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Fertilizer use by crop

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Contents

List of figures

List of tables

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This publication was compiled by Ms. T. van den Bergen and Mr. K. Isherwood performed the analysis.

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Preface

The Food and Agriculture Organization of the United Nations (FAO) has commissioned a number of publications on fertilizer use by crop in different countries. Twenty-one booklets have been issued, each focusing on a different country. The countries represent five regions:

- Africa;
- Asia (South Asia, Southeast Asia and Northeast Asia);
- Central Europe, Eastern Europe and Central Asia;
- Latin America;
- West Asia and North Africa.

The booklets have covered the following aspects:

- land, population and the agriculture sector;
- agro-ecological zones;
- farming systems;
- agricultural production;
- fertilizer supplies, distribution and credit;
- fertilizer consumption;
- economics of fertilizer use;
- organic manures;
- research and information transfer;
- constraints on correct fertilization.

The efficient use of plant nutrients, whether from mineral fertilizers or from other sources, involves the shared responsibility of many segments of society. These include: 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.

List of acronyms

CGIAR	Consultative Group on International Research
DAP	Di-ammonium phosphate
GDP	Gross domestic product
HYV	High-yielding variety
ICARDA	International Center for Agricultural Research in Dry Areas
IFA	International Fertilizer Industry Association
INIFAP	Insituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias
INTA	Insituto Nacional de Tecnología Agropecuaria
K_2O or K	Potash*
MAP	Mono-ammonium phosphate
MDG	Millennium Development Goal
N	Nitrogen
NFDC	National Fertilizer Development Centre
NGO	Non-governmental organization
NPK	Nitrogen, phosphate and potash
P_2O_5 or P	Phosphate*
R&D	Research and development
RPS	Retention Price Scheme
SSA	Sub-Saharan Africa
UAN	Urea ammonium nitrate
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
VCR	Value–cost ratio
WANA	West Asia and North Africa
WTO	World Trade Organization

Abstract

This publication is based on 21 country reports on fertilizer use by crop issued by FAO between 2002 and 2006. Its objective is to demonstrate the importance of information on fertilizer use by crop, not only on a national level but also by agro-ecological zone, or in even greater detail. It also aims to demonstrate how the correct use of fertilizers could help to achieve the first target of the Millennium Development Goals (MDGs) of the United Nations, i.e. eradicate extreme poverty and hunger. Three out of four people suffering from hunger live in rural areas. Increased agricultural productivity in the afflicted regions would help to alleviate the poverty of these people. Another MDG is to ensure environmental sustainability, by using natural resources wisely and protecting the ecosystems. The correct use of fertilizers could contribute also towards this goal.

The chapters in this publication focus on the following areas:

- **Agro-ecological zones.** Appropriate recommendations for fertilizer use depend on the characteristics of the different agro-ecological zones.
- **Farming systems.** On large, privately owned estates devoted to commercial farming, fertilizer use is often almost optimal in both developed and developing countries. In the smallholder/subsistence sector, productivity and fertilizer use is often low although there are some exceptions.
- **Fertilizer supplies, distribution and credit.** Globally, fertilizer supplies are more than sufficient and are likely to remain so. However, in several of the countries surveyed, fertilizers are sometimes not available at the time and in the quantities and forms required by farmers. Inexpensive credit is needed by farmers (to carry them over until harvest) and by distributors (who have to carry stocks of the high-volume, low profit margin, seasonal-demand product that is fertilizer).
- **Fertilizer consumption.** This chapter provides information on national fertilizer consumption trends and the reasons for changes in them. The use of fertilizers may be beneficial or detrimental to the environment depending on how they are used.
- **Fertilizer use by crop.** This chapter provides an analysis of available statistics on fertilizer use by crop in the countries and regions covered by the reports as well as at a global level.
- **The economics of fertilizer use.** Where the use of fertilizers is not profitable, farmers, whatever their scale, will not use them. In several of the countries covered, the relationship between the produce price and the input price is unfavourable for the smallholder sector. Internationally traded agricultural commodities are less sensitive to fertilizer price changes.
- **Organic manures.** Adequate quantities of manure of good quality are often not available where they are required. The rural poor in developing countries

often use the manure for other purposes, such as fuel, leaving little for application in agriculture.

- **Research.** In several of the countries surveyed, government funding of agricultural research and advisory services dropped considerably in the late 1980s and 1990s. Private research has continued where justified by the economics of the important internationally traded agricultural products. Research into crop production systems in the subsistence/small-scale farming sector in developing countries has often been a low priority.
- **Constraints.** The reports have identified a number of constraints on adequate, efficient and sustainable fertilizer use. Subsistence, smallholder farmers tend to face them all.

Chapter 1
The issues

Outlined below are some of the topical issues concerning agricultural production and involving fertilizer use.

POVERTY AND UNDERNUTRITION

Eradication of extreme poverty and hunger is the first target of the Millennium Development Goals (MDGs) of the United Nations. A guideline poverty threshold of US$1/day has been established. According to the 2005 Millennium Report, 1 000 million people have an income below this threshold. More than 800 million people suffer from hunger and malnutrition. The number of people without sufficient food increased between 1990 and 2002 by 34 million in sub-Saharan Africa (SSA) and by 23 million in South and West Asia. In SSA, the average income of the extremely poor has declined. Three out of four people suffering from hunger live in rural areas and depend on natural resources such as land and water for their survival. Increased agricultural productivity in the regions concerned would help to alleviate their poverty. Even where not engaged in their own agricultural activities, the people in these regions rely on non-farm employment and income that depend directly or indirectly on agriculture. Overall growth in a national economy may not necessarily improve the welfare of the rural poor. Indeed, it may increase the disparities between the urban and rural populations.

ENVIRONMENTAL SUSTAINABILITY

Another MDG is to ensure environmental sustainability, using natural resources wisely and protecting the ecosystems. Land is becoming degraded at an alarming rate. Plant and animal species are disappearing in record numbers. This affects the rural poor most immediately as their day-to-day subsistence often depends on the natural resources around them. In the past decade, almost 1 000 million km^2 of forests have been converted into farmland, logged or lost to other uses (United Nations, 2005). The use of fertilizers may be beneficial or detrimental to the environment depending on how they are used.

AVAILABILITY OF ARABLE LAND

At a global level, there is a large reserve of unused potential farmland. However, only a fraction of this land is realistically available for agricultural expansion as much is needed for other purposes, such as forest cover and to support infrastructure development. Moreover, much of this land is fragile, requiring skilful management if it is not to become degraded. More than half the land that

could be opened up is located in seven countries of tropical Latin America and SSA. Other regions and countries face a shortage of suitable land, and increased food production must come from a nearly static land base. In the region of West Asia and North Africa (WANA), at least 87 percent of suitable land is already farmed; in South Asia, the corresponding figure is 94 percent. In many areas, land degradation threatens the productivity of existing farmland and pasture.

CROP YIELDS AND INTENSIFICATION

Comparing the means between 1962 and 1964 with those between 2000 and 2002, the world area of arable land and permanent crops increased by 13 percent while the world population increased by 89 percent. Thus, the area per capita fell from 0.42 to 0.25 ha. Nevertheless, the availability of food remained adequate globally. A steady fall in cereal prices indicates that supply was more than sufficient to meet the demand. This was because yields per hectare of cropped area increased in the same period. World average grain yields have almost doubled since the early 1960s. Overall, it is estimated that some 70–80 percent of future increases in crop production in developing countries will have to come from intensification, i.e. higher yields.

AGRICULTURAL PRODUCTION

The world population is currently forecast to continue to increase, albeit more slowly than in recent decades. In addition, rising living standards are reflected in an increasing demand for food items such as meat, whose efficiency as a provider of calories is much less than that of directly consumed cereals. Global crop and livestock production continue to increase but agricultural performance in WANA continues to be characterized by very pronounced fluctuations caused by variable climate conditions in many countries of the region. SSA has recorded growth in agricultural output in recent years, but the growth has been variable and recent growth rates are below the average of the 1990s.

FERTILIZERS

In this publication, the term fertilizers relates to inorganic manufactured products that supply plant nutrients. Before the introduction of mineral fertilizers in the nineteenth century, soil fertility was maintained mostly by the recycling of organic materials and crop rotations that included nitrogen-fixing leguminous crops. However, under this system, periodic famines were endemic. At the beginning of the twentieth century, there was particular concern about the availability of adequate quantities of nitrogen (N) fertilizers, then largely dependent on natural Chilean nitrate. The industrial fixation of atmospheric N resolved this issue. Since the beginning of the 1960s, the large increase in the demand for food, caused by the substantial increase in the world's population and improved diets, has been met largely by improved agricultural productivity, in which the use of fertilizers played an important role. World fertilizer use has increased almost fivefold since 1960. Smil (2002) estimates that fertilizer N has contributed an estimated

40 percent to the increases in per-capita food production in the past 50 years, although there are local and regional differences and varying efficiencies.

THE ECONOMICS OF FERTILIZER USE

The economic return, as indicated by the value–cost ratio (VCR) or the net return from fertilizer, is a determining factor as regards fertilizer use. There are regions where the expected responses may be below the cost of the input, e.g. in the case of dryland crops in semi-arid regions. In the case of advanced agricultural systems, fertilizer use today often approximates to the optimum. In the case of poor small-scale farmers, the cost of fertilizers can represent a high proportion of the total variable cost of production, an investment that they can particularly ill afford where there is a risk of crop failure. It is in this sector that fertilizers can today contribute most to achieving the first target of the MDGs. However, the greater is the risk, the higher the VCR should be.

ORGANIC MATERIALS

Organic manures supply plant nutrients and contribute towards soil fertility. However, the quantities of plant nutrients available in manures are insufficient to meet crop requirements. It is estimated that animal manures provide about 11 percent of the total N required for global food production (Smil, 1999). In many countries, most manure is produced some distance from where it is required for application in agriculture, and the transport of manure is difficult and expensive. In many developing countries, a substantial proportion of the available manure is used for purposes other than application in agriculture, e.g. as fuel. The nutrient content of manures varies considerably and, if poorly stored, most of the N may be lost, polluting the atmosphere.

FERTILIZER-USE EFFICIENCY

Average fertilizer productivity, as measured by the amount of product obtained per kilogram of fertilizer nutrient, varies considerably, reflecting factors such as differences in agro-ecological resources (soil, terrain and climate) and economic incentives. Fertilizer productivity is related to soil moisture availability and, hence, to irrigation. Where used correctly, the increase in the solar energy captured by the biomass as a result of the application of fertilizers represents several times the quantity of energy used to produce, transport and spread them. In general, in developed countries, there has been a marked improvement in the efficiency of fertilizer use. However, in developing countries, fertilizer use is often inefficient. For example, in the case of rice, the N losses are more than half of the quantity applied. This is not only an environmental hazard but also a substantial economic loss.

RESEARCH, TECHNICAL DEVELOPMENTS AND INFORMATION TRANSFER

Economic programmes have resulted in a substantial reduction in government-funded research on fertilizer use. For net food-importing countries, increased

food security and the alleviation of rural poverty require improvements in the productivity of local food crops. Subsistence farmers require simple and sustainable techniques. Fertilizer-use recommendations need to change with new developments, such as new varieties or better methods for assessing crop requirements. This information needs to reach the farmers and be implemented. Investment in infrastructure, research, training, advisory and extension services would increase agricultural productivity and would not be trade distorting, i.e. they are not restricted by international trade agreements.

Chapter 2

Land, population and the agriculture sector

The demand for fertilizers depends on the demand for agricultural and livestock products, and the demand for agricultural and livestock products depends on the size of the population and the standard of living. The contribution of agriculture to the national gross domestic product (GDP) and to exports tends to be higher in developing countries than in developed countries. Agriculture provides work and a livelihood for the rural population, whose proportion of the total population tends to be higher in developing countries. In many developing countries, poverty occurs largely in the rural sector, many poor people being subsistence farmers. This chapter summarizes the situation in the countries covered in the *Fertilizer use by crop* publications (Annex 1).

LATIN AMERICA

Argentina

The total land area of Argentina is 274 million ha, of which 142 million ha are under permanent pasture, 34 million ha under arable crops and 1 million ha under permanent crops. Its population is 38 million people, with a growth rate of 0.9 percent/year. Agriculture contributes about 11 percent to GDP.

Brazil

Brazil covers an area of 855 million ha, of which 64 percent (550 million ha) is considered potential farmland. Brazil has almost 50 million ha under annual and permanent crops. In 2000, the rural population was 32 million inhabitants, about 19 percent of the country's population. About 21 percent of the total labour force is engaged in agriculture, and each farmer produces enough food for ten non-farming persons.

Cuba

The population of Cuba is about 11 million people, with a growth rate of 0.3 percent/year. The permanent and temporary crops of Cuba cover some 3.7 million ha. The cultivated arable area in Cuba is about 1.4 million ha, with about 1 million ha harvested every year.

Mexico

Mexico is the world's twelfth largest country. Almost one-quarter of the Mexican population of 102 million, with an annual growth rate of 1.4 percent, depend

on the farming sector for their livelihood. There is a great deal of rural poverty, mainly in the south of the country. In Mexico, 10 million people live on less than US$1/day, 20 million people live on less than US$2/day. People living below the accepted poverty level are often subsistence farmers. At least 1.5 million farmers have left their farms to find work either in the industrial belt of Mexico bordering the United States of America or in the United States of America.

WEST ASIA AND NORTH AFRICA

Algeria

The total area of Algeria is 238 million ha, but 191 million ha are unproductive. In 2003, its population was 32 million people, with a growth rate of 1.7 percent/year. The total effective agricultural area is 8.2 million ha. The agricultural area represents 3 percent of the country's total land area.

Egypt

The total land area of Egypt is 100 million ha, of which 3.5 million ha are agricultural land. The population is estimated at 70 million people, inhabiting less than 5 percent of the national territory, compared with 11 million at the beginning of the nineteenth century. The rural population represents about 51 percent of the total. The agriculture sector contributes almost 20 percent of GDP and about 20 percent of total exports and foreign exchange earnings.

Iran (Islamic Republic of)

With an area of more than 160 million ha, the Islamic Republic of Iran is the sixteenth largest country in the world. Its cultivated area is about 15 million ha. According to soil and land surveys, a total of about 17 million ha of land could potentially be cultivated although most have some limitations. In 2002, the population was 68 million people, the rural population being about 23 million. The agriculture sector accounts for about 40 percent of GDP.

Morocco

The total land area of Morocco is 45 million ha. The agricultural area is 8.4 million ha, or 19 percent of the total, of which 1.5 million ha are irrigated. Its population is estimated at 30 million people, with an annual growth rate of 1.4 percent. Fifty percent of the population is rural. The agriculture sector contributes 17 percent of GDP, accounts for 30 percent of exports and provides employment for 50 percent of the population (80 percent of the rural population). The increasing population and the need to improve living standards in rural areas require an improvement in agricultural productivity.

Syrian Arab Republic

The land area of the Syrian Arab Republic is 18.5 million ha, of which 13.7 million ha are used for agricultural purposes. About 60 percent is permanent pasture or steppe. The total population is about 17 million people, with an annual

growth rate of 2.4 percent, and incomes are rising. About half the population of the Syrian Arab Republic depend primarily on agriculture for their livelihood, and agricultural exports are a major source of foreign currency for the country.

AFRICA

Ghana

The total land area of Ghana is 24 million ha. The potential agricultural area is 14 million ha, of which 6 million ha are cultivated at present. Much of the remainder is infertile, and poor agricultural practices have resulted in soil degradation and erosion. Ghana has a population of 20 million people, increasing at a rate of 1.7 percent/year; almost two-thirds live in rural areas. Agriculture accounts for about one-third of GDP although this share is tending to decline. Although agricultural production is sometimes affected by adverse weather, especially drought in the north, the country is relatively well favoured by rainfall in many regions compared with many other countries in SSA.

South Africa

The total land area of South Africa is 127 million ha. However, only 14 million ha receive sufficient rainfall for arable crop production, and periodic droughts affect these rainfed areas. Agriculture, fishing and forestry contribute about 13 percent to GDP. In 2000, the population was about 45 million. The current annual population growth rate is estimated at 1 percent or less, compared with 2.1 percent in 1991. Eighteen million people (40 percent of the population) live in poverty, most of them living in rural areas. While the country is self-sufficient in food production, 43 percent of households are vulnerable to food insecurity. The number of subsistence farmers in South Africa ranges between 1.3 and 3 million.

Sudan

The Sudan is the largest African country in terms of area. It has almost 17 million ha of cultivated land, and the area that could be cultivated is much larger. This is the largest area of cultivable land in the Arab world. Despite increasing oil exports, the agriculture and livestock sectors continue to make a major contribution to national GDP and they provide a livelihood for some three-quarters of the population.

Zimbabwe

Zimbabwe's total land area is about 39 million ha. The population is 13 million people. Agriculture makes a significant contribution to Zimbabwe's GDP and exports.

SOUTH ASIA

India

India has a total land area of 328 million ha. The cultivated area is about 141 million ha. This has remained constant for the past 30 years. However, the cropping intensity has increased from 118 to 135 percent in the same period.

The population of India exceeds 1 000 million people and is forecast to reach 1 400 million people by 2025. Agriculture accounts for about 22 percent of GDP. Almost three-quarters of the population live in rural areas. Almost one-third of the population live below the national poverty line despite considerable progress.

Pakistan

Pakistan has a total land area of 80 million ha. The total cropped area is 22 million ha. Pakistan has a population of more than 150 million people, growing at an annual rate of 2 percent, with almost one-third living below the poverty level. Agriculture accounts for 24 percent of GDP, employs 48 percent of the labour force and accounts for about 60 percent of export earnings. About 32 percent of the population live below the poverty level.

SOUTHEAST ASIA

Indonesia

The Indonesian archipelago consists of 17 435 islands with a total land area of 192 million ha. The agriculture sector accounts for 18 percent of GDP, provides the staple foods, and employs 70 percent of the population of 215 million people (or 44 percent of the work force). About 127 million people (59 percent of the total population) reside in the more fertile areas of the densely populated inner islands, which together account for only 8 percent of Indonesia's land area. The remaining 88 million inhabitants occupy the less fertile soils in the more sparsely populated outer islands. Almost one-fifth of the population live below the poverty level.

Malaysia

Malaysia has a total land area of 34 million ha, consisting of two geographical regions (West or Peninsular Malaysia, and East Malaysia) separated by the South China Sea. Agriculture has played a key role in the development of modern Malaysia, resulting in the country becoming the world's leading palm oil producer and the third largest producer of natural rubber. In 2003, the agriculture sector grew by 5.5 percent, ranking third in importance behind the manufacturing and the service sectors. In 2004, the Government of Malaysia declared the agriculture sector to be the third engine of national growth.

NORTHEAST ASIA

Democratic Peoples Republic of Korea

The total land area of the Democratic People's Republic of Korea is 12 million ha. The agricultural area amounts to 1.9 million ha, of which 0.6 million ha are under rice, 0.5 million ha under maize, 0.2 million ha under potato and 0.1 million ha under wheat and barley. There is little spare arable land, and increased production must come from higher yields, which depend among other factors on a satisfactory supply of inputs such as fertilizers.

Taiwan Province of China

The land area of Taiwan Province of China is 3.6 million ha, but only 0.8 million ha are cultivated. The country's population is about 30 million.

POLAND, UKRAINE AND UZBEKISTAN

Poland

The agricultural area of Poland is 18.4 million ha, of which 14.1 million ha are arable and 4.1 million ha are grassland. The population is 39 million people.

Ukraine

Natural conditions in Ukraine are fundamentally favourable to agriculture. More than half the land area of Ukraine, which is one of the largest countries in Europe, has fertile black earth soils. The population is 49 million people. In the early twentieth century, Ukraine was a major supplier of wheat to the world market, with a production comparable with that of the United States of America.

Uzbekistan

The total land area of Uzbekistan is 44.9 million ha, of which 4.3 million ha are irrigated, 3.3 million ha being irrigated arable land and 1 million ha irrigated pasture. The rainfed arable area is 0.8 million ha. The total area of permanent pasture is 23.5 million ha. The population of the country is about 26 million people. Agriculture accounts for 26 percent of GDP.

Chapter 3

Agro-ecological zones, irrigation and cropped areas

Many factors influence crop response to the application of fertilizers. The response varies between different seasons or climate areas and is influenced by irrigation and by soil characteristics. The factors involved include:

- yield increase at different levels of the basic yield without fertilization;
- fertilizer-use management;
- changes in fertilizer response with time;
- the influence of price variations on the economics of fertilizer use;
- soil acidity;
- deficiency of other plant nutrients;
- cultivation techniques;
- sowing dates;
- different varieties;
- crop rotations.

The following example (Table 1) demonstrates the differences in the response by maize to fertilizers at different locations, taken from results of a large number of trials in six regions of the Democratic Republic of the Congo. The trials were carried out in the framework of the FAO Fertilizer Programme.

Based on 1986 prices, fertilizer use on maize was very profitable in Kasai Oriental and Kasai Occidental, marginal in Bandundu and Shaba and unprofitable in Bas-Zaire. The differences related to the different growing conditions, particularly with regard to climate and soils.

Therefore, information on fertilizer use by crop on a national basis is necessary. However, it is not sufficient for informed policy decisions on a national basis. Such information is required for the different agro-ecological zones at least.

TABLE 1
Results of maize trials in the Democratic Republic of the Congo, 1978–1984

Region	Number of sites	Yield without fertilization	Yield with fertilization	Productivity index*
		(kg/ha)		
Bandundu	142	1 040	2 210	11.6
Bas-Zaire	36	840	1 170	4.2
Haut-Zaire	175	1 590	2 300	7.1
Kasai Occidental	144	1 150	2 510	13.6
Kasai Oriental	484	1 380	3040	16.6
Shaba	204	1 510	2 640	11.3

* The productivity index is the additional yield (in kilograms per hectare) per kilogram of plant nutrients applied.
Source: FAO, 1989.

Descriptions of the different agro-ecological zones (determined by the climate, topography and soils) and the main soil types are available in the *Fertilizer use by crop* publication for the various countries. This information is summarized below.

LATIN AMERICA

Argentina

Argentina can be divided into three large agricultural regions:

- The humid region, covering about 68 million ha (25 percent).
- The semi-arid region (15 percent). Irrigation is often necessary in this region.
- The arid region (60 percent). Practically all the region of Patagonia to the south of Rio Colorado is in the arid region, with little agricultural activity.

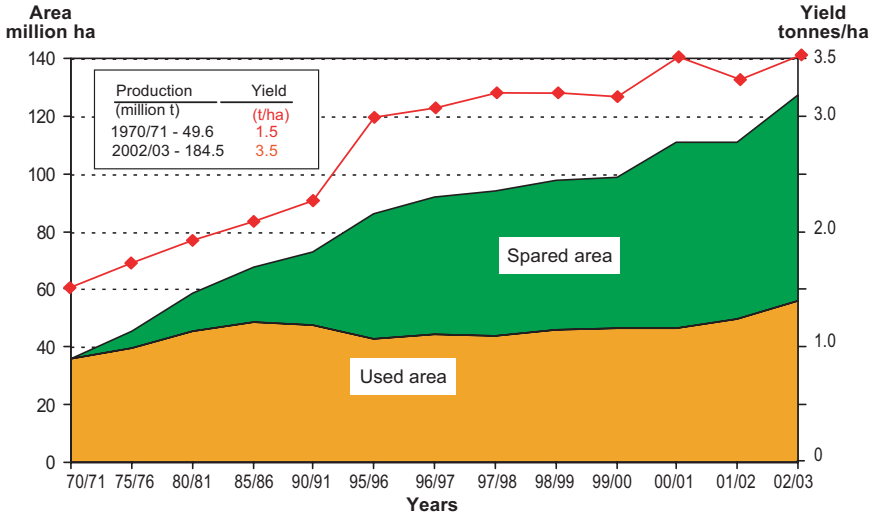
About 5 percent of the arable area is irrigated. In three important provinces of the northern regions, barely 25–30 percent of the best land is cultivated. The land in these areas is relatively fertile and is not much fertilized. However, once cultivated, the nutrient reserves of their soils decline rapidly and fertilization is required.

Brazil

Brazil is characterized by a large diversity of soil types, resulting from the interaction of the relief, climate, parent material, vegetation and associated organisms.

- North. This region 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, often saturated with exchangeable aluminium (which is toxic for most plant species).
- Northeast. The climate varies from hot and humid to hot and dry (semi-arid), with a transitional semi-humid area. A moisture deficit, sometimes associated with salinity and/or high levels of sodium, is the main factor limiting agricultural production in this region.
- Central Plateau, Centre West Region. This is a plain formed by natural erosive processes. The predominance of a hot tropical climate with accentuated dry spells during the rainy season is characteristic of this region. Most soils in this region have physical characteristics and topographical conditions that permit intensive agricultural mechanization.
- Southeast. This region comprises plateaus and highland areas, with several peaks higher than 2 000 m. It has a tropical climate with hot summers in the lowlands, and mild weather in the mountain areas. Most soils are naturally fertile.
- South. 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.

