | Ammonium sulphate |
| DAP | Diammonium phosphate |
| MAP | Monoammonium phosphate |
| NPK | Compound fertilizers containing N, $P_2O_5$ and $K_2O$ |
| NK | Compound fertilizer containing N and $K_2O$ |
| SSP | Single superphosphate |
| TSP | Triple superphosphate |

| | |
|---|---|
| N: | Nitrogen |
| $P_2O_5$ or P: | Phosphate* |
| $K_2O$ or K: | Potash* |

* Phosphate and potash may be expressed as their elemental forms P and K or as their oxide forms $P_2O_5$ and $K_2O$. Nitrogen is expressed as N. In this study phosphate and potash are expressed in their oxide forms.

# Chapter 1

# Introduction

The Northern region of Brazil comprises the states of Acre, Rondônia, Amazonas, Roraima, Amapá, and Tocantins. The centre west region includes the states of Mato Grosso, Mato Grosso do Sul, and Goiás, as well as the Federal District, capital of the Brazilian Government. The Northeast region encompasses the states of Maranhão, Piauí, Ceará, Paraíba, Rio Grande do Norte, Pernambuco, Alagoas, Sergipe, and Bahia. The Southeast region is formed by the states of Minas Gerais, São Paulo, Rio de Janeiro, and Espírito Santo. The Southern region includes the states of Paraná, Santa Catarina and Rio Grande do Sul (Figure 1).

FIGURE 1
**States and regions of Brazil**


Source: GuiaNet, 2003a.

Brazil covers an area of 8 547 000 km$^2$ or 854.7 million ha, of which 64 percent (550 million ha) is considered to be potential farmland. The country's continental dimensions lead to many types of climate and soils and consequently to a large diversity of crops and land use (Table 1). A modern, technically advanced agriculture dedicated to the production of export products coexists with a low-technology production of basic food crops for domestic consumption. This is especially the case with subsistence farming, which is most common in the poorer areas of the semi-arid northeast region, although it occurs to a smaller extent in other regions.

TABLE 1
**Land utilization in Brazil**

| Types of land use or vegetal cover | Million ha | Percentage |
|---|---|---|
| **1. Land with an economic utilization** | | |
| Temporary crops | 38.5 | 4.5 |
| Temporary crop land under fallow | 4.0 | 0.5 |
| Permanent crops | 7.5 | 0.9 |
| Improved pastures | 99.7 | 11.7 |
| Natural pastures | 78.0 | 9.2 |
| Planted forests | 5.4 | 0.6 |
| Irrigated land | 3.0 | 0.4 |
| Subtotal | 236.1 | 27.8 |
| **2. Natural cover** | | |
| Humid forests | 367.7 | 43.1 |
| Dry forests | 54.4 | 6.4 |
| Flooded forests | 14.2 | 1.7 |
| Transitional forests | 28.2 | 3.3 |
| "*Cerrados*" (savannahs) and grassland types | 73.2 | 8.6 |
| Subtotal | 537.7 | 63.1 |
| **3. Lands with other uses** | | |
| Rocks and bare soils or with dispersed vegetation | 3.5 | 0.4 |
| Rivers, natural and artificial lakes | 11.4 | 1.4 |
| Urban | 2.1 | 0.2 |
| Other uses or undefined | 60.7 | 7.1 |
| Subtotal | 77.7 | 9.1 |
| **Total** | 851.5 | 100.0 |

Source: Adapted from Manzatto *et al*., 2002 and Embrapa, 2003.

The rural population amounted, in 2000, to 31.8 million inhabitants or 18.7 percent of the country's population. Owner-occupancy of farms predominates, accounting for 74.2 percent of the total number; tenants account for 5.5 percent, partners for 5.7 percent and occupiers for 14.6 percent. About 21 percent of the total labour force is engaged in agriculture and each farmer produces enough food for ten non-farming persons.

# Chapter 2
# Soils and climate

## Soils[1]

Brazil is characterized by a large diversity of soil types, resulting from the interaction of the different reliefs, climates, parent material, vegetation and associated organisms. This diversity and the consequent potential uses are reflected in the regional differences.

The North of the country comprises plains and low plateaus, with an equatorial climate, high and constant temperatures and high atmospheric humidity levels. The soils are deep, highly weathered, acidic and of low natural fertility. They are commonly saturated with exchangeable aluminum, which is toxic for most plant species. These characteristics reduce considerably the productive potential of the land, unless it is managed appropriately.

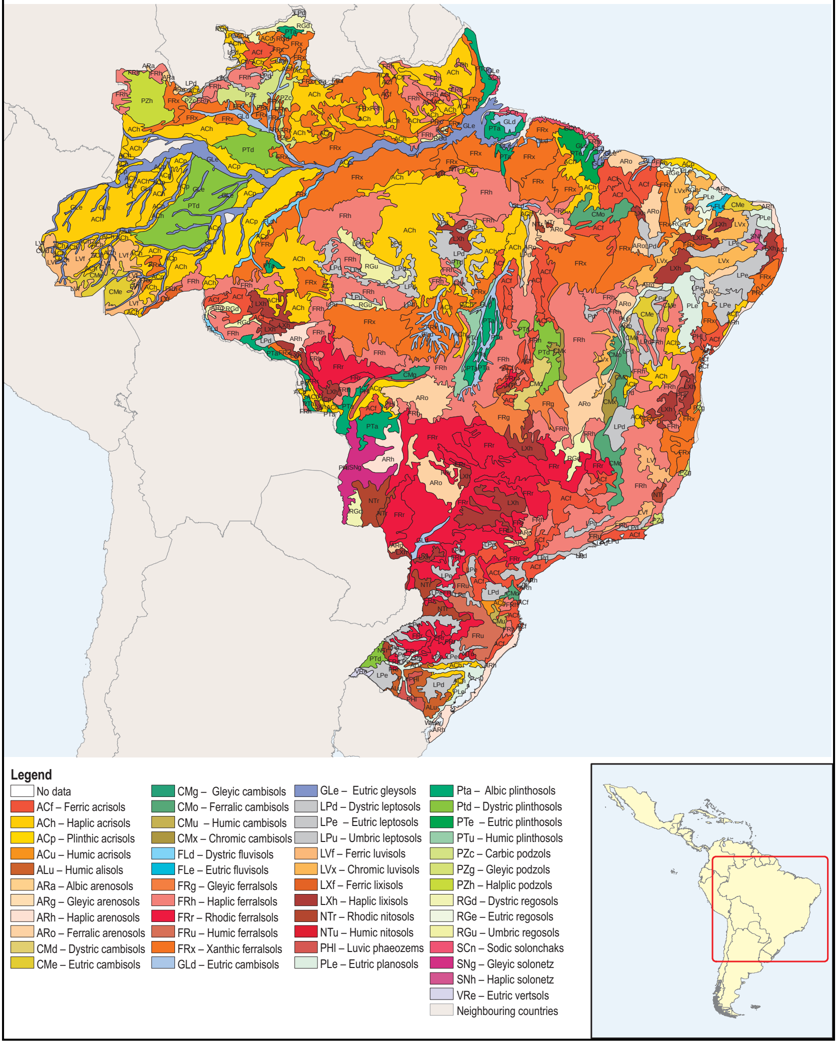
In the Northeast, the climate varies from hot and humid to hot and dry (semi-arid), with a transitional semi-humid area. In this transitional area, a large proportion of the soils are of medium to high natural fertility but most are shallow due to a low degree of weathering. A moisture deficit, sometimes associated with salinity and/or high levels of sodium, is the main factor limiting agricultural production in the Northeast.

The Brazilian Central Plateau, that is characteristic of the Centre West region, is a plain formed by natural erosive processes. The predominance of a hot tropical climate with accentuated dry spells during the rainy season is very characteristic of this region. There are extensive areas of deep, well-drained soils, of low natural fertility, though easily corrected by liming and fertilization. Most of the soils in this region have favorable physical characteristics and topographical conditions that permit intensive agricultural mechanization. This is the region of Brazil where most agricultural development in grain production is occurring.

Plateaus and highland areas, with several peaks higher than 2 000 metres, characterize the Southeast region. This region has a tropical climate with hot

[1] Adapted from Coelho *et al.*, 2002.

FIGURE 2
**Dominant soils in Brazil** (original scale 1:5 000 000)




Source: Soils and terrain database for Latin America and the Caribbean, FAO-ISRIC-UNEP,1998. FAO-GIS Jan. 2004

summers in the low land and mild weather in the mountain areas. The soils are predominantly deep and usually of low natural fertility.

TABLE 2
**Extent and distribution of soils in Brazil, Brazilian nomenclature**

| Soil types | 1 000 km² | Total | North | North-east | Centre West | South-east | South |
|---|---|---|---|---|---|---|---|
| | | | Percent | | | | |
| Alissolos | 372 | 4.4 | 8.7 | 0.0 | 0.0 | 0.0 | 6.3 |
| Argissolos | 1 714 | 20.0 | 24.4 | 17.2 | 13.8 | 20.6 | 14.8 |
| Cambissolos | 232 | 2.7 | 1.0 | 2.1 | 1.6 | 8.6 | 9.3 |
| Chernossolos | 42 | 0.5 | 0.0 | 1.0 | 0.3 | 0.2 | 3.9 |
| Espodossolos | 133 | 1.6 | 3.1 | 0.4 | 0.3 | 0.4 | 0.0 |
| Gleissolos | 311 | 3.7 | 6.4 | 0.8 | 2.8 | 0.5 | 0.4 |
| Latossolos | 3 318 | 38.7 | 33.9 | 31.0 | 52.8 | 56.3 | 25.0 |
| Luvissolos | 226 | 2.7 | 2.7 | 7.6 | 0.0 | 0.0 | 0.0 |
| Neossolos | 1 247 | 14.6 | 8.5 | 27.5 | 16.3 | 9.4 | 23.2 |
| Nitossolos | 120 | 1.4 | 0.3 | 0.1 | 1.2 | 2.6 | 11.5 |
| Planossolos | 155 | 1.8 | 0.2 | 6.6 | 1.7 | 0.2 | 3.0 |
| Plintossolos | 509 | 5.9 | 7.6 | 4.7 | 8.8 | 0.0 | 0.0 |
| Vertissolos | 169 | 2.0 | 3.2 | 1.0 | 0.4 | 1.2 | 2.6 |
| **Total** | 8 548 | 100 | 100 | 100 | 100 | 100 | 100 |

Source: Adapted from Coelho *et al.*, 2002.

In the Southern region, the soils originated from basic rocks and there are several sedimentary soils. The relief is very varied. A subtropical climate prevails, with well-defined seasons. The soils are fertile with a good agricultural, forestry and livestock production potential.

Table 2 presents information concerning the soil classes in Brazil, according to Embrapa (1981) and the current Brazilian Soil Classification System (Embrapa, 1999).

In Table 3 the FAO Revised Legend (FAO, 1998) nomenclature approximately equivalent to the Brazilian nomenclature is shown.

## CLIMATE

The location of 92 percent of the Brazilian territory in the inter-tropical region and at low altitudes explains the predominance of hot climates, with average temperatures above 20 °C. The main climatic types are equatorial, tropical, tropical of altitude, tropical Atlantic, semi-arid and subtropical (Figure 3).

