THE FEASIBILITY STUDY REPORT
ON
THE ESTABLISHMENT OF A PHOSPHATE FERTILIZER PLANT
IN
THE REPUBLIC OF PARAGUAY

MARCH, 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Republic of Paraguay, the Government of Japan has decided to conduct a feasibility study on the Establishment of a Phosphate Fertilizer Plant in that country and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Paraguay a study team headed by Mr. Yukihiko Fujiki of Japan Consulting Institute in the period from June to July, 1986.

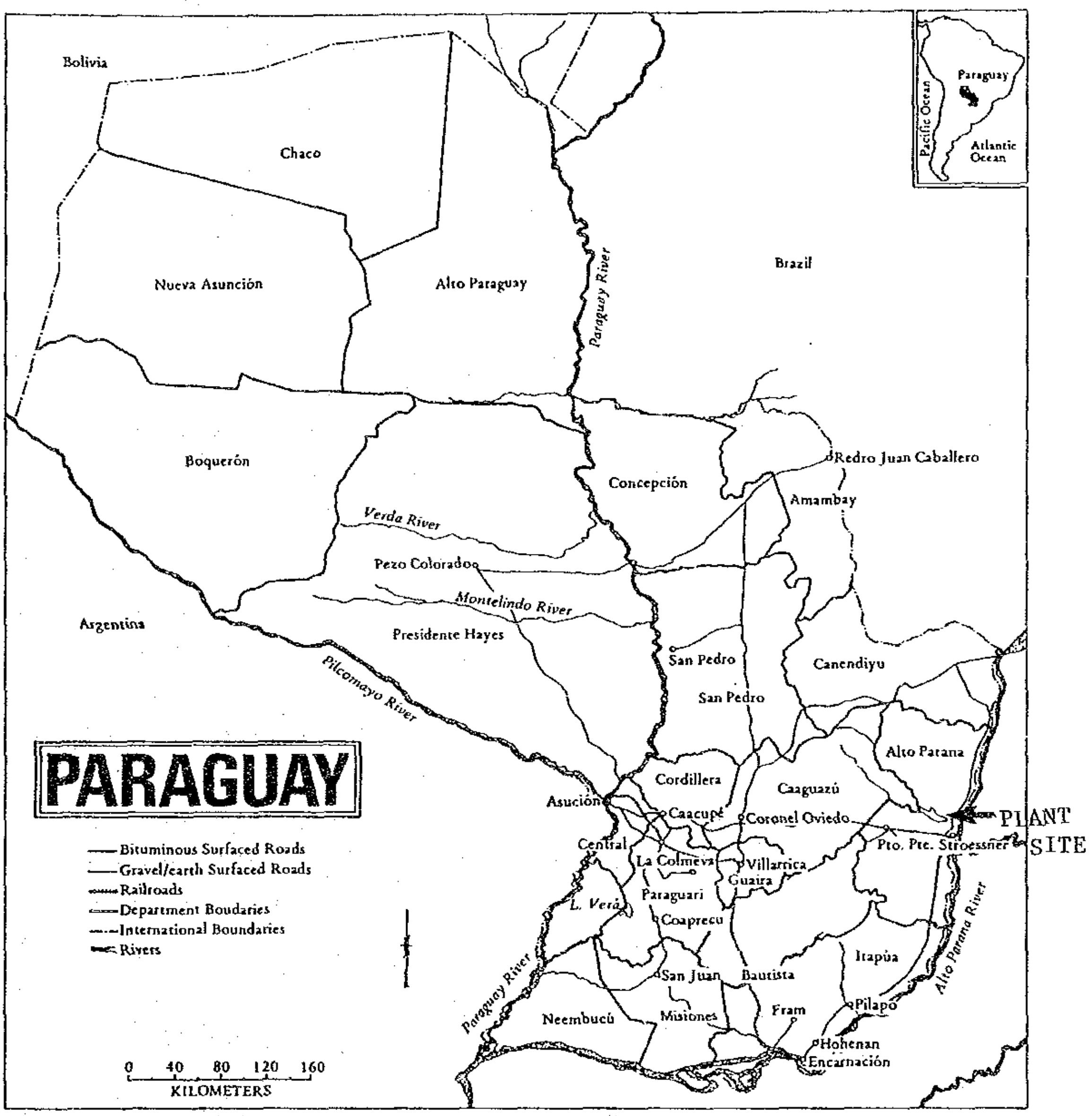
The team had discussions with the officials concerned of the Government of Paraguay and conducted a field survey in the project-related areas. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Government of Paraguay for their close cooperation extended to the team.

Tokyo, March 1987

Keisuke Arita
President
JAPAN INTERNATIONAL COOPERATION AGENCY



Bolivia
Chaco
Nueva Asunción
Alto Paraguay
Paraguay River
Brazil
Boquerón
Concepción
Pedro Juan Caballero
Amambay
Verda River
Pezo Colorado
Montelindo River
Argentina
Presidente Hayes
San Pedro
San Pedro
Canendiyu
Pilcomayo River
Alto Parana
PARAGUAY
Cordillera
Caaguazú
Asución
Caacupé
Coronel Oviedo
PLANT SITE
Central
La Colmena
Villarrica
Guaira
Pto. Pte. Stroessner
Bituminous Surfaced Roads
Gravel/earth Surfaced Roads
Railroads
Department Boudaries
International Boundaries
Rivers
L. Verá
Paraguarí
Coaprecu
Itapúa
Alto Parana River
San Juan
Bautista
Paraguay River
Neembucú
Misiones
Fram
Pilapo
Hohenan
Encarnación
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CHAPTER I INTRODUCTION

1.1 General

1.1.1 Topography and Geography

Paraguay is a landlocked nation centrally located on the South American continent, surrounded by Brazil, Argentina and Bolivia. The national area encompasses 406,752 km^2, about 1.1 times that of Japan.

The Rio Paraguay flows from north to south through the center of the country, essentially dividing it into two distinct regions. The eastern half, composed of a flat section and a hilly section, contains 40% of the land area. The highest point is only 800 m above sea level, the lowest 80 m. The remaining 60% of the national area is west of the river, and is a gently sloping plateau lacking in topographic relief.

The two major rivers in Paraguay are the Rio Paraguay and the Rio Parana, which flow together to form the Rio de la Plata. These rivers put Paraguay in touch by water with the port cities of Buenos Aires (Argentina) and Monte Video (Uruguay).

1.1.2 Climate

The climate of Paraguay is sub-tropical, with distinct summer and winter seasons separated by a brief spring (September-October) and autumn (April-May). The average annual temperature is around 24.5°C.

Winter lasts about 3 months from June through August, and the average temperature is 14.5°C. In the forested parts of Itapua and Alto Parana Departments, however, temperatures sometimes drop below freezing, causing frosts.

Summer is the longest season, spanning approximately 5 months from November through March. Temperatures during this period average

31.5°C, but may reach higher than 40°C. During spring and autumn the daily changes in temperature may be extreme, with fluctuations of over 20 degrees sometimes recorded within a single day.

Generally speaking, the temperature gradients tend to run northeast and southwest, with the highest temperatures in the Chaco region, and the lowest along the southernmost reaches of the Rio Parana.

Average annual precipitation is about 1,500 mm, and more tends to fall in the east than in the west. During tropical downpours known as "torumento" the roads, which lack drainage facilities, turn into rivers. Some areas are then completely cut off from communications. Recently, however, improvements are lessening the damage year by year. On a national scale, there are no clearly distinguishable wet and dry seasons, but precipitation tends to be heavier between February and March, and during November and December.

1.1.3 Population

The population of Paraguay was estimated at 3.6 million for 1984. Population density is exceptionally low, 8.8 people/km^2; but an annual population growth rate of 3.0% is relatively high. Table 1-1-1 illustrates this growth over the past ten years.

Table 1-1-1 Population

Year	Population Total	Growth Rate
1976	2,778,567	3.43
1980	3,167,985	3.24
1981	3,268,489	3.17
1982	3,369,966	3.10
1983	3,472,509	3.04
1984	3,576,281	2.99

Approximately 30% of Paraguay's population lives in urban areas and their surrounding environs. The population of Asuncion, the capital city, is estimated at 490,000. Furthermore, about 97% inhabit the fertile eastern half; while only 100,000 people live in the western section, which accounts for 60% of the land area. Compared to the depopulated western district, more and more people are moving to the urban areas, where land is becoming scarce and expensive.

1.1.4 Economy

In the past, Paraguay's economy has relied chiefly on export of primary products such as meat, soy beans, raw cotton and lumber. Recently, however, the existence of subsurface reserves has been confirmed, such as uranium and oil in northern Chaco along the border with Bolivia. These resources will most likely be exploited in the future.

In the past few years, the government has instituted a number of programs, such as financing and tax incentives, designed to promote and encourage industry. Particular emphasis has been placed on the development of agricultural products for export, and results can be seen in the tremendous growth exhibited by raw cotton and soy beans.

Paraguay is handicapped economically by its landlocked position, which necessitates heavy transportation costs. This, combined with a limited domestic market, has hindered general economic development. However, as can be seen in Table 1-1-2, the GDP at current price base has been growing over the past ten years. Since 1981 the rate of economic growth has averaged in double figures; 26.4% in 1981, 4.0% in 1982, 11.0% in 1983 and 30.8% in 1984, and these high growth rates are due partially to the effect of inflation.

National consumption patterns are also becoming more diversified, and the demand for durable goods is growing especially fast. The general material standards of living are improving.

Table 1-1-2 Gross Domestic Product by Economic Sectors

(million Gs, Current Price)

Year	1976	1980	1981	1982	1983	1984
Agriculture	45,043	101,238	120,086	114,677	127,291	191,082
Livestock	21,313	46,652	55,405	56,506	62,722	81,862
Forestry	7,397	16,402	20,300	18,370	20,390	32,642
Hunting & Fishing	208	845	993	1,092	1,212	1,527
Sub-Total	73,961	165,137	196,784	190,645	211,615	307,113
Mining	529	2,285	2,933	3,142	3,487	4,359
Industry	34,221	92,338	118,469	120,966	134,273	172,003
Construction	9,038	34,317	46,740	49,544	54,994	66,873
Sub-Total	43,788	128,940	168,142	173,652	192,754	243,235
Electricity	3,208	11,238	13,148	15,778	17,514	22,127
Water	527	1,685	2,123	2,342	3,124	3,937
Transport & Communication	8,703	23,784	29,059	31,107	34,529	44,059
Sub-Total	12,438	36,707	44,330	49,227	55,167	70,123
Commerce-Finance	51,502	144,870	188,378	196,158	217,210	272,599
General Government	7,623	19,115	26,678	32,858	36,472	45,225
Housing	5,570	14,993	20,091	22,500	24,976	30,971
Others	19,187	50,697	64,286	72,000	79,920	101,178
Sub-Total	83,882	229,675	299,433	323,516	358,578	449,973
Gross Domestic Product	214,069	560,459	708,689	737,040	818,114	1,070,444

In addition, stabilization of government has accompanied this social and economic development; as witnessed by the numerous government sponsored program, beginning with a five-year national reconstruction plan implemented between 1943 and 1948, and including five national development programs launched between 1965 and 1981. The sixth national development plan was started in 1982.

One result of implementation of these development plans has been the active introduction of foreign currency. Especially conspicious is investment in the agro-business sector, to increase exports of agricultural products; and in the industrial sector, with the purpose of substituting domestically produced products for imports and encouraging exports.

The cost of goods in Paraguay is highly susceptible to influences from outside the country. Economic trends and inflation in Brazil and Argentina, Paraguay's main trading partners, have the greatest effect; followed by the direction of the US dollar. When the value of the Paraguayan guaranie weakens, the cost of goods imported from nations with strong currencies rises.

1.1.5 National Development Plans

Economic development in Paraguay is planned according to two to five year "National Economic and Social Development Plans," which are devised by the Secretaria Tecnica de Planification (STP), located directly under the President. The project offices in STP supervise the projects enacted under these plans.

Although three such national plans were implemented in the 1960's, the first serious development projects came under the plan which lasted from 1971 until 1975. During this period a goal was set at 6% annual growth in GDP, and the actual result was a 6.6% growth. During the next planning period, from 1977 to 1981, a goal of 7.6% growth annually was more than matched by an actual figure of 10.9%.

Between 1980 and 1984, however, total domestic production grew at an average rate of only 1.9% annually, and production in the agricultural sector at the rate of 3.4%.

The five-year national plan currently being constructed, like its predecessors, contains mostly agricultural development projects. The four fundamental directions of the plan are; aid to the small farmer, greater production of export crops, substitution of domestic crops for imports (mostly wheat), and protection of the environment. This plan has not yet been approved by the government, so details such as projected total growth in domestic production have not been made public.

The Paraguayan Ministry of Agriculture and Livestock recognizes the importance of fertilization for increasing production of food resources and for maintenance and recovery of soil condition for planting; and is thus solidly in favor of constructing a domestic fertilizer plant.

1.2 Background and Purpose of Study

1.2.1 Background

Agriculture is the most important industry in Paraguay, accounting for over 30% of the GDP. As a result of traditional extensive farming practices, however, agricultural productivity has decreased because of soil deterioration. In recent years the shift to intensive cropping with active fertilization has been encouraged, but as there is no domestic fertilizer plant, all fertilizer must be imported. This situation results not only in loss of foreign exchange credits, but in an unstable and insufficient supply of fertilizer as well.

On the other hand, Itaipu power station (12.6 million kW), a cooperative project between Paraguay and Brazil, is expected to be completed in the early 1990's. In 1982, the Japan International Cooperation Agency implemented preliminary research to determine how to put this large quantity of electricity to good use in power-intensive industry. As the results of research, the production of fertilizer using this large quantity of electricity was listed as one of possible projects in Paraguay. The Government of Paraguay, then, made a request to the Government of Japan to conduct a feasibility study on the establishment of a phosphate fertilizer plant. Upon receiving the request, the Japan International Cooperation Agency dispatched a pre-survey team in February 1986 and a scope of work for the feasibility study was agreed.

The field survey was conducted from June 16 to July 17, 1986 based on the scope of work. This report has been worked out as the results of the field survey in Paraguay and home study in Japan.

1.2.2 Purpose of Study

The purpose of this study is to assist the Government of Paraguay in its plans to develop a domestic fertilizer industry by analyzing the market, technical, financial and economic aspects in Paraguay.

1.2.3 Project Outline

The products earmarked for manufacture under this project are phosphate fertilizers suitable for the Paraguayan agriculture, and are presently being imported.

The processes to be employed in this study require large amounts of electric power, which is recommended to be supplied directly from Itaipu power station.

Phosphate rock, the major raw material, will be imported from Brazil, and used to produce DAP (29,000 ton/yr), TSP (5,000 ton/yr), NPK 6-30-10 (32,000 ton/yr) and NPK 15-15-15 (4,000 ton/yr) fertilizers.

In addition to these water soluble phosphate fertilizers, the production of FMP (15,000 ton/yr), which is soluble in citric acid, is studied.

Taking into consideration such factors as supply of electric power, transportation of raw materials and marketing of the products, Hernandarias City, close to Itaipu Dam, was chosen as the location for the plant.

CHAPTER II WORLDWIDE SUPPLY AND DEMAND AND PRICE TRENDS FOR PHOSPHATE FERTILIZERS

2.1 World Supply and Demand for Phosphate Fertilizers

Worldwide statistics on supply and demand for phosphate fertilizers are compiled by FAO, and the latest data available is for 1983/84. The following discussions rely primarily on this FAO material.

2.1.1 Production

Table 2-1-1 shows yearly production figures and annual growth rates for phosphate fertilizers. Between 1980/81 and 1981/82, production fell 8.2% from 3.45 million ton P_2O_5 to 3.17 million ton P_2O_5. Afterwards, however, production recovered, and by 1983/84 regained the 1980/81 level with a total of 3.49 million ton P_2O_5.

The worldwide average annual growth rate in the four years between 1979/80 and 1983/84 was a low 1.1%. Among these countries, however, the average growth rate during this period was 8.0%/yr for the developing countries, and in the communist bloc nations 3.5%/yr. These gains were offset by an average decline in production of 2.3%/yr among the developed countries.

From the standpoint of absolute production, however, the developed nations still account for around 50% of the world total and have been playing an important role in phosphate fertilizer production. The developing nations are increasing their share of total production, while the percentage produced by the communist bloc countries stays essentially the same.

The rapid production increase can not be expected reflecting the stagnant consumption and it is considered that the annual growth rate will be as low as 2-3%.