FIGURE 1
Crop production, yields and land spared from deforestation, Brazil, 1970–2002



The increased use of mineral fertilizers has played an important role in the development of agricultural productivity and environmental preservation in the past 30 years in Brazil (Figure 1). An additional cropped area equivalent to 77 million ha of cleared forest would have been necessary if the current total production were to be obtained with the yield average of 1970.

Cuba

The agro-ecological zones of Cuba are follows:

- Mountain.
- Highland zone. Rainfall increases from east to west. Temperature variations are less marked than elsewhere owing to its position, mostly in the centre of the island.
- North coastal zone. This zone is characterized by relatively low rainfall levels in the coastal area of Moron-Gibara, but with a generally good distribution during the year, especially in the more western regions.
- South coastal plain zone. The rainfall is relatively low, especially in the eastern region (where it is about 600 mm/year).
- Marshy and calcified plain zone.
- Denuded interior plain zone. These areas are characterized by relatively high rainfall, increasing to the east of the country, generally with a good distribution during the year. There is an extensive sugar-cane area in this region, and the flat topography favours mechanization.

Mexico

The largest geographical formation is the high plateau or the Mexican Plateau. This plateau, at an altitude of more than 500 m, is bordered in the east by the Sierra Madre Oriental and by the volcanic axis, to the south of Mexico City. To the east and west of the Sierras are the coastal plains of the Gulf of Mexico and of the Pacific Ocean. In the northeast, there is the extremely arid peninsula of Baja California. In the southeast, there are the Chiapas highlands, which are an extension of the Central American cordilleras. More than half the territory of Mexico is arid or semi-arid, and rainfall is the main factor limiting agricultural production. Irrigated crops account for 26 percent of the sown area, but 54 percent of the value of sales.

WEST ASIA AND NORTH AFRICA

FAO has identified the WANA region as one with a probability of increasing food supply problems. The region contains large areas of semi-arid rainfed land that are marginal for crop production. The cropping in the area is highly dependent on the amount and reliability of the rainfall (Figure 2).

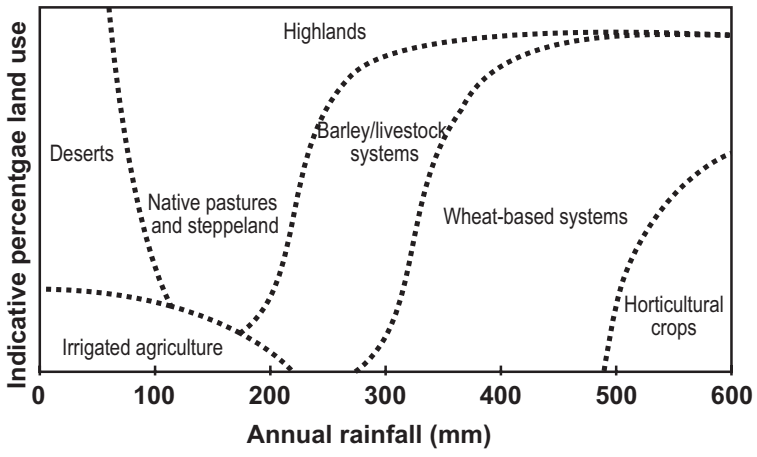
Algeria

The three main agro-ecological zones are:

- Rainfed northern zone. Various crops are produced in this zone and there is semi-intensive livestock production (especially of milk and meat).
- Intermediate zone, with extensive grazing.
- Sahara.

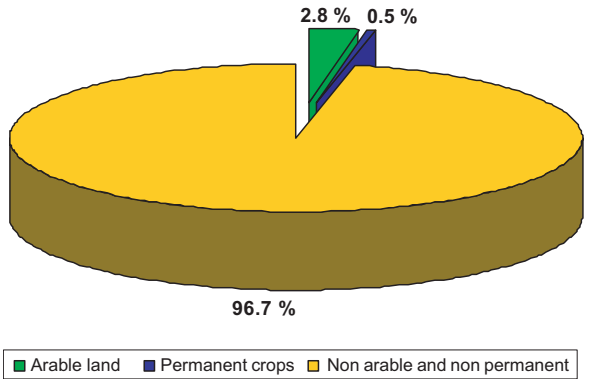
Rainfall diminishes from north to south.

FIGURE 2
Land use according to rainfall in the WANA region



The agricultural area occupies 3 percent of the country's total land area. Arable crops occupy 47 percent of this agricultural area, fallow 45 percent, fruit crops 7 percent, and vineyards 1 percent.

FIGURE 3
Land use in Egypt



Source: Ministry of Agriculture and Land Reclamation (MALR), 2002.

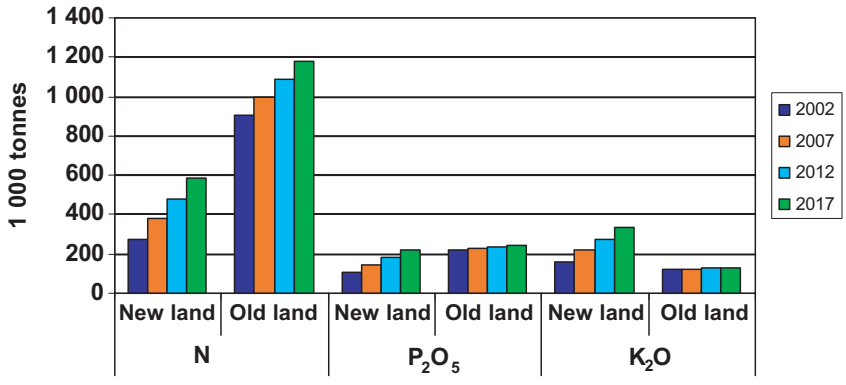
Egypt

There are four zones (Figure 3). "Old land", amounting to 2.25 million ha, is located in the Nile Valley and Delta, irrigated by water from the Nile River. "New land", reclaimed since the 1950s and irrigated from the Nile River and underground water, amounts to about 1 million ha. Together, the rainfed areas and oases amount to about 200 000 ha.

Two-thirds of the agricultural land has alluvial soil, fertilized for thousand of years by the Nile River floods.

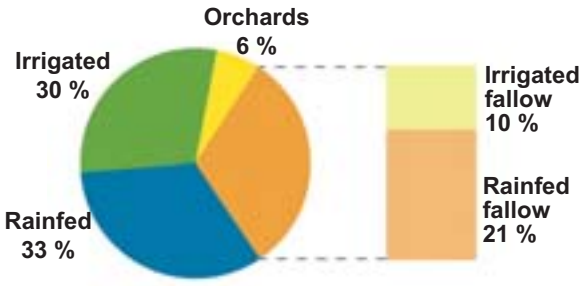
There is no effective rainfall in Egypt except on the narrow band along the north coast. Therefore, Egyptian agriculture relies almost completely on irrigation. The irrigation water is not used efficiently. One million ha in the irrigated areas, mostly in the Nile Delta, suffer from salinization problems, waterlogging and salt toxicity. There is an increased focus on restoring salt-affected soils. Sprinkler irrigation and drip irrigation are common in the recovered areas. Fertigation is practised on 13 percent of agricultural land (Figure 4).

FIGURE 4
Estimated fertilizer requirements on "new" and "old" land, Egypt



Source: MALR, 2003.

FIGURE 5
Distribution of major categories of agricultural land use in the Islamic Republic of Iran



Iran (Islamic Republic of)

The country consists of ten agro-ecological zones. A wide variety of field, fruit and vegetable crops is produced but by far the most important irrigated crop is wheat (Figure 5).

The main constraint on agricultural expansion is water availability not land availability. Low rainfall, high air temperatures and high evaporation rates result in a high water requirement for agriculture. Salinity and drought are among the most important environmental stresses that limit crop production in the Islamic Republic of Iran. At least 40 percent of the wheat is rainfed, with an average yield of only 0.8 tonnes/ha. Even under irrigation, the average wheat yield rarely exceeds 3 tonnes/ha, which is low by world standards. The country cannot always rely on favourable rainfall, and an intensification of production to provide higher yields under less favourable climate conditions is necessary if the target of self-sufficiency is to be maintained.

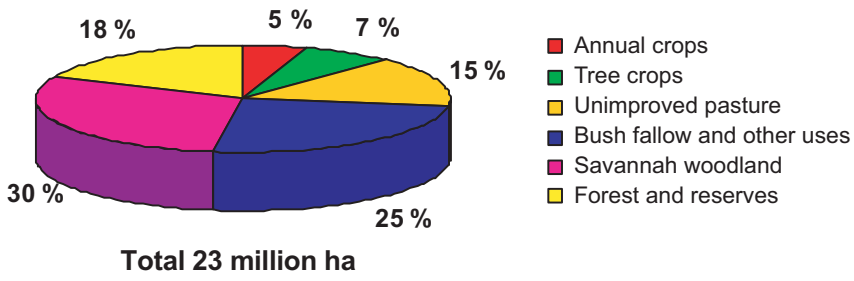
Morocco

The agro-ecological zones are defined in terms of climate, topography, natural resources and production systems. The areas most favourable to agriculture are located in the northwest of the country, with annual rainfall exceeding 400 mm. The effective agricultural area of Morocco (8.4 million ha) accounts for 13 percent of the agricultural land area of the country. Cereals account for 60 percent of the cropping in this area, vegetable crops 10 percent, tree crops 12 percent, and fallow 15 percent. The remainder consists of rough grazing (30 percent), alfalfa (5 percent), forest (8 percent) and uncultivable land (44 percent). Rainfall in Morocco is variable, both within and between years. The irrigated area is 1.5 million ha. The future of agricultural production depends largely on irrigation.

Syrian Arab Republic

The agricultural area is 4.9 million ha, of which 1.4 million ha are irrigated. For the purpose of medium- and long-term agriculture sector planning, the country has been divided into five agro-ecological zones, defined largely in terms of their suitability for rainfed crop production, and to some extent by the probability of rainfall. The steppe land is used mainly for communal grazing.

FIGURE 6
Land use in Ghana



Source: FAOSTAT.

AFRICA

Ghana

The country has been divided into five agro-ecological zones. Annual rainfall ranges from an average of 800 mm in the Coastal Savannah zone to 2 200 mm in the Rain Forest zone. The coarse nature of the soils has an impact on their physical properties, and water stress is common during the growing season. Traditional, soil-exhausting cultivation practices are still in extensive use (Figure 6).

South Africa

Ten percent of the arable area, or 1.35 million ha, is irrigated, but the irrigated area accounts for a substantial proportion of the value of the country's total agricultural output, in particular from the horticultural, fruit and wine sectors.

Sudan

The climate is generally hot, tropical in the south and arid in the north. Rainfed agriculture depends largely on the arrival in the main agricultural belt of rain-bearing southwesterly winds. The frequency of low-rainfall years is tending to increase, and creeping desertification is a problem in the north. When the rains fail, as happened especially in the 1970s and 1980s, drought and famine follow. Rainfall is low and/or uncertain but the Blue Nile River and the White Nile River have enabled the development of large irrigation schemes. The productivity of these schemes has declined in recent years. Almost 1.9 million ha, or about 11 percent of the cultivated area, are equipped for irrigation, 96 percent of which is fed from surface waters. Large-scale Nile-based irrigation schemes have dominated the Sudan's agricultural development, the largest and best known being the Gezira scheme, covering some 870 000 ha. A large proportion of Sudan's population depends on rainfed agriculture.

Zimbabwe

The country has been divided into five agro-ecological zones. Rainfall is the major determinant of agricultural production patterns. Most soils in Zimbabwe are of inherently low fertility and their quality declines rapidly where they are not fertilized regularly with organic and inorganic fertilizers. The soils of the smallholder subsector are particularly vulnerable.

SOUTH ASIA

India

The country has been divided into 20 agro-ecological zones, and the soils classified into eight major groups. The organic carbon content of most Indian soils is very low and N deficiency is universal. Drought occurs regularly every year in some part of India, and irrigation is an essential and long-established practice. Today, 56 percent of total agricultural production comes from irrigated agriculture. The area of land receiving irrigation from different sources amounts to almost 55 million ha. Water conservation requires a reduction in the water losses from the irrigation systems.

Pakistan

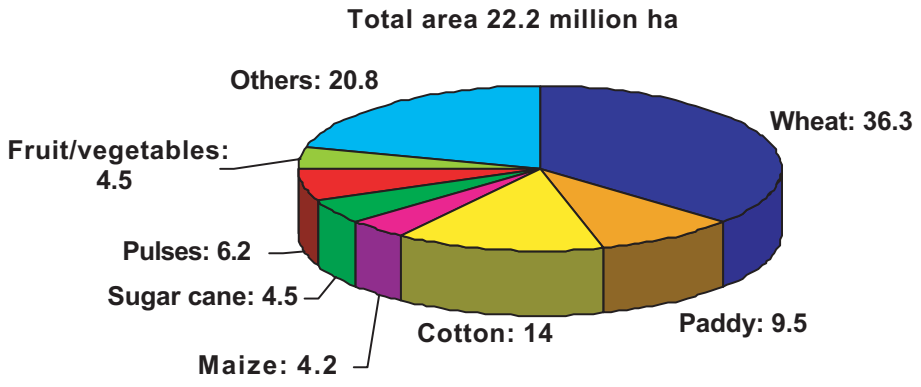
About 18 million ha (80 percent) of the cropped area are irrigated (Figure 7). According to the 1985–1990 soil survey, there are 1.8 million ha of saline soils. Waterlogging is an important issue.

SOUTHEAST ASIA

Indonesia

The lowland farming system, with rice as the single crop, provides the staple food for the population. About 70 percent of the lowland rice area in Indonesia produces

FIGURE 7
Percentage of cropped areas under different crops, Pakistan



two crops per year. Upland areas are abundant in the country, and they have potential for agricultural development. To date, this land has been underutilized and, in the absence of appropriate fertilizer applications, its productivity is low.

Malaysia

Malaysia characteristically experiences heavy rainfall (2 540 mm/year and more), average daily temperatures of 21–32 °C, and a humidity averaging about 85 percent. The seasonal variation in solar radiation is low. In consequence, there is a year-round day length of 12.5 hours. The climate and agro-ecological environments of the agro-ecological zones are somewhat different despite their belonging to the same warm humid tropics classification.

NORTHEAST ASIA

Democratic People's Republic of Korea

In recent years, the weather has had a major negative impact on crop production. The effects of weather are more pronounced in the uplands, which generally do not have irrigation.

Taiwan Province of China

Taiwan Province of China is divided into five zones:

- Southeast Zone: The climate is hot, with heavy summer rains and a five- to six-month dry season in winter.
- South Zone: The climate is humid in summer and dry in winter. This is not an important agricultural area.
- East Coast Zone.
- East Mountainous Zone: Located at about 500 m above sea level, this area enjoys an even distribution of rainfall (with a higher precipitation in September–October). There are two crops per year of rice.
- Central Mountainous Zone. Summer precipitation is high, particularly in June.

POLAND, UKRAINE AND UZBEKISTAN

Ukraine

Figure 8 shows the relative importance of the main crops grown in Ukraine.

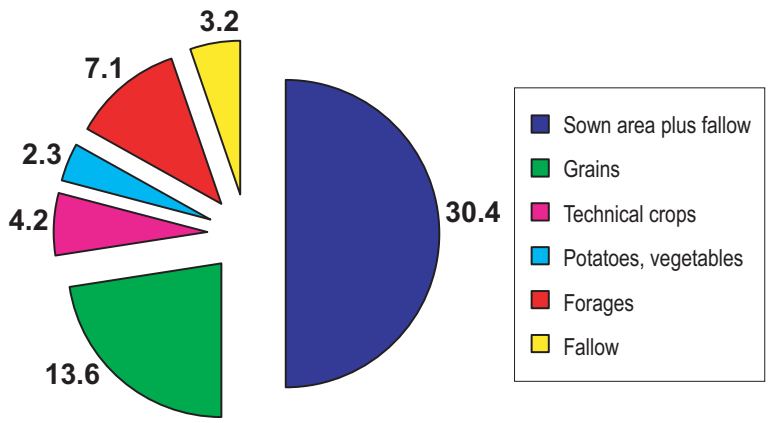
The climate is generally favourable for agriculture, but periodic drought and winter kill of crops occur.

Uzbekistan

The country is divided into three climate zones:

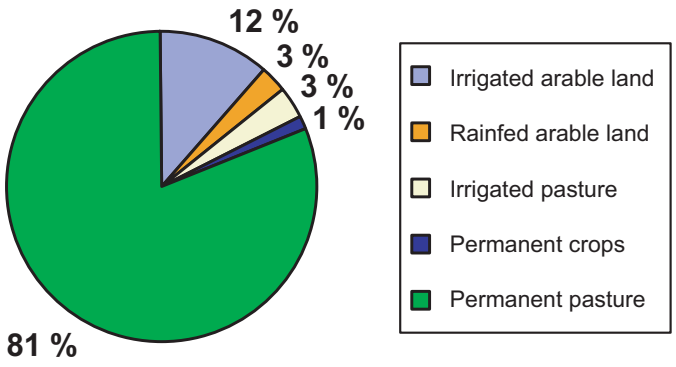
- Northern. In this zone, crops such as cotton, rice, melon, vegetables and various fruit-tree crops are grown (Figure 9).
- Central. In this zone, crops such as cotton, cereals, tobacco, potatoes, tomatoes and other vegetable and fruit crops are produced.
- Southern. In this zone, subtropical crops can be grown.

FIGURE 8
Land use in Ukraine



Data source: SCS.

FIGURE 9
Agricultural area, Uzbekistan



The monoculture of cotton during the Soviet period led to serious problems of land degradation in Uzbekistan and to the environmental catastrophe of the Aral Sea.

IRRIGATION

Table 2 illustrates the potential benefits of irrigation.

Irrigated crops require higher levels of fertilization for optimal productivity, and there is often synergy between the irrigation and the fertilizers. In the context of the FAO Fertilizer Programme, the response of wheat to fertilizers

was compared under rainfed and irrigated conditions in Morocco. The crops were grown in the same areas, where the average annual precipitation was 400–600 mm. Table 3 shows the results.

Irrigation even without fertilization increased the yield by 35 percent in the case of hard wheat and by 18 percent in the case of soft wheat. The application of fertilizers resulted in yield increases of 503 kg/ha and 585 kg/ha, respectively under rainfed conditions, but an additional 357 kg/ha (+71 percent) and 395 kg/ha (+68 percent) when the crop was irrigated.

Irrigation accounts for a large proportion of global water consumption, and the water losses caused by inefficient irrigation practices and poorly maintained systems are matters of concern. As a result of poor management, large areas of irrigated land have become unproductive through waterlogging and salt toxicity.

TABLE 2
Irrigated and rainfed average yields, Mexico

Crop	Yield		Crop	Yield	
	Irrigated	Rainfed		Irrigated	Rainfed
	(tonnes/ha)			(tonnes/ha)	
Alfalfa, green	131	70	Cotton	4.3	2.9
Avocado	25.7	17.8	Maize, forage	99.4	51.6
Barley, grain	7.3	3.9	Maize, grain	7.7	4.0
Beans, dry	2.0	1.8	Mango	26.9	21.5
Citrus, lemon	36.8	18.7	Meadows	75.7	62.2
Citrus, orange	29.8	19.5	Oats, forage	40.8	30
Cocoa	0.8	0.7	Sorghum	11.1	5.5
Coconut,	2.5	1.8	Sugar cane	118.6	92.8
Coffee	6.2	5.8	Wheat, grain	7.1	3.4

Source: A. Galvis, personal communication, 2000.

TABLE 3
Effect of irrigation on the response of wheat to fertilizer, Morocco

Crop	No. of sites	Treatment	Fertilization			Unfertilized yield	Response
			N	P_2O_5	K_2O		
			(kg/ha)				
Hard wheat	246	Rainfed	40	60	0	925	503
	491	Irrigated	35	60	40	1 250	860
Soft wheat	40	Rainfed	40	60	40	912	585
	134	Irrigated	57	60	43	1 080	980

Source: FAO, 1989.

Chapter 4
Farming systems

The system of farming has a marked impact on fertilizer use. On large privately owned estates and farms devoted to commercial farming or in the plantation sector, fertilizer use is often near to or at the economic optimum in both developed and developing countries. However, in most developing countries, the smallholder/subsistence farming sector often consumes little or no fertilizer. Much of the world's poverty is in this subsistence farming sector.

LATIN AMERICA

Argentina

There has been a substantial reduction in the number of producers and increases in average farm size in the Pampas region. For example, in the province of Buenos Aires, the number of farms declined from 196 000 to 136 000 between 1988 and 2002 and the average farm size increased from 391 ha to 531 ha. There is a growing trend towards the purchase of land for renting. In the regions, there are two distinct systems: a commercial system, and a subsistence system.

Brazil

In Brazil, large estates coexist with a large number of small farms. 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. In 1995, out of 4.8 million agricultural establishments, almost 90 percent had an area of less than 100 ha. According to a 1985 census, these farms occupied 21 percent of the total area dedicated to agricultural activities. However, these farms are responsible for more than three-quarters of the national production of beans and cassava, more than half of that of potatoes, maize, wheat, coffee and cocoa, and more than one-third of that of rice and soybeans. Larger farms of 100 ha or more are concentrated mainly in the Centre West region, where soybeans predominate as the main crop. In the Northeast region, more than two-thirds of farms are smaller than 10 ha and are mainly involved in subsistence farming. Owner-occupancy of farms predominates, accounting for 74 percent of the total number of farms; tenants account for 6 percent, partnerships for 6 percent, and 14 percent is "occupied".

Mexico

Mexican agriculture is characterized by a large number of small-scale farmers, many living below the poverty level, and a modern larger-scale farming sector, often with irrigated land. The Mexican revolution of 1910 and the subsequent

agrarian reform changed the agricultural structure of Mexico fundamentally. More than half of the land is communal, the holdings having an average area of about 5 ha. These farmers are gradually obtaining title to their land, but the situation has become very complex after so many decades. More than half of them are subsistence farmers.

WEST ASIA AND NORTH AFRICA

Algeria

In 1990, land nationalized during the agrarian revolution was returned to the owners, and there are now more than 1 million farms. Today, 70 percent of the farms in Algeria are smaller than 10 ha. These farms account for only about one-quarter of the effective agricultural area. Average-sized farms, with an area of 10–50 ha, occupy 53 percent of the total area. Farms of more than 50 ha account for 23 percent of the total area.

Egypt

The average farm size is about 0.6 ha; 90 percent of farms are smaller than 2 ha. The legal maximum holdings are 21 ha for an individual and 42 ha for a family. There are many landless people in rural areas.

Morocco

There are about 1.5 million farms in Morocco. Farms smaller than 5 ha account for 70 percent of the total but occupy only 24 percent of the arable land. The 5–30-ha group accounts for 27 percent of the number of farms and 47 percent of the effective agricultural area.

AFRICA

South Africa

The commercial farming sector produces more than 95 percent of the total marketed agricultural output, the smallholder sector 5 percent. Estimates of the number of subsistence farmers in South Africa range between 1.3 and 3 million, located mainly in the communal areas of former homelands. It is estimated that 240 000 formerly subsistence farmers have progressed to a higher level of production and provide a livelihood for more than 1 million of their family members.

Zimbabwe

Until 2000, there were two dominant farming subsectors in Zimbabwe: the large-scale commercial subsector, comprising 4 500 farmers with freehold title to 12 million ha; and the smallholder subsector, with 850 000 farmers occupying 16 million ha of communal land. Most of the large-scale farms were located in areas of better agricultural and economic potential, often on the more fertile land, whereas most of communal lands were in marginal agro-ecological regions. In

2000, the Government embarked on an agrarian reform programme that involved the redistribution of land. Almost 12.5 million ha (6 796 farms) were acquired by the State and transferred into two new categories of farming subsectors. By 2003, more than 3 000 farming units covering about 3 million ha had been established in these two new subsectors.

SOUTH ASIA

India

There are about 116 million farmholdings with an average size of 1.4 ha. In 1970, the average size was about 2.3 ha. About 62 percent of farmholdings are smaller than 1 ha and these represent 17 percent of the agricultural land. These farms are not only small but also fragmented. Farms with more than 10 ha constitute only 1.2 percent of the total number of farms but cover 15 percent of the cultivated area.

Pakistan

There are more than 5 million farms in the country, 81 percent of which are smaller than 5 ha. Only 7 percent of the farms are larger than 20 ha, but they account for 40 percent of the farmed area.

SOUTHEAST ASIA

Indonesia

Indonesian agriculture is characterized by a large number of small-scale farmers, often producing rice on farms of 0.5 ha or smaller, and a substantial plantation sector. Rubber and oil-palm, the two major perennial crops, are produced both on large estates and by smallholder farmers. The large plantations are both government and privately owned. Some farmers still practise a traditional shifting cultivation, the slash and burn system, particularly in the remote areas on islands outside Java.

NORTHEAST ASIA

Taiwan Province of China

In Taiwan Province of China, almost 800 000 families are engaged in small-scale farming operations. Ninety-seven percent of the farms are smaller than 5 ha. Most rice farmers are not full-time farmers.