TABLE 3
**Brazilian and FAO soil nomenclature**

| Brazilian taxonomy | FAO-WRB System |
|---|---|
| Alissolos | Chromic & Haplic Alisols |
| Argissolos | Rhodic & Haplic Acrisols and some Lixisols |
| Cambissolos | Umbric & Haplic Cambisols |
| Chernossolos | Calcaric, Chernic, Luvic & Haplic Phaeozems |
| Espodossolos | Carbic, Gleyic & Haplic Podzols |
| Gleissolos | Thionic, Sodic & Haplic Gleysols |
| Latossolos | Xanthic, Rhodic & Haplic Ferralsols |
| Luvissolos | Chromic & Haplic Luvisols |
| Neossolos | Lepto, Fluvi, Rego & Arenosols |
| Nitossolos | Rhodic & Haplic Nitisols |
| Planossolos | Sodic, Gleyic & Haplic Planosols |
| Plintossolos | Petric & Haplic Plinthosols |
| Vertissolos | Gleyic, Haplic & Chromic Vertisols |

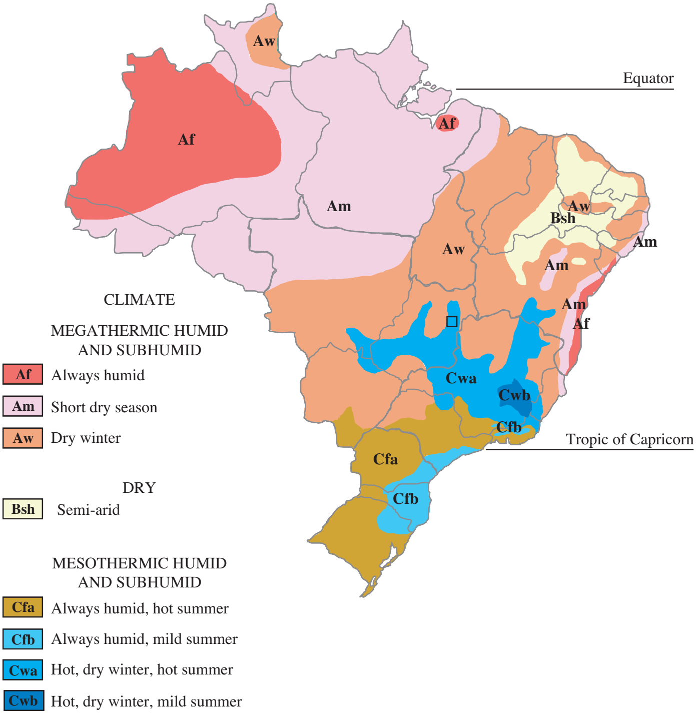
An equatorial climate dominates in the Northern region, except in Tocantins, characterized by average temperatures between 24 $^{o}$C and 26 $^{o}$C and an annual thermal amplitude (differences between the maximum and the minimum temperature registered during one year) of up to 3 $^{o}$C. The rains are abundant (more than 2 500 mm/year) and regular, caused by the action of the continental equatorial mass. In the winter, the area can receive cold fronts originating from the Antarctic polar mass.

Extensive areas of the Central Plateau in the Centre West, Northeast and Southeast regions are dominated by a tropical climate. In these areas, the summer is hot and humid and the winter cold and dry. Average temperatures exceed 20 $^{o}$C, with an annual thermal amplitude of up to 7 $^{o}$C. The rainfall varies from 1 000 to 1 500 mm/year.

A tropical altitude climate prevails in the high parts of the Atlantic Plateau of the Southeast, extending from the north of Paraná state in the Southern region to the south of Mato Grosso do Sul State in the Centre West region. The average temperatures are between 18$^{o}$ C and 22 $^{o}$C and annual thermal amplitude between 7 $^{o}$C and 9 $^{o}$C. The rainfall pattern is the same as that of the tropical climate. The summer rains are more intense due to the action of the Atlantic tropical mass. In the winter, the cold fronts from the Antarctic polar mass can cause frosts.

A coastal band that goes from Rio Grande do Norte state in the Northeast to Paraná State in the Southern region is influenced by the tropical Atlantic climate.

FIGURE 3
**Climatic map of Brazil**




Source: GuiaNet, 2003b.

The temperatures vary between 18 °C and 26 °C, with an increase in thermal variation towards the south. The rainfall amounts to about 1 500 mm/year. On the coast of the Northeast, the rainfall intensifies in the autumn and in the winter. Further to the south, the rainfall is higher in the summer.

A semi-arid climate prevails in the depressions of the plateaus of the Northeastern interior and in the Rio São Francisco valley in Bahia State. It is characterized by high average temperatures, around 27 °C, and a thermal amplitude of 5 °C. The rainfall does not exceed 800 mm/year and is irregular. This results in the long periods of drought, the "droughts of the Northeast".

A subtropical climate prevails to the south of the Tropic of Capricorn, in parts of São Paulo (Southeast region), Paraná (Southern region) and Mato

Grosso do Sul States (Centre West region) and in the States of Santa Catarina and Rio Grande do Sul in the Southern region. It is characterized by average temperatures below 18 $^{o}$C, with a thermal amplitude between 9 $^{o}$C and 13 $^{o}$C. In the highest areas, the summer is mild and the winter cold, with occasional snow. Rainfall amounts to between 1 500 mm and 2 000 mm/year, well distributed between the seasons.

# Chapter 3
# The agricultural structure

## THE DEVELOPMENT OF AGRICULTURE IN BRAZIL[1]

During the first four centuries of Brazil's history, national production was intimately linked to the agricultural activities, mainly sugar cane planted along the coast using manual slave labour. The ownership of the land during that period was through donations by the Portuguese crown, the so-called *sesmarias* (crown land donations), which varied in size depending on the wealth of the person receiving the land. This benefited only landlords and military personnel. In this way, the territory of Brazil was divided into immense properties, with very little land remaining without an owner in the areas where the Europeans lived, mainly along the coast.

Mono-cropping required extensive areas of land in order to reduce production costs, facilitate trade, permit industrialization and to utilize the slave labour. In addition to the landowners and the slaves, there was a small free population (white but not belonging to the landlord class, ex-slaves, mestizos, etc.) who occupied small strips of land for subsistence production. These people did not own the land but they could produce most of their subsistence requirements as well as surpluses for the domestic market. These mixed, multiple cropping farming systems, implemented initially in the Southeast region, expanded with demographic growth and development of the interior. Pioneers from the State of São Paulo, when creating settlements in the interior, reproduced the small farm system, producing food crops.

With few exceptions, up to 1820 the increase in the number of small properties in Brazil was a result of the illegal ownership of land since it could not be acquired except by donation from the Portuguese crown. The *sesmarias* system ended but at first it was not substituted by new legislation. This accelerated the system of ownership of unoccupied land, resulting in a further expansion of the small production units.

In the middle of the nineteenth century, the Brazilian economy started again to be based on export agriculture, especially coffee. This resulted in new land

[1] Adapted from Planeta Orgânico, 2003.

policies, with the promulgation in 1850 of a Land Law, which abolished the old ownership regime and prohibited the acquisition of land means other than by purchase. This law resulted in an increase in the price of land and made acquisition difficult. The lots could be sold only in public auctions, with cash payment. The product of the sales was to be used to promote the immigration of people from other countries to work on the large farms.

At that time, England was campaigning against slavery, which was prohibited in 1851. There was, therefore, a lack of labour for the large coffee plantations. Foreign immigrants arriving in Brazil were not permitted to own land, except in the Southern region where agricultural production was not intended for export. However, due to the large area of the country, the Land Law was not very effective. The small producers moved on, resulting in an expansion of the pioneering frontier.

At the end of the nineteenth century and at the beginning of the twentieth century, there was a large increase in coffee production, which had expanded to cover vast portions of the State of São Paulo after penetrating the State of Rio de Janeiro. This resulted in the emergence of a domestic market for food crop products in the urban centres that developed.

The coffee plantations were located in recently deforested areas and they were highly productive in the early years. However, the coffee yields later started to decline and farmers had to buy and deforest more land in the north and northwest areas of the state, penetrating after some time into the north of the State of Paraná. The abandoned land of the old coffee plantations was divided and purchased largely by the established immigrants. The censuses of 1920 and 1940 recorded the process of land redistribution that occurred during that period, especially after the crisis of 1929, when the price of all agricultural export products fell heavily.

## Agricultural structure

Brazil is characterized by the coexistence of large estates with a large number of small farms. In 1985, out of 5.8 million agricultural establishments, almost 90 percent had an area of less than 100 ha and occupied only 21 percent of the total area dedicated to agricultural activities. However, apart from sugar cane and to a lesser extent soybeans, rice and citrus, agricultural establishments possessing less than 100 ha are responsible for a substantial proportion of the agricultural production of the country. These smaller farms are responsible for: 37 percent of the production of rice, 37 percent of the soybeans, 14 percent of the sugar cane, 61 percent of the cocoa, 54 percent of the coffee, 54 percent of the wheat, 78 percent of the common beans (*Phaseolus vulgaris*), 66 percent of the cotton, 85 percent of the cassava, 69 percent of the potatoes, 64 percent of the maize and 43 percent of the citrus production in Brazil.

However, in some regions, a higher proportion of the production of these products comes from larger farms. This is the case of sugar cane in the Southeast, Northeast and Centre West regions; of soybeans in the Centre West region; of rice in the Centre West and South regions and of maize in the Centre West region. Large farms of 100 ha or more are concentrated mainly in the Centre West region, where soybeans predominate as the main crop.

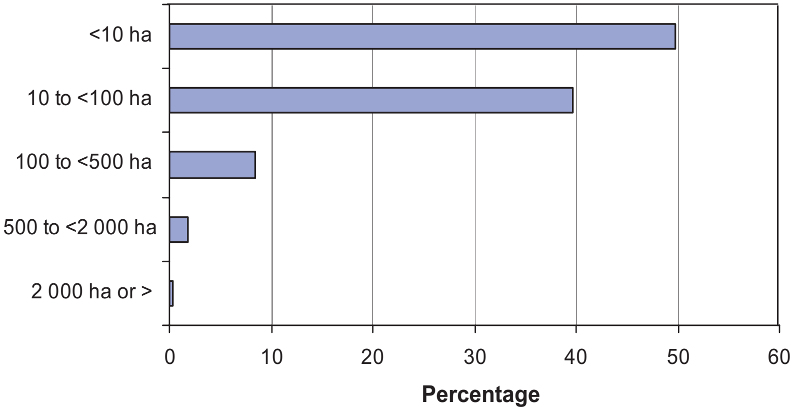
The South and Southeast regions have limited land available for agricultural expansion. The Southern region has registered in recent decades a reduction in the number of farms mainly due to modernization. Many of the farmers who moved out went to the new agricultural frontier areas, mainly in the Centre West and in the North region. The states of Rondônia and Acre in the North region have the best soils and hence are economically viable for small farmers.

The expansion of the total area of the farms has been accompanied by significant growth of the areas planted with grain crops. Maize and soybeans alone occupy more than half of the area dedicated to grain crops.

Policies for the promotion of livestock production have had most impact in the North and Centre West regions. In the North, the number of cattle increased from 1.2 million head in 1960 to 3.9 in 1980 and then to 13.3 million in 1990. In the Centre West region the figures were 10.5 million head in 1960 and 45.9 million in 1990. In the Centre West region, the increase was facilitated by the predominance of savannah *(Cerrado)*. In the Northern region, livestock farming involved deforestation and the impoverishment of the soils, once deforested, was another factor. Even so, in 1985 livestock occupied 52 percent of the land under production in this region.

The expansion of Brazilian livestock has been characterized more by the incorporation of new areas into the productive process than by the intensification of production, for example in feedlots. In the Southeast, the proximity of the consumer markets led to a qualitative improvement of the herds and a specialization in improved breeds of milk and beef cattle (Brahma or European), rather than an expansion in numbers. In the Southern region, much farmland

FIGURE 4
**Farm numbers by size**




Source: Instituto Brazileiro de Geografia e Estatística (IBGE), 2003.

traditionally devoted to livestock production was converted to the production of export crops such as soybean.