Table 2-1-1 Phosphate Fertilizer Production and Growth Rate

	Production (million t P_2O_5)					Annual Growth Rate (%)				
	1979/80	1980/81	1981/82	1982/83	1983/84	1980/81	1981/82	1982/83	1983/84	1979/80–1983/84
Developed Market Economies	18.29 (54.8%)	18.07 (52.4%)	15.08 (47.6%)	15.17 (47.2%)	16.64 (47.8%)	-1.2	-16.5	0.6	9.7	-2.3
Developing Market Economies	4.21 (12.6%)	5.19 (15.0%)	4.73 (14.9%)	5.10 (15.9%)	5.73 (16.4%)	23.3	-8.9	7.8	12.4	8.0
[in which Latin America]	[1.60]	[1.90]	[1.53]	[1.48]	[1.40]	[18.8]	[-19.5]	[-3.3]	[-5.4]	[-3.3]
Centrally Planned Economies	10.89 (32.6%)	11.25 (32.6%)	11.88 (37.5%)	11.87 (36.9%)	12.48 (35.8%)	3.3	5.6	-0.0	5.1	3.5
World Total	33.39 (100%)	34.51 (100%)	31.69 (100%)	32.14 (100%)	34.85 (100%)	3.4	-8.2	1.4	8.4	1.1

Source: FAO

Table 2-1-2 Phosphate Fertilizer Consumption and Growth Rate

	Consumption (million t P_2O_5)					Annual Growth Rate (%)				
	1979/80	1980/81	1981/82	1982/83	1983/84	1980/81	1981/82	1982/83	1983/84	1979/80-1983/84
Developed Market Economies	14.27 (45.9%)	13.48 (42.8%)	12.68 (41.2%)	12.00 (39.2%)	12.86 (39.1%)	-5.5	-4.6	-5.4	7.2	-2.6
Developing Market Economies	5.94 (19.1%)	6.64 (21.0%)	6.09 (19.8%)	6.41 (21.0%)	6.55 (19.9%)	11.8	-8.3	5.3	2.2	2.5
[in which Latin America]	[2.46]	[2.78]	[2.19]	[2.17]	[1.85]	[13.0]	[-21.2]	[-0.1]	[-14.7]	[-6.9]
Centrally Planned Economies	10.88 (35.0%)	11.43 (36.2%)	12.03 (39.0%)	12.18 (39.8%)	13.44 (41.0%)	5.1	5.2	1.2	10.3	5.4
World Total	31.09 (100%)	31.56 (100%)	30.80 (100%)	30.59 (100%)	32.86 (100%)	1.5	-2.4	-0.7	7.4	1.4

Source: FAO

Table 2-1-3 Consumption of Phosphate Fertilizer per Arable Land and Permanent Crops

(Unit: kg P_2O_5/ha)

	1979	1981	1983
South America	15.6	11.8	9.3
(Paraguay)	1.7	2.5	2.8
(Brazil)	24.4	18.0	13.4
(Argentine)	1.7	1.1	1.4
Asia	13.2	15.4	18.9
North/Central America	22.0	20.4	21.0
Africa	5.3	6.8	6.2
Oceania	28.6	24.8	23.4
World	17.9	21.3	21.0

Source: FAO

2.1.2 Consumption

Annual amounts and growth rates for consumption of phosphate fertilizers are listed in Table 2-1-2. As can be seen, world consumption fell in 1981/82 and 1982/83, but then rose again in 1983/84, reaching a level of 3.29 million ton P_2O_5 in that year. The overall world growth rate for the four year period between 1979/80 and 1983/84 was a low 1.4%. Consumption in the developed nations fell an average of 2.6%/yr, while in the communist bloc and developing nations consumption rose at an average annual rate of 5.4% and 2.5% respectively.

The developed nations share of total world consumption dropped from 46% in 1979/80 to 39% in 1983/84, while the communist bloc nations increased their percentage from 35% to 41% over the same period. The share of the developing nations has remained stable at 20%.

Table 2-1-3 presents, for five world regions, average amounts of phosphate fertilizers used per unit area of arable land and permanent crops. In 1983, the average for South America as a whole was less than half the world figure, and for Paraguay even lower.

2.1.3 Phosphate Fertilizers Trade

Annual volumes and growth rates for export and import of phosphate fertilizers are shown respectively in Table 2-1-4 and Table 2-1-5. In 1983/84, world export volume was 82 million ton P_2O_5, or 1/4 of total production. Of this, 70% was accounted for by the developed nations, who export to other developed nations, developing nations, and communist bloc nations. For developing nations, however, exports are increasing while imports decrease, reflecting a growing importance of phosphate fertilizers in these countries.

On a regional basis, volumes of exports are accounted for by North America (especially the U.S.), Western Europe and North Africa (especially Morocco and Tunisia), in that order. Western European

Table 2-1-4 Exports of Phosphate Fertilizer

	Exports (1,000 t P_2O_5)					Annual Growth Rate (%)				
	1979/80	1980/81	1981/82	1982/83	1984/85	1980/81	1981/82	1982/83	1983/84	1979/80–1983/84
Developed Market Economies	5,442 (80.0%)	6,033 (80.3%)	5,108 (79.2%)	5,372 (76.1%)	6,017 (73.4%)	10.9	-15.3	5.2	12.0	2.5
North America	3,790	4,217	3,565	3,649	4,042					1.6
Western Europe	1,570	1,721	1,453	1,591	1,798					3.4
Oceania	3	5	1	0	0					-
Others	78	90	89	132	176					22.6
Developing Market Economies	872 (12.8%)	973 (13.0%)	875 (13.6%)	1,182 (16.7%)	1,610 (19.6%)	11.6	-10.1	35.1	36.2	16.6
Africa	377	431	584	671	896					24.2
Latin America	71	42	21	15	71					0.0
Near East	100	121	100	208	339					35.7
Far East	283	344	142	262	282					-0.0
Others	40	36	28	27	22					-13.9
Centrally Planned Economies	488 (7.2%)	500 (6.7%)	467 (7.2%)	509 (7.2%)	576 (7.0%)	2.5	-6.6	9.0	13.2	4.2
Asia	2	N.A.	N.A.	1	N.A.					-
Europe/USSR	486	500	467	509	576					4.3
World Total	6,802 (100%)	7,506 (100%)	6,450 (100%)	7,064 (100%)	8,202 (100%)	10.3	-14.1	9.5	16.1	4.8

Source: FAO

Table 2-1-5 Imports of Phosphate Fertilizer

	Imports (1,000 t P_2O_5)					Annual Growth Rate (%)				
	1979/80	1980/81	1981/82	1982/83	1983/84	1980/81	1981/82	1982/83	1983/84	1979/80–1983/84
Developed Market Economies	2,474 (42.4%)	2,323 (35.2%)	2,247 (40.8%)	2,444 (39.5%)	2,604 (38.2%)	-6.1	-3.3	8.8	6.5	1.3
North America	392	359	313	283	260					-9.8
Western Europe	1,956	1,797	1,717	1,814	1,955					-0.0
Oceania	26	50	61	148	203					67.2
Others	101	117	156	199	186					16.5
Developing Market Economies	2,731 (46.8%)	3,361 (51.0%)	2,306 (41.8%)	2,446 (39.5%)	2,458 (36.1%)	23.1	-31.4	6.1	0.5	-2.6
Africa	205	284	293	230	321					11.9
Latin America	973	960	705	713	543					-13.6
Near East	667	855	482	562	752					3.0
Far East	881	1,257	820	936	837					-1.3
Others	5	5	6	4	4					-5.4
Centrally Planned Economies	632 (10.8%)	911 (13.8%)	959 (17.4%)	1,298 (21.0%)	1,742 (25.6%)	44.1	5.3	35.3	34.2	28.8
Asia	176	378	374	633	1,023					55.3
Europe/USSR	456	533	585	665	718					12.0
World Total	5,837 (100%)	6,595 (100%)	5,512 (100%)	6,188 (100%)	6,804 (100%)	13.0	-16.4	12.3	10.0	3.9

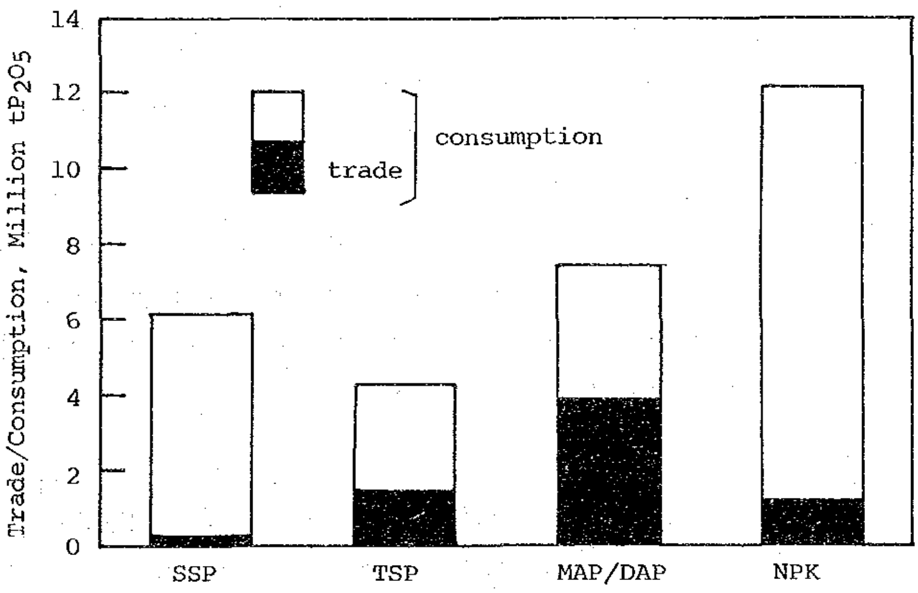
Source: FAO

exports, however, are mostly confined to their own region, and the U.S., Morocco and Tunisia are foremost in exports to other parts of the world.

Imports, on the other hand, are concentrated in Asia, with China, India and Iran importing large volumes of phosphate fertilizers.

2.1.4 Supply and Demand of Phosphate Fertilizers by Product

Figure 2-1-1 graphs world trade and consumption of four types of phosphate fertilizers for 1983.



Source : IFA

Figure 2-1-1 P_2O_5 Trade and Consumption in 1983

NPK accounts for the greatest amount of phosphate fertilizer used in agriculture, but comparatively little of this product is traded internationally. In comparison, exports account for 35% of total TSP consumption, and 50% of MAP/DAP.

Table 2-1-6 lists changes in export levels for various phosphate fertilizer products.

Table 2-1-6 Phosphate Fertilizer Exports by Product

(Unit: 1,000 tP_2O_5)

	1982/83	1983/84	1984/85
Triple superphosphate (TSP)	1,521	1,642	1,886
Other straight P_2O_5	429	405	363
Diammonium phosphate (DAP)	2,535	3,154	4,415
Monoammonium phosphate (MAP)	493	633	548
Other compounds	1,390	1,573	1,585
Total	6,368	7,407	8,797

Source: British Sulfur

As can be seen, DAP and TSP are most important in world trade. In 1984/85, export of these two products accounted for over 70% of the total, 50% for DAP and 21% for TSP.

Export of TSP is dominated by the U.S., Western Europe (Holland, Turkey) and North Africa (Morocco, Tunisia), with these three regions exporting 1.5 million ton P_2O_5, or 83% of the total. The U.S. alone accounts for over 70% of all DAP exports.

2.2 Regional Supply and Demand for Phosphate Fertilizers in Neighboring Countries

2.2.1 Latin America

Table 2-2-1 projects the supply and demand balance for phosphate fertilizers in Latin America until 1989/90.

Table 2-2-1 Latin America: Fertilizer Supply-Demand Balance
1984/85-1989/90 (forecast)

(Unit: 1,000 tP_2O_5)

	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90
Potential P_2O_5 Fertilizer Supply	1,580	1,593	1,752	1,975	1,980	2,049
P_2O_5 Fertilizer Consumption	2,490	2,210	2,390	2,580	2,740	2,900
Surplus (deficit)	(910)	(617)	(638)	(605)	(760)	(851)

Source: British Sulfur

Although Fertimex is scheduled to complete a new phosphoric acid/phosphate fertilizer plant at Lazaro Cardenas in Mexico, the shortage of this fertilizer in Latin America remains unresolved.

Venezuela and Brazil have plans for new phosphate fertilizer plants, but there is little possibility that these projects will be implemented before the early 1990's. Thus the shortage of phosphate fertilizer in Latin America, 600 thousand ton in 1985/86, is expected to reach the 1 million ton mark by 1990. The deficit in supply is made up by imports from places like the U.S. and Morocco, which as was explained in Section 2.1.3, are major exporters of this product.

2.2.2 Brazil

Table 2-2-2 lists supply and demand balance for phosphate fertilizer in Brazil.

Table 2-2-2 Supply and Demand Balance of Phosphate Fertilizer in Brazil

(Unit: tP_2O_5)

	1980/81	1981/82	1982/83	1983/84
Supply				
Production	1,582,478	1,186,600	1,115,200	1,055,200
Import	408,608	135,600	98,100	N.A.
Supply Total	1,991,086	1,322,200	1,213,300	-
Demand				
Consumption	1,988,486	1,318,300	1,210,400	999,700
Export	2,600	3,900	2,900	55,500
Demand Total	1,991,086	1,322,200	1,213,300	1,055,200

Source: FAO

Both production and consumption reached a peak in 1980/81. Since then both have tapered off, and in 1983/84 stood around the million ton P_2O_5 mark. This decline can be contributed to cutbacks in agricultural aid programs due to a downturn in the national economy.

In 1986, however, due to economic recovery measures based on introduction of the new currency system (the Cruzado Plan) in February, and to the new Agricultural Development Plan (1986-1989) which was announced in August and aims to increase crop production, fertilizer consumption is expected to increase by 7-8%.

Under the new Agricultural Development Plan, an agricultural development fund had been set up, which is scheduled to provide 36 billion Cruzado ($2.6 billion) for agricultural investment and financing for farmers by 1987. Fertilizer consumption is expected to rise as a result of this financing.

Tables 2-2-3 through 2-2-6 show the supply and demand balance for SSP, TSP, DAP, and MAP fertilizers respectively. As can be seen, demand is greatest for SSP, with TSP, MAP and DAP following in that order.

Table 2-2-3 Supply and Demand of SSP in Brazil

(Unit: t)

	1980	1981	1982	1983	1984
Supply					
Production	1,660,401	1,427,968	1,144,032	1,277,939	2,015,161
Import	108,531	39,781	48,889	-	7,950
Supply Total	1,768,932	1,467,749	1,192,921	1,277,939	2,023,111
Demand					
Consumption	1,768,917	1,467,749	1,192,901	1,277,760	2,023,061
Export	15	-	20	179	50
Demand Total	1,768,932	1,467,749	1,192,921	1,277,939	2,023,111

Source: Production: SIACESP
Export : CIEF
Import : CACEX

Table 2-2-4 Supply and Demand of TSP in Brazil

(Unit: t)

	1980	1981	1982	1983	1984
Supply					
Production	1,660,440	665,689	551,873	429,497	715,618
Import	291,518	114,556	54,066	-	52,715
Supply Total	1,351,958	780,245	605,939	429,497	768,333
Demand					
Consumption	1,348,938	777,493	599,769	422,052	759,461
Export	3,020	2,752	6,170	7,445	8,872
Demand Total	1,351,958	780,245	605,939	429,497	768,333

Source: Production: SIACESP
Export : CIEF
Import : CACEX

Table 2-2-5 Supply and Demand of DAP in Brazil

(Unit: t)

	1980	1981	1982	1983	1984
Supply					
Production	340,599	222,695	194,596	226,247	183,598
Import	440,464	161,588	88,007	-	94,648
Supply Total	781,063	384,283	282,603	226,247	278,246
Demand					
Consumption	779,256	380,448	274,557	122,937	267,443
Export	1,707	3,835	8,046	103,310	10,803
Demand Total	781,063	384,283	282,603	226,247	278,246

Source: Production: SIACESP
Export : CIEF
Import : CACEX

Table 2-2-6 Supply and Demand of MAP in Brazil

(Unit: t)

	1980	1981	1982	1983	1984
Supply					
Production	468,637	402,044	437,114	374,397	472,678
Import	4,195	1,553	71	3	10
Supply Total	472,832	403,597	437,185	374,400	472,688
Demand					
Consumption	472,832	403,597	431,560	369,355	472,493
Export	-	-	5,625	5,045	195
Demand Total	472,832	403,597	437,185	374,400	472,688

Source: Production: SIACESP
Export : CIEF
Import : CACEX

2.2.3 Argentina

The balance of supply and demand for phosphate fertilizers in Argentina is shown in Table 2-2-7. With the exception of some basic slag, Argentina does not produce this fertilizer, and relies entirely on imports. Consumption decreased in 1981/82, but has recovered since, and stood at 50,000 ton P_2O_5 in 1983/84.

Table 2-2-8 provides estimated consumption of various fertilizers in 1985/86. Figures of 100,000 ton for DAP, 50,000 ton for TSP and 30,000 ton for NPK bring the total for phosphate fertilizers up to 180,000 ton. The data sources of Tables 2-2-7 and 2-2-8 are different, but it can be said that the phosphate fertilizer demand increase is observed from 1983/84 (50 thousand tP_2O_5) to 1985/86 (69 thousand tP_2O_5). It stems from the governmental subsidy made on a part of phosphate fertilizer for wheat in 1985.