POLAND, UKRAINE AND UZBEKISTAN

Poland

In Poland, there are more than 3 million agricultural holdings. During the centrally planned period, small farms remained in private hands, with an average size, excluding plots below 1 ha, of 7 ha. Today, there are about 2 000 farms in the public sector, with an average size of 600 ha. The economic viability of the small farms poses a problem.

Ukraine

There are almost 17 000 large "agricultural enterprises" in Ukraine, successors to the large state-owned and cooperative farms, and a large and increasing number of privately owned small and medium-sized farms. A progressive restructuring of the sector is taking place.

Uzbekistan

Since independence, a new agriculture structure has been put into place, with farmers leasing land from the State. These family farms account for more than 60 percent of agricultural production. Thus, farming, but not land ownership, has been privatized.

Chapter 5
Agricultural production

LATIN AMERICA

Argentina

Argentina has historically been a cattle-raising country. In 1960, it accounted for one-third of the world's exports of meat and veal. Today, almost all the meat produced is consumed domestically but Argentina has become the world's third largest exporter of soybeans, the third largest exporter of maize and the fourth largest exporter of wheat. Soybean exports have increased almost threefold since 1990.

In Argentina, three levels of technology adoption have been defined according to the type of technology used by a given farm sector. The variables include:

- yields;
- areas of production;
- number of producers;
- economic indicators;
- farm size;
- constraints on adopting technology (ranging from none to serious).

The difference between the extremes is about 50 percent for each group of crops. In the case of grains, high and medium technology producers account for 82 percent of the area and 86 percent of the production, while in the case of fruit crops the 7 percent of producers with a high level of technology accounted for 42 percent of the production. In the case of industrial crops, 14 percent of producers with a high level of technology produced 50 percent of the output.

Brazil

Agricultural production has increased more than threefold in the past 30 years, and the use of mineral fertilizers has shown a corresponding increase. 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. While yield levels of the major export crops are satisfactory, the average yields of food crops for domestic consumption are low. Most of the numerous small-scale, often subsistence, farmers use little or no fertilizer.

Cuba

Sugar cane dominates agriculture in Cuba, accounting for about half of the cultivated area. Limitations imposed by the economic crisis faced by the country for more than a decade have had a negative impact on yields. Among the causes of the reduced yields of sugar cane are: the ageing of the plantations, inadequate

attention to the crop, shortage of fuel, shortage of herbicides, and a reduction in available irrigation water. In order to alleviate the impact of the shortage of inputs, including fertilizers, the Government gives priority to certain key crops, such as sugar cane (because of its economic importance) and potatoes and bananas (as key food crops).

Mexico

Annual crops account for 78 percent of the total agricultural (sown) area of the country, of which grain crops represent 90 percent. Rainfed annual crops occupy 58 percent of the sown area but account for only 26 percent of national sales. Irrigated annual crops account for 20 percent of the land area and 36 percent of the sales, while irrigated perennial crops account for 6 percent of the land area and 18 percent of the sales. Under the terms of the North American Free Trade Agreement of 1994, import duties on agricultural products from North America have been reduced progressively. Non-trade-distorting agricultural support has been maintained and has cushioned the impact. For most crops, Mexico has difficulty in competing with farmers from the United States of America in an unprotected market. The performance of the high-value crop sector has been disappointing.

WEST ASIA AND NORTH AFRICA

Algeria

Agricultural production in Algeria is concentrated in the rich, rainfed zone in the north of the country. The crops include cereals, vegetable and fruit crops and semi-intensive livestock production, particularly for milk and meat. An intermediate zone, with its large areas of steppe and extensive pasture, is grazed by sheep, goats and camels. The third ecological region is the unproductive Sahara, where the only agricultural activities are oasis agriculture and date-palm cultivation. The average cereal yield, mainly wheat, averages only 1 200 kg/ha, while yields of 5 000 kg/ha are often achieved. Cereal imports have increased by a factor of ten since 1970.

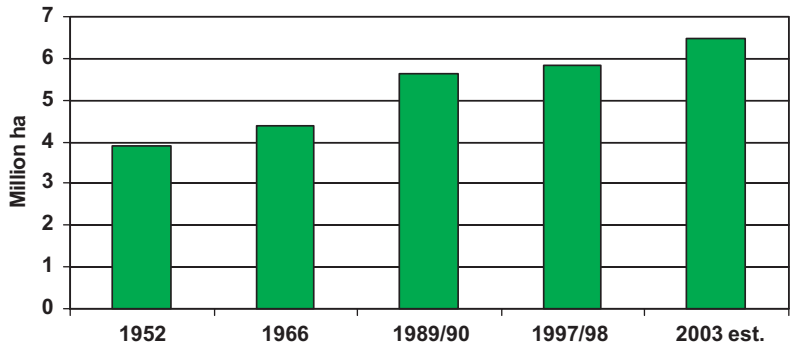
Egypt

Increased agricultural production has largely been achieved through intensification. Average yields are relatively high. The total area cropped annually increased from 4.7 million ha in 1982 to 6.5 million ha in 2003 (Figure 10) owing to increased cropping intensity, i.e. more than one crop on the same area of land during the year. The cropping intensity has reached about 180 percent. This was made possible by the introduction of earlier-maturing varieties of various crops, which permit up to three harvests per year. The aim is to reach a cropping intensity of 220 percent in the next 20 years.

Iran (Islamic Republic of)

Until recently, the Islamic Republic of Iran relied heavily on wheat imports to meet its growing domestic demand. Annual imports have ranged from 2.5 to

FIGURE 10
Cropped area in Egypt



Source: MALR, 2003.

7.5 million tonnes/year in the past two decades, making the Islamic Republic of Iran a major world wheat importer. However, a record wheat harvest in 2004 (following an already excellent crop in 2003) reduced wheat imports in 2004/05 to 0.2 million tonnes. Strong governmental support for wheat production has played a large part in raising output, but favourable rainfall during these seasons, after three years of drought, has also had a major impact. Yields of both irrigated and rainfed wheat are low by world standards. An intensification of production, in particular through a greater efficiency of fertilization and irrigation, is required in order to achieve a permanent reduction in the country's dependence on wheat imports, even under less favourable climate conditions.

Syrian Arab Republic

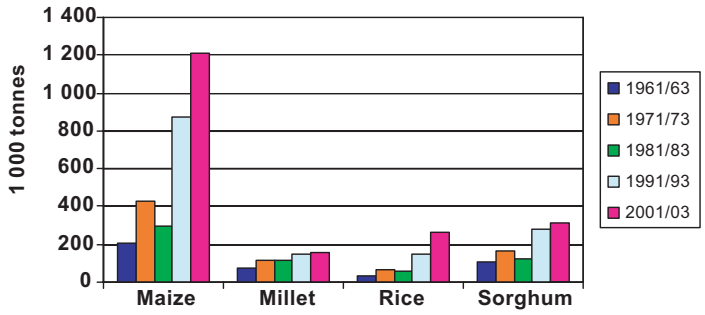
The main cereal crops are wheat and barley. The main irrigated crops are wheat and cotton. Agricultural production in the Syrian Arab Republic is not sufficient to meet domestic demand, which is rising as a result of population growth, rising incomes and urbanization. Agricultural production is planned, and farmers need a licence before they may plant certain specified crops.

AFRICA

Ghana

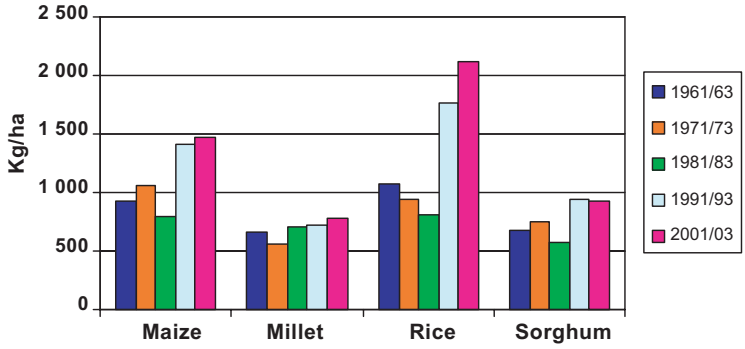
Cocoa is the main export crop and provides a livelihood for 25 percent of the population. It covers about 28 percent of the cropped land. The production of cocoa halved between the early 1970s and the mid-1980s. It regained its former level by the mid-1990s but has since tended to stagnate. Cocoa is produced on a large number of small "crop tree" farms. Oil-palm is the second most important cash crop after cocoa. The production and exports of higher value crops, fruit and vegetables, are tending to increase. Maize production increased during the 1980s and 1990s largely owing to an expansion in the area sown (Figures 11 and 12).

FIGURE 11
Cereal production in Ghana



Source: FAOSTAT.

FIGURE 12
Cereal yields in Ghana



Source: FAOSTAT.

South Africa

In view of climate and certain physical constraints (soils), the average yields of rainfed cereals are low compared with those of the temperate regions of the Northern Hemisphere. However, the implementation of best practices can result in high yields even under these conditions. Governmental support and regulation of the agriculture sector has been reduced considerably, resulting in marginal cereal areas being taken out of cultivation. Almost 2 million ha of maize and wheat have been taken out of production in the past 20 years.

Sudan

Cotton is the main export commodity, followed by oilseeds and livestock. In the 1990s, irrigation schemes were privatized but without adequate preparation.

Cotton production is now half that of the early 1990s. Yields of all crops are well below their potential. Food production has increased owing to expansion in the cropped area, while yields have tended to fall. Wheat, cotton and sorghum are the most important crops in irrigated areas, followed by groundnuts. Food production per capita has kept pace with population growth but productivity is low.

Zimbabwe

The major crops grown in Zimbabwe are maize, cotton, soybeans, wheat, tobacco and horticultural crops, such as roses, cut flowers and vegetables. Maize is the country's staple crop. Cotton, tobacco and certain horticultural crops are the main export crops.

SOUTH ASIA

India

Food security has long been a major concern in India, with memories of serious famines and with a rapidly increasing population. The promotion of the production and use of fertilizers in order to increase crop yields has been a major objective of the Government of India for more than 30 years. The policy has succeeded and food production in India has kept pace with requirements. The forecast population of 1 400 million by 2025 will require 300 million tonnes of food grain compared with the about 200 million tonnes of today. Little extra land is available and the increase in production will have to come from higher yields, for which there is ample scope.

Pakistan

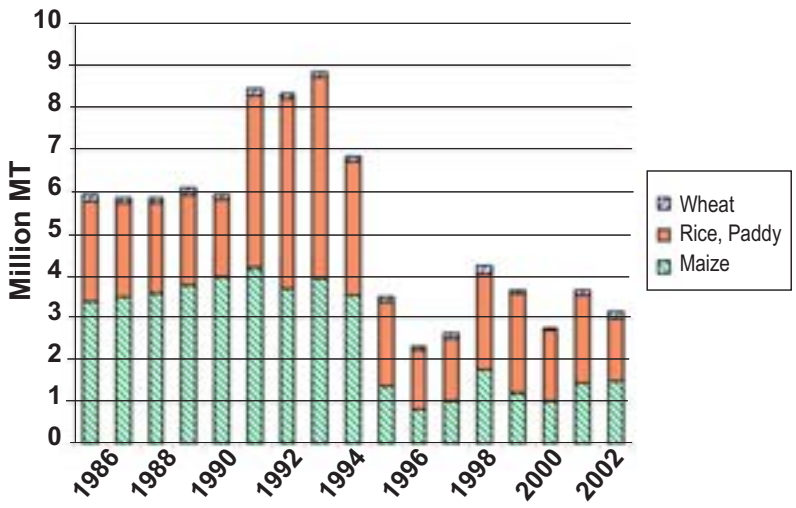
Total food crop production in Pakistan increased from 10 million tonnes in 1970/71 to about 25 million tonnes in 2002/03. The share of food grains in the total cropped area is 54 percent, followed by cotton and sugar cane, which account for 20 percent. Wheat is the main cereal crop. The yields of the major crops are below their agronomic and genetic potential.

SOUTHEAST ASIA

Indonesia

Following the oil crisis of 1974, Indonesia implemented several measures in order to become self sufficient in rice. This goal was achieved in 1984. There was considerable investment in irrigation and other infrastructures. During this period, fertilizers were subsidized and their consumption increased several times over. However, since 1984, Indonesia's rice production has not kept pace with population growth, and Indonesia has again became a regular importer of rice. Rubber and oil-palm are the two major perennial crops, produced both in large estates and by smallholders. Indonesia is the world's second largest producer of oil-palm and rubber and the third largest producer of cocoa. The production of oil-palm and sugar cane has risen substantially owing to significant increases both

FIGURE 13
Grain production in the Democratic People's Republic of Korea



Source: FAOSTAT.

in their harvested areas and in the yields per hectare. However, the production of rubber has fallen because of a reduction in area, largely owing to the conversion of substantial areas to oil-palm production.

NORTHEAST ASIA

Democratic People's Republic of Korea

The main food crops in the Democratic People's Republic of Korea are maize, rice, wheat, barley and, a relatively recent introduction, potatoes. Yields of the crops are far below their potential. The knowledge is available but the means are not. In recent years, agricultural production has fallen sharply (Figure 13) owing largely to a shortage of inputs (compounded by drought). This situation has resulted in serious food shortages and large-scale humanitarian interventions have been required.

The FAO and the international aid community have implemented programmes to increase agricultural production by: increasing the intensity of crop production; and producing extra crops on the land that otherwise remains fallow between the harvest in autumn and the planting of the main summer crop. The crops concerned are winter wheat, spring barley and spring potatoes.

Taiwan Province of China

More than 200 different crops are produced in the varied geographical and climate conditions of Taiwan Province of China. With its entry into the World Trade

Organization (WTO) framework in late 2001, the agriculture sector faced increased competition from foreign countries, especially in the rice market. Government policies on agriculture have shifted from increasing agricultural productivity to improving agricultural competitiveness, coupled with moves to promote the food processing industry, quality agricultural production and agritourism. High-value crops are challenging the primacy of traditional staple crops.

POLAND, UKRAINE AND UZBEKISTAN

Poland

The arable area includes 8.8 million ha of cereals, 1.2 million ha of potatoes and 0.3 million ha of sugar beet. Most of the arable land is cropped with cereals. Yields tend to be low compared with Western Europe. This is partly because of the natural conditions – unfertile and acid soils cover 50–65 percent of the arable land in Poland. Moreover, climate conditions are not optimal for agricultural production. Conditions in the eastern region, a region with a large number of very small farms, are particularly difficult.

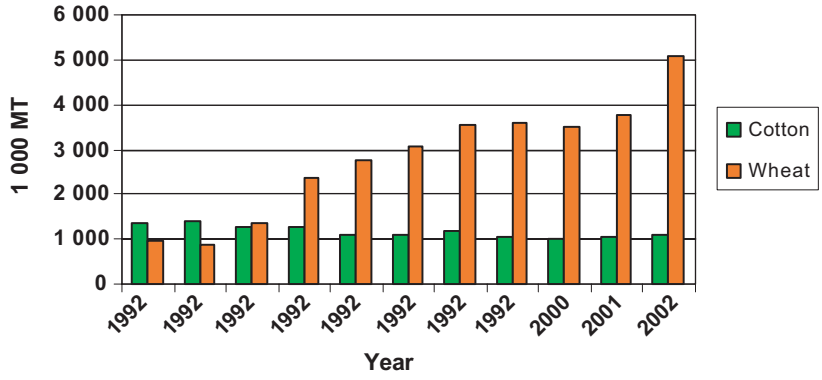
Ukraine

In the Soviet period, there was a major campaign to increase wheat production by using advanced technologies, including fertilizer use. This resulted in a substantial increase in yields. Following independence in 1991, agricultural production declined sharply as a result of a financial crisis in the agriculture sector. There was a particularly sharp fall in livestock numbers, and the area of land devoted to forage crops declined by nearly 40 percent. Sunflower became the most profitable crop and the area of this crop increased substantially. A low point of agricultural production was reached in 1999, since when there have been signs of a slow recovery.

Uzbekistan

In the Soviet period, the emphasis was on the production of cotton. The monoculture of cotton has led to problems of land degradation, especially from salinization and waterlogging. Since independence, priority has been given to the diversification of agricultural production. Yields in the rainfed area are low but this has become an important grain producing area (Figure 14), which has permitted a large reduction in grain imports.

FIGURE 14
Cotton and wheat production in Uzbekistan, 1992–2002



Chapter 6

Fertilizer supplies, distribution and credit

Globally, fertilizer supplies are more than sufficient and are likely to remain so. Fertilizer production units are generally efficient, both in order to be competitive and in order to comply with environmental regulations. Where there are supply shortages, it is for other reasons (e.g. Cuba and the Democratic People's Republic of Korea). It is in the distribution sector, after the fertilizers leave the plant or port, that most inefficiencies occur. Distribution costs can account for a substantial proportion of the final farm cost, and the distribution sector often offers the best opportunities for economies.

Fertilizers are high-volume, low-profit-margin products with a seasonal demand. The dealer needs inexpensive credit if adequate stocks of the types of fertilizer required by the farmer are to be available at the time they are required. The farmer has to finance the period between the application of the fertilizer and the harvesting and sale of the resulting agricultural product. An insufficient availability of credit, at an affordable price, is frequently mentioned as a constraint on fertilizer use.

In general, the higher rainfall and irrigated areas with more fertile soils are adequately supplied with fertilizer and other inputs, as well being efficient in the purchasing, processing and marketing of products. However, as rainfall declines or conditions become otherwise more difficult, farmers become increasingly averse to risking expenditure on inputs.

LATIN AMERICA

Argentina

Until 1991, a national industry supplied the fertilizer market, protected by import duties of 60–65 percent. Then, customs barriers protecting the national urea industry were removed, opening the way to a large increase in fertilizer imports. There followed a high level of investment in infrastructure, particularly port infrastructure. Suppliers began to invest in distribution facilities and the provision of services. A number of firms entered the market. Then, the market consolidated. Today, some eight or nine enterprises cover about 90 percent of the sales volume. Each of them is able to produce physical mixtures, according to local requirements, in strategically located plants. Table 4 shows the recent trends in fertilizer production and trade.

The fertilizer producers have arrangements with exclusive or non-exclusive distributors, cooperatives, etc., and have their own structures for direct sale to the farmers. Several retailers offer services to the farmers, such as blending, soil

TABLE 4
Fertilizer production and trade, Argentina

	Item	1998	2000	2002
		('000 tonnes product)		
Imports	Urea	437	553	113
	DAP/MAP	569	631	522
	Others	188	401	293
Production	Urea, prilled	120	188	180
	Urea, granulated	0	0	925
	UAN	15	32	36
Exports	Urea	1	2	507

analysis, financing and agronomic assessments.

Since the introduction of direct seeding, with no or reduced tillage, urea and di-ammonium phosphate (DAP) have been the most used fertilizers. More recently, with the identification of the impact of sulphur on yields, the application of mixtures containing ammonium sulphate or potassium and magnesium sulphate has increased. Field trials have not yet shown a response to potash in the Pampas region.

A credit system unique to Argentina is the "Canje plan". This system provides credit against delivery of the grain. From 1997 to 2001, Canje accounted for 24 percent of farm credit. After the 2001 financial crisis, fertilizers were supplied mostly either against grain or cash, but with the stabilization of the economy, resort to the Canje system has again increased.

Brazil

Until the beginning of the 1960s, the domestic demand for fertilizer raw materials was met essentially by imports. In the second half of 1960s, new phosphate fertilizer plants were constructed. Increasing demand, associated with high prices on the international market as a consequence of the oil crisis in 1974, led to the development of the National Programme for Fertilizers and Agricultural Limestone (PNFCA). This stimulated investment in several fertilizer and raw material complexes. In the early 1990s, a substantial proportion of raw material production, until then undertaken by state-owned companies, was transferred to the private sector. National production is supplemented with imports. In 2002, national production supplied 42 percent of the N, 53 percent of the P_2O_5 but only 12.3 percent of the K_2O consumed in the country.

The distribution of fertilizers in Brazil is carried out by the private sector. Agricultural cooperatives account for about 10 percent of current fertilizer sales.

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.) finance 18 percent of the sales. The cooperatives are also increasing their role in financing the purchase of fertilizer mixtures by their members. The remaining 42 percent of sales are financed either from the farmers' own resources or through commercial banks.

Cuba

Today, all mineral fertilizers used in Cuba are imported. Nitrogen fertilizers were formerly produced at a plant at Cienfuegos and compound fertilizers at a plant at

Matanzas. These plants have been idle for several years, mainly because of a lack of raw materials and spare parts.

Mexico

Towards the end of the 1960s, the State established Fertimex in order to develop the production, marketing, distribution and supply of fertilizers to Mexican agricultural producers. In 1990/92, Fertimex was privatized, and national and foreign investors acquired its assets. Only ammonia production remained under state control, as a monopoly of the national energy company, Pemex. The importation of fertilizers was liberalized in 1992 at the time of privatization of fertilizer production.

Until about 1992, Fertimex had the exclusive rights to distribute fertilizers in Mexico. Following privatization, a number of companies entered the market. There was subsequently consolidation of the market with a few large private distributors, large international producers that have subsidiaries in Mexico, and smaller distributors that have joint purchasing arrangements.

The Government used to provide substantial subsidized credit to farmers. Following the financial crisis of 1995, this credit was reduced considerably. Today, credit is used mainly by the larger farmers; banks hesitate to extend credit to poor small-scale farmers. The Federal Government provides support to small-scale farmers through the "Credito a la Palabra" programme. Prior to its abolition in 1999, the Compañía Nacional de Subsistencias Populares implemented price support schemes for several crops.

WEST ASIA AND NORTH AFRICA

Algeria

The country is rich in two important natural resources, phosphate rock and natural gas, for the production of fertilizers for the domestic and export markets.

Egypt

Nitrogen fertilizers are produced by a national fertilizer industry from domestic resources of natural gas, part of the production being exported. Egypt also has deposits of phosphate rock, from which phosphate fertilizers are produced. All potash requirements are imported. Previously under complete government control, fertilizer distribution and pricing were liberalized in the 1990s. However, the Government has subsequently intervened when malfunctioning has occurred. Maximum domestic fertilizer prices are still imposed on manufacturers.

Iran (Islamic Republic of)

The country has large reserves of natural gas and also some phosphate rock deposits. The national petrochemical company manufactures almost 2 million tonnes of urea and ammonium phosphates annually. In addition, some 200 smaller-scale producers are licensed to produce compound fertilizers, although their performance has been variable. The Agricultural Support Services Company is responsible for providing

and distributing mineral fertilizers, pesticides, seeds and improved plant varieties. There is an extensive rural and agricultural cooperative network. With about 5 million members, the network covers 98 percent of villages of the country, with a population of about 25 million people. The cooperatives play an important role in the marketing of produce and providing services and support.

Morocco

Morocco has the world's largest resources of phosphate rock but relies on imports for N and K_2O.

Syrian Arab Republic

Nitrogen fertilizers and triple superphosphate are manufactured in the Syrian Arab Republic. Production reached a peak in 1983 but then declined (owing to technical problems) to reach a low point in 1991. Shortfalls are made up by imports, especially of N, whose consumption is increasing at a faster rate than that of the other nutrients. The parastatal Agricultural Cooperative Bank is responsible for the distribution of fertilizers, but there is also an unofficial parallel market.

AFRICA

Ghana

All the fertilizers used in Ghana are imported. Traditionally, the main fertilizers have been ammonium sulphate and compound fertilizers, and these fertilizers still account for a large proportion of the imports. A special grade of fertilizer has been developed for use on cocoa. The fertilizer market in Ghana is liberalized, but there has been little economic incentive for entrepreneurs to invest in the up-country market for small-scale farmers. Donated fertilizers have sometimes disturbed the private distribution sector, but sometimes it is only donated fertilizers that reach the small-scale farmers.

South Africa

South Africa has a long-established fertilizer industry. Until the 1980s, the fertilizer and agriculture sectors were protected and received substantial governmental support. However, the opening up of the economy that started in 1984 resulted in a progressive rationalization and restructuring of the industry; South Africa changed from being a net exporter to being a net importer of fertilizers. With no national deposits of potassium salts, all K requirements have to be imported.

Sudan

Until 1992, the Government controlled the marketing of agricultural inputs and outputs. As part of the economic reforms in the 1990s, most of the controls on private traders were removed. However, parastatal organizations still dominate the fertilizer supply system. The Agricultural Bank of Sudan and commercial banks provide agricultural credit, but farmers in rainfed areas have difficulty in obtaining formal credit.

Zimbabwe

There are four major fertilizer manufacturers in Zimbabwe. The country has domestic phosphate rock deposits but all K requirements have to be imported. The production of fertilizers has tended to decline since the mid-1990s owing to a fall in domestic demand together with restrictions on exports, a lack of foreign exchange for the purchase of equipment and raw materials, transport problems, the increasing energy cost and low profitability. There is freedom of entry into the inputs distribution sector but the governmental input supply schemes reduce the quantities that farmers are willing to purchase from private distributors. There is a subsidized credit scheme for the purchase of inputs, and some private-sector firms involved in the buying of agricultural commodities provide advice and credit.