TABLE 4
**Number of farms by region, Brazil, 1995/96**

| Region | Number ('000) | Percentage of total |
|---|---|---|
| North | 444 | 9.2 |
| Northeast | 2 309 | 47.7 |
| Southeast | 841 | 17.3 |
| South | 1 002 | 20.8 |
| Centre West | 242 | 5.0 |
| **Total Brazil** | 4 838 | 100 |

Source: IBGE, 2003.

The total number of farms in Brazil is 4 848 183, with the largest number located in the Northeast (47.7 percent), South (20.8 percent) and Southeast (17.3 percent), which together account for 85.8 percent of the total (Table 4). The percentage of farms by size is shown in Figure 4.

Of the total number of farms, those with less than 10 ha represent almost 50 percent of the total, those with less than 100 ha for 89.3 percent and those above 100 ha for only 10.7 percent (Table 5). In the Northeast region, which has one of the lowest rates of fertilizer consumption per ha in the country and is among the regions with the lowest productivity of basic food crops, over two thirds of farms have less than 10 hectares. These farms are mostly involved in subsistence farming.

TABLE 5
**Farms according to size, 1995/96**

| Range (ha) | <10 | 10 to <100 | 100 to <500 | 500 to <2000 | >2000 |
|---|---|---|---|---|---|
| **Region** | **Percentage** | | | | |
| North | 30.4 | 48.3 | 17.0 | 2.8 | 0.9 |
| Northeast | 68.1 | 26.2 | 4.8 | 0.8 | 0.1 |
| Southeast | 34.1 | 51.0 | 12.6 | 2.0 | 0.3 |
| South | 37.7 | 55.4 | 5.6 | 1.2 | 0.1 |
| Centre West | 13.4 | 45.8 | 25.9 | 10.8 | 4.1 |
| **Total Brazil** | 49.7 | 39.6 | 8.5 | 1.8 | 0.4 |

Source: IBGE, 2003.

## ADOPTION OF AGRICULTURAL TECHNOLOGY

A low level of adoption of productive technologies can explain the low crop productivity in the North (N) and Northeast (NE) regions. This can be seen from Table 6, taken from an agricultural census of 1995/96. For example, advisers from the rural extension service visited only 6.6 percent (N) and 4.1 percent (NE) of the farms. In addition, only 9.5 percent (N) and 18.2 percent (NE) of the farmers reported they were using lime and fertilizers and only 0.8 percent (N) and 6.5 percent (NE) practiced some kind of soil conservation. Irrigation is little used in Brazil. In the Northeast region, which includes a large area with a semi-arid climate, irrigation is used on only 4.9 percent of the farms.

TABLE 6
**Proportion of farms using agricultural technology and electricity**

| Region | TA[1] | LF[2] | PC[3] | SC[4] | I[5] | EE[6] |
|---|---|---|---|---|---|---|
| North | 6.6 | 9.5 | 44.2 | 0.8 | 0.7 | 10.7 |
| Northeast | 4.1 | 18.2 | 50.5 | 6.5 | 4.9 | 20.0 |
| Southeast | 30.6 | 64.5 | 83.2 | 30.1 | 12.4 | 61.9 |
| South | 48.6 | 76.4 | 92.2 | 45.5 | 5.4 | 73.7 |
| Centre West | 32.9 | 36.8 | 91.6 | 19.4 | 4.4 | 51.9 |
| **Total** | 19.6 | 38.4 | 66.3 | 18.8 | 5.9 | 39.1 |

(1) TA = Technical assistance; (2) LF = Lime and fertilizers; (3) PC = Pest control;
(4) SC = Soil conservation; (5) I = Irrigation; (6) EE = Electrical energy.
Source: IBGE, 2003.

## Crops

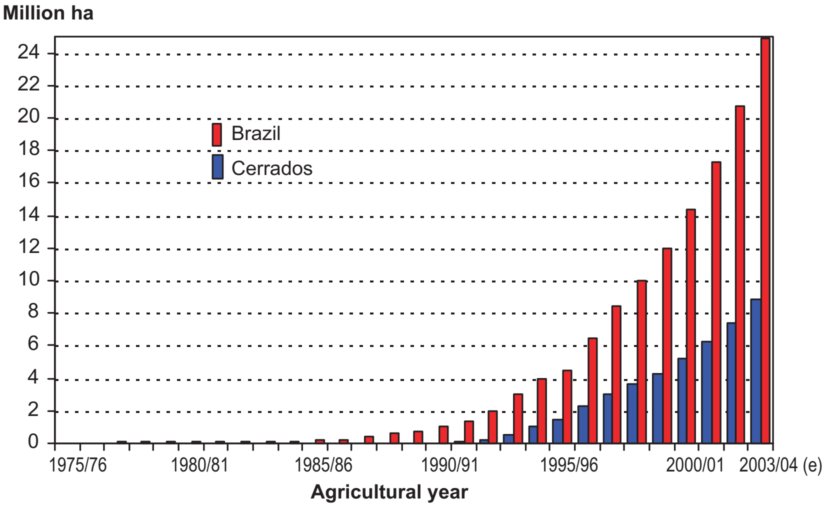
The continental dimensions of Brazil and the diversity of soil types and climates permit the production of a large variety of crops in the various agro-ecological zones of the country. Most of the potential farmland of Brazil (550 million ha) is under pasture (178 million ha), with some 78 million ha of natural pastures and 100 million ha of improved pastures, mainly in the Centre West, Southeast and South regions. Of the current total agricultural area (50 million hectares), the cultivation of grains (rice, maize, soybean, common beans, sorghum, and wheat) occupies 38 million ha, representing 76.7 percent of the cropped area. Sugar cane with 5.1 million ha, coffee with 2.3 million, cassava with 1.7 million and citrus with 0.8 million ha are other important crops.

At first Brazilian agriculture was concentrated on the most fertile soils along the Atlantic coast and in the South and Southeast regions of the country, notably with the production of coffee, sugar cane and some cereals. This situation prevailed until the end of the 1960s and the beginning of the 1970s, when governmental incentives promoted the settling of the Centre West region, known as the *Cerrado* (a savannah type vegetation), whose total area amounts to 207 million ha. With highly weathered, acid soils of very low natural fertility, Ferralsols (mostly Oxisols and Ultisols), with a well defined dry season going from May to September and with the occurrence of dry spells of variable length during the rainy season *(veranicos),* the area was once considered to be marginal for agricultural production. However, it is in this area that the greatest revolution in the Brazilian agriculture is taking place.

The *Cerrado* area currently accounts for 43 percent of the Brazilian production of beef cattle, 23 percent of the coffee, 34 percent of the rice, 59 percent of the soybeans and 29 percent of the maize. In addition, there are 12 million hectares planted with other annual and perennial crops and 50 million hectares of natural and improved pastures. This has been made possible by years of research in different agronomic science disciplines. In particular, strategies have been developed for building-up soil fertility by the use of lime and mineral fertilizers, especially phosphorus, potassium and micronutrients. The estimated production potential of the *Cerrado* region is 252 million annual tonnes of grains, 12 million tonnes of meat and 90 million tonnes of perennial crop produce, on an area of 136 million hectares with 71 million hectares available for environmental conservation (Macedo, 1995).

Another important aspect is the substitution, mainly during the last two decades of the traditional plough and disk cultivation for annual crops with the

FIGURE 5
**Development of no-till cropping in Brazil and in the *Cerrado* region**




Source: Federação Brasileira de Plantio Direto na Palha (FEBRAPDP), 2003.

"no-till" system. There are many advantages of no-till cultivation for tropical agriculture. These include a reduction of soil erosion, a greater efficiency in water use and absorption and a decrease in the incidence of pests due to the adoption of crop rotations. In addition, the no-till system emits eight times less greenhouse effect gases compared with the conventional system of ploughing and disking (Robertson, 2000). The current estimates are that close to 40 percent of the area of grain crops in Brazil, about 25 million hectares, is already cultivated using no-till systems (Figure 5).

Crop yields in Brazil are satisfactory for the export crops (71.4 t/ha for sugar cane, 22.3 t/ha for citrus, 1.1 t/ha for coffee, and 2.6 t/ha for soybeans in 2002). The use of agricultural technologies, including the use of appropriate rates of mineral fertilizers, is widespread on these crops. However, the average yields of basic food crops for domestic consumption are low: 3.3 t/ha for rice, 0.7 t/ha for common beans, 3.2 t/ha for maize, and 13.7 t/ha for cassava. Nevertheless, even in the case of these crops, many farmers obtain, by the rational adoption of technologies already available, high yields of the order of 8 t/ha for irrigated rice, 3.5 t/ha for irrigated common beans, 10 t/ha for maize, and 40 t/ha for cassava.

TABLE 7
**Crop areas and yields by region (2002)**

| Crop | North | Northeast | Centre West | Southeast | South | Total area/ Average yield |
|---|---|---|---|---|---|---|
| **Cotton** | | | | | | |
| Area '000 ha | 0 | 157 | 439 | 99 | 29 | 725 |
| Yield kg/ha | 0 | 2 049 | 3 565 | 2 552 | 2 293 | 3 051 |
| **Rice** | | | | | | |
| Area '000 ha | 526 | 727 | 612 | 129 | 1 174 | 3 169 |
| Yield kg/ha | 2 215 | 1 587 | 2 812 | 2 378 | 5 034 | 3 241 |
| **Potato** | | | | | | |
| Area '000 ha | 0 | 3 | 0.1 | 74 | 71 | 148 |
| Yield kg/ha | 0 | 24 633 | 24 815 | 24 188 | 14 808 | 19 681 |
| **Coffee** | | | | | | |
| Area '000 ha | 168 | 167 | 45 | 1 876 | 124 | 2 380 |
| Yield kg/ha | 691 | 549 | 921 | 1 138 | 964 | 1 055 |
| **Sugar cane** | | | | | | |
| Area '000 ha | 15 | 1148 | 499 | 3146 | 407 | 5 215 |
| Yield kg/ha | 62 099 | 53 936 | 75 310 | 76 640 | 73 557 | 71 377 |
| **Beans** | | | | | | |
| Area '000 ha | 166 | 2 424 | 207 | 705 | 870 | 4 371 |
| Yield kg/ha | 754 | 408 | 1752 | 1229 | 1186 | 785 |
| **Citrus** | | | | | | |
| Area '000 ha | 17 | 111 | 10 | 640 | 49 | 827 |
| Yield kg/ha | 14 188 | 15 661 | 17 558 | 24 350 | 15 053 | 22 358 |
| **Maize** | | | | | | |
| Area '000 ha | 513 | 2 927 | 1 981 | 2 460 | 4 734 | 12 615 |
| Yield kg/ha | 1 788 | 1 229 | 3 841 | 3 975 | 4 208 | 3 375 |
| **Soybeans** | | | | | | |
| Area '000 ha | 190 | 1 241 | 8 044 | 1 481 | 7 489 | 18 445 |
| Yield kg/ha | 2 641 | 2 032 | 2 891 | 2 725 | 2 842 | 2 798 |
| **Wheat** | | | | | | |
| Area '000 ha | 0 | 0 | 114 | 41 | 1 909 | 2 064 |
| Yield kg/ha | 0 | 0 | 1 201 | 2 067 | 1 430 | 1 431 |
| **Other crops** | | | | | | |
| Area '000 ha | 731 | 3 034 | 741 | 753 | 1 425 | 6 685 |
| **All crops** | | | | | | |
| Area '000 ha | 2 325 | 11 939 | 12 692 | 11 406 | 18 283 | 56 646 |

Source: ANDA, 2003.