Table 2-2-7 Supply and Demand Balance of Phosphate Fertilizer in Argentina (Unit: tP_2O_5)

	1980/81	1981/82	1982/83	1983/84
Supply				
Production*	500	89	100	-
Import	49,515	42,500	55,914	56,100
Supply Total	50,015	42,589	56,014	56,100
Demand				
Consumption	44,164	40,000	48,400	49,700
Export	405	-	-	-
Demand Total	44,569	40,000	48,400	49,700

* : Basic slag Source: FAO

Table 2-2-8 1985/86 Forecast of Fertilizer Consumption

(Unit: t)

Crop	Urea	DAP	TSP	Compound	Ammonia	Ammonium Sulphate
Wheat	150,000	80,000	30,000		5,000	-
Corn	20,000	-	-	-	3,000	-
Sugarcane	40,000	-	-	-	-	-
Fruit	10,000	10,000	-	15,000	-	-
Tobacco	-	-	-	10,000	-	-
Other Crops	50,000	10,000	20,000	5,000	-	20,000
Total (est.)	270,000	100,000	50,000	30,000	8,000	20,000

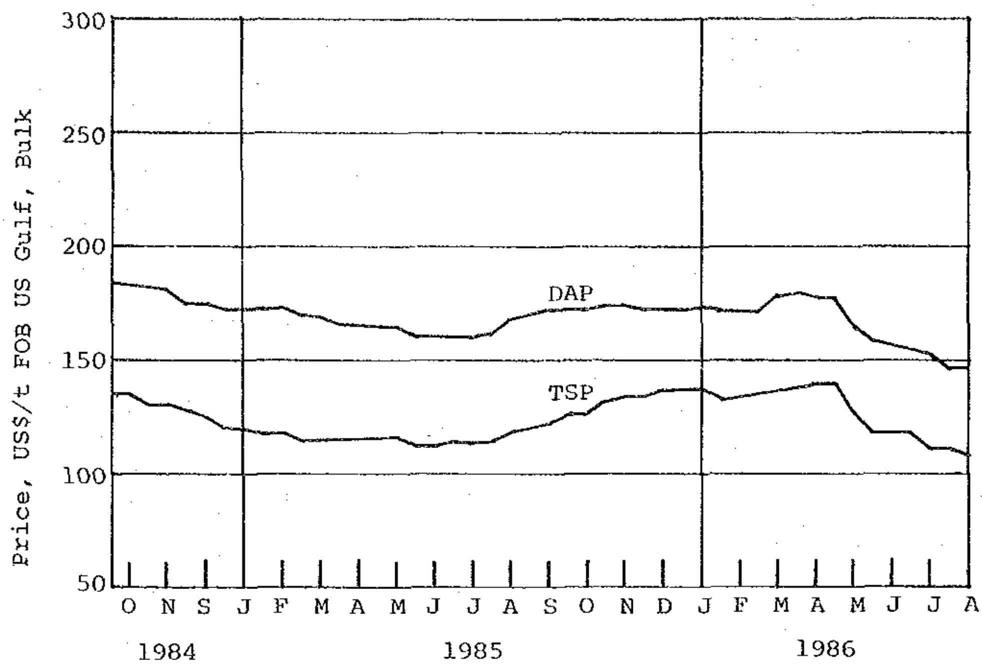
Source: Fertilizer International No.203, 23 May 1985, British Sulfur

2.3 Price Trends for Phosphate Fertilizers on the World Market

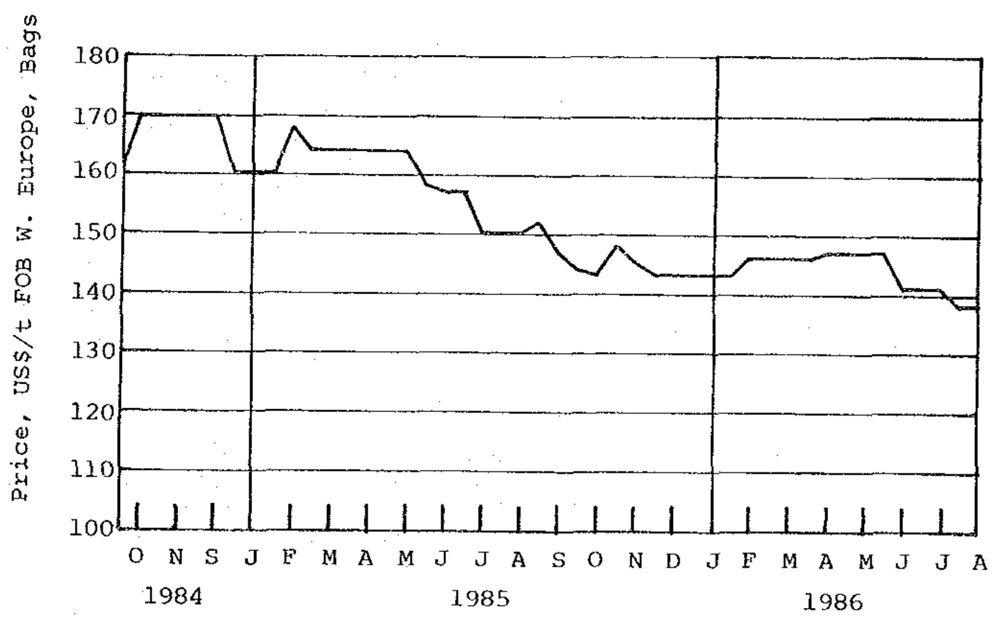
World exports of phosphate fertilizers totalled 8.8 million ton P_2O_5 in 1984/85. On a regional basis, North America was the leader with 49% of the total, followed by Western Europe (22%), Eastern Europe (10%), Asia (10%) and Africa (9%). Almost all of the North American exports originate in the U.S., and it is safe to conclude that the world market prices for phosphate fertilizers are based on U.S. standards.

Numerous types of phosphate fertilizers are produced, but DAP, TSP and NPK are most important on the world market. NPK fertilizers are available under a variety of product names with different compositions, but this discussion will focus on 15-15-15, which is most common on the international market. Figure 2-3-1 charts export price trends for DAP, TSP and 15-15-15 fertilizers.

In July of 1986, the export price for DAP dropped to $149-155/ton FOB bulk U.S. Gulf, the lowest since the oil shock of 1978/79. Prices for bagged fertilizer are a bit higher, ranging from $180 to $190/ton FOB exporting country. These price levels are exceptionally low, and the U.S. estimates that an FOB bulk U.S. Gulf price of $200/ton is necessary to turn a profit. If the export price drops below $135/ton, many plants are expected to close down.



(a) D A P and T S P



(b) 15 - 15 - 15

Figure 2-3-1 Export Price Trends

The reason for these low prices is stagnation in demand. Grain surpluses in countries like the U.S. contribute to the decline in demand for fertilizer. The demand for DAP fertilizer in the U.S. in 1985/86 is down 29% from the previous year, and in Western Europe the decline is estimated at 5%. In addition, oil exporting nations like Mexico, Iran and Indonesia are strapped for foreign reserves because of falling oil prices, and are thus less able to purchase fertilizer from abroad.

Under these difficult conditions, U.S. fertilizer plants are said to be operating at an average of 52-55% of capacity. Construction of new plants can only add to this gap between supply and demand, which shows no signs of dissolving. The recent prices, however, are usually low, and over the long run, can be expected to recover and fluctuate between $180 and $200/ton bulk.

TSP prices are linked to those of DAP, and thus market trends are approximately simialr. FOB U.S. Gulf prices for TSP are now around $109-112/ton for bulk, and $142-168/ton for bagged fertilizer. In the long run, however, if bulk DAP prices return to the $180-200/ton range, TSP can be expected to fluctuate between $140 and $150/ton bulk.

Prices for 15-15-15 fertilizer have not dropped as sharply as those for TSP and DAP, and now stand at $135-140/ton FOB Western Europe for bagged fertilizer.

CHAPTER III PARAGUAYAN AGRICULTURE

3.1 Introduction to Agriculture in Paraguay

3.1.1 Outline of Topography and Soils

Paraguay is one of two landlocked nations in South America, surrounded by Brazil, Argentina and Bolivia. Located between 19°18' and 27°31' south latitude, and 54°45' and 63°27' west longitude, Paraguay occupies a total area of 406,752 km^2. The Rio Paraguay flows from north to south through the center of the country, dividing it into two regions with distinctive difference of geographical features.

The west side of the river, formerly known as the "Chaco" region, accounts for 57% of the total area. Although this region has a flat topography, for reasons of climate and soil conditions, agricultural development has been slow, and the population density remains at a low level. The majority of soils in the Western region are accumulations of sand and clay that originate in the Andes, and are effected by sub-surface salts.

East of the river, there is a region of low hills in the northeast, with elevations of around 500 m, that stretch southward through the center of Eastern Paraguay. Aside from these hills, however, the topography is relatively flat, with altitude decreasing gradually from the northeast towards the southwest. The easternmost section is formed of a plateau called the Parana-Highlands, which drops off rapidly at its eastern edge into the Rio Parana and the boundary with Brazil.

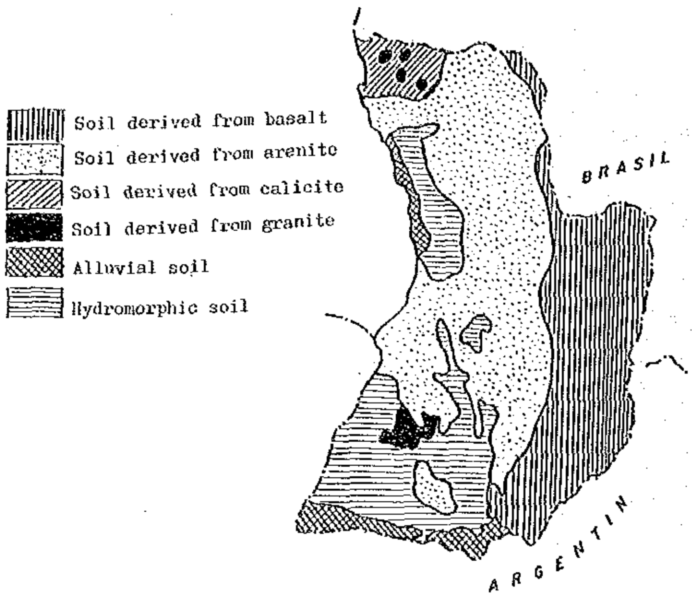


Figure 3-1-1 General Conditions of Soil in Eastern Paraguay

Although a finer analysis would show many different types of soils to be mixed together, generally speaking, soils can be divided into those derived from basalt, arenite, calcite or granite, alluvial soils, and hydromorphic soils.

Basalt derived soils can be found mostly in the Parana-Highlands, and account for about 27% of the Eastern Region by area. The soils are clayish and deep, and show predominantly dark redish color. The water holding capacity of the soils is usually very high. The soils are commonly called "terra-roxa" because of their color, and are known to be highly fertile.

Soils derived from arenite are distributed in a north-south band running through the center of the Eastern Region, and covering 28% of the area. The soils are usually sandy loam, and in color, they range from yellowish red to red with gray tint, and have low fertility and low water holding capacity. None the less, the regions with these soils have been developed for agriculture and grazing since long ago.

Hydromorphic soils are located in the lowlying areas in the southern part of the eastern region, and account for 26% of the area. As they need to be drained before cultivation, these soils have not been used extensively for upland crops, but serve mostly as pastureland.

Alluvial soils form along the banks of the Rio Paraguay and Rio Parana, and are of a gray or brownish gray color. If properly drained and irrigated, these soils are capable of supporting various crops.

3.1.2 Introduction to the Climate

Paraguay, being located inland on the South American continent, has a overall semi-tropical continental climate, but actual conditions vary substantially from region to region. For example, while the "Chaco" region is dry with high temperatures, eastern Paraguay has substantial rainfall with lower temperatures.

Annual mean temperatures are shown in Figure 3-1-2. In the Chaco or western region, these range between 23 and 26°C, and in the Eastern Region 20-23°C. During the summer, however, the Chaco Region gets intensely hot, with monthly mean temperatures surpassing 27°C. The highest recorded temperature is 44.8°C in Alto Chaco. As is characteristic of a continental climate, temperatures in winter tend to run towards the other extreme, dropping below freezing in some places. The lowest temperature on record, measures in Alto Chaco, is -7.0°C. These low temperatures can cause crop damage due to frosts.

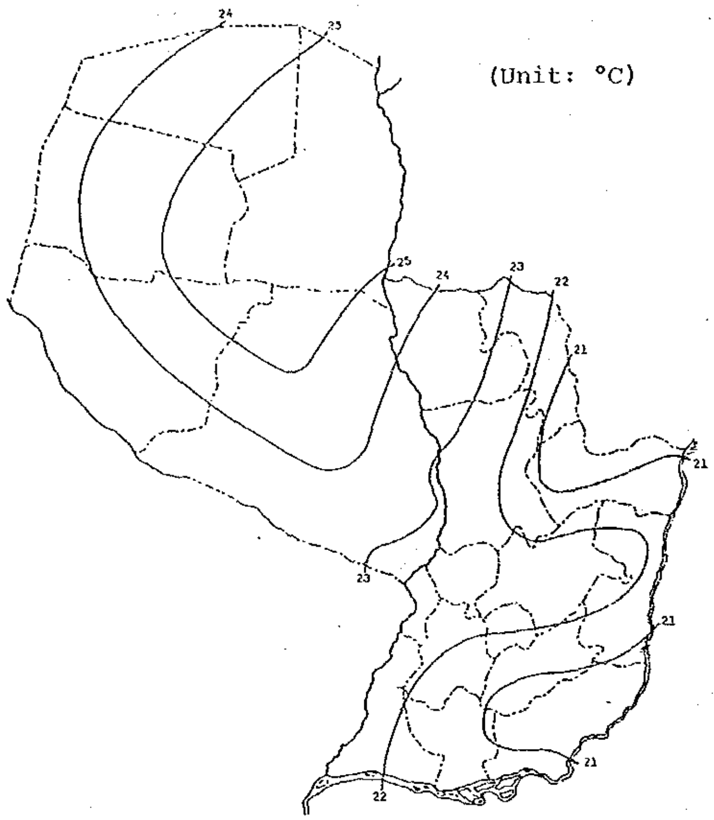
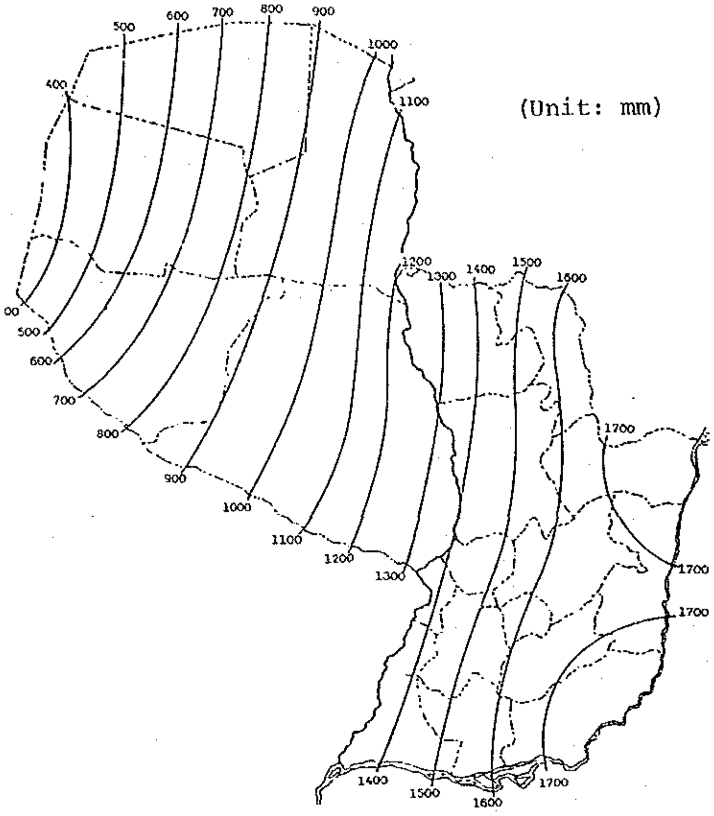


Figure 3-1-2 Annual Mean Temperature in Paraguay
Source: STP

Average annual precipitation is graphed in Figure 3-1-3. The figures decrease as one moves from east to west across the country, with 1,400-1,700 mm falling in eastern Paraguay compared to less than 1,000 mm in most of the Chaco Region. Although Paraguay has no clearly distinguishable dry and wet seasons, rainfall is usually abundant in the summer months from November to March, and relatively scarce during the winter from May to August. This pattern, however, varies greatly from place to place and from year to year.



(Unit: mm)

Figure 3-1-3 Average Annual Precipitation in Paraguay
Source: STP

This unpredictable pattern of precipitation exerts a strong influence on planting and harvesting of crops, and is thus a major problem in agricultural production. In addition, rain often falls in sudden and intense squalls, typical of tropical regions, which also presents problems in terms of soil erosion and crop damage.

3.1.3 Patterns of Land Use and the Agricultural Population

Table 3-1-1 breaks down the agricultural land in Paraguay according to various uses.

Table 3-1-1 Agricultural Land

	Area 1,000 ha	%
Arable Land	2,775	12.6
Temporary Crops	1,208	5.5
Temporary Pasture	918	4.2
Permanent Crops	116	0.5
Fallow Land	553	2.4
Permanent Pasture	10,420	47.5
Forest	8,437	38.5
Others	308	1.4
Total	21,940	100.0

Source: Censo Agropecuario 1981

22 million ha, which amounts to 54% of the national area, is considered as agricultural land. Almost half of this figure, however, is devoted to permanent pasture, and extensive forests remain as well. Thus only 2.8 million ha is left as "arable" land, of which a further 1.2 million ha is used for temporary crops.

Patterns of land use for agriculture and pasture vary immersely from region to region. Table 3-1-2 charts these patterns for each Department. In the Chaco Region, permanent pasture for stock raising and forest predominate, and arable land is scarce; while in the Eastern Region, arable land is relatively extensive.

Even within the Eastern Region, however, the percentage of arable land varies Department to Department. In Guaira, Caaguazu, Alto Parana and Itapua Departments the percentage of arable land to total land is high; and Amambay, Alto Parana, Caaguazu, San Pedro and Itapua are high in terms of total area of arable land. These Departments thus contribute most heavily to agricultural production in Paraguay.

Table 3-1-2 Agricultural Land in Each Department (1,000 ha)

Department	Arable Land	Permanent Pasture	Forest and Others	Total
Concepcion	172	1,166	370	1,708
San Pedro	311	527	650	1,488
Cordillera	97	173	34	304
Guaira	91	107	56	254
Caaguazu	262	165	304	731
Caazapa	88	327	122	537
Itapua	415	260	308	983
Misiones	61	629	35	725
Paraguari	124	422	74	620
Alto Parana	249	34	360	643
Central	34	106	23	163
Neembucu	37	687	104	828
Amambay	229	324	268	821
Canendiyu	153	61	309	523
East Region	2,323	4,988	3,017	10,328
Pte. Hayes	169	3,571	2,338	6,078
Alto Paraguay	26	1,231	2,128	3,385
Chaco	2	306	220	528
Nueva Asuncion	4	11	127	142
Boqueron	251	313	915	1,479
West Region	452	5,432	5,728	11,612
Total	2,775	10,420	8,745	21,940

Source: Censo Agropecuario 1981

In addition, research by the STP Regional Planning Office in 1984 estimates total potential arable land in Paraguay at 6.75 million ha, with large tracts of undeveloped arable land remaining in Caaguazu, Canendiyu. Itapua, San Pedro and Alto Parana Departments. These figures are indicators of the potential for agricultural growth in Paraguay.