SOUTH ASIA

India

Concern about food security increased when international grain and fertilizer prices rose sharply during the oil crisis of 1973/74. This provided an impetus to the development of policies aimed at improving the country's fertilizer supplies and food security. The production of N and P fertilizers increased from 1.8 million tonnes of nutrients in 1975/76 to 14.2 million tonnes of nutrients in 2003/04. Foremost among the measures of the Government of India was the Retention Price Scheme (RPS) for fertilizers, initiated in 1978. The principle was that of a "low-input, low-output" price system. The benefits of the RPS have included:

- The development of a viable fertilizer manufacturing industry, with a mix of state-owned, privately owned and cooperative enterprises.
- Improvement in the food security of the country.
- Fertilizers are supplied to farmers at prices that even the small-scale farmers can afford.
- Basic food products are available at prices that are lower than would otherwise be the case.
- The fertilizer production industry has been able to employ agronomists, invest in advisory services, fund university professorships, and participate in rural development.

In the absence of domestic natural resources, all K fertilizers are imported; the imports in 2003/04 amounted to 2.6 million tonnes of K_2O compared with 0.4 million tonnes in the mid-1970s.

Fertilizer distribution is carried out through private channels, cooperatives and certain institutions. There are 283 000 sales outlets in the country.

A substantial amount of institutional credit is provided for the agriculture sector. However, the provision of adequate credit to small-scale farmers at reasonable rates of interest remains a problem. A farmer credit card scheme introduced in 1998/99 has gained popularity.

Pakistan

The fertilizer sector has been privatized and deregulated. Farm price subsidies have been eliminated and prices decontrolled. Almost 90 percent of fertilizers are distributed by the private sector through a network of some 8 000 dealers.

SOUTHEAST ASIA

Indonesia

The Government of Indonesia became concerned about food security in the mid-1970s and implemented measures aimed at achieving self-sufficiency in rice. They included the construction of several fertilizer plants, N production being facilitated by the country's natural gas reserves. Six fertilizer plants provide the country's fertilizer requirements of urea, superphosphate and ammonium sulphate. The raw materials for phosphate production and K are imported. The distribution of fertilizers is regulated. The regulations have been modified several times in recent years in order to adjust to the prevailing conditions. The consistent objective has been to provide adequate and affordable supplies of fertilizers to farmers.

Malaysia

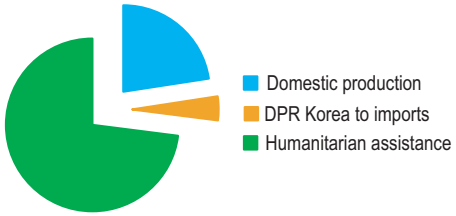
Nitrogen fertilizers are produced by large-scale plants from domestic natural gas resources for domestic consumption and for export. The domestic market is well covered; more than 50 companies are involved in the distribution of fertilizers, with more than 350 brands of various grades.

NORTHEAST ASIA

Democratic People's Republic of Korea

The production of fertilizers has fallen sharply. The shortage of foreign exchange to buy raw materials and spare parts has constrained domestic fertilizer production severely. Fertilizer imports are limited by foreign exchange availability. Recently, most of the fertilizers used have been provided by international aid (Figure 15).

FIGURE 15
Fertilizer supplies from different sources, Democratic People's Republic of Korea



Taiwan Province of China

Fertilizer supplies, from domestic production and from imports, are sufficient to meet the demand in Taiwan Province of China, and prices are reasonable. The fertilizer production sector is adjusting to meet changing agricultural structures resulting from entry into the WTO.

POLAND, UKRAINE AND UZBEKISTAN

Poland

Poland has a long-established fertilizer industry. The former distribution system of the centrally planned economy collapsed after 1990, and manufacturers have since become involved in organizing the distribution of their own products.

Ukraine

There is a strong fertilizer manufacturing industry in the Ukraine. With the collapse of the domestic market for fertilizers, manufacturers turned to the export market, and Ukraine became a major exporter of N fertilizers, especially of ammonium nitrate and urea.

Agriculture is supported by the State. This support includes state intervention in the pricing, subsidization and supply of fertilizers for the domestic market and in the provision of agricultural services and distribution.

Uzbekistan

The main fertilizer products manufactured in Uzbekistan are N fertilizers, single superphosphate and mono-ammonium phosphate (MAP). Supplies are adequate.

Chapter 7
Fertilizer consumption

There are large variations between the 21 countries featured in the *Fertilizer use by crop* publications in terms of: land area, population, fertilizer use per hectare, and fertilizer use per person (Table 5).

For the past 100 years, fertilizer consumption statistics have reflected world events, and the past 20 years have proved no exception.

Fertilizer consumption has increased substantially, although not consistently, in countries with rapidly increasing exports of agricultural commodities, such as Argentina and Brazil.

Structural Adjustment Programmes implemented in certain developing countries in the 1980s and 1990s, in order to correct their financial imbalances, had a negative impact on fertilizer use in the small-scale farming sector.

In countries where a centrally planned system, with its heavy support to agriculture and the allocation of fertilizers according to plans, was replaced around 1990 by a market-oriented system, fertilizer consumption fell abruptly.

TABLE 5
Fertilizer consumption in various countries, 2000/02

	$N + P_2O_5 + K_2O$	Arable + permanent crops	NPK/ha	Population	NPK/person
	(1000 tonnes)	(million ha)	(kg)	(million)	(kg)
Taiwan Province of China	468	0.9	547	30	16
Egypt	1 279	3.3	383	71	18
Malaysia	1 183	7.6	156	24	49
Uzbekistan	723	4.8	150	26	28
Pakistan	2 957	22.1	134	150	20
Poland	1 557	14.3	109	39	40
Brazil	7 029	66.1	106	176	40
Democratic People's Republic of Korea	268	2.7	99	23	12
India	16 723	170.0	98	1 050	16
Indonesia	2 768	33.6	82	217	13
Iran (Islamic Republic of)	1 337	16.7	80	68	20
Syrian Arab Republic	329	5.4	61	17	19
Mexico	1 603	27.3	59	102	16
South Africa	823	15.7	52	45	18
Zimbabwe	143	3.4	43	13	11
Morocco	376	9.4	40	30	13
Cuba	153	4.1	37	11	14
Argentina	822	34.9	24	38	22
Ukraine	501	33.5	15	49	10
Algeria	99	8.2	12	31	3
Ghana	25	6.2	4	21	1
Sudan	65	16.7	4	33	2

Source: FAOSTAT (except Taiwan Province of China).

In the few developing countries where fertilizer use continued to receive government support, sometimes despite pressures to the contrary, fertilizer consumption continued to increase.

Taiwan Province of China has been adapting its agriculture following entry into the WTO.

Inadequate and/or inefficient fertilization is often a constraint to achieving satisfactory crop yields and is a major contributor to soil degradation. In some countries, the balance between the plant nutrients is unsatisfactory. Nitrogen is the "motor of plant growth", showing its effect soon after application, and farmers tend to give preference to this nutrient, especially where their financial resources are limited. The ample supply of N fertilizer on the international market and its relatively low price per unit of nutrient also contribute to imbalanced fertilizer use in favour of N, especially in Asia. Imbalanced excess N represents not only a substantial financial loss but also a cause of pollution of the environment.

LATIN AMERICA

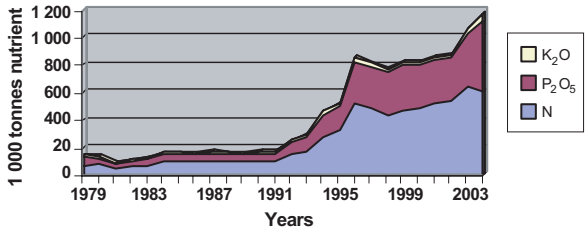
Argentina

In the 1960s, practically no fertilizers were used on the extensively grown crops of the Pampas region of Argentina. Natural soil fertility made the use of fertilizers unnecessary. However, fertilizer consumption increased strongly in the first half of the 1990s as a result of improved economics and availability (Figure 16). In the mid-1990s, fertilizer consumption levelled off temporarily, mostly as a result of economic problems but also partly because of the modification of the cropping pattern in favour of soybeans at the expense of cereals and a progressive diminution in economies of scale. While almost 90 percent of wheat producers now fertilize their crops, only 28 percent did so in 1993. Seventy-two percent of maize farmers currently apply fertilizers, a sixfold increase since 1993.

At the end of the 1990s, with increasing intensification of agriculture and falling levels of soil nutrients, responses to nutrients other than N and P developed. Especially on soils with a low organic matter content and those that had been cultivated for a long period, deficiencies in nutrient sulphur started to become apparent. Subsequently, deficiencies of K and micronutrients such as zinc and boron were identified. To date, cotton has been little fertilized, but the new varieties, especially the transgenic ones, respond to fertilization. Trials in the 1970s showed no response of sugar cane to P and K. However, trials in the past five years have demonstrated that many soils are deficient in P and that some are deficient in K.

As regards the form of fertilizers, the use of bulk and bulk

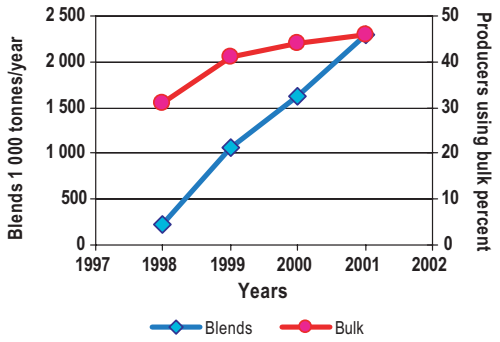
FIGURE 16
Fertilizer consumption in Argentina



Source: FAOSTAT.

blend fertilizers has developed recently in Pampas agriculture, offering the economy of dispensing with bags and a gain in operating time (Figure 17). The use of liquid fertilizers has also progressed for the same reasons.

FIGURE 17
Use of blends and bulk fertilizers, Argentina, 1998–2000

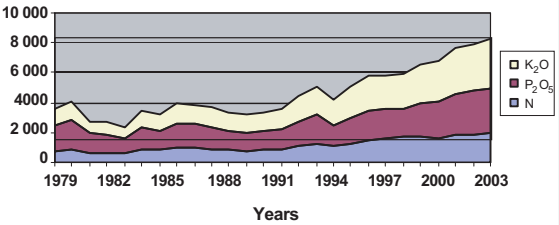


Source: FAOSTAT.

Brazil

In 1970, fertilizer consumption in Brazil amounted to about 30 kg of total nutrients per arable hectare while total crop production was 49.6 million tonnes, and the average yield was 1.45 tonnes/ha (in terms of agrovegetal matter on a dry-weight basis). In 2002, agrovegetal production was 184.5 million tonnes, an increase of 370 percent, with an average fertilizer consumption of 138 kg of nutrients per hectare and an average yield of agrovegetal matter of 3.45 tonnes/ha. In the same period, the cultivated area increased by 154 percent, from 36.4 to 56.2 million ha.

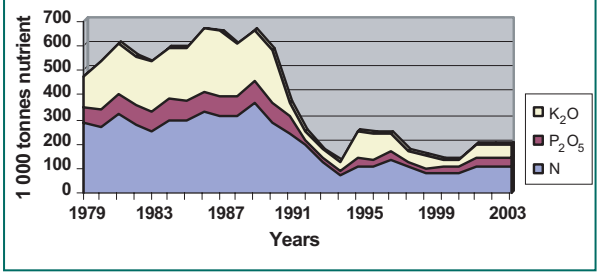
FIGURE 18
Fertilizer consumption in Brazil



According to the 1995/96 agricultural census, only 10 percent of farmers in the North region were using lime and fertilizers. The situation was a little better in the Northeast region, where only 18 percent of farmers were using fertilizers. Advisers from the rural extension service visited only about 5 percent of the farms in these two regions. The Northeast region includes a large area with a semi-arid climate, but irrigation is used on only 5 percent of the farms.

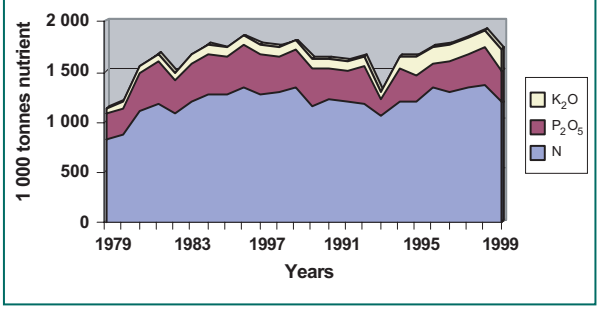
By international standards, the use of N is low in Brazil in relation to that of P and K. The consumption of P_2O_5 is relatively high (Figure 18), partly as a consequence of the increasing cultivation of soils of the "Cerrado" area in the Centre West region of the country, which are extremely deficient in P. Soybeans require P_2O_5, but in Brazil very little N is applied to the crop. Excluding soybeans, the N:P_2O_5:K_2O ratio in the period 2002–04 was about 1:0.85:1.03. The relatively low consumption of N in relation to P and K was confirmed by a study involving calculations of nutrients removed by the 16 main crops in Brazil. It is concluded that the low rates of N use are one of the main factors limiting yield increases in a number of crops.

FIGURE 19
Fertilizer consumption in Cuba



Source: FAOSTAT.

FIGURE 20
Fertilizer consumption in Mexico



Source: FAOSTAT.

Concerning the types of fertilizers, Brazil has an unusually high proportion of nutrients (more than 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 because of the demand for this fertilizer for use on soybeans, owing to its sulphur content.

Cuba

All Cuba's fertilizer requirements are imported and the quantities available are limited by foreign exchange availability. After the end of the special relationship with the Union of Soviet Socialist Republics, fertilizer use fell by 80 percent (Figure 19). Present levels of fertilizer use are insufficient to maintain yields and soil fertility. P and K are applied only where the soil levels are below the critical levels according to soil analyses. Of crops other than sugar cane, only the potato crop continues to be fertilized adequately. Priority is given by the State to the production of potatoes in view of the importance of the crop to food security. Bananas constitute an important food item, particularly in the east of the country, where potato production is limited by unsuitable growing conditions. Despite limited fertilization, the production level of the banana crop has been maintained or even increased. This is the result of:

- new management technologies;
- an improved cloning structure;
- better quality seed obtained by tissue culture;
- substitution of mineral fertilizers with organic materials;
- improved incomes
- higher prices for the producer.

Mexico

Fertilizer consumption in Mexico grew strongly in the 1970s and the first half of the 1980s, during a period when both crops and fertilizers were subsidized heavily, to reach a peak in 1987 (Figure 20). It then stabilized. Mexico has

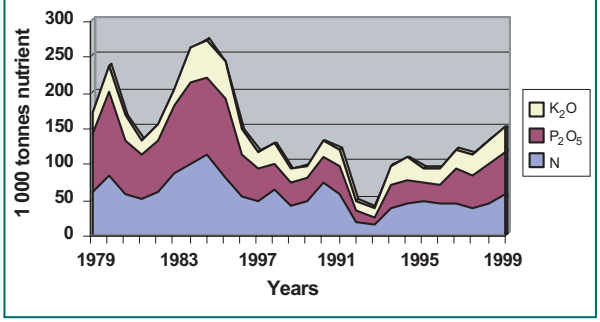
suffered two serious economic crises in the past two decades, the first in the early 1980s and the second in the mid-1990s. Following the first crisis, a Structural Adjustment Programme was implemented. The high level of subsidization of fertilizers and crop prices was terminated. Fertilizer consumption stagnated, but did not fall because the larger-scale farmers with irrigated land continued to use them. Moreover, crop prices remained protected by import duties. The average level of fertilizer consumption between 2000 and 2002 was very similar to that between 1987 and 1990. Policy changes have had a greater negative impact on the small-scale farming sector than on the larger commercial, often irrigated, sector. However, this has not had a major influence on overall fertilizer consumption as few of the small-scale farmers were using fertilizers in any case.

WEST ASIA AND NORTH AFRICA

Algeria

Fertilizer consumption increased substantially in Algeria between 1971 and 1986. This was largely as a result of the application of increasing quantities of subsidized fertilizers on state-owned land. However, the application of fertilizers was poorly adapted to crop requirements. The consumption of fertilizers then fell sharply between 1986 and 1996 before stabilizing at a low level (Figure 21). A Structural Adjustment Programme, implemented from 1986 onwards, involving redistribution of land, liberalization of the markets and a large cut in subsidies, had a negative impact on fertilizer use.

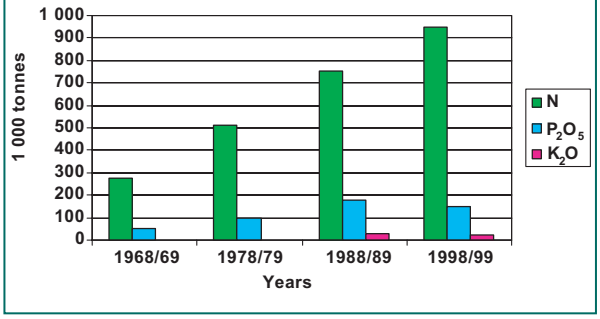
FIGURE 21
Fertilizer consumption in Algeria



Source: FAOSTAT.

Despite the ample availability of natural resources for the production of fertilizers, the average application rate of fertilizers in Algeria remains low and well below the requirements. Only one-quarter of cereal farmers apply fertilizers and/or manure. Cereal imports have increased tenfold since 1979.

FIGURE 22
Consumption of N, P_2O_5 and K_2O, Egypt



Source: Taha, 2000.

Egypt

Fertilizer use has tripled in the past 30 years (Figure 22). The increase

Figure 23
Fertilizer consumption in the Islamic Republic of Iran

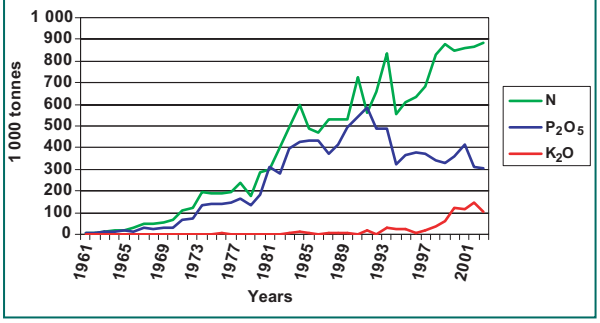


FIGURE 24
Nitrogen consumption in the Islamic Republic of Iran

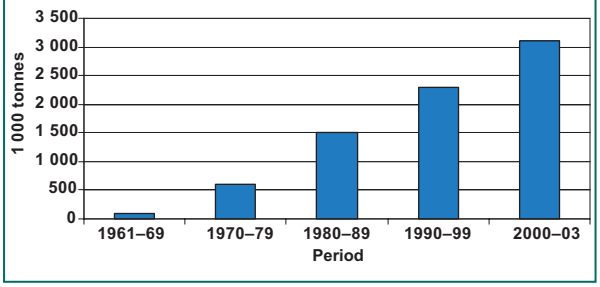
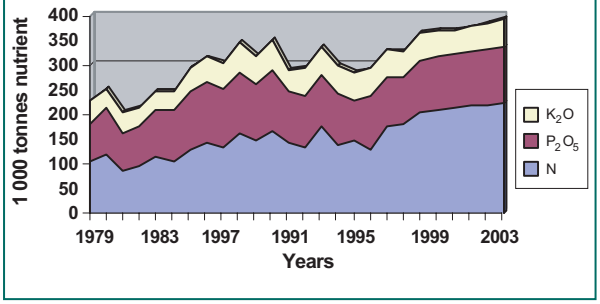


FIGURE 25
Fertilizer consumption in Morocco



Source: FAOSTAT.

stems from various factors, including: (i) the introduction of new high-yielding varieties (HYVs) that need higher rates of fertilizer application; (ii) the construction of the High Aswan Dam, which reduced the quantity of suspended materials deposited on the soil during Nile floods; and (iii) the additional cropped area, from reclaimed land, and an increasing cropping density. Under Egyptian agricultural conditions, N is considered the most critical nutrient in crop production. The rate of N application in Egypt is one of the highest in the world.

Iran (Islamic Republic of)

The consumption of fertilizers has increased by more than two and a half times since the 1980s (Figures 23 and 24). Improvements in fertilizer use are necessary. It is estimated that correct fertilization could increase production levels by up to 60 percent.

Morocco

Fertilizer consumption in Morocco has increased by 70 percent since 1980 (Figure 25).

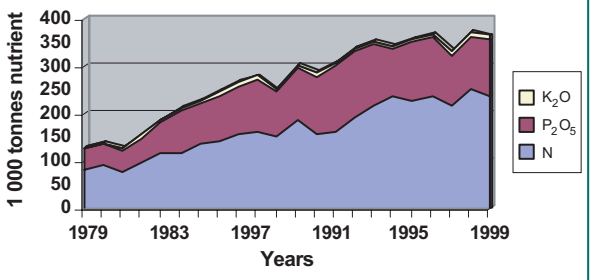
However, fertilizer use remains inadequate. Only half the farmers use fertilizers. Current consumption amounts to 40–45 kg of nutrients per hectare, which represents less than one-third of the requirements. In spite of a subsidy of 50 percent on the cost of soil testing, few farmers take advantage it. After 1986, growth in fertilizer consumption was checked by a less favourable crop–fertilizer price relationship. Fertilizer subsidies were first reduced and then withdrawn in 1991.

Syrian Arab Republic

Figure 26 shows the development of fertilizer consumption in the country.

Further increases in fertilizer use are expected as a result of the expansion of the irrigated areas, the development of fertilizer use on fodder crops and increased use on fruit crops.

FIGURE 26
Fertilizer consumption in the Syrian Arab Republic



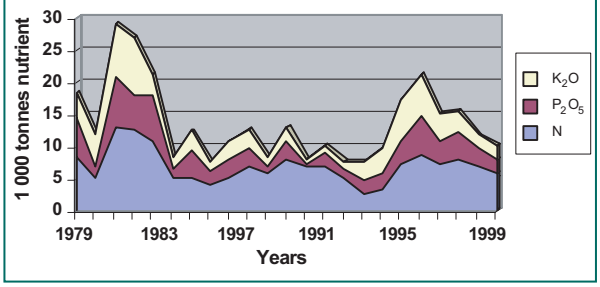
Source: FAOSTAT.

AFRICA

Ghana

After a period of rapid increase in the 1970s, fertilizer consumption fell substantially in the early 1980s, following the implementation of a Structural Adjustment Programme that included the removal of most support to agriculture, including subsidies. It started to recover in the mid-1990s but then fell again as a result of further financial problems and depreciation of the national currency (Figure 27). The level of fertilizer consumption is half that of 25 years ago. It has recently started to recover owing to improved economic circumstances.

FIGURE 27
Fertilizer consumption in Ghana

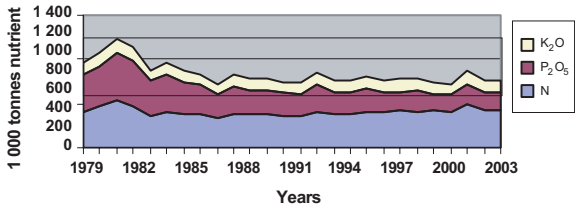


Source: FAOSTAT.

National fertilizer consumption is about 4 kg of nutrients per hectare of arable land and permanent crops, and most of that is used on cash crops for export. This is low even by SSA standards. The fertilization level of export crop sectors, such as cotton, oil-palm, tobacco and pineapple, has been better maintained than that of staple food crops. The rates on food crops are far below the quantities removed by crops and erosion. Producers of the more profitable horticultural crops in the vicinity of towns are more motivated to use production inputs.

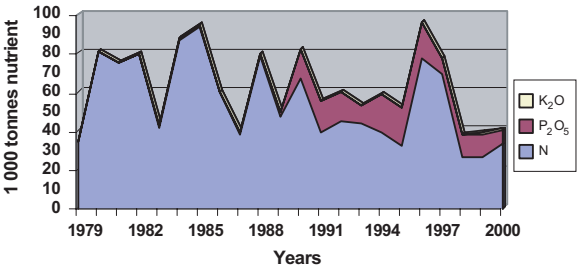
Despite its importance, cocoa has been little fertilized. The Government has launched a major programme with the objective of improving the production technology of the crop. Cocoa production increased again in 2002/03. Recent on-farm trials on cocoa, using a special grade of cocoa fertilizer, have shown a yield increase compared with unfertilized plots of 62 percent in the first year rising to 107 percent in the fourth year of application.

FIGURE 28
Fertilizer consumption in South Africa



Source: FAOSTAT.

FIGURE 29
Fertilizer consumption in the Sudan



Source: FAOSTAT.