Hence agricultural technologies that can lead to substantial yield increases of the basic food crops are available but they need to be implemented. This is not relevant for large farmers, since these farmers are in any case anxious to use these technologies. Many large farmers pay consultants in order to have all possible technologies implemented on their farms. The issue is much more critical for subsistence or family farming systems, especially the small rural producers who are not members of agricultural cooperatives. This problem is particularly acute on small farms located in the North and Northeast regions, where, as a consequence of the running-down of the official agricultural extension service, simple technologies that can have a large impact on food crop yields are not used. As shown in Table 6, an agricultural census of 1995/1996 revealed that only 4.1 percent of the farmers in the Northeast region, where the largest number of small farms in the country is concentrated, had some kind of advice from the official rural extension service.

Crop areas and average yields in the different regions of the country are shown in Table 7.

# Chapter 4
# The fertilizer sector

## MINERAL FERTILIZER PRODUCTION[1]

Some of today's large fertilizer companies were already operating at the end of the 1940s and the beginning of the 1950s. Until the beginning of the 1960s, the domestic demand for fertilizer raw materials was met essentially by imports. Local production was limited to phosphate rock from a mine discovered in the 1940s in the State of São Paulo, to an ammonia, nitric acid, ammonium nitrate and calcium ammonium nitrate plant and to some producers of single superphosphate.

In the second half of the 1960s, new single superphosphate plants and the first complex fertilizer plant were constructed, marking the beginning of phosphoric acid production in the country. This enterprise also installed the first large-scale unit for the production of anhydrous ammonia, nitric and sulphuric acids, ammonium nitrate and DAP (diammonium phosphate). Other new projects became operational during the following decade.

Starting in 1971, the demand for fertilizers increased considerably, mainly as a consequence of agricultural development in the *Cerrado* in Central Brazil. This was constrained, however, by the need for additional imports at rising cost. This increasing demand, associated with high prices on the international market as a consequence of the conflict in the Near East and other factors, resulted, in 1974, in the development of the National Program for Fertilizers and Agricultural Limestone (PNFCA), whose main objective was the expansion and modernization of the fertilizer and agricultural limestone industry in Brazil. This program stimulated investment in several fertilizer and raw material complexes.

In the early 1990s, the fertilizer sector in Brazil underwent an intense privatization process, in which a substantial proportion of raw material production, until then undertaken the by state-owned companies, was transferred to the private sector.

[1] Adapted from ANDA, 1987.

The company responsible for the only production of potassium chloride in Brazil was transferred to the private sector. Some subsidiaries of a state-owned company producing a substantial portion of the nation's phosphate and nitrogen fertilizers also were later privatized. Summaries of the capacities of the main producers of raw materials and fertilizers respectively are presented in Tables 8 and 9. Their geographical location is illustrated in Figure 6.

At least 250 mixed NPK compound fertilizers plants are located in the different agricultural areas of the country.

TABLE 8
**Raw materials and intermediates capacities ('000 tonnes product per annum)**

| Product | Location | Capacity |
|---|---|---|
| **Ammonia** | Araucaria (PR) | 438 |
| | Camaçarí (BA) | 488 |
| | Cubatão (SP) | 191 |
| | Laranjeiras (SE) | 406 |
| | Total | 1 523 |
| **Phosphate rock** | Araxá (MG) | 799 |
| | Cajati (SP) | 536 |
| | Catalão (GO) | 2 253 |
| | Irecê (BA) | 150 |
| | Lagamar (MG) | 560 |
| | Patos de Minas (MG) | 150 |
| | Tapira (MG) | 1 688 |
| | Total | 6 136 |
| **Sulphuric acid** | Araxá (MG) | 343 |
| | Cajati (SP) | 580 |
| | Catalão (GO) | 432 |
| | Cubatão (SP) | 1 315 |
| | L. Eduardo Magalhães (BA) | 36 |
| | Paulínia (SP) | 330 |
| | Santa Luzia do Norte (AL) | 15 |
| | Uberaba (MG) | 1 762 |
| | Total | 4 813 |
| **Phosphoric acid ($P_2O_5$)** | Cajati (SP) | 164 |
| | Catalão (GO) | 118 |
| | Cubatão (SP) | 269 |
| | Uberaba (MG) | 496 |
| | Total | 1 047 |

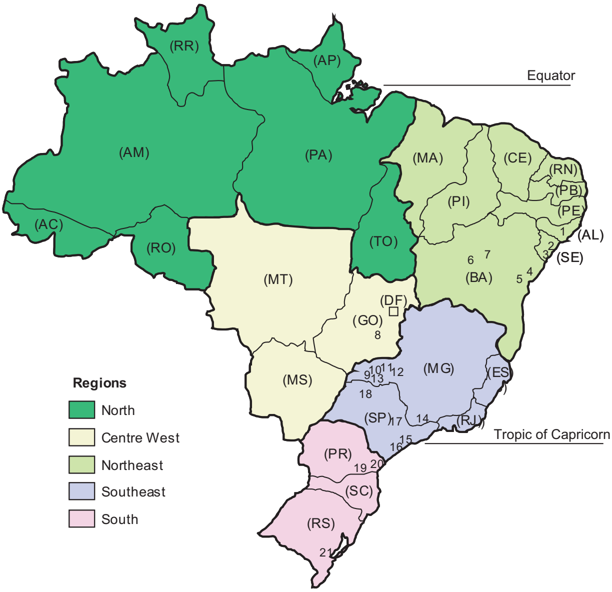
Source: ANDA, 2003.

TABLE 9
**Fertilizer plant capacities ('000 tonnes product per annum)**

| Product | Location | Capacities |
|---|---|---|
| **Ammonium sulphate** | Camaçari (BA) | 159 |
| | Cubatão (SP) | 34 |
| | Total | 193 |
| **Urea** | Araucaria (PR) | 630 |
| | Camaçari (BA) | 495 |
| | Laranjeiras (SE) | 594 |
| | Total | 1 719 |
| **Ammonium nitrate** | Cubatão (SP) | 406 |
| **Single superphosphate** | Araxá (MG) | 679 |
| | Camaçari (BA) | 230 |
| | Candeias (BA) | 150 |
| | Catalão (GO) | 908 |
| | Cubatão (SP) | 1 077 |
| | Guará (SP) | 342 |
| | L. Eduardo Magalhães (BA) | 108 |
| | Paranaguá (PR) | 400 |
| | Patos de Minas (MG) | 100 |
| | Paulínia (SP) | 675 |
| | Rio Grande (RS) | 983 |
| | Santa Luzia do Norte (AL) | 90 |
| | Uberaba (MG) | 463 |
| | Total | 6 205 |
| **Triple superphosphate** | Catalão (GO) | 37 |
| | Cubatão (SP) | 28 |
| | Rio Grande (RS) | 187 |
| | Uberaba (MG) | 435 |
| | Total | 687 |
| **Monoammonium phosphate** | Catalão (GO) | 113 |
| | Cubatão (SP) | 253 |
| | Uberaba (MG) | 610 |
| | Total | 976 |
| **Diammonium phosphate** | Cubatão (SP) | 8 |
| **Thermal phosphate** | Poços de Caldas (MG) | 150 |
| **Potassium chloride** | Taquari Vassouras (SE) | 541 |

Source: ANDA, 2003.

FIGURE 6
**Location of the raw material and fertilizer plants**




1 – Santa Luzia do Norte; 2 – Laranjeiras; 3 – Taquari Vassouras; 4 – Camaçari; 5 – Candeias; 6 – Luiz Eduardo Magalhães; 7 – Irecê; 8 – Catalão; 9 – Uberaba; 10 – Tapira; 11 – Patos de Minas; 12 – Lagamar; 13 – Araxá; 14 – Poços de Caldas; 15 – Cubatão; 16 – Cajati; 17 – Paulinia; 18 – Guará; 19 – Araucária; 20 – Paranagua; 21 – Rio Grande.

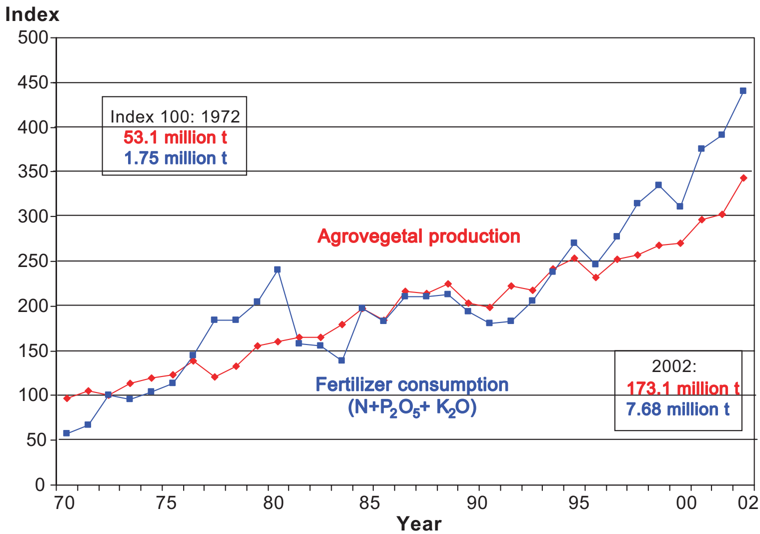
Source: Adapted from ANDA, 2003.

## MINERAL FERTILIZER CONSUMPTION

There is a close relationship between the consumption of fertilizers and crop production. Fertilizer consumption and the production of the 16 main crops (dry weight basis) between 1970 and 2002 are shown in Figure 7.

These data demonstrate that the development of the national production of these 16 crops in the last three decades was the result much more of an increase in the use of modern production technologies, especially on the efficient use of mineral fertilizers, than of the simple expansion of the area planted. On the one hand, during this period, the production of these 16 crops increased 3.4 times and the consumption of fertilizers increased by 4.4 times. On the other hand, the cropped area increased only 1.5 times, going from 36.4 million ha to 56.2 million ha.

FIGURE 7
**Relationship between agricultural crop production and fertilizer consumption**




Source: Lopes, Guilherme and Silva, 2003.

A better estimate of the above relationships can be obtained when the development is calculated on the basis of three-year averages, as shown in Table 10. For many years and until the beginning of the 1980s, the average consumption of fertilizers ($N+P_2O_5+K_2O$) in Brazil was around 50 kg/ha. It was only during the 1990s that a substantial increase occurred, reaching 132 kg/ha in the three-year period from 1999/00 to 2001/02. Unofficial data for the year of 2002/2003 indicate a record production of cereals of around 120 million tonnes, with an average consumption of fertilizers ($N+P_2O_5+K_2O$) of 138 kg per ha for the 16 major crops.

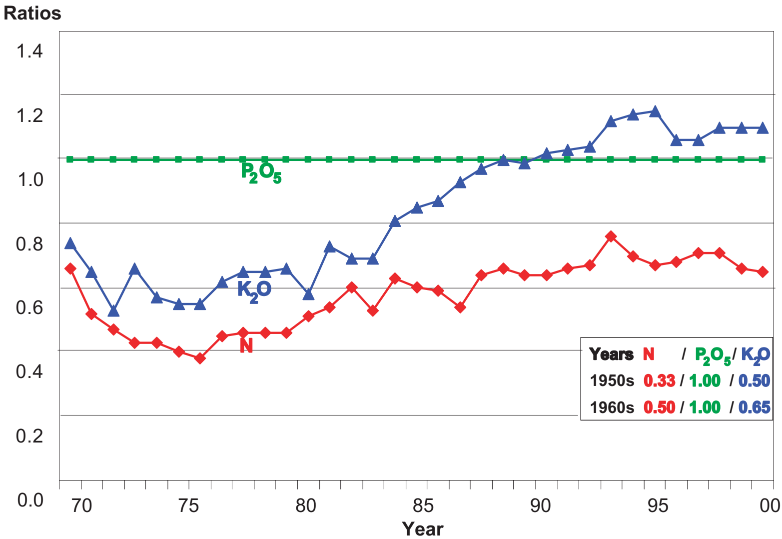
Another relevant aspect is the development of the $N:P_2O_5:K_2O$ consumption ratio in Brazilian agriculture, as shown in Figure 8. During the 1950s the ratio was 0.33:1.00:0.50. It changed to 0.50:1.00:0.55 in the 1960s, to 0.67:1.00 0.80 in 1970 then to 0.37:1.00:0.52 in 1976. Nitrogen and potash then tended to increase again in relation to phosphorus, with a ratio of 0.79:1.00:1.14 in 2002. The consumption of phosphate is relatively high partly as a consequence of the increasing cultivation of soils of the *Cerrado* area in the Centre West region of the country, which are extremely deficient in phosphorus.