The population of Paraguay is relatively small compared to the national area. Although less than 3 million in the 1970's, a yearly growth rate of approximately 3% has been sustained, and the population at present is estimated at around 3.5 million. These people are not distributed evenly over the landscape. The Chaco Region, with 57% of the national area, has only 2% of the population. Within the Eastern Region, approximately 1 million people are crammed into Asuncion and its surrounding environs, Central Department, while the remaining 2 million are distributed throughout the other 13 Departments.

Table 3-1-3 estimates the agricultural population for Paraguay. Although 1.7 million people are considered as part of the agricultural population, an estimated 0.55 million, or 47% of the economically active population, are actually engaged in farming.

Table 3-1-3 Agricultural Population and Economically Active Population (in thousand)

Year	Total Population	Agricultural Population	Economically Active Population		
			Total	in Agriculture	% in Agriculture
1970	2,290	1,205	725	382	52.6
1975	2,686	1,364	857	435	50.8
1980	3,168	1,549	1,019	498	48.9
1983	3,472	1,658	1,124	537	47.8
1984	3,576	1,695	1,161	550	47.4

Source: FAO Production Yearbook 1984

3.1.4 Patterns of Land Ownership and Farm Management

In Table 3-1-4, the number of farms and total area are displayed according to size of individual holdings. Generally speaking, there is a wide range in the size of farms, with large scale operations owning more than 20,000 ha, and small scale farmers less than 1 ha.

Although the 10-20 ha class had the greatest number of farms, 55% of the total are less than 10 ha. The area encompassed by these 55%, however, amounts to only 2.2% of the total farming area. Holdings larger than 10,000 ha, on the other hand, although only 0.2% by number of farms, control 51% of the total area.

Table 3-1-4 Land Holding by Farmer

Land Size	Number of Farm	%	Area 1,000 ha	%
< 1 ha	14,190	5.9	5.7	0.0
1 - 2	21,781	9.0	26.0	0.1
2 - 5	46,405	19.2	137.4	0.6
5 - 10	49,511	20.5	322.0	1.5
10 - 20	56,476	23.4	694.2	3.2
20 - 50	36,007	14.9	942.4	4.3
50 - 100	7,008	2.9	465.4	2.1
100 - 200	4,012	1.6	538.2	2.5
200 - 500	2,920	1.2	858.8	3.9
500 - 1,000	1,053	0.4	707.0	3.2
1,000 - 2,500	1,117	0.4	1,720.3	7.9
2,500 - 5,000	482	0.2	1,673.7	7.6
5,000 - 10,000	366	0.2	2,522.4	11.5
10,000 - 20,000	177	0.1	2,324.4	10.6
> 20,000	147	0.1	9,002.6	41.0
Total	241,652	100.0	21,940.5	100.0

Source: Censo Agropecuario 1981

This uneven distribution of agricultural land is steadily being corrected, and the number of medium-sized farms are gradually increasing as the large scale operations split up. Large scale holdings are particularly numerous in the Chaco Region, but most of these are ranches managed on a relatively loose basis. In contrast, small farms are worked carefully by hand at what essentially amounts to a subsistence level, with farmers often engaged as seasonal laborers in other industries.

Even in the Eastern Region, which is the heart of agricultural production in Paraguay, there is considerable variation in the size of farm holdings. As an example, Table 3-1-5 analyzes holdings for two Departments, Cordillera and Caazapa, that have a long history of agriculture; and two Departments, Itapua and Alto Parana, that have been developed for agriculture only recently.

As can be seen from the Table, while farms of less than 5 ha predominate in the older regions, larger farms are the rule in the newly developed areas. Holdings over 500 ha, virtually absent in Cordillera and Caazapa, are conspicuous in the newly developed Departments, especially in Alto Parana.

These regional differences in the size of farm holdings are also reflected in crop patterns. Soy beans, which have expanded rapidly in recent years, are grown mostly on farms of 50-200 ha in Itapua and Alto Parana Departments. Cotton, on the other hand, is grown primarily on small holdings of less than 10 ha in the historic farmland areas.

Table 3-1-5 Difference of Land Holding on Four Departments

Arable Land Size	Cordillera		Caazapa		Itapua		Alto Parana	
	Farm Number	%	Farm Number	%	Farm Number	%	Farm Number	%
< 1 ha	2,536	13.7	989	6.6	1,095	3.8	522	4.0
1-2	3,848	20.9	2,138	14.2	2,032	7.0	779	6.0
2-5	6,954	37.7	5,583	37.1	8,637	29.7	2,799	21.4
5-10	3,561	19.3	4,341	28.8	9,545	32.8	3,711	28.4
10-20	1,135	6.2	1,695	11.3	4,554	15.7	3,037	23.2
20-50	339	1.8	260	1.7	1,725	5.9	1,518	11.6
50-100	43	0.2	30	0.2	867	3.0	361	2.8
100-200	12	0.1	13	0.1	535	1.8	235	1.8
200-500	11	0.1	8	0.0	73	0.3	82	0.6
500-1,000	-	-	1	0.0	7	0.0	10	0.1
1,000-2,500	3	0.0	-	-	1	0.0	9	0.1
2,500-5,000	-	-	-	-	1	0.0	1	0.0
> 5,000	-	-	-	-	-	-	2	0.0
Total	18,442	100.0	15,058	100.0	29,072	100.0	13,066	100.0

Source: Censo Agropecuario 1981

3.1.5 Crop Production

Due to the climatic conditions discussed earlier, various crops can be grown in Paraguay. Table 3-1-6 lists these crops in order of cultivated area in 1984. Although there are various kinds of crops, those with significant amounts of cultivated area are relatively few. Crops with more than 100,000 ha number only five, and together account for 86% of the total area under cultivation.

Table 3-1-7 lists cultivated area, production and yield for these principal crops over the past five years; and Figure 3-1-4 graphs changes in cultivated area since 1975. Soybeans are now cultivated over nearly 750,000 ha, and account for more than 1 million ton in production. This level places Paraguay below the U.S., Brazil, China and Argentina as a major world producer of soybeans.

Table 3-1-6 Production of Various Crops in Paraguay (1984)

Crop	Cultivation Area 1,000 ha	Production 1,000 t	Yield kg/ha
Soybean	746.8	1,172.5	1,631
Maize	481.5	800.8	1,702
Cotton	400.7	469.3	1,216
Cassava	202.2	2,633.3	14,154
Wheat	134.4	184.6	1,477
Porotobean	59.6	49.5	866
Sugarcane	56.0	2,726.5	49,000
Groundnut	39.9	44.2	1,130
Castorbean	33.8	37.4	1,131
Irrigated rice	21.0	74.1	3,598
Upland rice	19.0	22.1	1,202
Tobacco	16.3	24.9	1,579
Sunflower	14.1	15.2	1,100
Sweet potato	13.1	100.2	7,748
Peppermint	12.2	52.1	4,285
Habillabean	10.5	9.3	891
Onion	4.7	18.9	4,100
Sweet pepper	3.6	17.7	4,852
Green peas	2.5	2.1	885
Tomato	2.4	59.6	24,754
Garlic	1.0	1.9	1,972
Sorghum	1.0	11.0	1,196
Potato	0.9	5.9	6,500
Carrot	0.9	6.0	7,100

Source: Censo y Estadisticas Agropecuarias/MAG

Table 3-1-7 Cultivation Area,[*1], Production[*2] and Yield[*3] of Principal Crops in Paraguay

Crop		1980/81	1981/82	1982/83	1983/84	1984/85
Soybean	Area	397	533	650	679	747
	Production	769	757	850	975	1,172
	Yield	1.94	1.51	1.50	1.53	1.63
Maize	Area	263	375	419	445	482
	Production	413	553	619	730	801
	Yield	1.57	1.50	1.55	1.68	1.70
Cotton	Area	243	290	298	302	401
	Production	317	260	236	320	469
	Yield	1.31	1.01	0.96	1.09	1.22
Cassava	Area	178	183	186	191	202
	Production	2,140	2,401	2,513	2,553	2,633
	Yield	12.0	13.0	14.0	14.0	14.2
Wheat	Area	49	70	80	125	134
	Production	61	84	99	139	185
	Yield	1.24	1.20	1.24	1.32	1.48

*1 Unit: 1,000 ha
*2 Unit: 1,000 t
*3 Unit: t/ha
Source: Censo y Estadisticas Agropecuarias/MAG

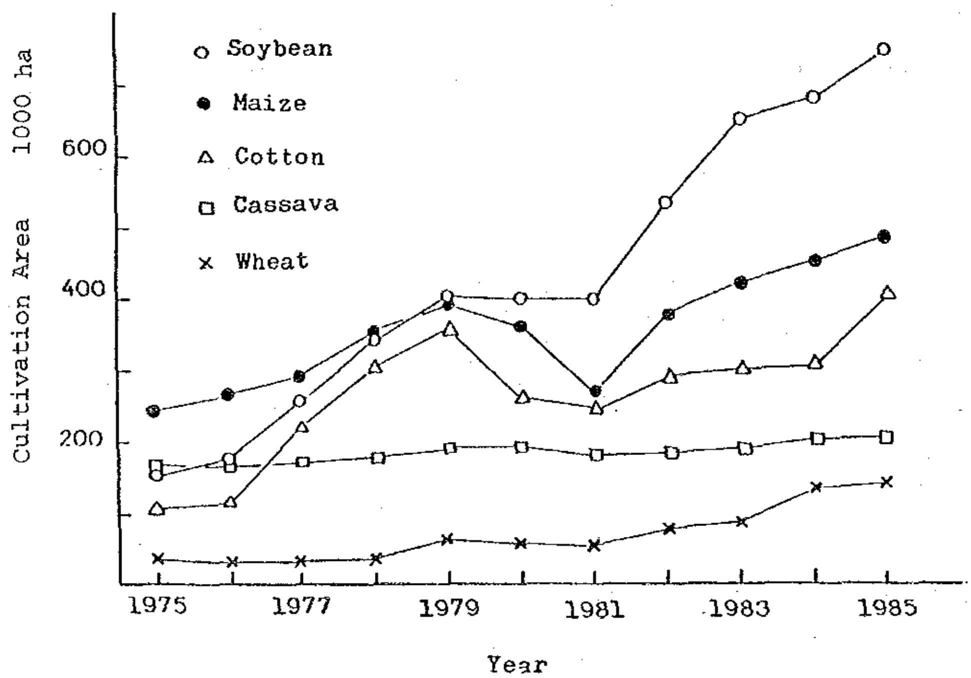


Figure 3-1-4 Changes of Cultivation Area in the Principal Crops

Soybean production in Paraguay, however, has a relatively short history, having begun in 1946 when a U.S. variety was introduced via Uruguay. Production per unit area stands at 1.2-1.5 ton/ha, which is close to the world average. Yields in neighboring Brazil and Argentina, however, are even higher, indicating that there is still room for improvement in Paraguay.

The rapid increase of soybean production described above is much indebted to the great efforts of the farmers as well as the National Soybean Development Program (Programa Nacional de Soja) which was effectively promoted by the government. As the result, soybean is contributing to the national economy of Paraguay as an important agricultural product for the exportation at the present time.

Corn (maize) has a long history grown in Paraguay, and cultivated area and production are now expanding, although slowly. In Paraguay, corn is grown primarily as a subsistence crop, with some being used as livestock fodder, and the recent increases in production have been in response to a rise in domestic demand.

Yield for corn fluctuates between 1.5-1.7 ton/ha, well below the 1.9 ton/ha overall average for South America. One reason for this is that corn is grown as a subsistence crop mainly by small farmers who lack the latest technology and varieties. Recently, however, efforts are being made at the private and government levels to introduce foreign varieties, and the future outloook is for increased development.

At present, cotton is Paraguay's most important export crop, with 400,000 ha under cultivation and production at 470,000 ton. These figures, however, are the result of rapid expansion over the last ten years or so. Around 1970, cotton production stood at 40,000 ton with less than 50,000 ha under cultivation. The explosive growth since then can be attributed to a national cotton development plan (Programa Nacional de Algodon), which was drafted in 1968 and provided technological and financial aid to the cotton industry.

Production per unit area for cotton was between 0.8-0.9 ton/ha around 1980, but has since climbed to above 1.0 ton/ha. This yield, although low in contrast to the world average of 1.3-1.4 ton/ha, compares well with results in neighboring Argentina. The recent rise in cotton yield can at least in part be attributed to the cotton experimental research project (Project de Investigacion y Experimentacion Algodonera, or PIEA for short), which was implemented between 1963 and 1980 with French cooperation.

Cassava is a favored food of the Paraguayan people, and is grown all over the country for subsistence and livestock fodder. As a result, production of cassava, although showing some slight increases over the past ten years, is essentially stable. Yields, 14.2 ton/ha in 1984/85, are high in comparison to other South American nations and to the world average of 9 ton/ha.

Wheat, although a food crop of major importance in Paraguay, had been produced in relatively low quantities until quite recently. In 1975, production stood at 18,000 ton and cultivated area at 36,000 ha, but both these figures have increased rapidly in the past few years.

Wheat is traditionally a temperate zone crop, with numerous restraints on production in a sub-tropical climate like Paraguay's. Thus production has always been low, and yearly imports of several tens of thousand tons have eaten up large chunks of Paraguay's foreign reserves. A national wheat development program (Programa Nacional del Trigo) was begun in 1966, but despite diligent efforts by the government, production and cultivated area remained at the low levels of 30,000 ton and 20,000-30,000 ha in 1978.

After 1978, however, wheat production rose rapidly, and Paraguay has almost reached the point of self-sufficiency. The yield figure for 1984/85 is rather high, and normally can be expected to vary around 1.2 ton/ha. Although at first glance this may appear exceptionally low compared to the world average of approximately 2.0 ton/ha; considering the climatic restraints, even these yield figures must be seen as a substantial accomplishment.

Paraguayan wheat is grown as a winter crop, and is thus occasionally susceptible to frost damage. In addition, drought, disease, and heavy rains during the harvest season also impede production. As a result, yields fluctuate widely from year to year, and instability in production is a major problem facing the Paraguayan wheat industry.

Regional patterns emerge in the cultivation of these five principle crops. Figure 3-1-5 profiles each Department in the Eastern Region according to cultivated area for the major crops.

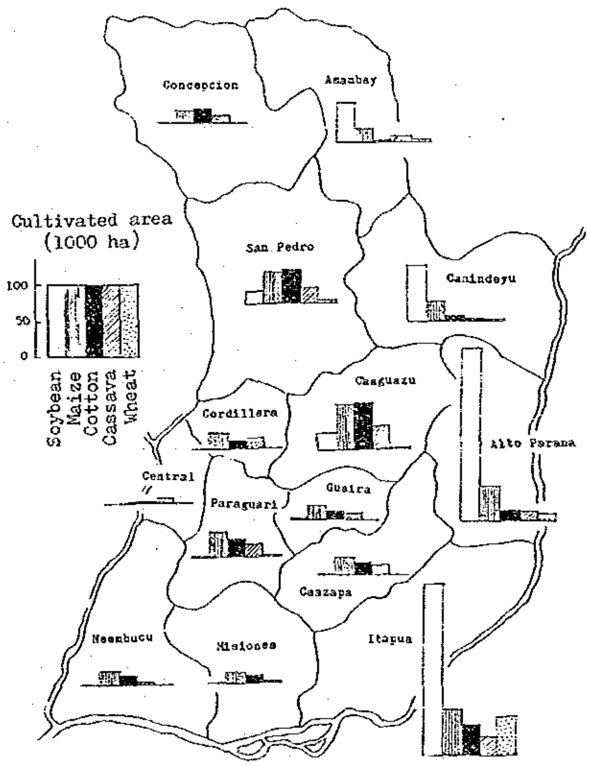


Figure 3-1-5 Cultivated Area of the Principal Crops in Each Department of Paraguay (1982/83)

As can be seen from the map and accompanying bar graph, corn and cassava are grown throughout the Eastern Region. Cotton also has a relatively wide distribution, but is especially heavy in San Pedro and Caaguazu Departments. Soybeans and wheat, on the other hand, are grown in a rather restricted area centering on Alto Parana and Itapua Departments, which together account for 73% of the total cultivated area for soybeans and 79% for wheat.

These agricultural products account for a high percentage of Paraguay's exports, and their importance has been growing in recent years. Export figures for Paraguay for 1981 and 1985 are presented in Table 3-1-8. As can be seen, the ratio of agricultural products to total exports has increased dramatically over this five year period. Among the agricultural products exported, cotton is foremost, followed by soybeans, which more than doubled their percentage between 1981 and 1985.

Table 3-1-8 Exportation in Paraguay (in million US$)

	1981		1985	
	Amount	%	Amount	%
Agricultural Products	237.9	80.4	281.0	92.5
Cotton	129.3	43.7	141.8	46.7
Soybean	47.5	16.1	100.5	33.1
Oil Cake	14.3	4.8	6.4	2.1
Tung Oil	11.6	3.9	5.9	1.9
Tobacco	6.5	2.2	6.0	2.0
Others	28.8	9.7	20.4	6.7
Animal Products	7.2	2.4	6.8	2.2
Forestry Products	42.0	14.2	13.8	4.5
Others	8.8	3.0	2.3	0.8
Total Export	295.5	100.0	303.9	100.0

Source: Technical Bureau, MAG

3.2 Role of Fertilizer in Paraguayan Agriculture

3.2.1 Fertilizer Use in Paraguay

Although fertilizer is an important element in agricultural production, use of fertilizer in Paraguay remains at a fairly low level. Table 3-2-1 lists average fertilizer consumption per unit area of arable and permanently cropped land for Paraguay, neighboring nations in South America, and several world regions. As can be seen, compared to world standards, fertilizer use in South America is low, especially in Paraguay, Argentina and Bolivia.