South Africa

Between 1955 and 1981, fertilizer consumption (heavily supported) grew at a steady rate. A protracted drought in 1982 followed by a sharp increase in interest rates and a mini-recession resulted in a fall in fertilizer use (Figure 28). A new equilibrium was established three years later as demand-driven agriculture began to take shape. Maize and wheat account for 48 percent of total fertilizer application, the second largest fertilizer consumer being sugar cane (18 percent). The horticultural and fruit crop sectors account for 20 percent of fertilizer consumption, but their contribution to the total value of crop production is much greater. A stable or slowly growing fertilizer demand is expected, with a further reduction in the cropped area being offset by more intensive production on the remaining areas.

Fertilizer manufacturers and blenders provide a technical service to farmers through sales representatives and technical support staff.

Sudan

Despite a generally poor mineral fertility of soils, fertilizer consumption is very low (Figure 29), averaging about 4 kg of total nutrients per cultivated hectare. Very little fertilizer is applied in the rainfed farming sector, whether traditional or mechanized. Even in the irrigation schemes, fertilizers are underused.

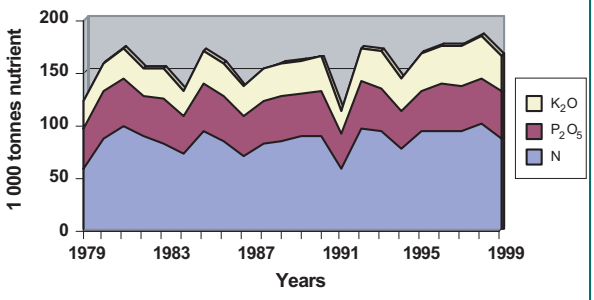
The yields of the staple crops, such as sorghum, have not increased, and higher production has been obtained by extending the cultivated area, with a negative environmental impact.

Zimbabwe

Prior to the land reform, the large-scale commercial sector accounted for more than 80 percent of fertilizer purchases. The average rate of fertilizer nutrient application was 290 kg/ha on the large-scale commercial farms compared with 15 kg/ha on the communal lands. Figure 30 illustrates the stable or perhaps slightly increasing consumption in the 1980s and 1990s. Fertilizer consumption

has fallen since 2000 owing to the disruption caused by the agrarian reform, physical unavailability, increased fertilizer prices and financial constraints. Only a small proportion of smallholder farmers use fertilizers.

FIGURE 30
Fertilizer consumption in Zimbabwe



Source: FAOSTAT.

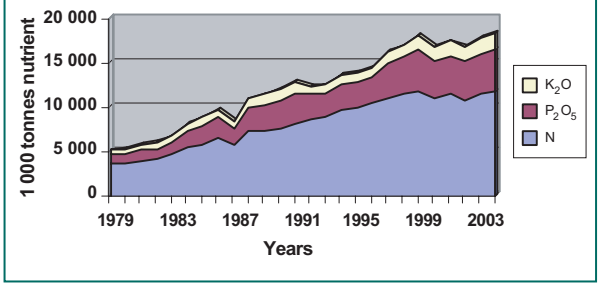
SOUTH ASIA

India

Fertilizer consumption has increased from fewer than 1 million tonnes of total nutrients in the mid-1960s to almost 17 million tonnes today (Figure 31). Government policies and the introduction of HYVs in the 1960s favoured the use of fertilizers. The intensity of fertilizer consumption varies greatly between the regions, from 40 kg/ha of total nutrients in Rajasthan to 184 kg/ha in Punjab.

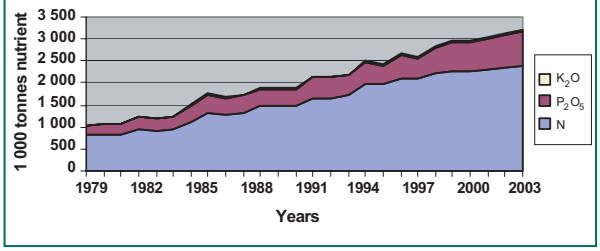
There are about 283 000 sales points for fertilizers in India, in a network that comprises private wholesalers and retailers, cooperatives and state-owned outlets, supported by governmental service centres. Three-quarters of them are privately owned, the others are cooperatives and institutional outlets. Urea accounts for 82 percent of total N consumption, DAP for 63 percent of P consumption, and complex fertilizers for a further 27 percent.

FIGURE 31
Fertilizer consumption in India



Source: FAOSTAT.

FIGURE 32
Fertilizer consumption in Pakistan



Source: FAOSTAT.

Pakistan

A threefold increase in food crop production in the past 30 years has been made possible by a thirteenfold increase in fertilizer use (Figure 32). Fertilization practices are still far from those recommended, with consequent inefficiencies, yield losses, financial waste and the loss of plant nutrients to the environment.

FIGURE 33
Fertilizer consumption by product, Pakistan

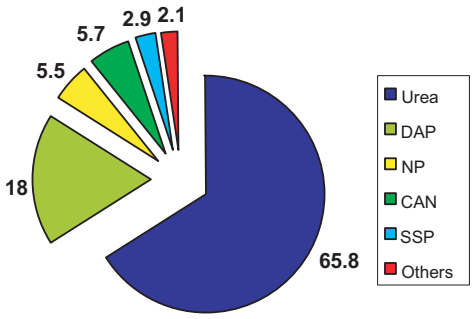
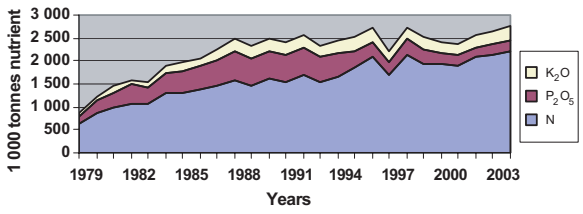
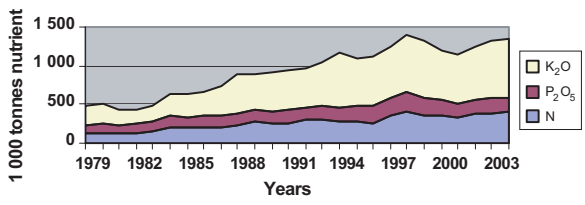


FIGURE 34
Fertilizer consumption in Indonesia



Source: FAOSTAT.

FIGURE 35
Fertilizer consumption in Malaysia



Source: FAOSTAT.

Most of the fertilizer is used on irrigated wheat, cotton, sugar cane and rice. On these crops, the N application rate is close to 80 percent of the recommendations, compared with about 40 percent or less, depending on the crop, in the case of P. Scarcely 2 percent of farmers apply K; the quantities used are applied to fruit and vegetable crops and sugar cane. Micronutrient deficiencies are common, but fewer than 5 percent of farmers apply micronutrient fertilizers. Figure 33 shows the breakdown of fertilizer consumption by product in Pakistan.

SOUTHEAST ASIA

Indonesia

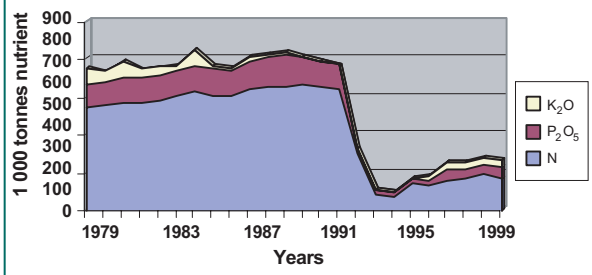
Large increases in the use of mineral fertilizer have resulted in a substantial increase in crop production, especially of lowland rice. They have also improved the P and K status of large areas of lowland rice soils. Fertilizer consumption increased sharply up to 1988 (Figure 34) as a result of a high level of government support, the objective being food security in rice. However, the implementation of a Structural Adjustment Programme after 1988, with a progressive reduction in support to agriculture (including the removal of fertilizer subsidies in 1993), led to stagnation in fertilizer use. A financial crisis in 1997 constrained government spending even further and there was a strong depreciation of the national currency. With an improving economic climate, a partial subsidization of fertilizers was resumed in 2003.

Malaysia

Mainly as a result of an expansion in crop production, especially of plantation crops (rubber, oil-palm and cocoa), there was a steady increase in fertilizer use until the end of the 1990s, since when it has tended to stabilize (Figure 35). K fertilizers have shown the largest increase as a result of a large increase in the use of this nutrient on oil-palm.

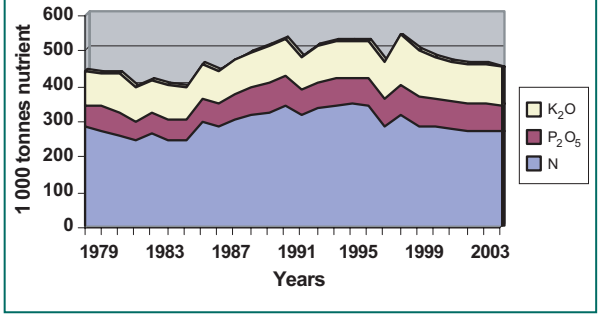
Fertilizer use in Malaysia is characterized by a large consumption of directly applied phosphate rock, made possible by the acidic nature of the soils and the large area of perennial plantation crops, and of K (owing to the large area of oil-palm).

FIGURE 36
Fertilizer consumption in the Democratic People's Republic of Korea



Source: FAOSTAT.

FIGURE 37
Fertilizer consumption in Taiwan Province of China



NORTHEAST ASIA

Democratic People's Republic of Korea

The supply and use of mineral fertilizers fell sharply in the 1990s (Figure 36). A shortage of foreign exchange resulted in a fall in the imports of fertilizers and greatly reduced production from national fertilizer plants owing to a shortage of raw materials and spare parts for plant maintenance. Humanitarian assistance provides almost three-quarters of the fertilizers used. The nutrient reserves of soils are being mined.

Taiwan Province of China

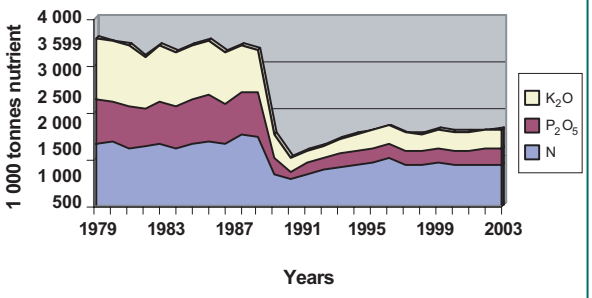
The large number of small-scale farmers in Taiwan Province of China apply a large range of organic and mineral fertilizers to the wide variety of crops under the varied agro-ecological conditions. As a result of the long-term application of superphosphate, most soils, particularly orchards and vegetable plots, have high levels of available P. A gradual fall in fertilizer use has occurred since 2000 as agriculture adapts to the impact of joining the WTO (Figure 37).

POLAND, UKRAINE AND UZBEKISTAN

Poland

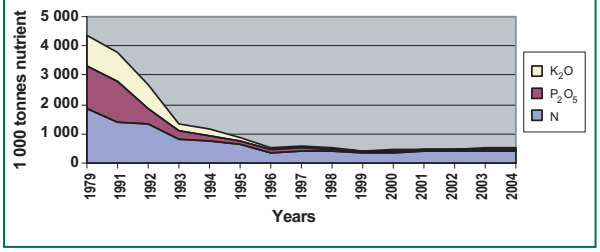
Fertilizer consumption reached a high and stable level, comparable with that of Western Europe, during the centrally planned period. After 1991, with the need

FIGURE 38
Fertilizer consumption in Poland



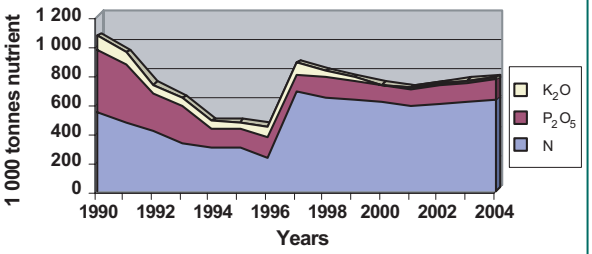
Source: FAOSTAT.

FIGURE 39
Fertilizer consumption in Ukraine



Source: FAOSTAT.

FIGURE 40
Fertilizer consumption in Uzbekistan



Source: FAOSTAT.

to adjust to market conditions, fertilizer consumption fell sharply and has only recently started to recover gradually (Figure 38).

Ukraine

Between the mid-1960s and the late 1980s, total annual nutrient consumption increased from 1.4 million tonnes to almost 5 million tonnes. Correspondingly, the average yield of winter wheat increased from 2.3 to 4.7 tonnes/ha. Following independence in 1991, there was a sharp reduction in the use of fertilizers and manures, resulting in falls in the yields of most major crops. Fertilizer consumption fell sevenfold compared with 1990 (Figure 39), with P and K use falling to very low levels. Wheat yields fell to little more than 2 tonnes/ha.

Recommendations concerning the rates of use on the different crops have been developed by on-going research, and these continue to be updated.

Uzbekistan

Fertilizer consumption in Uzbekistan fell after independence but recovered in part in the second half of the 1990s (Figure 40). Fertilizer consumption fell less than in most other states of the former Soviet Union. This was because state support continued and cereal production was developed to diversify from cotton, whose cultivation amounted to almost monoculture in the Soviet period. According to the scientific institutes, the overall use of mineral fertilizers in Uzbekistan is 20–30 percent below recommended levels.

Chapter 8
Statistics on fertilizer use by crop

Statistics on the rates of fertilizer use on the different crops grown in the individual countries, as reported in the country booklets, are given in Annex 2 of this publication.

This chapter presents an analysis of statistics on fertilizer use by crop given in another source, the FAO statistical publication also titled *Fertilizer use by crop*, the fifth edition of which was issued in 2002 (FAO, 2002). The analysis covers five of the regions under study: Latin America, Africa (sub-Saharan developing), West Asia and North Africa, South Asia and Southeast Asia, as well as a global overview.

LATIN AMERICA

Statistics on fertilizer use by crop are available for 16 countries in Central and South America:

- South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Uruguay and Venezuela.
- Central America: Cuba, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico and Nicaragua.

Table 6 summarizes the relevant crop statistics for these countries, accounting for about 96 percent of the fertilizer consumption for all crops of the region as a whole.

Cereals (maize, wheat, rice and sorghum) account for 41 percent of the fertilizer used. The correlation between N consumption and cereal yields from 1990 to 2002 has an R^2 correlation coefficient of 0.85 (1.0 being a perfect correlation).

Seven crops (maize, soybean, sugar cane, beans, wheat, coffee and rice), plus vegetables and fruits, account for 88 percent of the total fertilizer consumption.

Soybean accounts for a much larger proportion of total fertilizer consumption in South America than in Central America, whereas vegetables and fruits account for a larger proportion in Central America, probably owing to the proximity to the North American market.

A substantial proportion of the fertilizer is used on agricultural cash and commodity crops for the domestic commercial market and export, e.g. coffee, cocoa, soybean, citrus, sugar cane, fruits and vegetables. Latin America accounts for 10 percent of the world's cereal exports. Although statistics are not available, it seems that little fertilizer is used in the subsistence/small-scale farming sector. Beans play a prominent role in the protein supply of the rural population in several countries of Latin America. Cassava/manioc (a little fertilized, soil-exhausting crop) is an important source of calories in the poorer areas.

TABLE 6
Fertilizer use by crop in Latin America

Fertilizer use	South America	Central America	Latin America	South America	Central America	Latin America
Crop	**(1 000 tonnes N + P_2O_5 + K_2O)**			**(%)**		
Cereals						
Wheat	712	108	820	8.6	4.7	7.7
Maize	1 755	858	2 613	21.1	37.4	24.6
Oats	25	0	25	0.3	0	0.2
Rice	608	70	678	7.3	3.0	6.4
Sorghum	78	147	225	0.9	6.4	2.1
Barley & oats	35	12	55	0.5	0.5	0.5
Roots						
Cassava	177	1	178	2.1	0	1.7
Potato	135	33	168	1.6	1.4	1.6
Pulses (beans)	707	156	863	8.5	6.8	8.1
Fruit crops						
Banana/plantain	182	117	299	2.2	5.1	2.8
Citrus	178	40	218	2.1	1.7	2.1
Other fruits	68	12	80	0.8	0.5	0.8
Oil crops						
Groundnut	6	0	6	0.1	0	0.1
Coconut	3	0	3	0	0.1	0
Oil-palm	48	14	62	0.6	0.6	0.6
Rape	3	0	3	0	0	0
Soybean	1 483	7	1 490	17.8	0.3	14.0
Sunflower	63	11	74	0.8	0.5	0.7
Others*	12	0	12	0.1	0.1	0.1
Beverages and sugar	0	0	0	0	0	0
Sugar beet	27	0	27	0.3	0	0.2
Sugar cane	938	285	1 223	11.3	12.4	11.5
Cocoa	84	5	89	1.0	0.2	0.8
Coffee	517	227	744	6.2	9.9	7.0
Fibres: cotton	145	31	176	1.7	1.3	1.7
Vegetables	116	148	264	1.4	6.5	2.5
Tobacco	54	7	61	0.7	0.3	0.6
Grassland	201	4	205	2.4	0.2	1.9
Total listed	8 331	2 293	10 624	100.0	100.0	100.0

* Coconut, groundnut, rapeseed.
Source: FAO, 2002.

SUB-SAHARAN AFRICA

The data in Table 7 represent 11 developing countries for which statistics are available: Ethiopia, Ghana, Guinea, Kenya, Madagascar, Malawi, Mauritania, Nigeria, Togo, United Republic of Tanzania, and Zambia.

In Africa, as in some countries of Asia and Latin America, roots and tubers are an important part of the diet. These crops generally respond well to medium fertilizer application, and in the absence of fertilization they can exhaust the nutrient content of the soils rapidly. Together with oil crops, such as groundnuts, cotton plays a major role as a cash crop for small-scale farmers in Africa.

In the developing countries of SSA, fertilizer use is very low, whether measured in absolute terms or as kilograms per inhabitant. For example, fertilizer consumption in Ghana and the Sudan amounts to about 4 kg/ha, as compared with 106 kg/ha for land devoted to crops in Brazil, and 383 kg/ha in Egypt.

Yields are correspondingly low. On average, between 2001 and 2003, the maize yield in SSA (excluding South Africa) was 1 595 kg/ha, compared with an average yield of about 8 500 kg/ha in North America and Western Europe. The average rice yield was 2 122 kg/ha, compared with an average of about 4 000 kg/ha in Asia and Latin America and almost twice that in North America and Oceania. In SSA, the average yield of maize fell from 1 245 kg/ha in 1994/96 to 1 216 kg/ha in 2001/03, and that of rice from 1 604 to 1 527 kg/ha.

This low productivity in Africa is not inevitable. The response of crops to fertilizers in Africa is comparable with that of other regions. Based on the results of a large number of trials and demonstrations carried out in the context of the FAO Fertilizer Programme (in 87 countries in the case of cereals), the most frequent ranges of productivity indices are shown in Table 8. The productivity index is the amount of additional yield in kilograms per hectare for each kilogram of plant nutrients applied.

The productivity indices for cereals were highest in Asia but Africa showed generally higher indices for maize, pulses and oil crops. For rice and cotton, there were no marked differences.

TABLE 7
Fertilizer use by crop in SSA

Crop	Fertilizer use (1 000 tonnes N + P_2O_5 + K_2O)	Percent
Cereals		
Barley	24.7	4.0
Maize	160.5	26.0
Rice	49.7	8.0
Sorghum & millet	107.8	17.4
Wheat	42.4	6.9
Roots & tubers		
Cassava, taro, yam	32.3	5.3
Potato	18.9	3.1
Pulses	25.5	4.1
Oil crops		
Groundnut	11	1.8
Oil-palm	2.8	0.5
Soybean	2.5	0.4
Fruit crops	17.1	2.8
Beverages and sugar		
Sugar cane	7	1.1
Coffee	17.8	2.9
Tea	9	1.5
Fibres: cotton	35.1	5.7
Vegetables	26.4	4.3
Tobacco	19.8	3.2
Others	7.6	1.2
Total	617.9	100.0

Source: FAO, 2002.

TABLE 8
Fertilizer productivity on selected crops, Africa, Asia and Latin America

Crop	Africa	Asia	Latin America
	Fertilizer productivity index		
Wheat	4–8	8–12	4–8
Rice	8–12	8–12	8–12
Maize	8–12	4–8	4–8
Sorghum	4–8**	8	> 12*
Pulses	4–8	< 4	< 4
Oil crops	8	4–8	4–8*
Cotton	4	< 4*	< 4*

* Brazil only.
** Africa: including millet.
Source: FAO, 1989.

TABLE 9
Fertilizer use by crop in West Asia and North Africa

Crop	Fertilizer use (1 000 tonnes N + P_2O_5 + K_2O)	Percent
Cereals		
Barley	571.9	10.2
Maize	364	6.5
Rice	170.8	3.1
Wheat	2 041.4	36.5
Roots & tubers		
Potato	219.7	3.9
Pulses	0	0
Beans	24.9	0.4
Other pulses	149	2.7
Oil crops		
Groundnut	7.3	0.1
Olive	90.4	1.6
Soybean	8.8	0.2
Sunflower	138.8	2.5
Fruit crops & nuts		
Citrus	166.0	3.0
Other fruit crops	390.7	7.0
Hazelnut	61.4	1.1
Beverages and sugar		
Sugar beet	155.2	2.8
Sugar cane	15.3	0.3
Tea	25	0.4
Fibres: cotton	227.9	4.1
Vegetables	506.4	9.1
Tobacco	3.5	0.1
Fodder	248.3	4.4
Total	5 586.7	100.0

Source: FAO, 2002.

WEST ASIA AND NORTH AFRICA

The data in Table 9 represent nine countries of the region for which statistics are available: Algeria, Egypt, Iran (Islamic Republic of), Jordan, Lebanon, Morocco, Saudi Arabia, Syrian Arab Republic, and Turkey.

In this group of countries, 56 percent of the fertilizer is used on cereals. Egypt's average rate of use of 383 kg of nutrients per hectare is one of the highest in the world, whereas that of Algeria is only 12 kg/ha.

This region has extensive areas with an arid or semi-arid climate. While water is the major limiting factor in dryland agriculture, many crops also suffer from plant nutrient deficiencies and respond well to fertilizers. The problem is that the lower the annual precipitation, the greater the risk of crop failure, and the lower the economic incentive for farmers to invest in inputs such as fertilizers. Moreover, much of this land is marginal and deteriorates rapidly where managed badly.

ASIA

The data in Table 10 represent ten countries for which statistics are available:

- South Asia: Bangladesh, India, Pakistan and Sri Lanka.
- Southeast Asia: Indonesia, Malaysia, Myanmar, Philippines, Thailand and Viet Nam.

In both regions, about 60 percent of fertilizers are used on cereals. In South Asia, crop production is oriented towards supplying domestic demand, whereas Indonesia, Malaysia, Thailand and Viet Nam are also important exporters.

There is a high degree of correlation between the rates of N use and the yields of rice among the countries of South and Southeast Asia covered by this review, with an R^2 of 0.87. However, the correlation between yields and total nutrients, N + P_2O_5 + K_2O, is not significant, with an R^2 of only 0.32. This is reflected in

TABLE 10
Fertilizer use by crop in South Asia and Southeast Asia

Crop	South Asia		Southeast Asia	
	(1 000 tonnes N + P_2O_5 + K_2O)	(%)	(1 000 tonnes N + P_2O_5 + K_2O)	(%)
Cereals				
Maize	448	2.1	628.4	7.6
Millet	285.6	1.4	0	0
Rice	6 584.4	31.6	4 214.3	50.8
Sorghum	487.1	2.3	0	0
Wheat	4 730.2	22.7	0	0
Roots & tubers				
Cassava/yam	15.6	0.1	109.4	1.3
Potato	0	0	75.8	0.9
Pulses	138.4	0.7	0	0
Oil crops				
Coconut	14.9	0.1	73.3	0.9
Groundnut	529.4	2.5	38.4	0.5
Oil-palm	0	0	1 346.5	16.2
Rapeseed	571.1	2.7	0	0
Soybean	0	0	25.0	0.3
Fruit crops	173.3	0.8	369.0	4.5
Beverages and sugar				
Sugar cane	1 292.4	6.2	149.4	1.8
Cocoa	0	0	70.9	0.9
Coffee	0	0	228.1	2.8
Tea	n.a.	n.a.	21.4	0.3
Fibres:				
Cotton	1 623.5	7.8	0	0
Jute	122.4	0.6	126.4	1.5
Vegetables	n.a.	n.a.	402.9	4.9
Rubber	5.9	0	360.6	4.4
Tobacco	1.3	0	49.5	0.6
Others	3 840.0*	18.4	0	0
Total	20 863.5	100.0	8 289.3	100.0

* Including fruit crops, tea, vegetables, forage.
Source: FAO, 2002.

the preference of farmers for N, especially farmers with limited cash or credit availability. However, if the N is not accompanied by the application of the other plant nutrients required by the crop, the soil nutrient reserves of these other nutrients will inevitably become exhausted. The efficiency of N use will diminish progressively, resulting in a substantial economic loss and environmental pollution.