TABLE 10
**Agriculture, fertilizer use and population (three year averages)**

| Item | Unit | 1981/82 to 1983/84 | 1990/91 to 1992/93 | 1999/00 to 2001/02 |
|---|---|---|---|---|
| Agricultural production (1) | 1 000 t | 90 226 | 112 696 | 154 993 |
| Grain production (2) | 1 000 t | 50 299 | 64 077 | 92 823 |
| Harvested area (3) | 1 000 ha | 44 087 | 45 984 | 47 655 |
| Fertilizer consumption (4) | 1 000 t | 2 541 | 3 312 | 6 282 |
| Yield | kg/ha | 2 047 | 2 451 | 3 252 |
| NPK consumption (5) | kg/ha | 58 | 72 | 132 |
| Population | 1 000 | 129 766 | 152 222 | 172 387 |
| "Per capita" production (6) | kg/person | 695 | 740 | 899 |

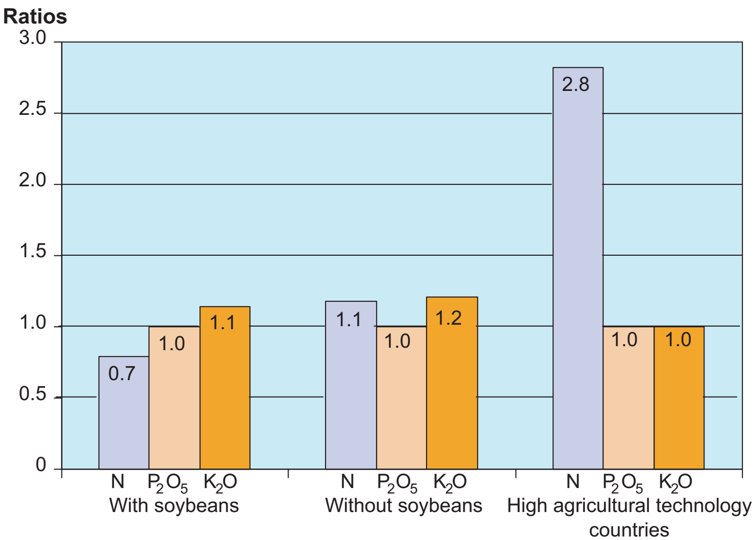
(1). Production of the 16 main crops, adjusted to a dry weight basis: sugar cane, cassava and potato (15 percent), citrus and tomato (10 percent).
(2) Cereals and oil crops.
(3). Sixteen main crops.
(4). N + $P_2O_5$ + $K_2O$ consumption in the year of planting.
(5). Harvested area.
(6). Agricultural production per capita in the harvest year.
Source: ANDA, 2003.

FIGURE 8
**Development of nutrient consumption ratios from 1970 to 2002. $P_2O_5$ = 1**




Source: Lopes, Guilherme and Silva, 2003.

FIGURE 9
**Ratios, $P_2O_5$ = 1, between the nutrients in 2002 (with and without soybean)**




Source: Lopes, Guilherme and Silva, 2003.

Excluding soybeans from the calculations, a crop that consumes almost no nitrogen fertilizers, the ratio is 1.18:1.00:1.21. If this ratio is compared with those of countries with a technically advanced agriculture, which average 2.82: 1.00:1.00, it can be concluded that the low rates of nitrogen are one of the main factors limiting yield increases in a number of crops (Figure 9).

The relatively low consumption of nitrogen in relation to phosphorus and potassium was confirmed by a study of Yamada and Lopes (1999), involving calculations of nutrients removed by the 16 main crops in Brazil (see Chapter 7).

A summary of the production, consumption, import and export of fertilizers in terms of N, $P_2O_5$ and $K_2O$ in Brazil from 1998 to 2002 is shown in Table 11. In 2002, national production supplied 41.5 percent of the N, 52.7 percent of the $P_2O_5$, but only 12.3 percent of the $K_2O$ consumed in the country.

Almost 50 percent of the nitrogen is accounted for by urea, 80 percent together with ammonium nitrate and ammonium sulphate. The ammonium

TABLE 11
**Fertilizer production, consumption and trade ('000 tonnes nutrient)**

| Nutrient | Item | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| **Nitrogen** | Production | 728 | 849 | 772 | 658 | 753 |
| **N** | Consumption | 1 455 | 1 393 | 1 668 | 1 640 | 1 816 |
| | Import | 852 | 845 | 1 263 | 1 081 | 1 176 |
| | Export | 66 | 32 | 39 | 21 | 65 |
| **Phosphorus** | Production | 1 369 | 1 359 | 1 496 | 1 445 | 1 480 |
| **$P_2O_5$** | Consumption | 2 129 | 1 967 | 2 338 | 2 482 | 2 807 |
| | Import | 773 | 675 | 1 120 | 1 151 | 1 298 |
| | Export | 37 | 42 | 37 | 89 | 93 |
| **Potassium** | Production | 326 | 348 | 353 | 357 | 376 |
| **$K_2O$** | Consumption | 2 261 | 2 079 | 2 562 | 2 716 | 3 059 |
| | Import | 1 993 | 1 942 | 2 566 | 2 527 | 2 692 |
| | Export | 23 | 17 | 22 | 51 | 53 |

Source: ANDA, 2003.

phosphates (MAP/DAP) account for 45 percent of total phosphate consumption, mostly MAP. The proportion of $P_2O_5$ consumption accounted for by SSP (29 percent) is almost twice that of TSP (16 percent). The direct application of high reactive phosphate rock accounts for only about 4 percent of total $P_2O_5$ applied in Brazilian agriculture. There has been a trend for the past 10 years for SSP to increase more than TSP, partly due to its sulphur content, a nutrient particularly required by soybeans. Potassium chloride is almost the only source of potassium used in Brazil, accounting for 98 percent of the market. Almost all the fertilizers are sold in solid form, in 50 kg bags and also in big bags of 500 to 1 000 kg.

A summary of the fertilizers sold in Brazil in 2002, in terms of type and nutrient content is presented in Table 12.

It is estimated that about 85 percent of the fertilizers consumed in Brazil are used in the form of mixed fertilizers.

As mentioned above, the consumption of mineral fertilizers has increased substantially during the past two decades. However, there are still substantial differences in the consumption of fertilizers a) in the different agro-ecological zones and b) within given agro-ecological zones.

TABLE 12
**Fertilizer consumption by product (2002)**

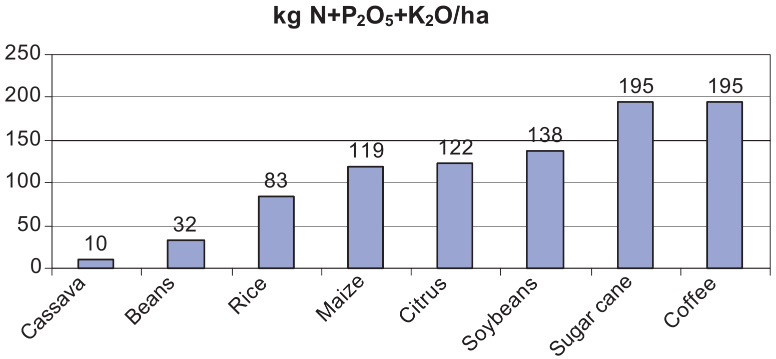
| Product | '000 tonnes | Percent |
|---|---|---|
| **Nitrogen (N)** | | |
| Ammonium sulphate | 308 | 16 |
| Urea | 895 | 48 |
| Calcium Ammonium nitrate | 2 | - |
| Ammonium nitrate | 305 | 16 |
| MAP/DAP | 256 | 14 |
| NK | 23 | 1 |
| NPK | 92 | 5 |
| **Total N** | 1 881 | 100 |
| **Phosphorus ($P_2O_5$)** | | |
| MAP/DAP | 1 313 | 45 |
| SSP | 831 | 29 |
| TSP | 478 | 16 |
| Thermophosphate | 22 | 1 |
| Reactive phosphate rock | 116 | 4 |
| NPK | 140 | 5 |
| **Total $P_2O_5$** | 2 900 | 100 |
| **Potassium ($K_2O$)** | | |
| Potassium chloride | 3 056 | 98 |
| Potassium sulphate | 22 | 1 |
| NK | 30 | 1 |
| NPK | 4 | - |
| **Total $K_2O$** | 3 112 | 100 |

Source: ANDA, 2003.

## a. Consumption variations in the different agro-ecological zones.

The continental dimensions of Brazil lead to a great diversity of soils, climates and types of land use, which is reflected in the variations in the use rates of mineral fertilizers applied to the different crops. For example, the average rate of consumption of fertilizers in states or regions where native pastures or even improved pastures prevail is much lower than that observed in states or regions where land use is dominated by the export crops (soybean, coffee, sugar cane, and citrus).

FIGURE 10
**Fertilizer consumption on some basic food crops and export crops in 2002**




Source: Lopes *et al.*, 2003.

**b. Consumption differences between some export crops and some basic food crops are illustrated in Figure 10.**

Even in states or regions with a high level of agricultural technology, there are large differences between the application rates of mineral fertilizers on export crops, which are much more profitable for farmers, and those of the basic food crops (cassava, beans, rice, and maize).

In the case of the export crops, the use of sustainable technologies that lead to high yields, especially the efficient use of mineral fertilizers, is normal farm practice. These farmers are always looking for technical means of increasing the productivity and profitability of their farms and are willing to invest in sustainable production technologies. In the case of the basic food crops, the use of sustainable production technologies that can lead to maximum economic yields is the exception rather than the rule. On these crops, the levels of consumption of mineral fertilizers are much less than those that are technically and economically recommended. In the case of subsistence farming the levels of mineral fertilizer use are critically low.

In the case of basic food crop production and especially of subsistence farming, the low use of production-enhancing technologies is due not to the lack of such technologies but rather to a series of constraints that prevent these technologies being used by the small subsistence farmers. This includes an absence of public policies that would improve the profitability of basic food crop production.

# Chapter 5
# Organic fertilizers

Reliable statistics concerning the consumption of organic fertilizers, especially manure, are not available. Brazil has the largest livestock herd in the world (176.4 million head), as well as a large number of pigs (32.6 million), equine (8.4 million), poultry (888.9 million), and sheep (24.2 million), according to IBGE (2003b). All of these animals are potential sources of organic manures. However, the commercial consumption of organic manures is limited to special situations, for example on horticultural and perennial crops, including fruit orchards located close to the producing areas and to intensive livestock producing farms. In the case of grain crops, except in the case of small subsistence or family farming systems or of large farms that integrate crop and animal production in confined systems, the use of organic fertilizers is uncommon.