Table 3-2-1 Fertilizer Consumption per Hectare of Arable Land and Permanent Crops, 1983 (kg of N, P_2O_5, K_2O)

	N	P_2O_5	K_2O	Total
Paraguay	0.9	2.8	1.0	4.6
Argentina	1.8	1.4	0.3	3.5
Brazil	7.6	13.4	5.7	30.7
Bolivia	0.9	0.8	0.1	1.8
Urguay	11.5	12.7	1.7	15.9
South America	7.7	9.3	6.3	23.4
North and Central America	47.0	21.0	21.9	90.0
Europe	108.0	60.4	61.5	229.9
Asia	55.6	18.9	6.6	81.2

Source: FAO Fertilizer Yearbook 1984

The land used to calculate these average, however, includes permanent pastures, and nations with large areas devoted to this use naturally register low in fertilizer use per unit area. None the less, even using the percent of devoted land exclusively to permanent pastures (about 21% of the total used in calculating Table 3-2-1), the average for Paraguay works out to only 4.3 kg N/ha, 13.3 kg P_2O_5/ha and 4.8 kg K_2O/ha, all relatively low levels.

In Paraguay, use of P_2O_5 is high compared to N and K_2O. The main reason for this, as will be explained in a later chapter, is that Paraguayan soils tend to be poor in phosphorus, and application of P_2O_5 fertilizers thus usually brings substantial results.

Changes in fertilizer consumption in Paraguay over the past ten years are documented in Table 3-2-2.

Table 3-2-2 Fertilizer Consumption per Hectare of Arable Land and Permanent Crops in Paraguay (kg of N, P_2O_5, K_2O)

Year	N	P_2O_5	K_2O	Total
1974	0.6	0.7	0.3	1.6
1975	0.3	0.5	0.3	1.1
1976	0.5	0.3	0.2	1.0
1977	0.2	0.5	0.1	0.7
1978	0.5	0.7	0.5	1.7
1979	0.6	1.7	1.0	3.3
1980	0.7	1.8	0.8	3.3
1981	1.2	2.5	1.1	4.8
1982	1.0	1.9	0.9	3.9
1983	0.9	2.8	1.0	4.6

Source: FAO Fertilizer Yearbook 1984

Recently, fertilizer consumption is increasing gradually, and now stands at over four times the level of 10 years ago. This increase is most likely related to the rapid expansion of the wheat and soybean crops described in the previous section.

3.2.2 Soil Conditions and the Need for Fertilization

Paraguayan agriculture is concentrated mainly in the central part of the Eastern Region, where soils derived from arenite prevail, and in the terra-roxa soils of the Parana-Highlands. Wheat and soybeans, which are mostly fertilized crops, are grown primarily in the Parana Highlands, so the conditions of the terra-roxa soils are of prime importance to this discussion.

The terra-roxa soils are known to be highly fertile soils containing abundant amounts of many nutrients. The fact that soybeans have been cropped here for many years without fertilization attests to the great natural fertility of these soils.

Terra-roxa soils, however, were originally formed under a humid tropical or sub-tropical climate, and as such are highly subject to weathering action and downward leaching of nutrients. Under natural forest cover, tree roots reach deep to bring the leached nutrients back up to the surface and replenish the soil, but after reclamation, nutrients leach down below the reach of the roots of cropped plants. In addition, nutrients tend to be depleted by the crops, reducing the fertility of the soil.

Strong rains, also are capable of eroding and washing away the soil, and in some places the subsoil that is worse in physical and chemical properties is exposed, with a resultant loss in fertility. Many farmers are fully aware of the depression of soil fertility in their lands.

To determine the natural nutrient supply of the terra-roxa soils, a field which has been continuously cropped for 20 years was chosen as an experimental field. The results of experiments measuring grain yield and total dry weight in soybeans against amount of applied fertilizer are graphed in Figure 3-2-1.

Compared to the natural yield, yield after fertilization with three nutrients showed a substantial increase, indicating that the natural fertility had been depleted.

In particular, as can be seen from the graphs, use of P_2O_5 fertilizer was most instrumental in increasing yields. Although some increase was gained by addition of N and K_2O fertilizers, this was small in comparison that resulting from the P_2O_5. The gains obtained by use of K_2O were especially small.

These results indicate that the terra-roxa soils are poor in supplement of natural phosphorus. For N, biological nitrogen fixation by the rhizobium in soybeans must be taken into account. The small amount of increased yield gained by addition of K_2O shows that the natural content of pottasium in terra-roxa soils is high.

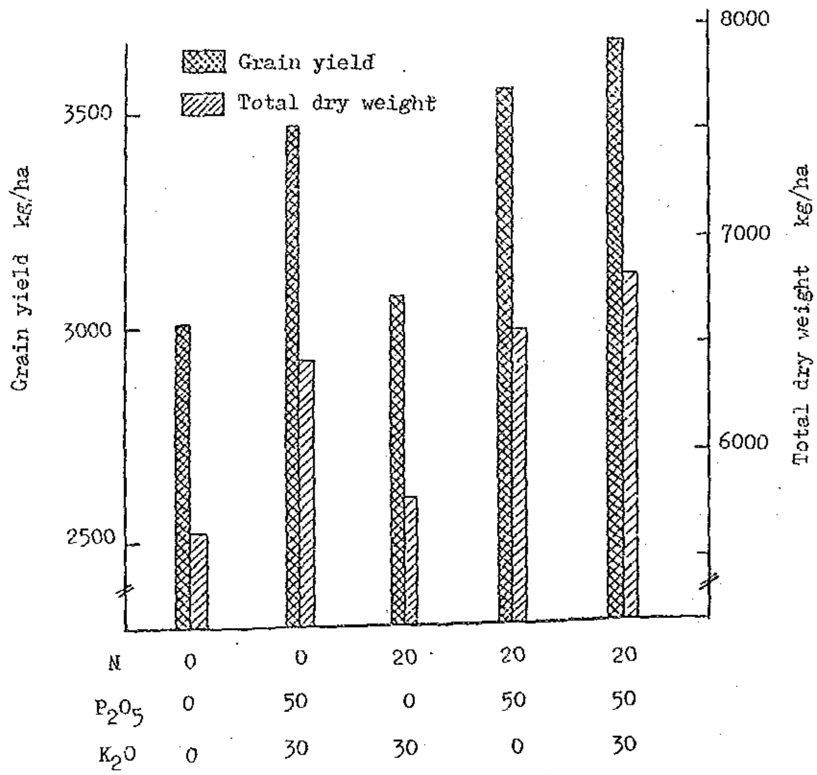


Figure 3-2-1 Result of Three Elements Experiment on Soybean
Source: CRIA 1985

Other experiments conducted in the colonized regions of Yguazu in Alto Parana Department confirm the fact that levels of available phosphate in the soils are low, and that fertilization of soybeans and wheat with phosphate results in substantial yield increases (Estacion Experimental Agropecuaria en Paraguay 1985).

From the above data, the terra-roxa soils, which have been previously accepted as highly fertile, are clearly lacking in some nutrients. Thus if the present production levels are to be increased or even maintained, artificial replenishment of the nutrients for the soil will be necessary. Although top priority must be given to resupply of phosphate, which is most noticeable lacking in the natural content, nitrogen and potassium must also be given due consideration. Even though the natural content of K_2O is relatively high, there is a limit to the soil's natural ability to continuously supply this nutrient, especially under heavy cultivation of crops like soybeans that required large amounts of potassium.

3.2.3 Fertilization of Soybeans and Wheat

The effectiveness of fertilizers depends on various factors such as climate and soil condition. For Paraguay, however, results of experiments within the country have given us a fairly clear idea of what kind of results can be expected under local conditions.

Figure 3-2-2 graphs the increases in yield obtained from fertilization with P_2O_5 for wheat and soybeans. As can be seen, the rate of increase climbs steadily for initial and low levels of fertilization, but then begins to level off as doses are increased. Above a certain dosage, no additional gains are to be had, or yields begin to even fall somewhat.

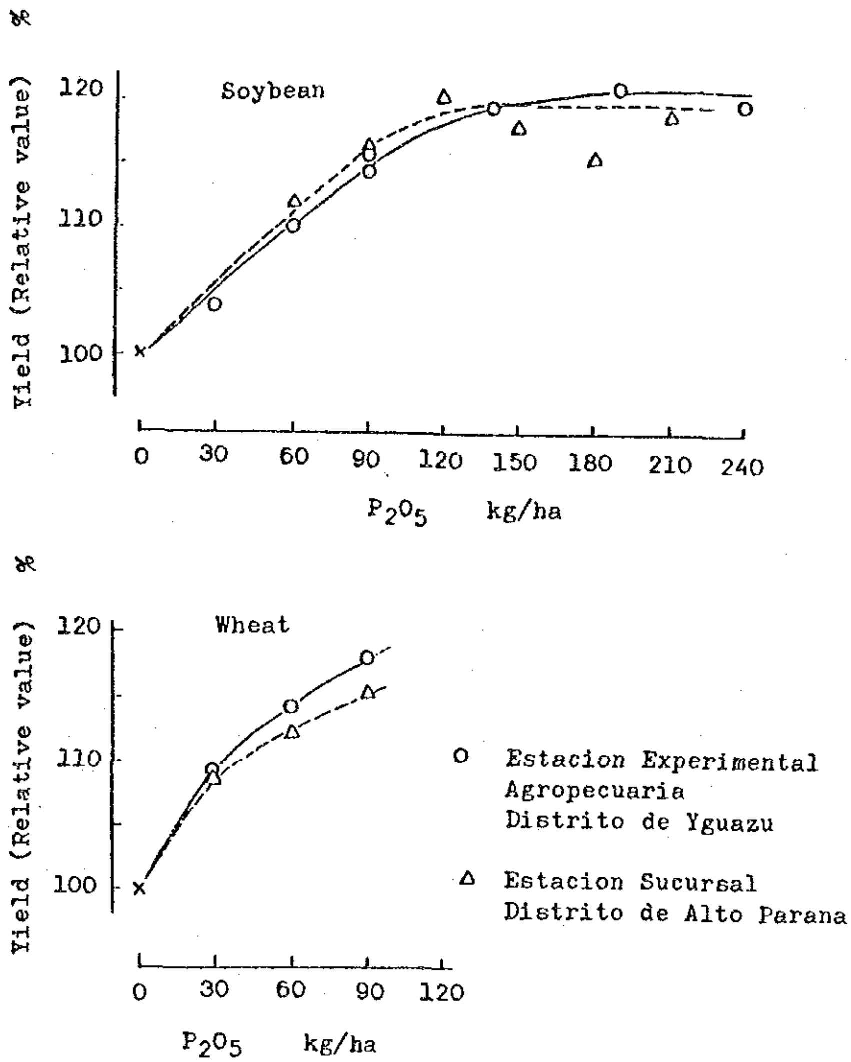


Figure 3-2-2 Yield Response to Phosphate Fertilization

The curves displayed in these Figures are typical responses to fertilization, but the rate of increase obtained with P_2O_5 in these experiments, which is about 20% for both soybeans and wheat, is exceptionally high. Furthermore, although no data is available yet for doses over 90 kg P_2O_5/ha applied to wheat, soybean yields peak at between 150-200 kg P_2O_5/ha, indicating a broad response to phosphate fertilizers.

The effect of nitrogen fertilization on soybeans is not very great, with only a 6% increase in yield obtained from a dosage of 40 kgN/ha (Estacion Experimental Agropecuaria en Paraguay 1982). One reason for this relatively small increase, as explained earlier, is that soybeans can obtain nitrogen from the air, and thus do not rely heavily on the soil for this nutrient.

Wheat, however, shows much better responses to nitrogen fertilization, with increases in yield ranging from 18%-40% for dosages of 80 kgN/ha (Estacion Experimental Agropecuaria en Paraguay, CRIA 1983). Potassium fertilizers can also draw a significant response from wheat crops, with yield increases of approximately 19% reported for a dosage of 60 kg K_2O/ha (CRIA 1985).

As can be understood from the above data, wheat and soybeans respond to fertilization with the three essential nutrients over a wide range of dosages. For actual use in the crop production, therefore, the most effective dosage must be determined for each crop and type of fertilizer.

In determining the most effective dosage, not only increases in direct yield must be considered, but the ratio of increased profit compared to fertilizer costs as well. Experiments were conducted at the Estacion Experimental Agropecuaria en Paraguay on the economic effectiveness of phosphate fertilizers on soybeans and wheat, and the results are displayed respectively in Table 3-2-3 and Table 3-2-4.

Table 3-2-3 Economical Effect of Phosphate Fertilization on Soybean

P_2O_5 dosage kg/ha	Yield kg/ha 1982/83	Yield kg/ha 1983/84	Yield Increase kg/ha	Profit*1 1,000Gs A	Fertilizer Cost *2 1,000Gs B	A - B 1,000Gs
0	4,421	4,155	-	-	-	-
30	4,598		177	9.9	10.2	-0.3
60	4,870		450	25.2	20.4	4.8
90	5,060	4,811	648	36.3	30.6	5.7
140		4,964	809	45.3	47.6	-2.3
190		5,039	884	49.5	64.6	-15.1
240		4,975	820	45.9	81.6	-35.7

*1 Price of soybean: Gs 56/kg
*2 Price of fertilizer (5-30-10): Gs 102/kg

Table 3-2-4 Economical Effect of Phosphate Fertilization on Wheat

Pre-ceeding Crop	P_2O_5 Dosage kg/ha	Yield kg/ha	Yield Increase kg/ha	Profit*1 1,000Gs A	Fertilizer Cost *2 1,000Gs B	A - B 1,000Gs
Soybean no P_2O_5	0	2,669	-	-	-	-
	30	2,915	246	16.7	7.9	8.9
	60	3,048	379	25.8	15.7	10.0
	90	3,149	480	32.6	23.7	8.9
Soybean with P_2O_5 30-90 kg/ha	0	2,931	-	-	-	-
	30	3,213	282	19.2	7.9	11.3
	60	3,184	253	17.2	15.7	1.5
	90	3,230	299	20.3	23.7	-3.4

*1 Price of wheat: Gs 68/kg
*2 Price of fertilizer DAP (18-46-0) Gs 121/kg

As can be seen from the Tables, a dosage of 90 kg P_2O_5/ha (equivalent to 300 kg/ha of 5-30-10 NPK fertilizer) applied to soybeans will result in a maximum increase of net profits for the farmer. With wheat, usually cropped in succession following soybeans, the most economically efficient dosage would be 60 kg P_2O_5/ha (130 kg of DAP fertilizer) if the previous crop of soybeans had not been fertilized, and 30 kg P_2O_5/ha (65 kg of DAP fertilizer) if the previous crop of soybeans has been given a dosage in the range of 30-90 kg P_2O_5/ha.

For nitrogen fertilizers, the Estacion Experimental Agropecuaria en Paraguay (1986) has reported that the most economically effective dosages are 40 kgN/ha for soybeans, and 40-60 kgN/ha for wheat. In addition, experiments involving fertilization of wheat with low, medium and high dosages of all three nutrients have shown that the medium dosage of 40 kgN, 70 kg P_2O_5, 30 kg K_2O/ha, bring the greatest increase in profits to the farmer (CRIA 1983).

The experimental results discussed above are all announced by the various research institutes as part of efforts to encourage fertilizer use in Paraguay.

3.2.4 Standard Fertilizer Dosages and Actual Patterns of Use

On the actual farms where fertilization occurs, however, the situation is not always exactly as the institutes recommend. Based on interview research at agricultural cooperatives in the wheat and soybean producing districts, fertilizer standard or target dosage levels are listed in Table 3-2-5.

Table 3-2-5 Standard Fertilization in Cooperatives

Cooperative	Soybean					Wheat				
	Ferti-lizer	Dosage kg/ha	Ingredient kg/ha			Ferti-lizer	Dosage kg/ha	Ingredient kg/ha		
			N	P_2O_5	K_2O			N	P_2O_5	K_2O
Takushin Yopoira	18-46-0	80	14	37	0	18-46-0	150	27	69	0
Pirapo	4-30-10	80	3	24	8	4-30-10	150	6	45	15
Unidas	4-30-10	100	4	30	10	18-46-0	130	23	60	0
	0-46-0	100	0	46	0					
Fram	4-30-10	100	4	30	10	18-46-0	100	18	46	0

As can be seen from the Table, actual standard fertilizer dosages are 0-14 kgN, 24-46 kgP_2O_5, 0-10 kgK_2O/ha for soybeans, and 6-27 kgN, 45-69 kgP_2O_5, 0-15 kgK_2O/ha for wheat. These dosages fall considerably below the recommended figures discussed above.

Fertilizer use varies widely from farmer to farmer. A survey of fertilization practices in all farmers cultivating soybeans or wheat would be exceedingly difficult. The Estacion Experimental Agropecuaria en Paraguay, however, has conducted some detailed research in the Yguazu colonies, and the results are presented in Tables 3-2-6 and 3-2-7.

For soybeans, 5-30-10 NPK fertilizer is used on a relatively frequent basis, and common dosage levels are around 100 kg/ha. This level compares favorably with standards listed by the agricultural cooperative, but many farmers actually fall below the standards.

Of particular interest is the use of fused magnesium phosphate fertilizers over a rather broad area. Soybean cultivation without fertilizers, on the other hand, accounts for 46% of the area, indicating that the tendency to depend on the natural fertility of the tera-roxa soils is still carried over from the early years of colonization.