Taiwan Province of China

Taiwan Province of China is characterized by 62 percent of the fertilizers being used on higher value crops (fruits, vegetables, tea, ornamentals and tobacco). An existing trend was accelerated as a result of the opening of its agricultural markets to imports, following entry into the WTO. Rice, produced mostly by a large

TABLE 11
World fertilizer use on arable and permanent crops

Crop group	Surveyed area	N	P_2O_5	K_2O	Total	Percent	Rate
	(million ha)	(million tonnes nutrient)					(kg/ha)
Cereals	601.9	38.2	16.2	7.0	61.4	64.8	102
Oilseeds	102.6	3.5	2.8	2.4	8.7	9.2	85
Vegetables	19.2	2.5	1.2	0.9	4.6	4.9	242
Sugar beet/cane	20.5	2.1	1.1	1.3	4.5	4.7	216
Roots/tubers	20.2	2.1	1.1	1.1	4.3	4.5	212
Fibres	29.6	2.8	1.0	0.4	4.2	4.4	144
Fruits	21.3	1.8	0.8	0.8	3.4	3.6	163
Tobacco, beverages	11.8	0.9	0.4	0.6	1.9	2.0	153
Pulses	42.7	0.7	0.8	0.3	1.8	1.9	39
All	869.8	54.6	25.4	14.8	94.8	100.0	109

TABLE 12
Crops with the highest fertilizer application rates

Rank	Crop	Average rates N + P_2O_5 + K_2O (kg/ha)
1	Banana	479
2	Sugar beet	254
3	Citrus	252
4	Vegetables	242
5	Potato	243
6	Oil-palm	242
7	Sweet potato	225
8	Tobacco	225
9	Tea	225
10	Sugar cane	202

Source: Soh, 1997

number of small-scale farmers (many of them part-time farmers), accounts for about one-quarter of fertilizer use. The average rate of fertilizer application is high at 547 kg/ha.

WORLD

Harris presented a global analysis of fertilizer use by crop at the annual conference of the International Fertilizer Industry Association (IFA), held in Toronto in 1998. This analysis used data published in the third edition of FAO's *Fertilizer use by crop* (published in 1996). Summarized in Table 11, the data covered about two-thirds of the world's area of arable and permanent crops.

In addition to the amounts in Table 11, about 10 million tonnes of nutrients were applied on grassland, fodder and silage.

Most fertilizers were applied on cereals, but the application rates per hectare were substantially higher on several other crops. Table 12 lists the ten crops with the highest fertilization rates.

Among the cereals, wheat received the largest amount of fertilizer but maize had a higher average application rate of application per hectare (Tables 13 and 14).

TABLE 13
Cereals – world areas and fertilizer use

Crop	Survey area	Nutrients applied				Rate
		N	P_2O_5	K_2O	Total	
	(million ha)	(million tonnes)				(kg/ha)
Wheat	177.1	12.7	6.5	1.3	20.5	116
Rice	141.4	10.3	3.9	1.7	15.9	112
Maize	115.1	9.6	3.2	2.8	15.6	136
Barley	36.1	2.3	1.0	0.6	3.9	107
Oats/rye	15.7	0.7	0.3	0.2	1.2	76
Sorghum	24.2	1.0	0.3	0.1	1.4	59
Millet	12.7	0.3	0.1	0	0.4	35
Other cereals*	79.7	1.2	0.9	0.3	2.4	30
All	601.9	38.1	16.2	7.0	61.3	102

* Includes unspecified cereals.

TABLE 14
Regional fertilizer rates and yields for wheat, maize and rice

Region	Wheat		Maize		Rice	
	Fertilizer rate*	Av. yield 1994–96	Fertilizer rate*	Av. yield 1994–96	Fertilizer rate*	Av. yield 1994–96
	(kg/ha)					
N. America	84	2 400	257	7 908	184	6 615
Lat. America	76	2 270	67	2 503	90	3 083
W. Europe	213	5 525	276	8 050	279	5 902
E. Europe	95	3 292	40	3 645	-	-
Former Soviet Union	25	1 447	294	2 538	107	2 578
Africa	63	1 853	55	1 556	19	2 164
Asia	144	2 349	117	3 641	140	3 777
Oceania	n.a.**	1 717	n.a.	6 161	n.a.	7 464
World	116	2 513	136	4 038	134	3 703

* $N + P_2O_5 + K_2O$.
** Australia provided rates grouped for all cereals.

Chapter 9

Economics of fertilizer use

The profitability of fertilizer use is the most important factor in determining the demand for fertilizers by farmers. Farmers will adopt and increase their use of fertilizers only when they perceive that it is in their interest to do so. Even the most humble farmers can observe when the investment of their meagre resources in fertilizers has not proved profitable.

Low farm produce prices constitute the main constraint on increased fertilizer use on food crops. In many SSA countries, the relationship between food crop prices and fertilizer prices is insufficiently attractive to motivate fertilizer use. There is evidence that the demand for fertilizers responds more to changes in crop output prices than to changes in fertilizer prices. However, an increase in basic food prices is a sensitive issue for countries with a large, politically active but low-income urban population.

A commonly used criterion for measuring the attractiveness of fertilizer use is the VCR. This is the ratio between the value of the additional crop yield and the cost of additional fertilizer. Where the VCR is greater than one, fertilizer use is profitable. However, a VCR of at least two, representing a 100-percent return on the money invested in the fertilizer, is regarded as the minimum to justify fertilizer use in view of the inevitable risks of crop production. The greater is the risk, the higher is the desirable VCR.

LATIN AMERICA

Argentina

The increased availability and fall in the price of fertilizers in the early 1990s resulted in a rapid increase in the demand for fertilizers. Subsequent to the 1996/97 season, a progressive decrease in the price of cereals and lack of finance led to stabilization of demand. Between 1996 and 2002, cereal prices to the producer fell by more than 15 percent in absolute value. Fruit crop production integrated with the agro-industry, using a high degree of technology, often receives high rates of fertilizers. The fertilization represents a relatively low proportion of the total cost of production, and the demand for fertilizers is inelastic. However, the deciduous fruit sector is not sufficiently profitable to attract much fertilizer use. All horticultural crops are fertilized, often using high rates, perhaps 700 kg/ha, in addition to manure or compost.

Brazil

The average prices in 2002 for all fertilizers were below those practised in 1993, and considerably lower than those observed in 1996. The final price of fertilizers

to the farmers is now related closely to the prices of imported fertilizers. The quantities of agricultural products needed to buy one tonne of fertilizer were similar in 2002 to those of 1993 in the cases of sugar cane and soybeans, had declined in the case of citrus, and had increased in the cases of cotton, rice, potato, coffee, beans and maize.

Mexico

Economic measures since the mid-1980s have halted the formerly strong increase in fertilizer consumption.

WEST ASIA AND NORTH AFRICA

Algeria

In 1993, less than 1 kg of hard wheat sufficed to buy 1 kg of N or P_2O_5. In 1997, 2 kg were needed, and, in 2004, 3 kg. In 1997, one unit of N cost DA19, and one unit of P_2O_5 cost DA20, or the equivalent of 2 kg of wheat. In 2004, 1 kg of urea, K_2O and P_2O_5 cost DA65, 54 and 72, respectively, or the equivalent of 3.4, 2.8 and 3.8 kg of hard wheat. Farmers benefit from several subsidies designed to promote agricultural production.

Iran (Islamic Republic of)

Fertilizers are subsidized, and the amount of subsidy has risen sharply with the increase in the amount of fertilizer used. There is some abuse of the system.

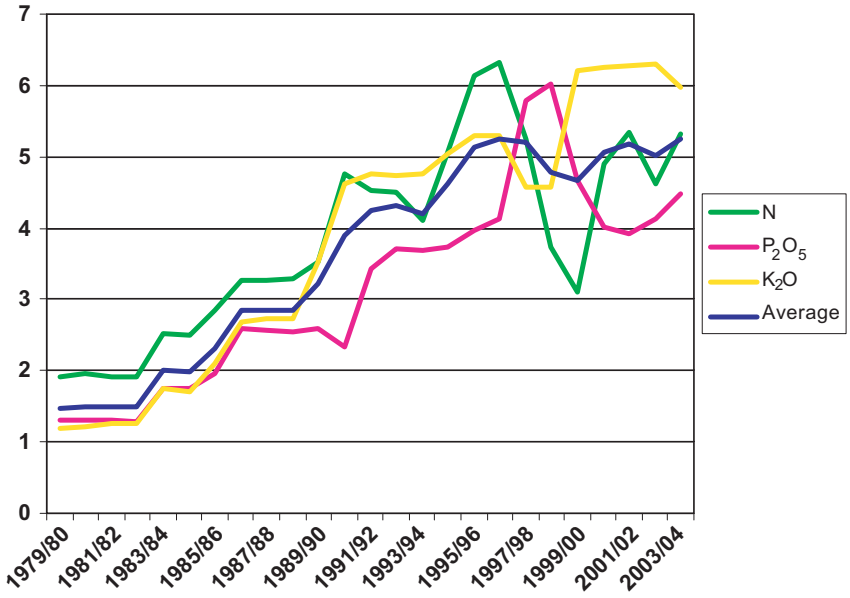
Morocco

The underuse of fertilizers is a consequence of increases in the cost of fertilizers (Figure 41) not being compensated by increases in agricultural product prices. In the period when fertilizers were subsidized, the relationship between the crop price and the fertilizer price remained stable, but it deteriorated once the subsidies began to be reduced. The price of the 24–28–14 compound fertilizer has increased from DH1 070/tonne in 1985 to DH2 570/tonne today (an increase of 140 percent), while the price of soft wheat has increased by only 39 percent.

Syrian Arab Republic

The prices of fertilizers supplied through official channels are fixed by the Government. There is a parallel market with prices depending on the market. Trials have demonstrated that the use of mineral fertilizers is profitable on irrigated crops (VCR > 2); but on rainfed crops, the VCR exceeds 2 only in good or normal seasons. Farmers may rationally choose to reduce rates of application under risky conditions, and post-sowing N fertilization may be adapted to the seasonal circumstances.

FIGURE 41
Development of fertilizer prices, Morocco (Dirham/kg)



Source: DPV/SAFP, 2005.

AFRICA

Ghana

Ghana made considerable economic and social progress following independence but the situation deteriorated after the 1970s. It reached crisis proportions in the first half of the 1980s. An economic recovery programme was launched in 1983. In the case of fertilizers, this involved the progressive removal of subsidies and the liberalization of importation and distribution. From 1992 onwards, the macroeconomic situation deteriorated again. In 1998, 0.7 percent of public expenditure was channelled into agriculture, compared with 3.5 percent in 1990. The retail price of fertilizers increased several times over between the 1980s and the 2000s owing to these economic measures and to depreciation of the national currency.

South Africa

The reduction in support to agriculture led to a substantial reduction in the area of cereals, marginal areas being taken out of cultivation and allowed to revert to natural grazing. Financial constraints and the reduced arable area resulted in a 37-percent fall in the use of P fertilizers, compensated only in part by a gradual but steady increase in N use.

Sudan
The prices of fertilizers have risen steadily in the past decade. The Ministry of Finance subsidizes the irrigation sector.

Zimbabwe
The Government controls the prices of the main fertilizers and crops, and it effectively subsidizes prices for the smallholder sector.

SOUTH ASIA
India
The Government of India fixes minimum support prices for the main crops, controls the farm price of urea, and issues indicative selling prices of other fertilizers. The aim is that the farmers should receive a price for their crops and pay a price for fertilizers that make the use of fertilizers acceptable and remunerative. The subsidy on fertilizers is channelled through the fertilizer production industry, being calculated to ensure a reasonable return to the industry. As fertilizer consumption has increased, this cost has become substantial.

Pakistan
Under the Structural Adjustment Programme and economic reforms, all subsidies on N fertilizer were removed in 1986, followed by their removal on P fertilizers in 1995 and K fertilizers in 1997. Import controls were lifted. In the past seven years, a number of field trials and demonstrations carried out in farmers' fields have shown that balanced fertilizer use remains profitable.

SOUTHEAST ASIA
Indonesia
In the 1990s, financial restrictions resulted in a progressive reduction in support to agriculture, including the removal of fertilizer subsidies in 1993. A financial crisis in 1997 constrained government spending severely. The relationship between crop prices and fertilizer prices deteriorated sharply in 1998/99 as the national currency depreciated. With an improving economic climate and concern about rice production, a partial subsidization of fertilizers was resumed in 2003.

Malaysia
The Government provides subsidies to smallholder farmers (through farmers associations) for the purchase of fertilizers. With a large number of distributors and companies involved in the fertilizer trade, fertilizers are accessible at competitive prices to farmers in all parts of the country. Information is provided to farmers on fertilizer prices, crop prices and, as an indication of the profitability of fertilizer use, on the crop-price to nutrient-price ratios for a selection of fruit and vegetable crops.

NORTHEAST ASIA

Taiwan Province of China

Between 1995 and 1999, the crop/fertilizer price ratio varied from a minimum of 0.6 (for gladiolus) to a maximum of 44 (for hand-picked tea). Fruit crops generally had higher ratios than vegetables, whose frequent overproduction often results in low crop/fertilizer price ratios. Rice production has periodic problems of overproduction. The Government authorizes farmers associations to buy the rice from the farmers, but they are also free to sell rice directly to local private buyers. Fertilizer costs do not represent a large share of total crop production costs in Taiwan Province of China. Nearly all farmers use cash to buy mineral fertilizers from farmers associations.

POLAND, UKRAINE AND UZBEKISTAN

Poland

Until 1990, the distribution of fertilizers was planned, and the effective end prices were much lower than the production costs. However, between 1989 and 1993, the prices of N, P and K fertilizers increased by 30, 36 and K 44 times, respectively. From 1993 to 1997, fertilizer prices increased at a rate comparable with that of inflation. Since then, fertilizer price increases have been below the inflation rate (with the exception of 2001). Economic analyses indicate that the profitability of fertilizer use is fairly good under present circumstances.

Ukraine

The farm cost of fertilizers is subsidized and manufacturers are encouraged to supply stipulated quantities at preferential prices. However, after 1991, state support to agriculture was reduced greatly. Farmers experienced a cost/price squeeze and experienced severe financial problems. The centrally planned system based on production targets was replaced by a market-oriented system. This has required changes in farmers' attitudes and in many aspects of farm management.

Chapter 10
Organic manures

Compared with fertilizers, the nutrient content of manures is low and variable, but they have the advantage of also contributing to soil fertility. The organic matter improves soil structure, reduces soil erosion, helps to store moisture, and provides fixation sites for certain plant nutrients. However, unless manure is well stored and composted, much of the initial N content is lost, polluting the atmosphere. In poor areas, people often use agricultural and livestock residues as a source of energy, and only a small proportion is returned to the land. The manure produced on extensively grazed land is not available for application to the arable crops. Manure is bulky, odorous and difficult and expensive to store, handle and transport. Therefore, the ease of fertilizer use has sometimes led to neglect of the use of organic materials in agriculture. However, in general, surveys show that farmers apply manures and composts where they are available and where there is adequate labour to collect, store and spread them.

LATIN AMERICA

Argentina

In spite of a large production of manure from the livestock sector in Argentina, its use is restricted. As livestock production is largely extensive, the main sources of manure for application in agriculture are from cattle in corrals. Half of the horticultural crops receive manure (poultry manure being particularly appreciated), as do one-quarter of fruit crops.

Brazil

Even taking into account the low plant nutrient content of most organic manures, the large number of animals, especially cattle, could contribute large amounts of nutrients to Brazilian agriculture. However, the commercial use 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, the use of organic manures is uncommon except in the case of small subsistence or family farming systems or of large farms that integrate crop and animal production in confined systems.

Cuba

In view of the limited supply of fertilizers, there is emphasis on making optimal use of available organic materials and composting. Biofertilizers have been tested but their performance has proved variable and their use has declined, apart from that of Rhizobium.

Mexico

The main arable areas, i.e. the areas with highest requirements of plant nutrient inputs, are located in the northwest, producing arable crops and vegetables on larger irrigated farms. However, the manure, especially that from cattle, is produced mostly in the north-central and Gulf of Mexico areas. Most of the manure application is on horticultural crops. Small-scale farmers often apply domestically available organic wastes.

WEST ASIA AND NORTH AFRICA

Algeria

The organic content of Algerian soils is low, and manures are sought after but are not generally available. The livestock production systems and the use of straw as cattle feed do not permit a substantial production of manure that is available for application in agriculture.

Egypt

The incorporation of manure in the soil during seed bed preparation, green manuring and the inclusion of a legume crop in the rotation are traditional practices in Egypt. Field trials have been carried out to study the fertilization values of different organic manures. Recently, there has been a national campaign for recycling agricultural residues by composting.

AFRICA

Ghana

Maize responds well to applications of fertilizers and to a lesser extent to manure. However, in on-farm trials, manure together with fertilizers has sometimes given much larger increases in yield. There is a good demand for poultry manure from the large commercial poultry enterprises, especially from high-value crop producers near towns. Small-scale farmers with livestock apply kraal manure around the homestead. Otherwise, the manure produced is not available where it is required.

South Africa

The application of nutrients in manures represents about 3–4 percent of the total nutrients applied in inorganic fertilizer. Important sources of manure are cattle feedlots and intensive poultry units.

Zimbabwe

A substantial amount of research has been carried out on the value of manure as a fertilizer, and there are recommendations concerning its efficient preparation and use. Cattle manure, especially kraal manure, is a useful source of plant nutrients and soil improvement on the communal lands. However, experiments have shown that manure alone is not sufficient for restoring soil fertility and increasing crops yields. It needs to be supplemented with inorganic fertilizers, particularly N, for optimal yields.

SOUTH ASIA

India

Organic manures make a significant contribution to the supply of plant nutrients and soil fertility. However, a substantial proportion of cattle manure is used for purposes other than fertilization, especially as fuel. The proportion of cattle manure available for fertilizing purposes decreased from 70 percent of the total produced in the early 1970s to 30 percent in the early 1990s.

The use of good quality biofertilizers is increasing in India although inconsistent crop responses remain a constraint. A contribution of 20–30 kg N/ha has been reported from the use of N-fixing biofertilizers. Among biofertilizers, most growth has occurred with phosphate-solubilizing micro-organisms.

Pakistan

Pakistan has a huge livestock population, but it is estimated that about half of the animal wastes are not collected, and that about half of what is collected is used as fuel. About 1.5 million tonnes of nutrients are thought to be applied through organic manure, compared with the 3 million tonnes applied in inorganic fertilizers. About one-third of farmers apply some form of organic plant nutrients on maize and 29 percent do so on sugar cane. On wheat, nearly 20 percent of farmers apply organic sources of plant nutrients. Manure is commonly applied to tobacco, potatoes and fruit crops. As in India, good-quality biofertilizers are promising.

SOUTHEAST ASIA

Indonesia

Livestock wastes, particularly chicken manure and cattle manure, are applied traditionally, especially in the livestock producing areas. There has been considerable progress in understanding the role of organic materials in soil-nutrient availability and the maintenance of soil organic matter. Research institutes have developed models simulating nutrient release patterns according to the quality of the resource and soil and climate conditions.

Malaysia

Improved use of available organic wastes, organic farming and integrated farming systems are being promoted. The use of organic fertilizers is increasing, especially on vegetable farms, for environmental reasons and because of consumer concern about hazards from mineral fertilizers.

NORTHEAST ASIA

Democratic People's Republic of Korea

In order to alleviate the shortage of fertilizers, the Government has sought alternative sources of nutrients. It has promoted the use of organic materials as a source of nutrients but, with reduced animal numbers, the material is often of poor quality. Biofertilizers have been tried but, apart perhaps from use on some vegetable crops, they have not given consistent results.

Taiwan Province of China

The Government is promoting the use of animal wastes and crop residues, and the use of these materials has increased. Green manuring is also becoming more common. The livestock industry produces large quantities of animal wastes. In 1997, the estimated content of N, P_2O_5 and K_2O in these organic manures was equivalent to 52, 96 and 38 percent, respectively, of the nutrients applied as inorganic fertilizers.

POLAND, UKRAINE AND UZBEKISTAN

Poland

The consumption of nutrients in organic materials, mainly manure, has fallen owing to a reduction in the number of animals. Nevertheless, as a consequence of an even larger fall in the consumption of mineral fertilizers, the share of nutrients in manure has increased substantially to about 50 percent of the total amount of nutrients applied in agriculture.

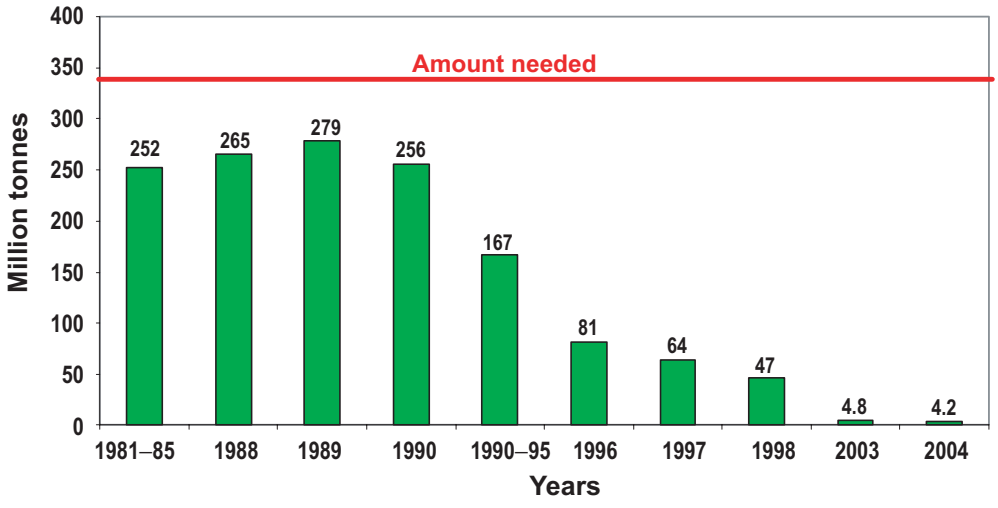
Ukraine

Figure 42 depicts the trend in manure applications compared with the recommended level for 2005.

Uzbekistan

The systematic use of farm manure on the typical Gleysols of Uzbekistan has doubled their humus content (from 0.83 to 1.65 percent). Annually,

FIGURE 42
Manure consumption, Ukraine



Source: SCS, UkrKhimProm.

17 million tonnes of organic manure are produced in Uzbekistan. This is equivalent to an annual application of 80–90 kg of N, 40–45 kg of P_2O_5 and 50 to 60 kg of K per hectare of cropland. The application of manure is well below recommended rates at 5 tonnes/ha of cropland instead of the recommended 20–30 tonnes/ha. The possibilities of storing and applying organic manure are not being exploited fully. The total loss resulting from poor management of manure amounts to 15 million tonnes, which, at 20 tonnes/ha, could be used to fertilize an additional 750 000 ha of cropped land.

Chapter 11

Research, technical developments and information transfer

The funding of agricultural research and advisory services in many developing countries was reduced greatly in the late 1980s and 1990s in the context of economic reforms. Privately funded research on internationally traded commodity crops continued while government-funded research suffered most. Moreover, governments already often accorded a lower priority to research on the problems in the subsistence, small-farming sector in difficult agricultural areas, such as the arid and semi-arid zones. Agricultural research was strong in the centrally planned economies, and the information obtained remains valid and the tradition persists. The problem was and remains the implementation of the findings in agriculture.

The Consultative Group on International Research (CGIAR) was created in 1971 to mobilize the best in agricultural science on behalf of the world's poor and hungry. The CGIAR comprises a network of 16 autonomous international agricultural research centres, which implement research in partnership with national governmental and non-governmental organizations (NGOs), universities and private industry. It is sponsored by the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), the World Bank and FAO.

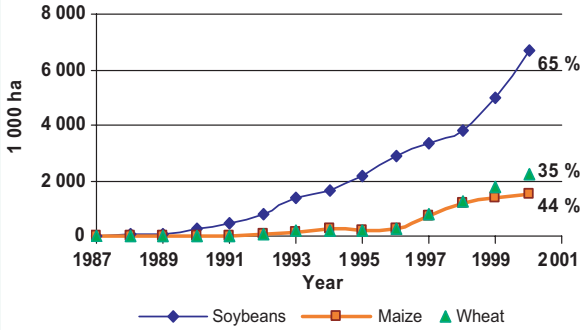
LATIN AMERICA

Argentina

Fertilizer research, development and extension is included in the programme of the Insituto Nacional de Tecnología Agropecuaria (INTA), whose work is based on a network of experimental stations, covering the whole of the country. At present, there are 15 regional centres, 42 experimental stations and 116 extension agencies. The investigations of these institutes concern all the different categories of crops, cereals, meat, fruit, horticultural crops etc. Twenty-eight national universities provide agronomic education in the different regions of the country. As a result, the FERTILIZAR project was established, financed by enterprises involved in the fertilizer market. This project also includes measures to communicate INTA findings on fertilizer use to farmers.