Even taking into account the low content of N, $P_2O_5$ and $K_2O$ in most organic fertilizers, the large number of animals, especially cattle, could contribute large amounts of nutrients to Brazilian agriculture. For example, assuming that the 176.4 million head of cattle mentioned above produce an average 24 kg of manure a day (average of 80 percent humidity, 0.55 percent of N, 0.25 percent of $P_2O_5$ and 0.60 percent of $K_2O$), it would theoretically be possible to have an annual production of 1 545 million tonnes of manure (176 400 000 x 0,024 x 365), containing 8.5 million tonnes of N, 3.9 million tonnes of $P_2O_5$, and 9.3 million tonnes of $K_2O$. This corresponds to 21.7 million tonnes of $N+P_2O_5+K_2O$, which is more than the total N, $P_2O_5$ and $K_2O$ contained in the mineral fertilizers used in Brazil in 2002. Vitti and Malavolta (1999) estimated that the manure produced in 1997 in intensive livestock systems involved no more than 5 percent of the 144 million cattle in Brazil, contributing only 371 250 t of N, 155 250 t of $P_2O_5$ and 405 000 t of $K_2O$ (a total of 931 000 t of N+ $P_2O_5$+ $K_2O$), compared with the total consumption of 5 935 500 t of N+ $P_2O_5$+ $K_2O$ as mineral fertilizers.

Sewage sludge and municipal solid waste treatment plants are much more the exception than the rule in Brazil and the use of their by-products, after transformation into organic compost, is usually restricted to reforestation activities and lawns, with very little use in agriculture. Recent research focusing on the agricultural use of this kind of material (biosolids) has shown its viability for several crops in Brazil (Silva *et al.*, 2000; Melo and Marques, 2000; and Bettiol and Camargo, 2000).

Estimates of the quantity and composition of municipal solid wastes in Brazil are presented in the Table 13. Of the total municipal solid waste produced, 76 percent is deposited in open areas, the so-called *lixões* (open-air garbage pits), which create substantial social inconvenience caused by effluents, odours and proliferation of insects and animals that are vectors of diseases. The additional social and public health problems due to the large number of people living near the pits are of concern. About 13 percent of the remaining municipal solid waste is deposited in controlled landfills and 10 percent in semi-controlled landfills, whereas 0.1 percent is incinerated and only 0.9 percent transformed into organic compost (AENDA, 2001).

TABLE 13
**Composition of municipal solid wastes in Brazil**

| Waste | Quantity ('000 tonnes/year) | Percentage |
|---|---|---|
| Organic material | 23 725 | 50 |
| Non-recycled material | 18 031 | 38 |
| Recycled material | 5 564 | 12 |
| **Total** | 47 450 | 100 |

Source: AENDA, 2001.

# Chapter 6

# Fertilizer consumption by crop

Reliable statistics on the consumption of nutrients by crop and by state are not available in Brazil. The figures presented in Table 14 are indirect estimates calculated as follows:

1. The demand for N-$P_2O_5$-$K_2O$ was calculated for each nutrient and region based on the planted area, the demand of each crop and the standard fertilizer formulae used on the crop.

2. The consumption of each crop in each region was adjusted so that the figures concerning the total consumption for each crop in Brazil coincide with the regional estimates of the Statistics Committee of ANDA.

3. Once this adjustment was made, the consumption of each nutrient in each region and for each crop was calculated. These numbers were also adjusted using a technology factor specific for each region. This factor is based on data, obtained by The Statistics Committee of ANDA, which compares the average consumption of nutrients in Brazil with that of each region.

4. Final estimates were then made for consumption by crop and by region.

## Nitrogen

The highest rates of nitrogen are applied on potato, coffee, sugar cane, cotton, and citrus. High rates of nitrogen are also used on vegetables and fruits for export, which are included in "other crops" in Table 14. The lowest rates are used on beans, rice, wheat, maize, and soybeans; the latter crop is a leguminous crop and does not usually utilize nitrogen. Improved pasture is not included in Table 14; the fertilization of improved pastures has increased in recent years. The extremely low rates of nitrogen used on practically all the crops in the North and Northeast regions may be noted. An exception in the Northeast region is the small area devoted to the production of irrigated fruits for export.

TABLE 14
**Fertilizer consumption by crop and region (kg/ha)**

| Crop | Region | Product | N | $P_2O_5$ | $K_2O$ | Total |
|---|---|---|---|---|---|---|
| Cotton | North | - | - | - | - | - |
| | Northeast | 595 | 49 | 75 | 83 | 207 |
| | Centre West | 1 067 | 90 | 147 | 136 | 373 |
| | Southeast | 1 093 | 96 | 142 | 124 | 362 |
| | South | 860 | 120 | 112 | 119 | 351 |
| | Total | 960 | 83 | 130 | 122 | 335 |
| Rice | North | 106 | 7 | 23 | 12 | 42 |
| | Northeast | 148 | 16 | 25 | 15 | 56 |
| | Centre West | 265 | 30 | 49 | 25 | 104 |
| | Southeast | 272 | 32 | 47 | 23 | 102 |
| | South | 214 | 40 | 37 | 22 | 99 |
| | Total | 193 | 27 | 35 | 20 | 82 |
| Potato | North | - | - | - | - | - |
| | Northeast | 1 761 | 55 | 215 | 134 | 404 |
| | Centre West | 3 156 | 100 | 433 | 233 | 766 |
| | Southeast | 3 235 | 109 | 407 | 200 | 716 |
| | South | 2 545 | 136 | 321 | 193 | 650 |
| | Total | 2 873 | 121 | 362 | 195 | 678 |
| Coffee | North | 232 | 28 | 13 | 53 | 94 |
| | Northeast | 323 | 63 | 14 | 65 | 142 |
| | Centre West | 579 | 115 | 28 | 108 | 251 |
| | Southeast | 593 | 123 | 26 | 98 | 247 |
| | South | 467 | 154 | 21 | 94 | 269 |
| | Total | 542 | 114 | 24 | 92 | 230 |
| Sugar cane | North | 198 | 14 | 28 | 63 | 105 |
| | Northeast | 277 | 31 | 30 | 79 | 140 |
| | Centre West | 496 | 57 | 60 | 130 | 247 |
| | Southeast | 509 | 61 | 57 | 118 | 236 |
| | South | 400 | 76 | 45 | 113 | 234 |
| | Total | 447 | 55 | 51 | 110 | 216 |
| Beans | North | 70 | 3 | 10 | 5 | 18 |
| | Northeast | 98 | 6 | 10 | 6 | 22 |
| | Centre West | 175 | 11 | 20 | 10 | 41 |
| | Southeast | 179 | 11 | 19 | 9 | 39 |
| | South | 141 | 14 | 15 | 9 | 38 |
| | Total | 122 | 8 | 13 | 7 | 28 |

| Crop | Region | Product | N | $P_2O_5$ | $K_2O$ | Total |
|---|---|---|---|---|---|---|
| Citrus | North | 187 | 14 | 13 | 25 | 52 |
| | Northeast | 261 | 30 | 14 | 32 | 76 |
| | Centre West | 468 | 55 | 27 | 52 | 134 |
| | Southeast | 480 | 59 | 26 | 47 | 132 |
| | South | 377 | 74 | 20 | 46 | 140 |
| | Total | 438 | 55 | 24 | 45 | 124 |
| Maize | North | 130 | 10 | 22 | 20 | 52 |
| | Northeast | 182 | 22 | 23 | 25 | 70 |
| | Centre West | 325 | 40 | 46 | 41 | 127 |
| | Southeast | 334 | 43 | 44 | 37 | 124 |
| | South | 262 | 53 | 35 | 35 | 123 |
| | Total | 262 | 40 | 35 | 33 | 108 |
| Soybeans | North | 165 | 2 | 36 | 33 | 71 |
| | Northeast | 229 | 4 | 39 | 41 | 84 |
| | Centre West | 411 | 7 | 76 | 68 | 151 |
| | Southeast | 422 | 7 | 73 | 62 | 142 |
| | South | 332 | 9 | 58 | 60 | 127 |
| | Total | 365 | 8 | 66 | 62 | 136 |
| Wheat | North | 0 | 0 | 0 | 0 | 0 |
| | Northeast | 0 | 0 | 0 | 0 | 0 |
| | Centre West | 336 | 9 | 64 | 53 | 126 |
| | Southeast | 344 | 9 | 62 | 48 | 119 |
| | South | 271 | 12 | 49 | 47 | 108 |
| | Total | 276 | 12 | 50 | 47 | 109 |
| Other crops | North | 11 | 3 | 2 | 2 | 7 |
| | Northeast | 29 | 8 | 5 | 6 | 19 |
| | Centre West | 707 | 63 | 167 | 128 | 358 |
| | Southeast | 833 | 147 | 92 | 79 | 318 |
| | South | 279 | 73 | 63 | 59 | 195 |
| | Total | 246 | 43 | 45 | 39 | 127 |
| All crops | North | 94 | 7 | 16 | 15 | 38 |
| | Northeast | 146 | 15 | 19 | 24 | 58 |
| | Centre West | 430 | 22 | 76 | 69 | 167 |
| | Southeast | 492 | 63 | 53 | 76 | 192 |
| | South | 299 | 31 | 49 | 49 | 129 |
| | Total | 327 | 31 | 48 | 52 | 131 |

### Phosphorus

The largest application rates of phosphorus are on cotton and potato. Medium level application rates are used on sugar cane, soybeans and wheat and low rates on rice, coffee common beans, citrus and maize. For this nutrient also the lowest rates are in the North and Northeast regions.

### Potassium

The rates for potassium are highest for cotton, potato, coffee and sugar cane. Medium rates are applied on citrus, soybeans and wheat and low rates on rice, common beans and maize. Also in the case of potassium, the lowest rates are in the North and Northeast regions.

# Chapter 7
# Nutrient balances

The relatively low consumption of nitrogen in relation to phosphorus and potassium was confirmed by a study of Yamada and Lopes (1999), involving calculations of nutrients removed by the 16 main crops in Brazil. This study assumed an average efficiency of 60 percent for nitrogen, 30 percent for phosphorus and 70 percent for potassium fertilizers. Using data for the period 1993 to 1996, the authors estimated an average annual deficit of 888 thousand tonnes of nitrogen, even assuming that the whole nitrogen consumption of soybeans and common beans originated from biological N fixation. The estimated deficit for phosphorus was 414 thousand tonnes of $P_2O_5$ and that of potassium was 413 thousand tonnes of $K_2O$. Thus, in spite of the substantial increases in the consumption of fertilizers in Brazil in recent decades, Brazilian agriculture is removing from the soil a substantial quantity of nutrients that should be replenished by fertilization, especially with nitrogen. This situation can lead, in the long term, to consequences that are very detrimental to the sustainability of Brazilian agriculture.

To update the results of Yamada and Lopes (1999) with current data, estimates were made for the year 2000, assuming efficiencies for nitrogen, phosphorus and potassium as before, but considering that only 40 percent of the nitrogen of the common beans originated from the biological N fixation. These estimates represent 94 percent of the cultivated area of the country, involving the 16 main crops.

Overall balances are shown in Tables 15, 16 and 17. A limiting factor in the work of Yamada and Lopes (1999), as well as in the data for 2002, is that the input of the nutrients was based on mineral fertilizers alone, not taking into account the possible contribution of manure and/or of nitrogen fixation in cover crops in crop rotation systems.

Despite these limitations some aspects regarding the balance of these nutrients are of interest.