Table 3-2-6 Actual Condition of Fertilization for Soybean (1983/84)

Fertilizer	Dosage kg/ha	Ingredient kg/ha			Area ha
		N	P_2O_5	K_2O	
5-30-10	60	3	18	6	50
	70	3.5	21	7	108
	80	4	24	8	149
	90	4.5	27	9	27
	100	5	30	10	473
	160	8	48	16	130
18-46-0	75	12.6	18.6		50
	100	18	46		56
12-12-17-2	75	9	9	13	5
FMP	70		13.3		16
	75		14.3		5
	80		15.2		89
	160		30.4		55
No fertilizer					1,039
Total					2,252

Table 3-2-7 Actual Condition of Fertilization for Wheat (1984/85)

Fertilizer	Dosage kg/ha	Ingredient kg/ha			Number of Farmer	Area ha
		N	P_2O_5	K_2O		
18-46-0	50+FMP16	9	26		1	10
	100	18	46		4	62
	120	22	55		3	48
	130	23	60		7	126
	140	25	64		1	30
	150	27	69		29	430
	170	31	78		3	77
	180	32	83		2	53
	200	36	92		10	220
	200+ FMP150	36	121		1	6
5-30-10	100	5	30	10	1	10
	150	8	45	15	2	80
	160	8	48	16	2	14
12-12-17-2	100+ FMP100	12	31	17	1	7
FMP	20		4		1	15
	120		23		3	50
	250		48		1	22
No Fertilizer					2	55
Total					74	1,315

For wheat, DAP (18-46-0) is used frequently, and the 150 kg/ha dosage recommmended by the agricultural cooperative is most common. A fair number of farmers, however, exceed this dosage in using 200 kg/ha. These levels of fertilization essentially provide the dosages of nitrogen and phosphate recommended by the research results discussed earlier, and there are very few cases of wheat being cultivated without fertilization. One reason for this is probably that wheat yields fall off notably without fertilization, so the farmers have naturally developed the habit of using fertilizers by themselves.

The gap between actual fertilizer use and the dosages recommended as most economically efficient can be attributed to the economic situation in farmers and to problems in the distribution of fertilizer. In the future, these problems must be resolved to the point where farmers are in a position to use the recommended levels, and experimental research should be conducted with the aim of developing a practical plan well suited to the actual conditions of farmers.

3.2.5 Fertilizer Costs as a Percentage of Production Costs

Table 3-2-8 provides examples of production costs for soybeans and wheat. Although these figures are estimates and not actual figures, they are based on an average size holding with a 60 HP class tractor, and are close enough to reality in Paraguay for discussion purposes.

For both wheat and soybeans, material costs outweigh operation costs, and fertilizer accounts for a high portion of these material costs. In the examples constructed here, fertilizer costs amount to 17.9% of total production costs for soybeans, and 16.3% for wheat, though in actuality this figure for both crops can be expected to vary from 15-20% in Paraguay.

Table 3-2-8 Production Cost of Soybean and Wheat

	Soybean		Wheat	
		Gs		Gs
Operation Cost		34,570		30,077
Soil Preparation	5 h	12,864	9 h	11,168
Planting	1 h	3,040	2 h	2,960
Field Managing	2 h	8,121	2 h	3,849
Harvesting	1 h	10,545	1 h	12,100
Material Cost		48,250		51,175
Seed	70 kg	12,600	100 kg	11,000
Inoculant	1 pack	700	-	-
Fertilizer	120 kg	15,600	100 kg	14,000
Herbicide	1 liter	6,710	1 liter	1,600
Insecticide	3 liter	12,640	2 liter	8,600
Fungicide	-	-	4 kg	15,975
Interest of Loan		4,497		4,388
Total cost		87,317		85,640
Expected Yield		2,000 kg		1,500 kg
Cost per kg of Product		43.7 Gs		57.1 Gs

Source: Technical Bureau, MAG
September 1985 for soybean
August 1984 for wheat

In Japan, fertilizer costs run at 16.0% of total production costs for soybeans, and 17.4% for wheat (Fertilizer Handbook 1983). The dosages of fertilizer used in Japan, however, are far higher than in Paraguay, and still account approximately for only the same percentage of total production. This indicates that fertilizer costs in Paraguay are high in comparison to other elements of material and operation costs.

3.2.6 The Problem of Soil Improvement

According to some research results, soils in some sections of Paraguay's arable land are physically and chemically inferior, and soil improvement measures are necessary.

Soil improvement usually takes the form of applying agricultural lime to correct soil acidity. The agricultural lime commonly used for this purpose is powdered limestone (main component is calcium carbonate), but dolomite is also used with combined effect of magnesium supply. In addition, calcium silicate is sometimes used to improve the soil.

Some of the agricultural lime used in Paraguay is imported from Brazil, but a domestic cement company (Industria Nacional del Cemento) also produces about 200,000 tons annually.

The amount of lime needed to correct the pH depends on the characteristics and condition of the soil, and a correct dosage can not be obtained without soil analysis. Usually, however, the dosage works out to several hundred kg/ha, sometimes to several ton/ha to attain the purpose. Agricultural lime in Paraguay costs 18-20 Gs/kg supplied to the farmer, but considering the large amounts which must be used, soil improvement could present economic difficulties for hard pressed farmers.

In acid soils, the level of available phosphorus is usually very low, and application of phosphorus material is necessary to improve the soil. Fused magnesium phosphate (FMP), which is a highly effective agent that not only supplies the necessary phosphorus, but corrects the acidity and replenishes the magnesium as well, is commonly used in these cases. In Paraguay, however, the possibilities of using FMP has not been tested in terms of necessary amounts, soil improvement effects and economic feasibility. In the future, experimental research involving fused magnesium phosphate needs to be carried out in Paraguay.

In the meantime, the slag will be produced as by-product from the proposed dry process plant of phosphorus production. It can be used as both soil restoration material and calcium silicate fertilizer.

3.2.7 Future Fertilizer Requirements

Nutritional needs vary from crop to crop, and fertilizer use must be adapted to these individual requirements. In the past, different fertilizers were supplied in individual units and used as needed to meet the requirements at hand. Recently, however, compound fertilizers designed for specific crops have come into wide use. Such compound fertilizers should play an especially heavy role in large scale Paraguayan agriculture.

The Paraguayan fertilizer plant can be expected to eventually produce compound fertilizers that are precisely suited to the needs of Paraguayan agriculture. At present, however, much experimental research still remains to be done in determining the best combinations for actual fertilization. Thus for the time being, the plant should concentrate on producing the most valuable and effective of the presently used fertilizers.

The types of fertilizers presently used in Paraguay with soybeans and wheat were shown in Table 3-2-5. Of these, an NPK fertilizer of 4-30-10 (or 5-30-10) would probably be best for soybeans. For wheat, which requires more nitrogen than soybeans, a DAP (18-48-0) would be suitable. For vegetables and irrigated rice, although the cultivated area of these crops is relatively small, 12-12-17-2 NPK fertilizer should be supplied.

In addition, Paraguayan soils being basically deficient in phosphorus, a single element fertilizer of phosphate will also be needed, the TSP (0-46-0) used widely at present will suffice for this purpose, but the possibilities of using fused magnesium phosphate (FMP) in its place should also be investigated.

The advantage of fused magnesium phosphate is that the phosphorus contained within does not dissolve in water, and is not easily absorbed to the soil or leached away. The disadvantage is that the fertilization effect thus occurs on a delayed reaction basis, and is therefore not suitable for single year plantings. In addition, the percentage of phosphate is low, so large quantities must be applied. There are most likely the reasons why FMP has not yet been considered for use in Paraguay.

At present, however, virtually no detailed research on fused magnesium phosphate has been accomplished in Paraguay, and people are not fully aware of the possibilities of using this fertilizer. Only one set of experimental results comparing various types of phosphate fertilizers is available, which shows that FMP has approximately the same effect on crop yield as TSP or super phosphate (Estacion Experimental Agropecuaria en Paraguay 1985).

Fused magnesium phosphate enjoy several advantages over other phosphate fertilizers. Detailed experiments should be conducted to see if these advantages can be put to use in Paraguayan agriculture.

CHAPTER IV MARKET STUDY

4.1 General

The industrial structure of Paraguay is dominated by agriculture and animal husbandry, which together account for over 30% of the GDP. Furthermore, foreign exchange earnings depend heavily on export of primary industry products such as cotton, soybeans and tobacco.

Agricultural production is centered in the "terra-roxa," the fertile brownish-red soil found in the southeast region section of the country. Long years of intensive cropping and soil erosion, however, have depleted the land's fertility, indicating that fertilization is necessary to increase yields.

At present, however, the level of fertilizer use is extremely low, amounting to an estimated 35,000 tons in 1985. The reason for this is that there are no fertilizer plants in the country, and the entire amount must be imported. Not only are fertilizer prices high, but import permits are delayed due to lack of sufficient foreign exchange. Farmers are thus unable to obtain fertilizer when they need it.

The government recognizes that the level of fertilization must be increased if crop yields are to be improved. For this purpose, as well as development and promotion of domestic industry, they feel that the best approach would be to construct a fertilizer plant in Paraguay.

This research on market conditions, performed in advance of such a fertilizer plant project, hopes to accomplish the following objectives.

(1) grasp past conditions of supply and demand for fertilizer
(2) project future supply and demand for fertilizer
(3) based on the above projections, draw up plans for a suitable product mix in a Paraguay fertilizer plant

(4) conduct research on the present conditions of fertilizer distribution system, extent of diffusion, patterns of use, farming practices and finance methods, identify the major problem areas, and suggest possible solutions.

4.2 Farming Practices and Patterns of Fertilizer Use

The fertile terra-roza soils that spread along the Rio Parana in southeast Paraguay (including Alto Parana, Itapua and parts of Canindeyu and Misiones Departments) can be expected to produce high yields for five to six years after cultivation without artificial replenishment. However, erosion of the fertile topsoil during heavy rains, and depletion of soil nutrients from intensive cropping without fertilization gradually reduce yields. In response, farmers began fertilizing about five or ten years ago. In fields where the topsoil has eroded and the acidic subsoil layer exposed, it has been necessary to neutralize the subsoil by mixing with lime. In other examples, such eroded fields have been converted into pasture land.

Soils of Paraguay are lacking in phosphorus, and most of the fertilizers in use contain phosphorus. Most of the farmers using fertilizers belong to the larger scale operations, with crop areas in excess of 50 ha, and wheat and soybean are the crops most frequently fertilized. In addition, vegetable and a small portion of the corn, sugarcane, rice, tobacco and fruit crops are also fertilized.

The percentage of the soybean crop that is fertilized is comparatively low, while that of wheat is high. In some cases where soybeans and wheat are cropped in rotation, the wheat is heavily fertilized, and the soybean expected to benefit from whatever remains. An estimate of the area of these crops fertilized would be 20% for soybean and 70% for wheat.

The type of fertilizer presently available, which varies greatly from time to time, depends heavily on supply and demand conditions in Brazil, from where the bulk of imports derive. There is also great variability in the amount available at any one time. Under such conditions, farmers make due with the type and amount of fertilizer available when the need arises. The difficulty and time required in obtaining an import permit intensifies the problem, preventing the farmer from obtaining the right amount of fertilizer at the right time (See Section 4.11).

Table 4-2-1 shows the type of fertilizers presently used by five agricultural organizations. Normally, DAP (18-46-0) is most commonly used for wheat, NPK (5-30-10 or 4-30-10) for soybeans, and NPK (12-12-17-2 or 15-15-15) for vegetables. In some wheat and soybean fields, TSP is used by itself or mixed with nitrogen and/or potash fertilizers.

Table 4-2-1 Fertrilizer Use by Cooperatives and Big Company (1985)

Organization	Crop					
	Wheat		Soybean		Vegetables	
	Kind	kg/ha	Kind	kg/ha	Kind	kg/ha
Takushin Yopoira	18-46-0	90 (150)	18-46-0	50 (80)	12-12-17 -2	500
Pirapo	18-46-0	156 (150)	4-30-10	n.a. (80)		
Fram	18-46-0 11-53-0	111 11 122	5-30-10 11-53-0	30 3 (100)		
Unidas*	18-46-0	n.a. (130)	4-30-10	n.a. (100)		
Agriex	18-46-0 0-46-0 0-0-60	50 50 50 150	a)0-46-0 b)9-46-0 0-46-0	100 50 50 100		

Note: Figures in parenthesis show recommended dosage.
*: Various types of fertilizer are used (Wheat: 73 kg/ha, Soybean: 24 kg/ha).

Research at the Agricultural Experimental Stations shows the DAP to be effective when used with wheat and the 5-30-10 with soybeans.

Cost-Benefit experiments with fertilizers are being conducted at places like the Estacion Experimental Agropecuaria en Paraguay and the CRIA facilities, to determine the most economically efficient amounts. This subject will be discussed in detail in Section 4.6.

Fused magnesium phosphate fertilizer (FMP) has been tried by some Japanese-Paraguayan farmers, but is expensive and difficult to obtain, and gives delayed reaction by nature. Furthermore, no detailed research is being carried out with this fertilizer at the agricultural experimental stations, so the government is in no position to advise farmers on its use. As a result, use of FMP is nearly non-existant at the moment.

4.3 Consumption of Fertilizer

Farmers depend on agricultural financing for their purchase of fertilizer. To be eligible for credit, farmers must own some sort of mortgageable property. Small scale farmers, with little productive potential and few possessions, are thus unable to obtain credit, and consequently must do without fertilizer. Ordinarily, farmers able to obtain financing fall into the medium and large scale categories, with land holdings over 50 ha. Most of these farmers belong to an agricultural cooperatives and purchase of fertilizer is usually accomplished through such cooperatives. Also extremely large scale operations such as Agriex, and grain merchants that control tenant farmers, are able to purchase fertilizer.

At present, all necessary fertilizer is imported. Farmers keep a small supply of fertilizer in stock, but because of financial difficulties and the problem of quality loss during storage, this figure remains very low. Therefore, it is reasonable to assume that supply and demand are equivalent, and as will be explained later in Section 4.4, that the projected supply determines the value of the projected demand.

Table 4-3-1 shows the changes in total fertilizer consumption over the past six years.

Table 4-3-1 Fertilizer Consumption

(Unit: t)

	1980	1981	1982	1983	1984	1985
P, NP, NPK-Fertilizers	13,000	16,000	19,000	22,000	25,000	31,500
N, K-Fertilizers *	2,000	3,000	3,000	3,000	3,000	3,500
Total	15,000	19,000	22,000	25,000	28,000	35,000

* : urea, KCl, etc.

Changes in fertilizer consumption for individual crops are difficult to estimate, because of lack of data on the level and extent of fertilizer use. For 1985, however, an estimate of fertilizer consumption for individual crops can be obtained from statistics and interview research. These estimates are presented in Table 4-3-2. As mentioned earlier, a wide variety of fertilizers is in use in Paraguay. Table 4-3-2, however, groups these into related categories and reports the types used most frequently by farmers on a regular basis.

Table 4-3-3 rearranges this data according to type of fertilizers used with individual crops. As can be seen, most of the fertilizer is used with wheat and soybeans, and only smaller amounts with tomatoes and other vegetables. Production of wheat and soybeans concentrates in the Itapua and Alto Parana Departments, and tomatoes in Central, Caaguazu and Alto Parana. Thus the geographical distribution of fertilizer use centers on these regions.

Table 4-3-2 Fertilizer Use Calculation Table (1985)

Crop	Fertilizer	Dosage (kg/ha)	Cultivated Area (1,000ha) Total	Fertilizer Use	(%)	Fertilizer Use (t)
Soybean	TSP 5-30-10	59 90	780	16 140	2 18	900 12,600
Wheat	TSP DAP	140 140	155	11 98	17 63	1,500 13,800
Tomato	12-12-17-2	700	2.5	2.5	100	1,800
Paddy	15-15-15	133	22	2.2	10	300
Sugarcane	15-15-15	250	57	2.3	4	600
Total	-	-	1,016.5	272	27	31,500

Table 4-3-3 Fertilizer Use by Crop (1985)

(Unit: t)

	Soybean	Wheat	Tomato	Others	Total
P, NP, NPK					
TSP(0-46-0)	900	1,500			2,400
DAP(18-46-0)		13,800			13,800
5-30-10	12,600				12,600
12-12-17-2			1,800		1,800
15-15-15				900	900
Sub Total	13,500	15,300	1,800	900	31,500
N (Urea etc.)					2,600
K (KCl etc.)					900
Total					35,000

4.4 Fertilizer Supply

As there are no domestic fertilizer plants in Paraguay, the entire supply must be imported. About 70-80% of the total supply comes from Brazil. Table 4-4-1 shows the changes in import levels over the past ten years. Fertilizer is formerly imported at the official exchange rate of 240 Gs/US$, and statistics usually reflect the amount traded at this rate. All importing is based on an allocation of foreign exchange and thus requires a permit.

Aside from official dealings, fertilizers are brought in from neighboring countries such as Brazil. There are other inflow not shown on the import statistics. Naturally, the official rate is not applied to such goods, and dealers usually deal at the free exchange rate (around 700 Gs/US$). Although such fertilizers avoid the many fees levied on official imports (custom clearance fees, L/C opening fees, etc.), the price is heavily influenced by the strength of the currency, and these fertilizers thus usually cost 80-100% more than official imports. As a result, the amount of these fertilizers have decreased along with the widening gap between free exchange and official rates since 1980, and at present totals an estimated 30% of the officially imported amount.

The figures presented in Table 4-4-1 include the estimated amount not shown on the import statistics from 1980 onwards. According to this chart, 35,000 tons (31,500 tons of which were phosphate fertilizer and NP/NPK fertilizers) were supplied in 1985. Our interview research with importers, presented in Table 4-4-2, produced a figure of 31,000-33,000 tons for this year. The difference between these two figures is not very great, about 10%.