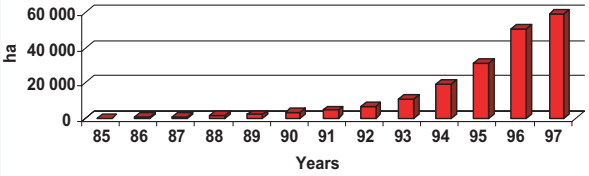
In recent years, two technical innovations, direct seeding and pressurized irrigation, have developed strongly in Argentina (Figures 43 and 44). The irrigation of fruit and horticultural crops with pressurized systems (sprays, drip and similar) has increased at an exponential rate.

FIGURE 43
Development of direct seeding for main crops, Argentina



Note: The percentage values indicate the proportion of the national total.

FIGURE 44
Development of pressurized irrigation, Argentina



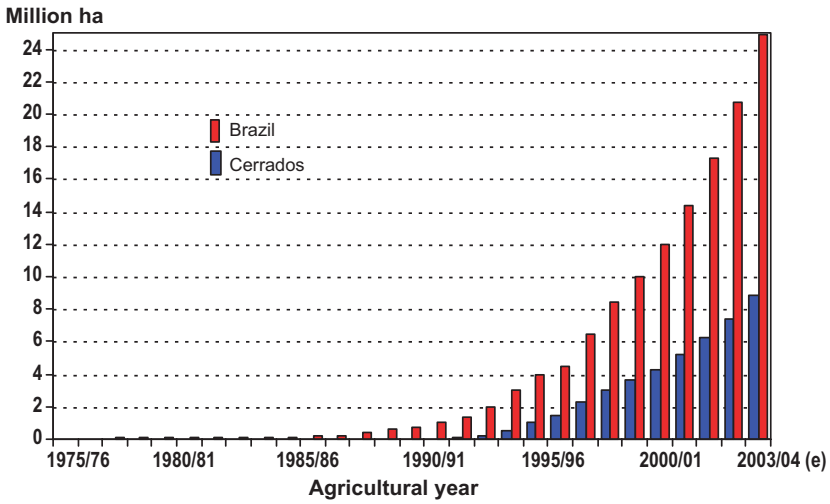
Brazil

Since the 1970s, multidisciplinary agricultural research has permitted a major agricultural development of the "Cerrado" region in the Centre West region (Figure 45). The total area of the region is 207 million ha. This area was once considered marginal for agricultural production. However, it now produces 43 percent of the country's beef cattle, 23 percent of its coffee, 34 percent of its rice, 59 percent of its soybeans and 29 percent of its maize. This has been made possible by the development of fertilization and soil amendment systems.

Cuba

Agricultural research is well established in Cuba. The Agromineral Pedological Service began its activities more than a century ago and is still operating.

FIGURE 45
Development of no-till cropping in the Cerrado region of Brazil



The specialized institutes (for sugar cane, rice, tobacco, citrus, vegetables, etc.) have established critical levels of the main nutrients in the soil, the extraction coefficients, and the rates to be used under different soil and climate conditions. The Sugar Ministry supervises the sugar-cane crop. It has established five soil and plant analysis laboratories and developed specialized decision-making software. The universities also play an important role. For all crops, there are well-established fertilizer application standards based on many field experimental results obtained under different conditions. In many cases, current financial limitations prevent the implementation of best practices.

Mexico

The state extension service is provided by the Agricultural Secretariat and by the Insituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias (INIFAP). In addition to information, the INIFAP provides other related services, such as the evaluation of new fertilizers and analytical laboratories for crops, water and fertilizers. However, there has been progressive disengagement of the State from research and development (R&D). Between 1982 and 2001, investment in agricultural promotion fell by 95 percent. Reduced financing for R&D by governmental institutes has been only partly offset by private enterprises, higher educational institutes and from abroad. Practically all the wholesalers with their own sales outlets offer advice, publications and general information on fertilizer use. Cash crop purchasing agencies also offer similar services. The sugar factories give advice to farmers on fertilizers and provide related services.

WEST ASIA AND NORTH AFRICA

The International Center for Agricultural Research in Dry Areas (ICARDA) is located in the Syrian Arab Republic. The ICARDA is the dominant organization for fertilizer research in the WANA region. It has been working on agricultural production in semi-arid areas for more than two decades.

Egypt

Research is ongoing to determine the most suitable time and proper method of fertilizer application on various crops. Research staff at the Agricultural Research Centre must allocate 30 percent of their time to extension activities.

Iran (Islamic Republic of)

Fertilizer research in the Islamic Republic of Iran is carried out mainly by the Soil and Water Research Institute. In cooperation with the agricultural universities, this institute carries out R&D activities on a wide range of topics concerning the efficient use of plant nutrients.

AFRICA

South Africa

A great deal of research has been carried out to determine fertilizer requirements for crops in South Africa. Systematic field calibration work, with field trails on the response of cereals to applied nutrients, was initiated in the early 1970s by the Department of Agriculture. The South African Sugar Research Institute is responsible for soil fertility research on sugar cane, including the economics of fertilizer use on the crop.

Sudan

The Sudan has a long history of agricultural research. In recent years, this research has been underfunded but it is still substantial. There have been a number of international cooperative programmes concerning the use of fertilizers. However, the consumption statistics do not indicate an effective implementation of the results.

Zimbabwe

A great deal of research on fertilization has been carried out in Zimbabwe. A fertilizer-based soil management package has been developed and promoted for the uncertain-rainfall communal areas. Minimum tillage practices are promoted. Some NGOs organize training programmes for fertilizer dealers in smallholder farming areas.

SOUTH ASIA

India

Agricultural research is strong in India, including research on fertilizer use, and coordinated by the Indian Council of Agricultural Research. Both the central and state departments of agriculture have extension service departments. Several fertilizer companies and cooperatives provide promotional and extension services.

Pakistan

Research on fertilizer use in Pakistan began in 1909 in Punjab. The response of various crops to N fertilizers was published in 1934. In 1978, the Government of Pakistan (with the assistance of FAO) established the National Fertilizer Development Centre (NFDC), which continues to provide a service to agriculture.

SOUTHEAST ASIA

Indonesia

Financial constraints resulted in the termination of the agricultural advisory and support service in the 1990s. This left a gap that the fertilizer industry is trying to fill in part.

Malaysia

A great deal of research is carried out privately in the plantation sector and also in the public sector.

POLAND, UKRAINE AND UZBEKISTAN

Ukraine

Trial results demonstrate that the application of fertilizers provides an average response in the case of wheat of 4–7 kg of grain per kilogram of nutrient supplied, economically significant but less than the response in most Western European countries. There is a need for research findings to be put into practice.

Chapter 12

Constraints on correct fertilization

The various country reports have identified a number of constraints on adequate and efficient fertilizer use. These include:

- an unattractive crop price / fertilizer price relationship, especially for food crops;
- limited purchasing power of small-scale farmers;
- inadequate credit availability for farmers and dealers;
- inadequate infrastructure (roads, etc.);
- inadequate distribution facilities;
- unsatisfactory arrangements for marketing agricultural produce;
- inefficiencies caused by traditional or entrenched but inefficient the farming systems;
- insufficient research, with out-of-date fertilizer-use recommendations;
- poor communication to farmers of known information on correct fertilizer use;
- poorly maintained irrigation systems and inefficient use of irrigation water.

The constraints vary from country to country but all of them tend to be present in the sub-Saharan countries of Africa, apart from South Africa (and, even in this country, there are many constraints in the facilities in the subsistence/smallholder sector).

LATIN AMERICA

Argentina

The availability of credit is an important constraint on fertilization and the adoption of new technology. Agricultural production needs to adapt more to demand in terms of quantity and of quality, and the marketing of produce needs to improve.

Brazil

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

- In the short term, the emphasis should be on reclaiming areas that are being degraded or are already degraded.
- 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.

- 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:
  - 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.
  - Alphabetization and the implementation of family planning, health care and other basic measures that could improve living standards.
  - Advice on how to increase the returns from agricultural products through their sale in local markets.

In most states in Brazil, the quantities of nutrients being removed in crops and lost to the environment exceed the quantities supplied.

Cuba

Limitations imposed by the economic crisis faced by the country, especially since 1990, have had a negative impact on agriculture. Among the causes of the reduced yields are: ageing of plantations; poor management; shortage of fuel; shortage of herbicides; and reductions in water supplies.

Mexico

An important constraint on increased fertilizer consumption in Mexico is the uncertainty concerning the prices of certain crops, particularly maize, as duties on agricultural products traded with North America are reduced progressively. The landholding system is a constraint, particularly in the small farm sector. Another important constraint is a level of agricultural production technology that compares unfavourably with that of farmers in North America. The wheat sector may be in a better position than that of maize as much of the wheat is produced under irrigation. Several intergovernmental and governmental programmes have been implemented to improve agricultural technology and increase the production of higher-value crops. However, the results to date have been disappointing.

WEST ASIA AND NORTH AFRICA

Algeria

The National Agricultural Development Programme (launched in 2000) aims to establish cropping systems suited to the agro-ecological zones of the country. It encourages a reduction in fallow. Especially in cereal areas, P and K are required in order to improve tolerance to drought and favour N uptake.

Egypt
In order to provide for a large and increasing population, while economizing on the scarce natural resources and minimizing adverse environmental impacts, the efficiency of both fertilizer and water use needs to improve. Increasing attention is being paid to the balance between nutrient supply and removal by crops and through losses.

Iran (Islamic Republic of)
In the context of a policy of becoming self-sufficient in wheat, in the past two years the Government has increased spending on providing higher quality seeds, improving machinery services, augmenting fertilizer usage, and enhancing water systems and pest management practices. The guaranteed procurement prices have been raised significantly. The distribution of fertilizers needs to improve, providing the required quantities and types of fertilizer at the time they are needed by the farmers. Balanced and efficient fertilization is a major component of the required intensification, as is an improvement in the efficiency of irrigation.

Morocco
Based on the average cereal yield of 1.2 tonnes/ha and a content of 22 kg of P_2O_5 per tonne of cereal, it is estimated that 26 kg of P_2O_5 per hectare are removed in cereals. This compares with an average annual supply of 8 kg of P_2O_5 per hectare, i.e. a deficit of 69 percent. Half the cost of soil testing is covered by subsidies but the facilities are poorly utilized.

Syrian Arab Republic
The unavailability of fertilizers at the time and in the quantities required by the farmers is an important constraint.

AFRICA
Ghana
Fertilizer use is generally not profitable on food crops, largely because of low farmgate food crop prices and an unfavourable fertilizer / food crop price ratio. The establishment of distribution facilities for the small-scale farming sector is not an attractive activity for entrepreneurs. Road and rail infrastructures are insufficient or inappropriate for the transportation of fertilizers and the harvested product at a reasonable cost. Credit facilities for food crop farmers and fertilizer distributors are either lacking or inadequate. Advisory services for the small-scale farming sector are insufficient. Fertilizer-use recommendations and product selection for food crops are out-of-date. Considerably less than 1 percent of the cultivated land is irrigated and several large irrigation schemes are underutilized.

South Africa
Subsistence/smallholder farming faces constraints relating to limited purchasing power, inadequate infrastructure, limited access to support services, and poorly

functioning output markets. Alleviating food insecurity and poverty will require more effort being directed towards subsistence agriculture and developing smallholder agriculture. Fertilizer application in these sectors could have a significant impact on raising smallholder agricultural productivity, especially in view of declining soil fertility levels.

Sudan

In the context of a 25-year plan, the Government is taking measures to promote the development of agriculture and to improve rural services.

Zimbabwe

Farmers in the smallholder sector need better financial and physical access to fertilizers, guidance concerning their use, and a profitable return. Inadequate investment in soil fertility is leading to problems of soil erosion and land degradation.

SOUTH ASIA

India

Especially when compared with many other developing countries (and given the external financial pressures and the very large number of small-scale farmers), the consistent increase in food crop production and fertilizer use in India in the past three decades is remarkable. Possible improvements include a greater integration of fertilizers with other inputs, improved credit facilities, enhanced coordination between stakeholders, a better balance between the nutrients, and a better match between fertilizers applied and soil and plant requirements. The balance between the fertilizer nutrients applied could be improved. Soil fertility depletion and the increasing deficiencies of certain micronutrients are causes of concern. There are 533 soil-testing laboratories in the country but the rate of utilization is currently only 43 percent. Better use could be made of the findings of the agricultural research institutes. The increased production of cash crops by smaller-scale farmers offers potential.

Pakistan

Growth in food production and, hence, fertilizer use will continue because of investments in irrigation projects and increased food demand. Known best practices are often not implemented. Fertilization practices are far from recommendations, with consequent yield losses, financial waste and environmental contamination. The balance between the fertilizer nutrients could be improved. The availability of quality seed is limited.

SOUTHEAST ASIA

Indonesia

An important constraint on fertilizer use by the small-scale rice farmers is a lack of working capital. They can obtain commercial credit only with difficulty and

are often obliged to sell their crop at harvest (when prices are lowest). When farmers buy fertilizers, they tend to buy only urea. Fertilizer use is imbalanced in favour of N, with a current $N:P_2O_5:K_2O$ ratio of 1:0.11:0.13. There is insufficient soil testing. Financial constraints have resulted in inadequate investment in irrigation, with resulting inefficiencies. Advisory services are inadequate. The official recommendations on fertilizer use on the different crops date from 1984.

Malaysia

The development of the agriculture sector and improvement in the living standards of small-scale farmers are priorities of the Government of Malaysia. The Government's policy towards agriculture focuses on increasing production in order to achieve food self-sufficiency and to develop exports in an efficient and competitive manner. For the crops sector, this effectively means expansion and/or intensification of cultivation, resulting in an increased need for and more efficient use of agricultural inputs, particularly mineral fertilizers.

NORTHEAST ASIA

Democratic People's Republic of Korea

Improving the efficiency of the limited quantities of fertilizers available is a priority. Lack of finance has led to the soil-testing service being run down. Improved varieties, green manuring and improved rotations are being promoted in order to improve efficiency.

Taiwan Province of China

Entry into the WTO and changing dietary tastes provide challenges for the agriculture sector, but adaptation seems to be proceeding satisfactorily.

POLAND, UKRAINE AND UZBEKISTAN

Poland

Land fragmentation into a large number of very small farms, especially in the east of the country, is a constraint on increased production.

Ukraine

According to the Institute of Agronomy and Agrochemistry, the annual need of Ukraine for mineral fertilizers is about 4.4 million tonnes. However, largely because of the limited purchasing power of farmers, the total demand for all kinds of fertilizers averages about 1.2 million tonnes. The structure of agriculture inherited from the centrally planned system is being modified gradually, with increasing private ownership, but problems remain. As a result of the reduction in the application of fertilizers and manures, the quality of the land has deteriorated with negative nutrient balances, with a resulting increase in soil erosion and other forms of land degradation.

Uzbekistan

Inadequate credit facilities, unsatisfactory produce-marketing arrangements and the underutilization of several large irrigation projects are among the identified constraints on increased fertilizer use.

References

FAO. 1989. *Fertilizers and food production: the FAO Fertilizer Programme 1961–1986*. Rome. 111 pp.

FAO. 2002. *Fertilizer use by crop*. Fifth edition. Rome.

Smil, V. 1999. Nitrogen in crop production: An account of global flows. *Glob. Biogeochem. Cyc.*, 13: 647–662.

Smil, V. 2002. Nitrogen and food production: Proteins for human diets. *Ambio*, 31: 126–131.

Soh, K.G. 1997. *Fertilizer use by crops*. IFA Agro-economics Meeting, Beijing, China.

United Nations. 2005. *The Millennium Development Goals Report 2005*.

Annex 1

Country reports

FERTILIZER USE BY CROP – COUNTRY PUBLICATIONS

Algeria (2005) French
Argentina (2004) (English and Spanish)
Brazil (2004)
Cuba (2003)
Democratic People's Republic of Korea (2003)
Egypt (2005)
Ghana (2005)
Indonesia (2005)
India (2006)
Iran (Islamic Republic of) (2005)
Malaysia (2004)
Morocco (2006) (French)
Pakistan (2004)
Poland (2003)
South Africa (2005)
Sudan (2006)
Syrian Arab Republic (2003)
Taiwan Province of China (2002)
Ukraine (2006)
Uzbekistan (2003)
Zimbabwe (2006)

Annex 2
Fertilizer use by crop – country tables

The data in this annex on fertilizer use by crop come from the *Fertilizer use by crop* booklets for the individual countries except in the cases that refer to the FAO publication *Fertilizer use by crop* (FAO, 2002).

ALGERIA

TABLE A2.1
Algeria – fertilization of potatoes in five regions in 2004

Region:	Sétif	Mila	El Oued	Batna	Tébessa
No. of farmers	10	10	13	11	14
Average kg fertilizer/ha	1 200	960	220	720	1 120

In 1998, two-thirds of the fertilizers were used on potatoes and 18 percent each on wheat and fruit crops (FAO, 2002).

ARGENTINA

TABLE A2.2
Argentina – sown area, proportion fertilized and average rates, 2002/03

Crop	Area ('000 ha)	Fertilized (%)	N	P_2O_5	K_2O
			(kg/ha)		
Pampas					
Wheat	6 175	88	40	26	0
Maize	3 057	85	28	19	0
Soybeans	12 219	30	2	6	0
Sunflower	2 290	29	10	7	0
Others	2 006	38	4	3	0
Subtotal	23 747				
Regions					
Sugar cane	204	65	80	2	0
Tobacco	65	95	93	74	117
Deciduous fruits	157	70	103	31	42
Vines	200	75	47	14	14
Citrus	148	70	116	36	55
Horticultural	246	90	72	43	23
Yerba & tea	245	5	3	1	2
Cotton	176	15	5	0	0
Rice (NEA)	85	90	36	19	20
Subtotal	1 526				
Pastures					
Winter cereals	2 006	38	11	8	0
New pastures	1 290	38	2	9	0
Subtotal	3 296				
Total	28 569				

The agricultural production regions may be divided into:

- The Pampas, comprising twelve subregions. The grain crops are grown mainly in this area.
- The regional economies: Nordeste (NEA), Nordoeste (NOA), Cuyo and Comahue.

Three groups of crops are grown in this area: industrial crops, fruit crops and horticultural crops.

TABLE A2.3
Argentina – fertilizer consumption by crop, 2002/03

Crop	N	P_2O_5	K_2O	Total	Percent
	('000 tonnes)				
Pampas					
Wheat	247	163	0	410	46
Maize	87	58	0	145	16
Soybeans	30	73	0	102	11
Sunflower	23	16	0	39	4
Others	8	5	0	14	2
Subtotal	395	315	0	710	78
Regions					
Sugar cane	16	0,4		16	2
Tobacco	6	5	8	19	2
Deciduous fruits	16	5	7	28	3
Vines	9	3	3	15	2
Citrus	17	5	8	30	3
Horticultural	18	11	6	35	4
Yerba & tea	1	0,2	0,4	2	
Cotton	1		0	1	0
Rice (NEA)	3	2	2	7	1
Subtotal	87	32	34	153	16
Pastures					
Winter cereals	22	17	0	39	4
New pastures	3	11	0	14	2
Subtotal	25	28	0	53	6
Total	507	375	34	916	100

TABLE A2.4
Argentina – proportions of farmers using fertilizers on different pampas crops

	1995–97	1999–2001
	Average numbers	
Wheat	64	78
Maize	55	75
Pastures	21	61
Soybean	6	18
Sunflower	n.a.	31

TABLE A2.5
Argentina – fertilizer consumption by crop, non-Pampas regions, 2002/03

Crop	Urea & N	DAP & P	Others & K
		('000 tonnes product)	
Cereals	20 440	10 364	3 226
Oil crops	740	12 231	236
Industrial crops	43 719	11 255	20 375
Fruit	60 056	18 114	40 814
Horticultural	12 793	9 763	12 353
Total	137 749	61 726	77 003

BRAZIL

TABLE A2.6
Brazil – fertilizer consumption by crop and region

Crop	Region	Product	N	P_2O_5	K_2O	Total
			(kg nutrient/ha)			
Cotton	North	0	0	0	0	0
	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	0	0	0	0	0
	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
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

TABLE A2.6
Brazil – fertilizer consumption by crop and region (Continued)

Crop	Region	Product	N	P_2O_5	K_2O	Total
			(kg nutrient/ha)			
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

CUBA

The data in Tables A2.7–2.12 refer to the means between 1998 and 2000 (approximately).

TABLE A2.7
Cuba – sugar cane – proportions fertilized and average rates

Year	N	P_2O_5	K_2O
Proportion receiving (%)	62	57	42
Average rate (kg/ha)	63	44	90

TABLE A2.8
Cuba – crops other than sugar cane – areas and proportions fertilized

Sown area ('000 ha)	Percentage fertilized		
Year total	Winter crop	Year total	Winter crop
445	189	17	33

TABLE A2.9
Cuba – banana – area, fertilizer application and production

Area	KCl	Urea or AN	Production
('000 ha)		(tonnes)	
121	7 565	5 807	514 000

TABLE A2.10
Cuba – potato and rice – area, fertilizer application and yields

Crop	Area	N	P_2O_5	K_2O	Yield
	(ha)		(kg/ha)		(kg)
Rice	95 700	151	53	37	2 831
Potato	13 700	24	18	23	26 300

TABLE A2.11
Cuba – citrus – main fertilizers and amendments used

Fertilizer	Product	N	P_2O_5	K_2O
		(tonnes)		
Ammonium nitrate	9 257	3101		
Triple superphosphate	454		204	
Potassium chloride	1 325			1 395
Potassium nitrate	233	33		103
Potassium sulphate	63			32
Complex (NPK)	114	17	17	17
Urea	467	215		
Total	11 913	3366	221	1 547
Lime (tonnes)	12 733			

On average, between 1999 and 2001, there were 59 525 ha of citrus fruits, with a production of 635 303 tonnes, i.e. 10.7 tonnes/ha.

TABLE A2.12
Cuba – tobacco and vegetables – area, fertilizer application and yields

Crop	Area	N	P_2O_5	K_2O	Yield
	(ha)		(kg/ha)		(kg/ha)
Tobacco	48	116	63	154	796
Onion	2 910	106	33	54	13 100
Pepper	1 941	142	67		12 400
Tomato	26 497	123	50	80	13 500

DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

TABLE A2.13
Democratic People's Republic of Korea – plant nutrient consumption on rice by province, averages 1998–2000

Province	N	P_2O_5	K_2O	Total
		(kg/ha)		
Pyongyang	100	16	2	118
S. Pyongan	87	14	3	104
N. Pyongan	96	16	4	116
Jagang	76	11	1	88
S. Hwanghae	90	21	5	116
N. Hwanghae	72	15	3	90
Kangwon	82	11	1	94
S. Hamgyong	80	8	2	90
N. Hamgyong	83	7	1	91
Ryanggong	50	0	0.5	51
Kaesong	78	20	0.5	98
Nampo	80	19	1	100
Average	81	13	2	96

TABLE A2.14
Democratic People's Republic of Korea – plant nutrient consumption on maize by province, averages 1998–2000

Province	N	P_2O_5	K_2O	Total
		(kg/ha)		
Pyongyang	66	15	16	97
S. Pyongan	61	14	14	89
N. Pyongan	64	14	17	95
Jagang	67	13	10	90
S. Hwanghae	65	18	19	101
N. Hwanghae	50	13	14	76
Kangwon	56	9	5	70
S. Hamgyong	54	11	11	76
N. Hamgyong	51	9	6	67
Ryanggong	68	5	5	78
Kaesong	66	16	15	97
Nampo	71	17	16	104
Average	58	12	11	81

EGYPT

TABLE A2.15
Egypt – fertilizer use by crop in 1997

Crop	Area	Rate			Consumption			
	('000 ha)	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Total
		(kg/ha)			('000 tonnes)			
Maize	814	233	36	0	190	29	0	219
Wheat	1 045	169	36	0	177	37	0	214
Rice	651	119	36	0	78	23	0	101
Tomato	169	298	107	114	50	18	19	87
Cotton	361	54	57	57	19	21	21	61
Clover	666	36	45	0	24	30	0	54
Potato	82	298	143	114	25	12	9	46
Citrus	91	267	62	86	24	6	8	38
Banana	19	1 071	214	229	20	4	4	28
Bean	149	36	71	57	5	11	9	25
Grape	57	209	90	83	12	5	5	22
Others	609				76	25	30	131
Total	4 713				700	221	105	1 026

Source: FAO, 2002.

GHANA

TABLE A2.16
Ghana – crop fertilizer use

Crop	Product	Mean 1990–94	Mean 1995–99
		(tonnes)	
Oil-palm	NPK	12 537	15 198
	Urea	2 010	755
	MOP	2 450	11 476
	Total	16 997 (14%)	27 429 (16%)
Cotton	NPK	26 269	37 479
	AS	30 100	43 085
	Urea	16 080	6 040
	Total	72 449 (62%)	86 604 (52%)
Tobacco	NPK	14 627	17 731
	KNP	580	13 301
	Urea	2 010	755
	Total	17 217 (15%)	31 787 (19%)
Pineapple	NPK	8 358	10 132
	MOP	2 450	11 476
	Total	10 808 (9%)	21 608 (13%)
Total product		117 471	167428
Average annual use	Total	23 494	33 485
Annual use as N + P_2O_5 + K_2O		9 400	14 100

Notes: NPK = compound fertilizers; MOP = Potassium chloride; AS = ammonium sulphate; KNP = potassium nitrate.