The input of nitrogen in the whole country, regions and states, was lower than its removal, giving a negative balance or probably a nitrogen deficiency. The total nitrogen deficit in 2002 was estimated at 859 thousand tonnes compared

TABLE 15
**Nitrogen balance, 2002**

| Region | Input[1] | Removal[2] | Balance[3] | Balance[3] |
|---|---|---|---|---|
| | | tonnes N | | kg N/ha |
| North | 9 926 | 55 651 | -45 725 | -21.4 |
| Northeast | 93 879 | 216 228 | -122 349 | -11.8 |
| Centre West | 177 803 | 281 832 | -104 029 | -8.6 |
| Southeast | 429 006 | 650 751 | -221 745 | -20.4 |
| South | 330 858 | 696 112 | -365 254 | -20.9 |
| **Brazil** | 1 041 472 | 1 900 574 | -859 102 | -16.2 |

(1) The amounts of effective nutrient applied as mineral fertilizers (assuming 60 percent efficiency).
(2) The amounts of nutrient removed with the products of the 16 major crops.
(3) The balance (negative or positive) in terms of tonnes and of kg nutrient/ha.
Source: Adapted from IBGE, 2003 and ANDA, 2003.

TABLE 16
**Phosphate balance, 2002 (assuming 30 percent efficiency)**

| Region | Input [1] | Removal [2] | Balance [3] | Balance [3] |
|---|---|---|---|---|
| | | tonnes $P_2O_5$ | | kg $P_2O_5$/ha |
| North | 10 534 | 26 322 | -15 788 | -7.4 |
| Northeast | 61 003 | 100 210 | -39 207 | -3.8 |
| Centre West | 292 978 | 395 454 | -102 476 | -8.5 |
| Southeast | 184 520 | 237 292 | -52 772 | -4.8 |
| South | 256 372 | 560 209 | -303 837 | -17.4 |
| **Brazil** | 805 407 | 1 319 487 | -514 080 | -9.7 |

(1) The amounts of effective nutrient applied as mineral fertilizers (assuming 60 percent efficiency).
(2) The amounts of nutrient removed with the products of the 16 major crops.
(3) The balance (negative or positive) in terms of tonnes and of kg nutrient/ha.
Source: Adapted from IBGE, 2003 and ANDA, 2003.

TABLE 17
**Potash balance, 2002 (assuming 70 percent efficiency)**

| Region | Input [1] | Removal [2] | Balance [3] | Balance [3] |
|---|---|---|---|---|
| | | tonnes $K_2O$ | | kg $K_2O$/ha |
| North | 24 157 | 47 462 | -23,305 | -10.9 |
| Northeast | 179 385 | 219 317 | -39,932 | -3.9 |
| Centre West | 627 719 | 683 857 | -56,138 | -4.7 |
| Southeast | 611 119 | 626 159 | -15,040 | -1.4 |
| South | 605 539 | 795 908 | -190,369 | -10.9 |
| **Brazil** | 2 047 919 | 2 372 703 | -324,784 | -6.1 |

(1) The amounts of effective nutrient applied as mineral fertilizers (assuming 60 percent efficiency).
(2) The amounts of nutrient removed with the products of the 16 major crops.
(3) The balance (negative or positive) in terms of tonnes and of kg nutrient/ha.
Source: Adapted from IBGE, 2003 and ANDA, 2003.

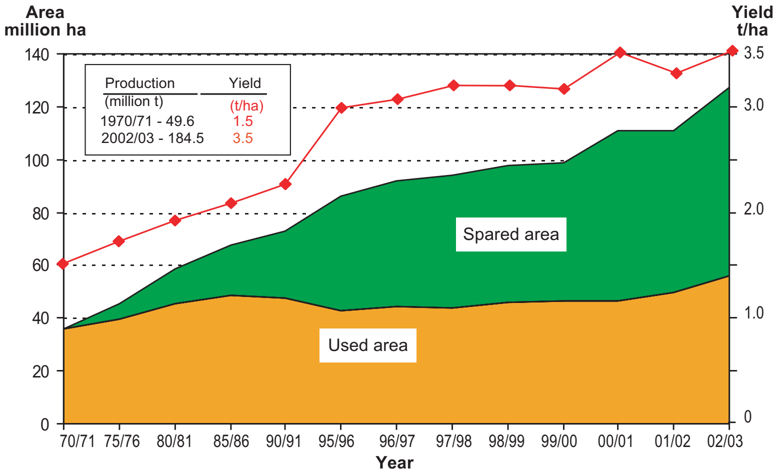
with the 888 thousand tonnes per year for the period of 1993 to 1996. In terms of deficits of nitrogen in kg/ha, some states have deficits higher than the Brazilian average of -16.2 kg of N/ha: Santa Catarina (-44.7), Rio de Janeiro (-41.0), São Paulo (-32.2), Pará (-29.9), Alagoas (-29.2), Acre (-26.2), Roraima (-24.0), Paraná (-22.9), Sergipe (-21.7), Amazonas (-21.1), Federal District (-19.5), Ceará (-16.6) and Paraíba (-16.2).

Regarding phosphorus, the total deficit in 2002, was 514 thousand tonnes of $P_2O_5$ compared with the average of 414 thousand annual tonnes per year for the period from 1993 to 1996. The input of $P_2O_5$ was larger than the removal by the crops in only two states (Amapá and Roraima). All the Southern states had deficits that where above the Brazilian average (-9.7 kg of $P_2O_5$/ha): Santa Catarina, -27.0; Paraná, -18.4, Rio Grande do Sul, -14.0. Deficits above the Brazilian average were observed also in the states of Roraima (-13.7), Goiás (-12.4), Mato Grosso do Sul (-11.9), Pará (-10.7), Rio de Janeiro (-10.1) and Acre (-10.0).

For the three macronutrients considered in this balance, the lowest deficit was for potassium. The total deficit for Brazil in 2002 was of 325 thousand tonnes of $K_2O$, compared with 413 thousand tonnes per year from 1993 to 1996. Five states presented an apparent potassium surplus (Roraima, Amapá, Minas Gerais, Federal District, Espírito Santo and Bahia). An extremely high deficit was observed in the state of Rio de Janeiro (-34.7 kg $K_2O$/ha). Deficits of between 10.0 and 20.0 kg $K_2O$/ha were observed in the states of Pará (-19.3), Acre (-17.7), Amazonas (-17.7), Paraná (-16.3), Alagoas (-15.7), Santa Catarina (-15.0), Sergipe (-13.3), São Paulo (-11.2) and Mato Grosso do Sul (-10.3).

Although the balance of nutrients in the Brazilian agriculture needs to be improved for most crops, especially the basic food crops, it is evident that the increased use of mineral fertilizers has played an important role in the development of agricultural productivity and environmental preservation during the past 30 years in Brazil. Figure 11 shows the evolution of the cultivated area and average yields in tonnes per hectare of the 16 main crops (dry weight basis) between 1970/71 and 2002/03. In 1970/71, total crop production was 49.6 million tonnes, fertilizer consumption around 30 kg of $N+P_2O_5+K_2O$ per hectare and the average yield 1.5 t/ha. In 2002/03, production amounted to 184.5 million tonnes, with an average consumption of 138 kg of nutrients per hectare and the average crops yield 3.5 t/ha. During the same period, the cultivated area increased by only 19.4 million hectares (from 36.4 to 56.2 million hectares). These yield increases were obtained through a more appropriate use of mineral fertilizers and other management practices. An additional cropped area equivalent to 71

FIGURE 11
**Crop production*, yields and land spared from deforestation, 1970 to 2002**




*16 main crops (dry weight basis)
Source: Lopes, Guilherme and Silva, 2003.

million hectares of cleared forest would have been necessary if the current total production were to be obtained with the yield average of 1970/71.

An example of the evolution of agricultural production technologies in Brazilian agriculture, especially for the export crops, is shown in Figure 12. This photograph shows the beginning of the harvest of soybeans under the no-till system in the State of Mato Grosso, Centre West region, on soils that until 30 years ago were considered to be marginal for intensive agricultural production. Just behind of the 35 soybean harvesters, 18 planting machines are sowing maize using the no-till system.

The soybean yields obtained by good farmers in the region reach 3.5 t/ha and the yield of maize, the following crop, 6 to 7 t/ha. The production cost of soybeans in the State of Mato Grosso is about US$6.23 per 60 kg bag compared with US$11.72 in the United States of America and the average yield is about 20 percent higher than the American average. In 2002, for the first time in history, the overall average yield of soybeans in Brazil (2.6 t/ha) was higher than the average yield in the United States of America (2.4 t/ha). It is reasonable to state that in the Centre West region, Brazilian farmers are practicing one of the most advanced and sustainable agricultural systems in the world.

FIGURE 12
**The no-till system in Mato Grosso; soybean harvesters followed by maize planters**

Source: Lopes, Guilherme and Silva, 2003.

## Chapter 8

# Prices and profitability of fertilizers

### Prices of mineral fertilizers

Since the beginning of the 1990s, when Brazil implemented a fourth process of trade liberalization, trade barriers for the Brazilian fertilizer industry, including barriers concerning raw materials, have been very small. As a result, the domestic market prices of straight fertilizers and their raw materials became comparable with those of imported products (Table 18).

Data on the average prices of fertilizers (US$ per tonne) in Brazil for the period of 1993 to 2002 (Table 19) indicate that for all fertilizers the average prices for 2002 are below those practiced in 1993 and considerably lower than those observed in 1996, a year when prices of fertilizers reached the highest level of the recent years. It has been observed that the final price of fertilizers to the farmers is now closely related to the prices of imported fertilizers.

### Prices of agricultural products

The prices of agricultural products are influenced partly by international prices and partly by the country's own supply and demand balance.

Exported products such as cotton, coffee, citrus, soybeans and wheat are strongly influenced by international prices. The prices of basic food products

Table 18
**International fertilizer price indices[1]**

| Product | 1993 | 1993 | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| | US$/t | | | Indices | | |
| Ammonium sulphate | 78 | 100 | 145 | 88 | 97 | 105 |
| Urea | 119 | 100 | 153 | 97 | 113 | 101 |
| Triple superphosphate | 130 | 100 | 146 | 152 | 115 | 108 |
| Monoammonium phosphate | 144 | 100 | 163 | 164 | 123 | 119 |
| KCl | 122 | 100 | 120 | 124 | 119 | 109 |
| **Average** | 118.60 | 100 | 145 | 125 | 113 | 108 |

[1] Average international prices (C&F). Indices of relative prices, 1993 = 100.
Source: ANDA, 2003.

TABLE 19
**Price indices of some fertilizers in Brazil**

| Product | 1993 | 1993 | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|---|---|
| | US$/t | | | Indices | | |
| **NPK compound** | | | | | | |
| 2-20-20[1] | 164 | 100 | 139 | 121 | 109 | 96 |
| 4-14-8[2] | 128 | 100 | 135 | 119 | 109 | 96 |
| 4-20-20[3] | 170 | 100 | 138 | 120 | 108 | 95 |
| 5-25-15[4] | 178 | 100 | 144 | 124 | 110 | 99 |
| 12-6-12[5] | 141 | 100 | 143 | 114 | 106 | 96 |
| 20-5-20[6] | 178 | 100 | 147 | 108 | 103 | 90 |
| Amm. sulphate | 136 | 100 | 147 | 99 | 94 | 94 |
| Urea | 200 | 100 | 170 | 93 | 92 | 83 |
| **Average** | 161 | 100 | 145 | 112 | 104 | 94 |

Compound fertilizer used on:
[1] Soybean
[2] Potatoes and common beans
[3] Cotton, maize and wheat
[4] Rice
[5] Citrus
[6] Coffee
Source: ANDA, 2003.