Table 4-4-1 Fertilizer Supply

(Unit: t)

	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
N-Fertilizer	580	1,404	1,424	624	571	1,441	1,299	1,047	1,502	2,493
P,NP,NPK-Fertilizers	4,955	7,902	7,063	4,406	8,219	10,855	13,419	12,122	19,391	24,492
K-Fertilizer	151	645	742	2,109	411	1,153	842	1,348	706	770
Total (Official Import)	5,686	9,951	9,229	7,139	9,201	13,449	15,560	14,517	21,599	27,755
Estimated Total Supply					15,000	19,000	22,000	25,000	28,000	35,000
in which P, NP, NPK Fertilizers					13,000	16,000	19,000	22,000	25,000	31,500

Source: Import-MAG/Banco Central del Paraguay

Table 4-4-2 Import of Fertilizer (1985)

Source	Trade Company	Tonnage (t)
Serrana (Brazil)	Par Trade	10,000
Ipiranga/Ferstil (Brazil)	Kasba	8,000
Trevo (Brazil)	Several Companies	8,000-10,000
Uruguay/Argentina	Isusa	3,000
West Germany		1,000
Japan	KR-II	1,000
Total		31,000-33,000

Source: Estimation by Par Trade

4.5 Fertilizer and Crop Value

This section treats the relationship between fertilization and value of the crops produced, which is considered to be a factor of major importance in farming management.

4.5.1 Price of Fertilizer

All fertilizer used in Paraguay is imported, with 70-80% originating in the neighboring Brazil. Using Brazilian imports as an example, the final price of fertilizer to a Paraguay farmer will usually include the following costs:

- FOB price
- truck freight and insurance costs to the national border (Foz do Iguacu)
- truck transshipment costs (Brazilian carrier to Paraguaian carrier)
- custom clearance fees (20% of CIF price)
- bank charge (10.5% of CIF price)
- domestic shipping costs
- commission of agricultural cooperatives or agricultural pharma-ceuticals/fertilizers trading firm

The CIF price mentioned above is calculated using the official exchange rate, which is to the farmer's advantage. FOB prices for fertilizer exported to Paraguay, however, are high as compared with international market prices, as demonstrated in Table 4-5-1. Furthermore, the numerous intermediate costs listed above result in a high final price paid by the Paraguay farmers.

Table 4-5-1 Comparison of FOB Prices (1985)

(Unit: US$/t)

	FOB Brazil for Paraguay (Bag) (Av. during Jan./Oct., 1985)	International Market	
		FOB	Place
DAP	341	165-175	US Gulf, bulk
TSP	250	120-135	US Gulf, bulk
Urea	226	110-130	W. Europe, bags
KCl	180	78- 82	Vancouver

Source: CACEX (FOB Brazil)
British Sulfur Corp. (International Market)

The high FOB price for Brazilian fertilizer is related to that country's policy of protecting its domestic fertilizer producers. An official limit on imports of basic fertilizers such as TSP isolates domestic prices from the influence of the world market and keeps them high. Furthermore, Paraguay imports only limited quantities, and there is no competitive supplier to force prices down.

Table 4-5-2 estimates changes in final price to farmers over the past four years for officially imported fertilizer.

Table 4-5-2 Changes of Farmer Price of Major Fertilizer

(Unit: Gs/kg)

	1982/83	1983/84	1984/85	1985/86	Remarks
DAP (18-46-0)	61	77	103	126	
TSP (0-46-0)	55	55-90	75-90	95	
NPK (5-30-10)	55	62	82	119	
NPK (12-12-17-2)	58	65	97	108	
Urea (46-0-0)	60	55-60	70-80	100	
KCl (0-0-60)	55	55-60	60	90	

Fertilizer not shown on the import statistics, although not subject to the custom clearance fee or bank charges, is influenced by the large gap between the free and official exchange rates, and thus probably costs the farmer 80-100% more than sanctioned imports.

4.5.2 Crop Value

Table 4-5-3 shows the price received by farmers for various crops over the past five years.

Table 4-5-3 Crop Prices Received By Farmers

(Unit: Gs/kg)

	1982/83	1983/84	1984/85	1985/86	1986/87	Remarks
Soybean*	25.5	30.9	66.3	55.5	92.0	Av. of cooperatives
Wheat	33.2	44.5	57.5	64.9	-	Av. of cooperatives
Cotton	-	118	95	116	-	
Tomato	65	66	83	-	-	Takushiu Yopoira

* Prices of soybean harvested in the previous year.

Prices for soybean and tomatoes are determined by market value, but the government sets an official rate for wheat and cotton purchased by processors. The farmers receive this official rate minus transportation charges to the processing plants.

4.5.3 Ratio of Crop Value to Fertilizer Price

As a measure of the economic value of fertilization, the ratio of per kilogram unit value of crop to price of fertilizer can be used. Experience dictates that if this ratio is greater than one, then fertilizer use can be considered economically efficient.

The results are presented in Table 4-5-4.

Table 4-5-4 Crop/Fertilizer Price Ratio

Crop	Fertilizer	1982/83	1983/84	1984/85	1985/86	Remarks
Soybean	5-30-10	0.53	1.02	0.68	0.77	
	TSP(0-46-0)	0.56	0.91	0.67	0.97	
Wheat	DAP(18-46-0)	0.54	0.58	0.56	0.52	
	TSP(0-46-0)	0.60	0.61	0.70	0.68	
Tomato	12-12-17-2	1.12	1.02	0.86	-	

For soybean and wheat, with the exception of soybeans in 1983/84, the ratio is consistently below one, indicating that fertilizer use may not be economically efficient. In very large scale operations, however, the overall increase in yields from fertilization may be great enough to economically justify the use. For tomatoes, a ratio around one indicates that fertilization is economically efficient to some extent.

4.6 Fertilization and Crop Yields

The extent to which yields are increased by fertilization depends on many factors such as crop variety, soil, climate and cultivation practices. As a result, it is difficult to calculate the amount of fertilizer necessary to produce optimum yields for the average farmers. Based on the results of experiments performed at the Paraguay Agricultural Experimental Stations, an estimate can be obtained for the amount of phosphate fertilizer needed to produce maximum economic benefits in terms of fertilizer use versus crop yield.

The overall economic efficiency of fertilization, however, can not be derived simply from the amount of additional yield produced by the fertilizer. The price of the crop and the cost of the fertilizer must also be taken into consideration. As a measure of overall economic efficiency, two methods are proposed: one is a method to calculate the difference between profit and fertilizer cost as mentioned in 3.2.3 and the other, to calculate VCR. The Value Cost Ratio (VCR) compares the cost of fertilization with the value (not just quantity) of the yield. In this calculation, fertilizer cost does not include manpower costs or machinery operating costs incurred during the actual process of fertilization.

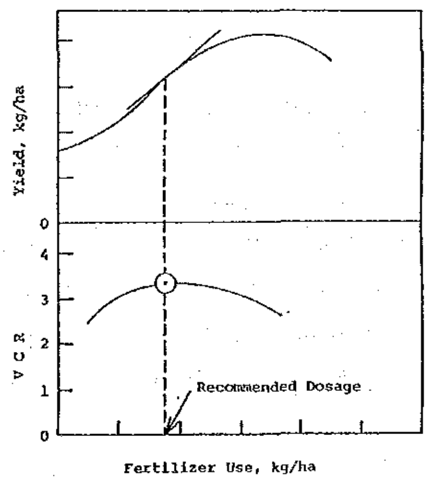


Figure 4-6-1 Fertilizer Use and VCR

Generally speaking, yields increase rapidly in response to initial fertilization, but gains tend to slow down above a certain dosage. More fertilizer may bring yields up to the optimum level, but after that any additional dosages will produce no gains, and will even reduce yields. VCR is determined by dividing value of yield by fertilizer cost, and the dosage which corresponds to maximum VCR is called the "recommended dosage."

In most cases, a VCR value greater than 2 is interpreted as evidence that fertilization is economically efficient, but for risky crops which are particularly sensitive to factors such as weather, the minimum VCR value is usually moved up to 3. When VCR is below 1, fertilizer costs outweigh any gains in value of yield, and fertilization will produce no beneficial results.

Each method has its own advantage and disadvantage in assessing the economics of fertilizer use. The absolute benefit can be obtained by the former method and the relative benefit can be obtained by the latter method (VCR calculation).

In the following analysis VCR is treated as the basic standard for measuring economic value of fertilization since it is normally used for the evaluation.

4.6.1 Soybeans

Experiments with soybeans and phosphate fertilizers are being conducted at the Estacion Experimental Agropecuaria en Paraguay. For the soybean-wheat crop rotation (first crop-soybean, second crop-wheat, third crop-soybean, fourth crop-wheat) which is most commonly used by dry-field colonists in the Yguazu Region, experiments have been conducted to determine the effect of phosphate fertilization on crop yields. The results of these experiments with soybeans are displayed in Table 4-6-1.

Table 4-6-1 Fertilizer Use and Yield for Soybean

a) First Plantation

Dosage ($kg\ P_2O_5/ha$)	Yield (kg/ha)		Yield Increase (kg/ha)
	1982/83	1983/84	
0	4,421	4,155	0
30	4,598	-	177
60	4,870	-	450
90	5,060	4,811	648
140	-	4,964	809
190	-	5,039	884
240	-	4,975	820

b) Third Plantation

Dosage ($kg\ P_2O_5/ha$)	Yield	
	kg/ha	Increase (kg/ha)
0	2,896	-
30	3,293	397
60	3,475	579
90	3,764	868

Similar experiments have been conducted at the Estacion using various types of fertilizers, and results have indicated that NPK (5-30-10) is most suitable for use with soybeans. This type of fertilizer is presently in common use among farmers.

Using the rate of yield increase from Table 4-6-1, VCR can be calculated for the first and third crops. The results are tabulated in Table 4-6-2.

Table 4-6-2 VCR Calculation

a) First Plantation

Dosage		VCR			
kg P_2O_5/ha	5-30-10 (kg/ha)	1982/83	1983/84	1984/85	1985/86
0	0	-	-	-	-
30	100	0.99	1.89	1.20	1.37
60	200	1.26	2.41	1.52	1.74
90	300	1.21	2.31	1.46	1.67
140	467	0.97	1.85	1.17	1.34
190	633	0.56	1.07	0.68	0.77
240	800	0.58	1.10	0.69	0.79

b) Third Plantation

Dosage		VCR			
kg P_2O_5/ha	5-30-10 (kg/ha)	1982/83	1983/84	1984/85	1985/86
0	0	-	-	-	-
30	100	2.23	4.25	2.67	3.07
60	200	1.63	3.10	1.96	2.24
90	300	1.63	3.09	1.96	2.24

In the first crop, except for a few examples in 1983/84 (dosage = 30, 60 kg P_2O_5/ha), the VCR values are all below 2, indicating poor economic efficiency.

One reason for this poor showing, however, is the high natural fertility of the soil at the Estacion. The yield at the Estacion without fertilization was more than 4,000 kg/ha, compared to an average of only 2,300 kg/ha among the Japanese-Paraguayan farmers of the Yguazu Region, where actual fertilization is being implemented. The high natural fertility of the soil at the Estacion negates the effect of the fertilizer in the first crop, but the effect would most likely be greater in the already-depleted soils being worked by the average farmers.

Results for the third crop, on the other hand, are generally high. An extraneous variable here, however, is that conscientious cultivation management practices at the Estacion might be partially responsible for producing the good results. None the less, even allowing for this extraneous variable, there seems to be at least some indication of actual benefits resulting from fertilization. Using 1985/86 as a base, a VCR of 3.07 at 30 kg P_2O_5/ha shows the most effective fertilization of the three dosage levels tested. Converted to NPK (5-30-10), this amounts to 100 kg/ha, which would be the recommended dosage for soybeans.

4.6.2 Wheat

Fertilizer experiments with wheat are being conducted at the Estacion Experimental Agropecuaria en Paraguay and at the CRIA facilities.

1) Experiment results at the Estacion Experimental Agropecuaria en Paraguay

Cultivation experiments at the Estacion have determined that DAP (18-46-0) is the most suitable fertilizer for use with wheat, and this type of fertilizer is now used commonly by wheat farmers. The Estacion experiments were conducted with wheat being grown on fields previously cropped in soybeans without phosphate fertilizer (N: 40 kg/ha, K_2O: 50 kg/ha), and the results are shown in Table 4-6-3.

Using data from these experiments, VCR was calculated for the past four years. As can be seen in Table 4-6-4 of the three dosages tested, 30 kgP_2O_5/ha proves to be the most effective for wheat.

Table 4-6-3 Fertilizer Use and Yield for Wheat

Dosage (kg P_2O_5/ha)	Yield	
	kg/ha	Increase (kg/ha)
0	2,669	-
30	2,915	246
60	3,048	379
90	3,149	480

(Note) N: 40kg/ha, K_2O: 40kg/ha

Table 4-6-4 VCR Calculation

Dosage		VCR			
kg P_2O_5/ha	DAP (kg/ha)	1982/83	1983/84	1984/85	1985/86
0	0	-	-	-	-
30	65	2.06	2.19	2.11	1.95
60	130	1.59	1.68	1.63	1.50
90	196	1.33	1.42	1.37	1.26

2) Experiment results at CRIA

Various varieties of wheat respond differently to fertilization, and at the CRIA facilities experiments are being conducted using the five main varieties common in the Itapua Region. Table 4-6-5 shows the composition of three dosage levels used in the experiments, and Table 4-6-6 the results for five varieties of wheat.

Table 4-6-5 Design of Fertilizer Use

(Unit: kg/ha)

	N	P_2O_5	K_2O
No fertilizer	0	0	0
Low level	20	35	15
Middle level	40	70	30
High level	80	140	60

ITAPUA-25 and 281/60 show relatively weak responses to fertilization. Data from these experiments was used to calculate VCR for the five varieties with the data of fertilizer (DAP) and crop prices. The results are summarized in Table 4-6-6.

Table 4-6-6 Fertilizer Use and Yield for Wheat

Variaties	Dosage	Yield	
		kg/ha	Increase (kg/ha)
ITAPUA-25	None	1,562	-
	Low	2,087	525
	Middle	2,615	1,053
	High	2,725	1,163
ITAPUA-1	None	1,928	-
	Low	2,862	934
	Middle	3,287	1,359
	High	3,396	1,468
C-3	None	2,421	-
	Low	3,031	610
	Middle	3,828	1,407
	High	3,883	1,462
EL PATO	None	1,990	-
	Low	2,437	447
	Middle	3,440	1,450
	High	3,740	1,750
281/60	None	2,115	-
	Low	2,718	603
	Middle	3,271	1,156
	High	3,359	1,244

Table 4-6-7 VCR Calculation

Variaties	Dosage (DAP) (kg/ha)	VCR			
		1982/83	1983/84	1984/85	1985/86
ITAPUA-25	0	-	-	-	-
	76	3.76	3.99	3.86	3.56
	152	3.77	4.00	3.87	3.57
	304	2.08	2.21	2.14	1.97
ITAPUA-1	0	-	-	-	-
	76	6.69	7.10	7.91	6.33
	152	4.87	5.17	4.99	4.61
	304	2.63	2.79	2.70	2.49
C-3	0	-	-	-	-
	76	4.37	4.64	4.48	4.13
	152	5.04	5.35	5.17	4.77
	304	2.62	2.78	2.68	2.48
EL PATO	0	-	-	-	-
	76	3.20	3.40	3.28	3.03
	152	5.19	5.51	5.32	4.91
	304	3.13	3.33	3.21	2.97
281/60	0	-	-	-	-
	76	4.32	4.59	4.43	4.09
	152	4.13	4.40	4.25	3.92
	304	2.22	2.36	2.28	2.11
Average	0	-	-	-	-
	76	4.47	4.74	4.79	4.23
	152	4.60	4.89	4.72	4.34
	304	2.54	2.69	2.60	2.40

3) Recommended dosage

Figure 4-6-2 plots VCR for wheat for experiments at CRIA and at the Estacion Experimental Agropecuaria en Paraguay.

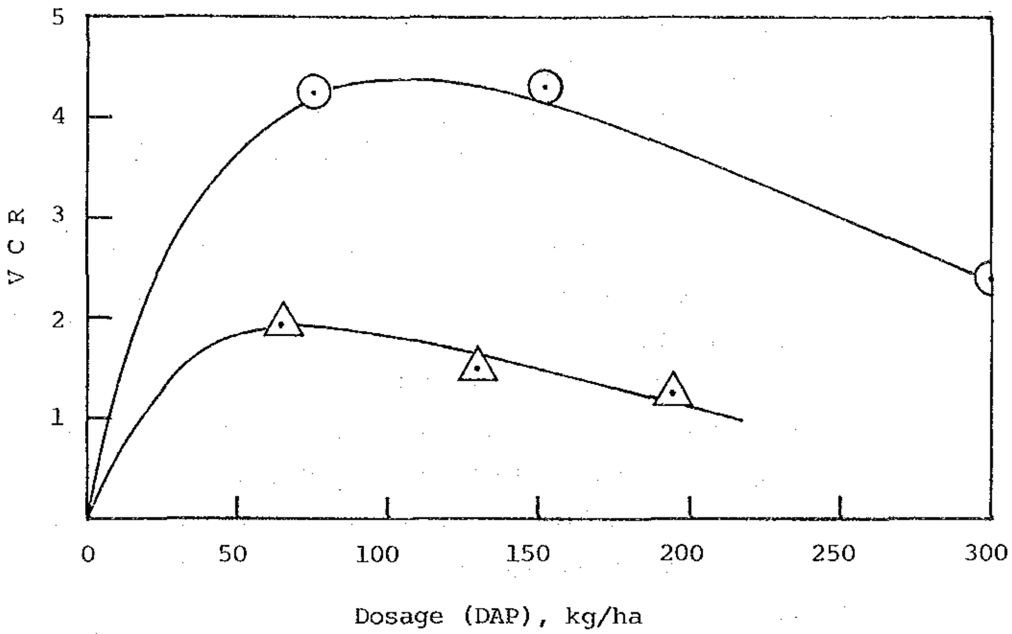


Figure 4-6-2 VCR for Wheat (1985/86)

As can be seen, a substantial gap separates the curves drawn from the two sets of experiments. At the Estacion, non-fertilized productivity was 2,669 kg/ha, over twice the 1,300 kg/ha estimated for average farmers. This high non-fertilized productivity at the Estacion, attributable to better cultivation management practices than in the farmer's, results in decreased gain from fertilization and produces the low VCR values.