INDIA

TABLE A2.17
India – fertilizer use on important crops, 2003/04

Crop	Gross cropped area	Share in fertilizer consumption	Fertilizer consumption			
			N	P_2O_5	K_2O	Total
	(million ha)	(%)	(kg/ha)			
Paddy	44.7	31.8	81.7	24.3	13.1	119.1
Irrigated	24.0	22.2	103.4	32.8	18.8	155.0
Rainfed	20.7	9.6	56.6	14.5	6.5	77.6
Wheat	25.7	21.0	99.6	30.2	6.9	136.7
Irrigated	22.8	19.7	105.6	32.1	7.3	144.9
Rainfed	2.9	1.3	55.7	15.9	4.3	75.9
Sorghum	9.9	2.9	29.2	14.2	4.1	47.5
Irrigated	0.8	0.5	58.5	29.1	10.7	98.3
Rainfed	9.1	2.4	26.9	13.0	3.6	43.6
Pearl millet	9.8	1.7	21.9	5.5	0.8	28.2
Irrigated	0.8	0.4	62.2	13.9	3.4	79.5
Rainfed	9.0	1.3	18.4	4.8	0.6	23.8
Maize	6.6	2.3	41.7	14.7	3.8	60.2
Irrigated	1.5	0.8	59.6	27.7	4.8	92.1
Rainfed	5.1	1.5	36.6	11.0	3.6	51.1
Pigeon pea	3.6	0.8	20.9	13.3	2.0	36.2

TABLE A2.17
India – fertilizer use on important crops, 2003/04 (Continued)

Crop	Gross cropped area (million ha)	Share in fertilizer consumption (%)	Fertilizer consumption			
			N	P_2O_5	K_2O	Total
			(kg/ha)			
Irrigated	0.2	0.1	36.9	20.9	2.2	60.0
Rainfed	3.5	0.7	19.6	12.6	2.0	34.2
Rapeseed & mustard	6.0	3.4	69.1	25.0	2.9	97.0
Irrigated	3.8	2.6	81.7	30.4	4.3	116.5
Rainfed	2.2	0.8	45.9	15.0	0.4	61.3
Groundnut	6.6	2.9	24.4	39.3	12.9	76.6
Irrigated	1.2	0.8	35.3	53.8	28.9	118.0
Rainfed	5.4	2.1	21.9	36.0	9.2	67.2
Sugar cane	4.3	5.4	124.8	44.0	38.3	207.1
Irrigated	4.2	5.3	126.4	45.0	40.6	212.0
Rainfed	0.1	0.1	106.0	32.0	12.4	150.4
Cotton	8.5	6.0	89.5	22.6	4.8	116.8
Irrigated	2.9	2.7	115.7	30.9	7.0	153.5
Rainfed	5.6	3.3	75.8	18.2	3.6	97.7
Jute	0.8	0.2	38.0	11.5	5.0	54.4
Irrigated	0.3	0.1	55.9	22.4	10.2	88.6
Rainfed	0.5	0.1	28.9	6.0	2.3	37.1
Other crops	60.4	21.6	34.5	18.5	7.1	60.1
Irrigated	12.6	13.3	113.5	46.8	16.5	176.7
Rainfed	47.8	8.3	13.6	11.0	4.7	29.3
All crops	187.0	100.0	59.2	22.1	8.5	89.8
Irrigated	75.1	68.5	103.2	35.3	14.5	153.1
Rainfed	111.9	31.5	29.7	13.1	4.5	47.3

INDONESIA

TABLE A2.18
Indonesia – fertilizer use by crop

Year: 2001	Area	Percent fertilized	Rate			Consumption			
	('000 ha)		N	P_2O_5	K_2O	N	P_2O_5	K_2O	Total
		(%)	(kg/ha)			('000 tonnes)			
Rice	11 523	90	105	22	14	1192.6	177.5	64.5	1 434.6
Oil-palm	2 500	80	95	30	75	190.0	52.5	131.3	373.8
Maize	3 402	80	5	25	8	258.6	51.0	13.6	323.2
Vegetables	773	80	145	40	75	89.7	21.6	29.0	140.3
Fruit crops	868	60	135	40	75	70.3	17.4	26.0	113.7
Coffee	900	70	70	30	40	44.1	16.2	14.4	74.7
Cocoa	360	70	95	55	65	23.9	11.9	9.4	45.2
Rubber	2 150	60	35	22	12	45.2	18.9	5.2	69.3
Cassava	1 360	40	65	35	30	34.5	14.2	4.1	53.7
Sugar cane	340	80	90	35	30	24.5	7.1	5.1	36.7
Coconut	2 800	15	45	30	25	18.9	8.4	3.5	30.8
Tobacco	223	80	75	25	85	13.4	3.9	13.3	30.6
Others	1 950					32.6	17.7	8.5	57.9
Others	27 199					2 005.7	400.6	319.4	2 726.6
Total	29 149					2 038.3	418.3	327.9	2 784.5

ISLAMIC REPUBLIC OF IRAN

TABLE A2.19
Islamic Republic of Iran – proportions of annual fertilizer use applied to different crops in 2001/02

Fertilizer	Wheat	Other crops	Orchards	Others
		(%)		
Nitrogen	43	40	15	2
Phosphate	42	41	15	2
Potash	24	59	15	2
Macronutrient	40	45	17	2
Micronutrient	47	47	13	2
Total	41	42	15	2

MALAYSIA

TABLE A2.20
Malaysia – fertilizer use on industrial crops

Crop	N			P_2O_5			K_2O		
	1997	2000	2002	1997	2000	2002	1997	2000	2002
	('000 tonnes)								
Rubber	15.8	9.3	6.2	15.4	9.0	6.1	40.5	23.8	15.9
Oil-palm	236.0	269.6	280.1	265.4	303.3	315.2	368.7	421.3	437.7
Paddy	38.3	38.5	37.7	14.9	15.0	14.7	10.6	10.7	10.5
Coconut	0.8	0.6	0.9	1.0	0.8	1.0	0.8	0.6	0.9
Cocoa	5.2	3.4	2.3	2.4	1.6	1.1	6.2	4.1	2.8
Tobacco	2.7	1.7	2.8	6.8	4.5	7.1	4.3	2.8	4.5

TABLE A2.21
Malaysia – fertilizer use on fruit crops

Crop	N		P_2O_5		K_2O	
	2000	2002	2000	2002	2000	2002
	(tonnes)					
Star fruit	31	24	31	24	44	34
Papaya	57	81	57	81	80	114
Chempedak	428	480	419	470	460	515
Durian	1 472	1928	1 472	1 928	2 265	2 966
Sweet orange	108	125	108	125	154	179
Mango	84	108	84	108	129	166
Mangosteen	146	176	147	176	207	249
Pineapple	2 164	2 340	2 164	2 340	2 564	2 773
Jackfruit	54	86	54	86	77	122
Banana	5 729	7 670	5 729	7 670	7 031	9 413
Rambutan	636	911	636	911	901	1 291
Watermelon	373	424	373	424	262	298

Note: Excluding Sabah.

TABLE A2.22
Malaysia – fertilizer use on vegetable crops

Crop	N		P_2O_5		K_2O	
	2000	2002	2000	2002	2000	2002
	(tonnes)					
Chinese spinach	81	107	81	107	115	152
Lady's fingers	150	124	150	124	212	176
Chili	361	302	361	302	511	428
Long bean	188	181	188	181	266	256
Cucumber	147	131	147	131	208	186
Tomato	282	275	282	275	400	389

Note: Excluding Sabah and Sarawak.

TABLE A2.23
Malaysia – fertilizer use on food crops

Crop	N		P_2O_5		K_2O	
	2000	2002	2000	2002	2000	2002
	(tonnes)					
Maize	529	687	232	301	529	687
Groundnut	10	11	20	22	17	18
Cassava	41	24	20	12	75	43
Sweet potato	99	125	99	125	141	177

Note: Excluding Sabah and Sarawak.

TABLE A2.24
Malaysia – fertilizer use on spice crops

Crop	N		P_2O_5		K_2O	
	2000	2002	2000	2002	2000	2002
	(tonnes)					
Hot chili	10.0	17.0	3.0	4.0	6.0	9.0
Ginger	17.0	31.0	17.0	31.0	24.0	43.0
Pepper	0.4	1 193.0	0.2	537.0	0.6	1 640.0
Total	27.4	1 240.0	20.2	572.0	30.6	1 692.0

MEXICO

TABLE A2.25
Mexico – fertilizer use by crop

Year: 1998	Area	Fertilized	Rate			Consumption			
	('000 ha)	(%)	N	P_2O_5	K_2O	N	P_2O_5	K_2O	Total
			(kg/ha)			('000 tonnes)			
Maize	7 877	75	80	20	10	473	118	59	650
Sorghum	1 953	60	80	30	0	94	35	0	129
Wheat	769	80	130	40	0	80	25	0	105
Sugar cane	631	90	100	45	40	57	26	23	105
Dry beans	2 147	50	60	25	0	64	27	0	91
Vegetables	617	90	80	40	30	43	25	19	87
Fruits	622	60	60	15	40	34	11	23	68
Coffee	679	60	60	40	15	25	16	6	47
Cotton	245	75	120	30	0	22	6	0	28
Total listed						892	289	130	1 310

Source: FAO, 2002.

TABLE A2.26
Mexico – fertilizer use on irrigated crops

Crop	Nutrient rate on irrigated crops only		
	N	P_2O_5	K_2O
	(kg/ha)		
Alfalfa, green	0	90	200
Avocado	150	250	100
Barley, grain	180	100	0
Beans, dry	30	90	0
Citrus	200	60	200
Cocoa	100	70	90
Coconut, copra	60	0.5	140
Coffee	150	150	150
Cotton	120	65	45
Maize, forage	100	40	0
Maize, grain	120	60	0
Mango	60	60	60
Meadows	325	100	150
Oats, forage	70	40	0
Sorghum, grain	120	60	0
Sugar cane	200	80	120
Wheat, grain	120	60	0

Source: A. Gavi, Personal communication, 2000.

MOROCCO

TABLE A2.27
Morocco – crop areas and proportions fertilized, rainfed and irrigated

Crop	Area	Area fertilized	
	('000 ha)	Rainfed	Irrigated
		(%)	
Cereals	5 000	20	90
Leguminous crops	380	20	90
Forage	360	50	100
Citrus	76	-	100
Rosaceae	194	40	80
Olives	548	30	60
Vines	50	60	100
Horticultural, glass	23	-	100
Horticultural, field	209	80	90
Date-palm	48	-	10
Sunflower	70	100	-
Sugar beet	61	-	100
Potato	60	-	100

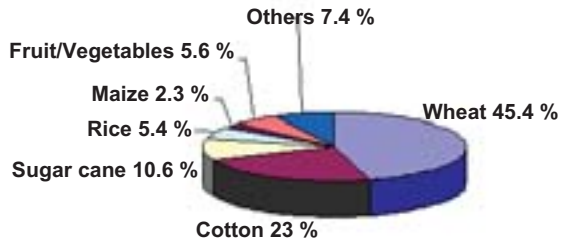
TABLE A2.28
Morocco – fertilizer use by crop, types and rates

Crop	Fertilizers	Average rates			
		Product	N	P_2O_5	K_2O
		(kg/ha)			
Cereals	14–28–14, DAP, urea, AN, AS		60	40	20
Leguminous crops	14–28–14, AS, SP, TSP	200	30	40	20
Forage	14–28–14, DAP, urea, AN	200–300	50	60	30
Citrus	14–28–14, DAP, AS, PS	600	160–180	50	150–180
Rosaceae	14–28–14, DAP, PS, AN	500	70	45	60
Olives	14–28–14, TSP, DAP, AN, AS	300–400	80	20	30
Vines	14–28–14, AS, DAP, PS, AN	600	150	100	120
Horticultural, glass	Straights and NPK with micronutrients	500–600	120	100	140
Horticultural, field	14–28–14, DAP, SP, AN, AS	200–350	70	60	80
Date-palm	14–28–14, AS, TSP	100–200	60	80	50
Sunflower	4–28–14, PS, DAP, AN	450	60	60	100
Sugar beet	AN, AS, DAP	650	160	100	200
Potato	AS, AN, SP, PS	800	30	150	180

Note: AN = ammonium nitrate; AS = ammonium sulphate; SP = single superphosphate; TSP = triple superphosphate; DAP = di-ammonium phosphate; PS = potassium sulphate; straights = containing one nutrient; NPK = compound containing N, P_2O_5 and K_2O.

PAKISTAN

FIGURE A2.1
Pakistan – percentages of total fertilizer nutrient use used on different crops



Note: Percentages of a total of 3 million tonnes of nutrients.

POLAND

TABLE A2.29
Poland – nitrogen rates by major crop and by region, averages 1999–2001

Region or province	Grassland	Wheat	Grain maize	Potatoes	Sugar beet
			(kg N/ha)		
Dolnoslaskie	29	49	62	36	91
Kuj. pomorski	59	98	124	75	182
Lubelskie	34	56	71	41	105
Lubuskie	53	88	112	65	164
Lódzkie	46	77	98	57	145
Malopolski	30	51	64	37	95
Mazowie	35	58	74	43	108
Opolskie	46	77	97	56	143
Podkarpackie	18	31	39	22	57
Podlaskie	39	66	83	48	123
Pomorskie	50	83	105	61	155
Slaskie	32	53	68	39	100
Swietokrzyskie	28	46	59	34	87
Warm. Mazurskie	43	71	90	52	133
Wielkopols	56	93	118	68	173
Zach.-pomorski	54	89	113	66	167
Poland	39	65	82	47	121

TABLE A2.30
Poland – phosphorus rates by major crop and by region, averages 1999–2001

Region or province	Rapeseed	Wheat	Grain maize	Potatoes	Sugar beet
			(kg P_2O_5/ha)		
Dolnoslaskie	32	22	28	16	41
Kuj. pomorski	31	21	27	16	40
Lubelskie	37	25	32	18	47
Lubuskie	42	28	36	21	53
Lódzkie	26	18	223	13	34
Malopolski	41	28	35	20	52
Mazowie	43	29	37	21	55
Opolskie	37	25	32	19	47
Podkarpackie	24	16	21	12	31
Podlaskie	38	26	33	19	49
Pomorskie	61	41	52	30	77
Slaskie	24	16	21	12	31
Swietokrzyskie	28	19	24	14	36
Warm. Mazurskie	29	20	25	14	37
Wielkopols	35	24	30	18	45
Zach.-pomorski	33	23	29	17	43
Poland	33	23	29	17	43

TABLE A2.31
Poland – potash rates by major crop and by region, averages 1999–2000

Region or province	Rapeseed	Wheat	Grain maize	Potatoes	Sugar beet
			(kg K_2O/ha)		
Dolnoslaskie	38	26	33	19	49
Kuj. pomorski	42	29	36	21	53
Lubelskie	43	29	37	21	55
Lubuskie	45	31	39	22	57
Lódzkie	31	21	26	15	39
Malopolski	43	29	37	222	55
Mazowie	52	36	45	26	66
Opolskie	60	41	52	30	77
Podkarpackie	26	18	23	13	33
Podlaskie	41	28	35	20	52
Pomorskie	78	53	67	39	99
Slaskie	35	24	30	17	44
Swietokrzyskie	25	17	22	13	32
Warm. Mazurskie	38	26	33	19	49
Wielkopols	48	33	42	24	62
Zach.-pomorski	55	38	48	28	71
Poland	42	29	36	21	53

SOUTH AFRICA

TABLE A2.32
South Africa – proportions of crops fertilized and average fertilizer rates

Crop/groups	Percent fertilized	N	P_2O_5	K_2O
	(%)		(kg/ha of the fertilized area)	
Field crops				
Maize	95	55	30	6
Wheat	100	30	40	4
Sunflower	85	15	21	2
Soybeans	40	7	25	8
Sugar cane	95	92	57	133
Lucerne	90	15	59	24
Other pastures	30	50	44	7
Industrial crops				
Tobacco	100	38	144	98
Cotton	50	36	22	3
Horticulture/fruit				
Citrus	100	80	35	60
Subtropical fruits/nuts	100	180	57	240
Vines	100	50	36	24
Deciduous fruit	100	110	159	83
Vegetables	100	170	159	120
Potatoes	100	170	160	120

TABLE A2.33
South Africa – fertilizer consumption by crop

Crop/groups	N	P_2O_5	K_2O	Total	Percent
	('000 tonnes)				
Field crops					
Maize	**175**	**73**	**17**	**265**	**41**
Wheat	25	18	3	46	7
Sunflower	8	11	1	20	3
Soybeans	< 1	1	< 1	2	< 1
Sugar cane	38	24	54	116	18
Lucerne	2	10	4	16	2
Other pastures	21	16	3	40	6
Subtotal	269	153	82	505	78
Industrial crops					
Tobacco	0.6	3	2	6	< 1
Cotton	0.5	0.5	0.1	1	< 1
Subtotal	1	4	2	7	1
Horticultural & fruit crops					
Citrus	5	2	4	11	2
Subtropical fruit	9	3	12	24	4
Vines	8	5	4	17	3
Deciduous fruit	6	2	4	12	2
Vegetables	16	15	11	42	6
Potatoes	9	8	6	23	4
Subtotal	53	35	41	129	20
Total	323	192	125	641	100

SUDAN

TABLE A2.34
Sudan – Approximate proportions of fertilizers applied by crop

Crop	Urea	TSP	NPK
		(%)	
Cotton (2N-3N)	about 35	0	0
Wheat (2N-1P)	20–30	60	0
Sorghum (1N)	15–20	0	0
Sugar cane(4N-5N	20	20	0
Vegetables (2N) NPK	10	5	90
Other crops	0	15	10

Source: Approximations from figures of the MOAF, Arab Organization for Agricultural Development (AOAD); FAOSTAT.

SYRIAN ARAB REPUBLIC

TABLE A2.35
Syrian Arab Republic – fertilizer use by crop

Year: 1995	Area	Average rates			Consumption		
	('000 ha)	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Crop		(kg/ha)			('000 tonnes)		
Barley	1 963	30	30	0	58.9	58.9	0
Cotton	204	50	50	0	10.2	10.2	0
Grape	67	35	30	0	2.3	2.0	0
Maize	69	35	30	0	2.4	2.1	0
Olive	422	35	30	0	14.8	12.7	0
Potato	23	35	30	0	0.8	0.7	0.1
Sugar beet	31	60	60	0	1.9	1.9	0
Tomato	20	50	30	0	1.0	0.6	0
Wheat	1 644	30	30	0	49.3	49.3	0
Total	4 443				141.6	138.4	0.1

Source: FAO, 2002.

TAIWAN PROVINCE OF CHINA

TABLE A2.36
Taiwan Province of China – fertilizer use by crop

Year: 1999	Area	Nutrient consumption			
	('000 ha)	N	P_2O_5	K_2O	Total
		('000 tonnes)			
Fruits	142.3	29.1	18.9	28.4	76.5
Vegetables	142.7	36.8	16.1	22.8	75.8
Rice	353.1	41.8	15.3	16.5	73.6
Tea	19.1	8.0	2.7	2.7	13.4
Sugar cane	32.3	6.8	1.4	2.5	10.7
Maize	44.8	3.8	2.7	2.9	9.4
Fodder	46.2	4.0	1.9	1.7	7.6
Ornamentals	3.1	1.1	0.9	1.1	3.1
Groundnut	26.5	0.5	1.2	1.1	2.8
Tobacco	4.2	0.3	0.5	0.8	1.6
Others	12.8	1.1	0.5	0.4	1.8
Total listed	827.1	133.3	62.1	80.9	276.3

Source: FAO, 2002.

UKRAINE

TABLE A2.37
Ukraine – fertilizer use by oblast on winter crops, cereals and green forage, 2004

Oblast	Area ('000 ha)	Fertilizer use (kg/ha)	Percent (%)
AR Crimea	316.7	15.2	82.7
Vinnytska	96.9	18.1	33.9
Volynska	71.8	32.3	65.6
Dnipropetrovska	200.2	25.7	55.2
Donetska	189.5	27.0	64.6
Zhytomyrska	44.7	11.2	27.2
Zakarpatska	10.9	46.3	68.1
Zaporizka	173.1	18.8	48.8
Ivano-Frankivska	22.4	32.5	77.5
Kyyivska	92.7	27.8	40.3
Kirovohradska	98.4	14.7	34.5
Luhanska	137.7	19.6	55.2
Lvivska	40.3	37.7	49.4
Mykolayivska	108.6	10.1	26.7
Odeska	189.6	17.2	32.1
Poltavska	80.9	13.2	29.1
Rivnenska	49.5	29.6	46.1
Sumska	85.5	17.8	40.3
Ternopilska	142.6	43.7	94.8
Kharkivska	135.0	13.3	36.5
Khersonska	75.4	8.8	32.4
Khmelnytska	137.6	22.8	52.8
Cherkaska	94.1	31.3	48.0
Chernivetska	25.2	20.4	60.6
Chernivetska	80.4	17.4	33.8
Total Ukraine	2 699.7	19.6	45.5

UZBEKISTAN

TABLE A2.38
Uzbekistan – main crops: use of mineral fertilizers and yields

Crop/year	Use of mineral fertilizers				Yield (tonnes/ha)
	Total	N	P_2O_5	K_2O	
	('000 tonnes)				
Cotton					
1998	385	290	69	26	2.1
1999	411	299	83	30	2.4
2000	355	291	62	2	2.2
Cereals					
1998	266	214	30	22	2.3
1999	259	221	36	2	2.3
2000	247	201	35	11	2.7

TABLE A2.39
Uzbekistan – main crops: rates of fertilization

Crop/year	Rates			
	Total	N	P_2O_5	K_2O
	(kg/ha)			
Cotton				
1998	253	191	45	17.0
1999	270	197	54	19.0
2000	256	210	45	1.2
Cereals				
1998	203	164	23	16.0
1999	197	169	27	1.3
2000	182	148	26	8.0

LATIN AMERICA

Statistics on fertilizer use by crop are available for 16 countries in Central and South America:

- South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Uruguay and Venezuela.
- Central America: Cuba, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico and Nicaragua.

TABLE A2.40
Latin America – fertilizer use by crop

Fertilizer use	South America	Central America	Latin America	South America	Central America	Latin America
Crop	('000 tonnes N + P_2O_5 + K_2O)			(%)		
Cereals						
Wheat	841.5	237.4	1 078.9	9.0	6.3	8.2
Maize	1 974.2	1 077.6	3 051.8	21.1	28.7	23.3
Rice	824.2	278.5	1 102.7	8.8	7.4	8.4
Sorghum	142.6	211.9	354.5	1.5	5.6	2.7
Barley	97.4	58.3	155.7	1.0	1.6	1.2
Roots: potato	246.5	125.5	372.0	2.6	3.3	2.8
Pulses (beans)	750.7	200.2	950.9	8.0	5.3	7.3
Fruit crops						
Banana	284.9	215.5	500.4	3.0	5.7	3.8
Citrus	187.3	43.9	231.2	2.0	1.2	1.8
Other fruits	13.5	34.6	48.1	0.1	0.9	0.4
Oil crops						
Oil-palm	95.6	61.4	157.0	1.0	1.6	1.2
Soybean	1 509.2	33.9	1 543.1	16.1	0.9	11.8
Beverages & sugar						
Sugar cane	991.8	338.4	1 330.2	10.6	9.0	10.1
Coffee	746.7	453.3	1 200.0	8.0	12.1	9.2
Fibres: Cotton	159.4	46.0	205.4	1.7	1.2	1.6
Vegetables	183.9	194.8	378.7	2.0	5.2	2.9
Grassland	295.4	150.0	445.4	3.2	4.0	3.4
Total listed	9 344.8	3 761.2	13 106.0	100.0	100.0	100.0

Source: FAO, 2002.

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17

FAO FERTILIZER AND PLANT NUTRITION BULLETIN

Fertilizer use by crop

Most of the world's hunger and poverty occurs in rural areas. The use of fertilizers could improve agricultural productivity in these areas. However, many developing countries attach a low priority to the subsistence/smallholder sector, particularly in disadvantaged areas.

This publication summarizes the information in 21 *Fertilizer use by crop* country booklets. Properly applied, fertilizer use is sustainable, not only improving agricultural productivity but also helping to avoid land degradation. Incorrectly used, fertilizers may be harmful. In order to assess the present and potential efficiency of fertilizer use, it is necessary to know, for each agro-ecological region of each country: the crops on which fertilizers are being used; the social and structural context; appropriate fertilizer application rates; the profitability of fertilizer application at these rates; the arrangements for supplying fertilizers to farmers and for marketing their produce; the credit facilities available to farmers and distributors; whether sufficient research on appropriate fertilization techniques is being carried out; and whether the resulting information is reaching the farmers. This publication reviews these various issues, substantiated by examples from each country, and analyses available statistics on fertilizer use by crop.

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