TABLE 20
**Agricultural product prices**

| Product | 1993 | 1996 | 1998 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| | | | US$ per unit of product[1] | | | |
| Cotton | 5.16 | 7.30 | 6.52 | 5.23 | 3.94 | 3.63 |
| Rice | 9.72 | 12.34 | 14.84 | 8.24 | 7.52 | 8.07 |
| Potato | 12.03 | 16.15 | 21.07 | 12.36 | 14.60 | 10.66 |
| Coffee | 63.94 | 126.13 | 134.80 | 84.74 | 47.49 | 40.29 |
| Sugar cane | 9.74 | 15.08 | 14.58 | 10.17 | 10.82 | 9.26 |
| Common beans | 30.33 | 36.50 | 53.79 | 20.22 | 24.21 | 23.84 |
| Oranges | 2.59 | 3.28 | 4.35 | 2.15 | 3.30 | 3.44 |
| Maize | 6.90 | 8.66 | 7.41 | 6.63 | 4.16 | 5.30 |
| Soybeans | 10.65 | 13.87 | 11.66 | 9.38 | 9.01 | 10.13 |
| Wheat | 7.40 | 11.26 | 7.93 | 7.08 | 6.42 | 7.52 |

[1] The “units of product” area as follows:
Cotton: 15 kg
Rice, potato, coffee, beans, maize, soybeans and wheat: 60 kg bag
Oranges: 40.8 kg box
Sugar cane: tonne

such as rice, potato, common beans, and maize are influenced much more by internal factors. Sugar cane prices are influenced by the international sugar market and by the domestic alcohol market.

The prices of basic food products have been constrained by the inflation control policies practiced by the Federal Government since 1994. The data in Table 20 indicate that the average prices for the great majority of the Brazilian agricultural products, apart from oranges and wheat, fell during the period of 1993 to 2002.

As shown in Table 21, the quantity of agricultural products needed to buy one tonne of fertilizer was similar in 1993 and 2002 in the cases of sugar cane and soybeans. It declined in the case of oranges and increased in the cases of cotton, rice, potato, coffee, beans and maize.

## PROFITABILITY OF FERTILIZER USE

In general, the profitability of fertilizer use in Brazil has been influenced much more by variations in the prices of the agricultural products than variations in the prices of fertilizers. For the great majority of crops shown in Table 22, the cost of fertilization per ha during the past five years has remained reasonably constant. However the share of fertilization costs in relation to the total income per ha increased substantially due to falls in income.

TABLE 21
**Units of products required to buy one tonne of fertilizer**

| Product | 1993 | 1996 | 1998 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|
| | US$ per unit of product[1] | | | | | |
| Cotton | 31.2 | 31.0 | 28.6 | 32.5 | 42.0 | 42.3 |
| Rice | 18.7 | 22.1 | 14.4 | 23.3 | 24.2 | 21.3 |
| Potato | 10.6 | 10.7 | 7.2 | 11.4 | 9.2 | 11.6 |
| Coffee | 2.8 | 2.1 | 1.4 | 2.2 | 3.7 | 4.0 |
| Sugar cane | 18.4 | 17.4 | 14.4 | 18.9 | 17.2 | 18.4 |
| Common beans | 4.2 | 4.9 | 2.8 | 6.9 | 5.6 | 5.2 |
| Oranges | 54.2 | 61.2 | 37.0 | 69.4 | 45.5 | 39.3 |
| Maize | 25.7 | 30.2 | 26.8 | 27.7 | 42.1 | 30.8 |
| Soybeans | 15.4 | 16.4 | 16.9 | 18.9 | 18.8 | 15.6 |
| Wheat | 23.0 | 20.9 | 25.7 | 26.0 | 27.1 | 21.5 |

[1] See footnote Table 20.

TABLE 22
**Expenditure on fertilizers[1] as a proportion of farm income[2] Centre-South region**

| Crop | US$/ha | 1998 | 2000 | 2002 | Average 1998/2002 |
|---|---|---|---|---|---|
| Cotton | Income | 1 630 | 1 308 | 908 | 1 205 |
| | Fertilizers | 119 | 108 | 99 | 108 |
| | Proportion | 7.3 % | 8.3 % | 10.9 % | 9.0 % |
| Rice | Income | 965 | 536 | 525 | 626 |
| | Fertilizers | 80 | 72 | 66 | 72 |
| | Proportion | 8.3 % | 13.4 % | 12.6 % | 11.5 % |
| Sugar cane | Income | 1 166 | 814 | 741 | 851 |
| | Fertilizers | 97 | 90 | 80 | 89 |
| | Proportion | 8.3 % | 11.1 % | 10.8 % | 10.4 % |
| Beans | Income | 1 883 | 708 | 1 883 | 1 244 |
| | Fertilizers | 89 | 83 | 89 | 84 |
| | Proportion | 4.7 % | 11.7 % | 4.7 % | 6.8 % |
| Citrus | Income | 3 480 | 1 720 | 2 752 | 2 568 |
| | Fertilizers | 113 | 104 | 95 | 103 |
| | Proportion | 3.2 % | 6.0 % | 3.5 % | 4.0 % |
| Maize | Income | 519 | 464 | 371 | 408 |
| | Fertilizers | 103 | 96 | 87 | 95 |
| | Proportion | 19.9 % | 20.7 % | 23.5 % | 23.2 % |
| Soybeans | Income | 490 | 394 | 426 | 410 |
| | Fertilizers | 49 | 44 | 39 | 44 |
| | Proportion | 10.0 % | 11.2 % | 9.2 % | 10.7 % |
| Wheat | Income | 333 | 297 | 316 | 298 |
| | Fertilizers | 51 | 46 | 41 | 46 |
| | Proportion | 15.3 % | 15.5 % | 13.0 % | 15.4 % |
| Coffee | Income | 2 696 | 1 695 | 806 | 1 913 |
| | Fertilizers | 154 | 147 | 129 | 141 |
| | Proportion | 5.7 % | 8.7 % | 16.0 % | 7.4 % |

1 Farm income: price received by the farmer multiplied by the average yield per ha.
2 Fertilizer cost: average annual price paid by the farmer multiplied by the quantity applied on the crop.
Source: ANDA, 2003.

# Chapter 9
# Fertilizer distribution

Until the middle of the 1960s, fertilizer consumption in Brazil was very low and the mixtures were produced in areas close to the ports, since most raw materials were imported. In the second half of the 1960s, the Brazilian industry started to locate the production of the fertilizer mixtures close to the demand areas. This was accompanied by the provision of services such as soil sampling and analysis, advice on the type and time of application of fertilizers etc.

At the same time, the Brazilian fertilizer industry implemented an intensive advisory program for the use of fertilizers, through the FAO-ANDA-ABCAR Project. This project consisted of a series of field demonstrations throughout the whole country and contributed to a strong increase in fertilizer consumption in Brazil. As a result, Brazilian demand for fertilizers increased from 360 thousand tonnes of nutrients in the 1960s to 3 291 thousand tonnes of nutrients in the 1980s, reaching an average consumption of 7 029 thousand tonnes of nutrients for the period of 2000 to 2002.

Today the distribution of fertilizers in Brazil is carried out by the private sector. State owned companies participated in distribution only from 1976 to 1981. Although the state-owned companies were privatized only in 1992, already in 1982 the government had transferred the mixture and distribution of fertilizers to the private sector. The activities of the state-owned sector were restricted to the production of raw materials and straight fertilizers.

The participation of agricultural cooperatives in the distribution of fertilizers has recently shown some growth. Agricultural cooperatives account for about 10 percent of current fertilizer demand. They purchase the product from the compound fertilizer producers and then sell it to their members but they also produce fertilizer mixtures themselves. This has increased the share of the cooperatives in the production of fertilizer mixtures from 2 percent in the 1990s to 5 percent at present.

Today 35 percent of fertilizer sales are financed through official agricultural credit, administered essentially by the Banco do Brasil (a Federal Government Bank). Joint operations between the fertilizer industry and the agribusiness sector (producers of vegetable oils, textile, tobacco, etc) are responsible for the financing of 18 percent of the sales. The cooperatives are also increasing their role in the financing of the purchase of fertilizer mixtures by their members. Although their participation is still very low (financing 5 percent of the total sales), their share is tending to increase since the cooperatives charge lower interest rates. The remaining 42 percent of the sales are financed either from the farmers' own resources or through commercial banks.

# Chapter 10
# Concluding remarks

Total cereal production in Brazil amounts to 122.8 million tonnes or around 694 kg per inhabitant. The current average yields are: maize, 3.0 t/ha; beans, 0.7 t/ha; wheat, 1.6 t/ha; rice, 3 t/ha; soybeans 2.7 t/ha. Of those crops, only soybeans have a high average yield level, a yield that is comparable to the world's best. However, higher yields of food crops are obtained by good farmers in most regions of the country, for example 10 t/ha for maize, 3.5 t/ha for irrigated beans, 6 t/ha for wheat and 8 t/ha for irrigated rice. Thus the problem of low average yields is due not to the lack of relevant agricultural technologies but rather to the poor implementation of these technologies.

In the case of the export crops (coffee, sugar cane, citrus and soybeans) advanced production technologies are used. These include not only appropriate rates of fertilization but also the application of a series of other agronomic recommendations. It is in the sector of food crops for domestic consumption (rice, maize, beans and cassava) that average yields are far below those attainable. One of the reasons for the low yields is inadequate mineral fertilizer application. This is particularly the case with subsistence farming, which is practiced in the poorer areas of the country, especially in the Northeast region, and in which practically no mineral fertilizers are used.

In general terms, the fertilizer nutrient balance in Brazilian agriculture is unsatisfactory. The removal of nutrients by the 16 main crops is higher than the quantities applied in the form of mineral fertilizers. The deficit is much greater in the case of nitrogen than in those of phosphorus and potassium. Thus the soil is being seriously depleted of nutrients and this represents a serious threat to long-term agricultural sustainability.

In spite of having the largest cattle herd in the world and a very large number of poultry and other livestock, the production and use of manure is limited largely to subsistence and family farms and to some large farms that integrate livestock and cereal crop production.

Some suggestions concerning measures that might be taken to help to remedy some major problems are:

a. In the short-term, emphasis should be placed on the reclamation of areas that are being degraded or are already degraded. The conversion of only 30 million hectares of the current 90 million hectares of degraded pastures into land for cereal production with an average yield of three tonnes per hectare would represent an annual increase of 90 million tonnes of cereals.

b. In the medium term, the highest priority should be given to measures whereby farmers implement sustainable technologies for increasing crop yields. Farmers should increase their production by improving yields in areas that are already being farmed rather than by expanding the area they cultivate. These measures should include the permanent monitoring of nutrient availability in soils and crops and the adoption of balanced fertilization.

c. The transformation of subsistence agriculture into profitable family farms requires long-term measures that would lead to a cultural change in this segment. Agricultural and social policy measures should include:

    1. Re-activation of the rural extension programmes in the relevant regions, communicating to subsistence farmers information on simple and sustainable technologies that would achieve not only large increases in crop yields but also help to prevent erosion and contribute to environmental preservation.

    2. Alphabetization and the implementation of family planning, health care and other basic measures that could improve their standard of living.

    3. Advice on how to increase the returns from their agricultural products through their sale in local markets.

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Brazil is the world's largest producer of coffee, sugar cane and citrus and is the world's second largest producer of soybeans. Agricultural production has increased more than threefold during the past 30 years and the use of mineral fertilizers has increased correspondingly. Multidisciplinary agricultural research has permitted a major agricultural development of the Cerrado region, once considered to be marginal for agriculture. Advanced production techniques are used to produce the major export crops. No-till systems are currently applied on almost 40 percent of the grain crop area. While yield levels of the major export crops are good, the average yields of food crops for domestic consumption are low. Most of the numerous small-scale, often subsistence, farmers use little or no fertilizers. Rural poverty is a major problem in some regions of Brazil and could be alleviated by improved agricultural productivity.

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