In the CRIA experiments, non-fertilized yields are also high to start with. After fertilization, however, yields increase to a level much higher than those obtained by farmers in the Pirapo/Fram agricultural cooperatives (average yield of 1,700 kg/ha using 130 kg/ha of DAP). This indicates that the high yields obtained at CRIA are influenced by the more controlled cultivation management practices at the facilities, and that the VCR values around 4 for the 70-150 kg/ha dosages should be considered higher than those obtainable under actual farming conditions.

Looking at the data from both experimental stations with the above reservations, the actual VCR curve for wheat can be estimated to fall somewhere in between the two curves presented in Figure 4-6-1, with a VCR figure around 3 for dosages in the range of 70-150 kg/ha. As the Paraguay wheat crop is relatively risky and easily influenced by weather, a VCR of 3 would represent a minimum value as an indicator of economic efficiency. Thus 70-150 kg/ha would be the recommended dosage of fertilizer for wheat.

4.7 Estimate of Future Demand for Fertilizer

At present, fertilizer use in Paraguay centers on the soybean and wheat crops. Research and experiments, both at JICA's Estacion Experimental Agropecuaria en Paraguay and at MAG's facilities (IAN, CRIA), also concentrate on these two crops, and results are gradually known among the farmers. Research at the above mentioned facilities, however, has only been ongoing for a few years. Much work thus remains to be done, and research on soybeans and wheat is still in progress at the moment.

Under such conditions, little research on fertilization of crops other than wheat and soybeans is being conducted, and the government is not actively promoting such fertilization among the farmers. Furthermore, farmers lacking previous experience with fertilizers do not adopt the practice in the absence of sufficient technical assistance and advice.

When considering demand for fertilizer over the next ten years, there is little expectation that the government will actively promote fertilization of crops other than soybeans and wheat. Thus fertilizer demand for such crops, with the exception of vegetables now being fertilized and a part of paddy and sugarcane, can be essentially ignored.

On the other hand, AGRIEX started to cultivate colza to get seeds from it. The company plans to export them and/or market them domestically. Colza is a winter crop and can be cultivated after the soybean harvesting. Colza can preserve soil fertility by leaving the residual stalk etc. in the soil after the harvesting. Colza will be cultivated on fields where wheat cultivation is suspended and/or on new fields after soybean harvesting. AGRIEX presently provides phosphate fertilizer with 40-45 kg/ha. However, the research on relationship of the yield and the dosage has not been investigated at the agricultural research institutes. In addition, whether the cultivation of colza is widely undertaken is not clear. Therefore, the projection of fertilizer use for colza is difficult at this moment. In this study, the fertilizer use for colza is not estimated, although there is such a potential.

The analysis of future demand, therefore, will center on wheat and soybeans, with allocations for paddy, sugarcane and tomatoes. Vegetables other than tomatoes are produced in such small quantities that the demand for fertilizer is insignificant, and cotton, although an important export crop, is raised mostly by small scale farmers who, for reasons mentioned earlier, are unable to purchase fertilizer. Unless the government institutes some sort of program to encourage fertilizer use among small-scale farmers, demand generated by the cotton crop can be ignored as well.

Analysis of future demand, estimated for the ten year period from 1985/86 until 1995/96, is based on predicted trends in standard dosage, cultivated area and fertilized area for individual crops. As the average fertilizer dosages now implemented by Japanese-Paraguayan soybean and wheat producers compare closely with the recommended dosages calculated in Section 4.6, these will be used as the standards.

The price of fertilizer in Paraguay is high, and as will be explained in detail in Section 4.9, farmers depend on agricultural credit for their purchases. Thus it is highly unlikely that the level of fertilizer dosages will rise in the near future, and the following analysis of future demand will assume that the dosage standards will remain fixed throughout the 10-year prediction period.

With regard to fused magnesium phosphate fertilizer (FMP), systematic experiments are not being conducted, and analysis of future demand will involve only those Japanese-Paraguayan farmers that already have some exerience with FMP and UNIDAS farmers.

With the above restrictions in mind, following is a crop by crop analysis of future demand for fertilizer in Paraguay.

4.7.1 Soybeans

1) Standard dosage level

Under the present day pricing system, around 100 kg/ha of NPK (5-30-10) is the most economically effective dosage. According to our interview research, actual dosages employed by Japanese-Paraguayans and other farmers run between 80 and 100 kg/ha. Thus 90 kg/ha (27 kg P_2O_5/ha) will be used as the standard dosage for soybeans.

2) Fertilized area

At present, approximately 20% of the soybean crop area is being fertilized (MAG statistics). As the importance of fertilizers to this crop is well known among farmers, the analysis assumes a 2% rise in fertilized area annually, with an estimated figure of 40% cultivated area under fertilization by 1995/96.

3) Cultivated area

Cultivated and harvested area for soybeans over the past ten years is displayed in Table 4-7-1.

Table 4-7-1 Cultivated and Harvested Area of Soybeans

(Unit: 1,000ha)

Year	Cultivated Area	Incremental	Harvested Area	Incremental
1976/77	257.6	-	228.8	-
1977/78	344.3	86.7	272.2	43.4
1978/79	403.4	59.1	360.3	88.1
1979/80	394.6	-8.8	357.1	-3.2
1980/81	396.9	2.3	-	-
1981/82	532.8	135.9	502.2	-
1982/83	649.7	116.9	567.8	65.6
1983/84	678.9	29.2	638.8	71.0
1984/85	746.8	67.9	718.8	80.0
1985/86*	780.0	33.2	750.0	31.2
Average	-	58.0	-	57.9

Source: MAG * : Estimate

Soybeans being an important export crop, the government has actively promoted a National Soybean Development Program (Programa Nacional de Soja). As a result, soybean area has showed an average annual increase of 58,000 ha over the past ten years.

Over 50% of the national soybean crop is produced in the Department of Itapua. The sudden increase in soybean area after 1981/82 is related to rapid development of new farmland made possible by completion of National Highway 6 linking Encarnacion and Stroesner.

In the future, however, such rapid development of new farmland is unlikely to continue, due to lack of new cultivatable land and rising development costs. According to an intermediate report on JICA's "Research on Plan to Increase Important Grain Crops in the Central Region of the Department of Itapua," of the approximately 480,000 ha (about 29% of Dept. of Itapua) chosen as the study area, land suitable for development amounts to only 44,500 ha or 9% (2,500 ha of which is suitable for paddy field).

Furthermore, interview research at the Japanese-Paraguayan agricultural cooperatives and the UNIDAS agricultural cooperative has determined that, with the exception of PIRAPO agricultural cooperative and TAKUSHIN YOPOIRA agricultural cooperative (*Department of Alto Parama*), undeveloped land is in very short supply. Based on such research and information, an estimated 150,000-200,000 ha of land suitable for agricultural development exists in the Department of Itapua. Addition of suitable land in the Department of Alto Parana brings the total up to 300,000-400,000 ha, a major portion of which will most likely be devoted to soybeans.

Given these trends, it is highly improbable that the rapid increases in soybean area seen over the past ten years (58,000 ha/annual average increase) can be sustained into the future. A more reasonable figure would be about half this rate, or 30,000 ha/yr, with all increases stopping around the one million ha mark.

4) Estimate of future demand for fertilizer

Based on the above-stated premises, Table 4-7-2 tabulates the predicted cultivated area, fertilizer area and fertilizer consumption for soybeans over the next ten years.

Table 4-7-2 Fertilizer Demand Projection for Soybeans

Year	Cultivated Area (1,000ha)	Fertilizer Applied Area (1,000ha)	Consumption (t P_2O_5)
1985/86	780	156	4,212
1986/87	810	178	4,806
1987/88	840	202	5,454
1988/89	870	226	6,102
1989/90	900	252	6,804
1990/91	930	279	7,533
1991/92	960	307	8,289
1992/93	990	337	9,099
1993/94	1,000	360	9,720
1994/95	1,000	380	10,260
1995/96	1,000	400	10,800

4.7.2 Wheat

1) Standard dosage level

Under the present pricing system, calculations show 70-150 kg/ha of DAP to be the most economically efficient dosage. According to interview research, Japanese-Paraguayans and other farmers use levels in the vicinity of 130-150 kg/ha. For the purpose of analysis, 140 kg/ha will be considered as standard dosage for wheat.

2) Fertilized area

At present 70% of the wheat area is being fertilized (MAG statistics). Considering the importance of fertilizers in wheat production, however, the analysis assumes an average annual increase of 2%, bringing the total to 90% by 1995/96.

3) Cultivated area

Table 4-7-3 presents estimates of the cultivated and harvested area for wheat over the past ten years.

Table 4-7-3 Cultivated and Harvested Area of Wheat

(Unit: 1,000ha)

Year	Cultivated Area	Incremental	Harvested Area	Incremental
1976/77	32.8	-	28.5	-
1977/78	34.3	1.5	31.5	3.0
1978/79	59.1	24.8	52.3	20.8
1979/80	55.0	-4.1	47.0	-5.3
1980/81	49.4	-5.6	N.A.	-
1981/82	70.4	21.0	69.7	-
1982/83	79.9	9.5	79.7	10.0
1983/84	125.1	45.2	105.7	26.0
1984/85	140.0*	14.9	134.4	28.7
1985/86	155.0	15.0	150.0	15.6
Average	-	13.6	-	13.5

Source: MAG
* : Estimate

Wheat is cultivated in rotation with soybeans, and wheat area has expanded with Paraguay's Wheat Self-sufficiency Program (Programa Nacional de Triego). Production, however, remains mostly for domestic consumption.

In the future, increases in production will be difficult to obtain, and the improvement in variety and technology necessary to facilitate export can not be achieved quickly. Thus the analysis assumes that the growth rate will be slow, and estimates an average annual increase of 10,000 ha over the next ten years.

4) Estimate of future demand for fertilizer

Based on the above assumptions, Table 4-7-4 lists estimated cultivated area, fertilized area and fertilizer demand for wheat over the next ten years.

Table 4-7-4 Fertilizer Demand Projection for Wheat

Year	Cultivated Area (1,000ha)	Fertilizer Applied Area (1,000ha)	Consumption (t P_2O_5)
1985/86	155	109	7,031
1986/87	165	119	7,676
1987/88	175	130	8,385
1988/89	185	141	9,095
1989/90	195	152	9,804
1990/91	205	164	10,578
1991/92	215	176	11,352
1992/93	225	189	12,191
1993/94	235	202	13,029
1994/95	245	216	13,932
1995/96	255	230	14,835

4.7.3 Tomatoes

1) Standard dosage level

Based on estimates of MAG and the results of interview research, the standard dosage for tomatoes is assumed to be 700 kg/ha of NPK (12-12-17-2) fertilizer (84 kg P_2O_5/ha).

2) Fertilized area

100% of the cultivated area for tomatoes is fertilized.

3) Cultivated area

Table 4-7-5 estimates tomato crop area for the past six years. Analysis of future demand assumes a continued annual average growth rate of 100 ha/yr.

Table 4-7-5 Cultivated Area of Tomatoes

(Unit: 1,000ha)

Year	Cultivated Area	Incremental
1979/80	N.A.	-
1980/81	1.8	-
1981/82	2.1	0.3
1982/83	2.3	0.2
1983/84	2.4	0.1
1984/85	2.4	0
1985/86*	2.5	0.1
Average	-	0.1

Source: MAG
* : Estimate

4) Estimate of future demand for fertilizer

Based on the above calculations, Table 4-7-6 presents estimated cultivated area and fertilizer demand for tomatoes over the next ten years.

Table 4-7-6 Fertilizer Demand Projection for Tomatoes

Year	Cultivated Area (1,000ha)	Consumption (t P_2O_5)
1985/86	2.5	210
1986/87	2.6	218
1987/88	2.7	227
1988/89	2.8	235
1989/90	2.9	244
1990/91	3.0	252
1991/92	3.1	260
1992/93	3.2	269
1993/94	3.3	277
1994/95	3.4	286
1995/96	3.5	294

4.7.4 Paddy

1) Strandard dosage level

No standard dosage has been calculated for fertilization of irrigated paddy. 20 kgP_2O_5/ha is presented as standard based on results of experiments at the CRIA facilities.

2) Fertilized area

Most farmers engaged in the cultivation of paddy do not employ fertilizers. As the land cultivated for this crop is extensive, farmers plant paddy for two or three years, when yields decrease and a heavy mixture of red rice becomes a problem, then allow the land to lay fallow for six or seven years. According to MAG statistics, 10% of the paddy cultivated area is being fertilized. When fertilizer is applied to paddy fields, irrigating facilities are required, and at present such facilities are insufficient. Considering the prevalent cultivation practices and the lack of necessary facilities, the amount of paddy field under fertilization is not likely to show rapid increases. The analysis thus assumes an annual average growth of 1%.

3) Cultivated area

Table 4-7-7 shows the changes in cultivated and harvested area for paddy over the past ten years.

Table 4-7-7 Cultivated and Harvested Area of Paddy

(Unit: 1,000ha)

Year	Cultivated Area	Incremental	Harvested Area	Incremental
1976/77	19.6	-	18.3	-
1977/78	23.1	3.5	20.7	2.4
1978/79	25.0	1.9	22.0	1.3
1979/80	10.0	-15.0	9.7	-12.3
1980/81	9.1	-0.9	-	-
1981/82	14.7	5.6	14.7	-
1982/83	16.2	1.5	16.0	1.3
1983/84	18.3	2.1	18.3	1.3
1984/85	21.0	2.7	20.6	2.3
1985/86*	22.0	1.0	21.5	0.9
Average	-	0.3	-	0.4

Source: MAG
* : Estimate

As can be seen, little increase has occurred during this period, and the analysis assumes that the cultivated area will remain fixed at 22,000 ha for the following ten years.

4) Estimate of future demand for fertilizer

Based on the above reservations, Table 4-7-8 lists cultivated area, fertilized area and fertilizer demand for paddy over the next ten years.

Table 4-7-8 Fertilizer Demand Projection for Paddy

Year	Cultivated Area (1,000ha)	Fertilizer Applied Area (1,000ha)	Consumption (t P_2O_5)
1985/86	22.0	2.2	44
1986/87	"	2.4	48
1987/88	"	2.6	52
1988/89	"	2.9	58
1989/90	"	3.1	62
1990/91	"	3.3	66
1991/92	"	3.5	70
1992/93	"	3.7	74
1993/94	"	4.0	80
1994/95	"	4.2	84
1995/96	"	4.4	88

4.7.5 Sugarcane

1) Standard dosage level

Based on MAG estimates, the amounts of fertilizer used with sugarcane is between 200-300 kg/ha of NPK (15-15-15). The analysis therefore uses a figure of 250 kg/ha (37.5 kg P_2O_5/ha) as the standard dosage.

2) Fertilized area

The amount of sugarcane crop area presently being fertilized is only 4% of the total (MAG statistics). For the next ten years this figure will be estimated double the present rate, namely a yearly increase of 0.4% will be projected.

3) Cultivated area

Table 4-7-9 shows cultivated and harvested area for sugarcane over the past ten years.

Table 4-7-9 Cultivated and Harvested Area of Sugarcane

(Unit: 1,000ha)

Year	Cultivated Area	Incremental	Harvested Area	Incremental
1976/77	-	-	33.0	-
1977/78	-	-	34.8	1.8
1978/79	-	-	34.9	0.1
1979/80	40.5	-	-	-
1980/81	48.1	2.6	-	-
1981/82	-	-	-	-
1982/83	-	-	51.8	-
1983/84	-	-	54.6	2.8
1984/85	56.0	-	55.2	0.6
1985/86*	57.0	1.0	56.0	0.8
Average	-	-	-	2.6

Source: MAG
* : Estimate

Sugar has the potential of being an export crop, and sugarcane is also used in production of ethanol for automobile fuel. Thus there is a high likelihood of steady increases in the future. The analysis assumes an average annual increase of 1,000 ha/yr.

4) Estimate of future demand for fertilizer

Based on the above assumptions, Table 4-7-10 presents cultivated area, fertilized area and fertilizer demand for sugarcane over the next ten years.

Table 4-7-10 Fertilizer Demand Projection for Sugarcane

Year	Cultivated Area (1,000ha)	Fertilizer Applied Area (1,000ha)	Consumption (t P_2O_5)
1985/86	57.0	2.3	86
1986/87	58.0	2.6	96
1987/88	59.0	2.8	105
1988/89	60.0	3.1	116
1989/90	61.0	3.4	128
1990/91	62.0	3.7	139
1991/92	63.0	4.0	150
1992/93	64.0	4.4	165
1993/94	65.0	4.7	176
1994/95	66.0	5.0	188
1995/96	67.0	5.4	203

4.7.6 Projected Total Demand for Phosphate Fertilizers

The total demand for phosphate fertilizers, as tabulated in Table 4-7-11, is the sum of the individual crop demands calculated in the previous five sub-sections.

Table 4-7-11 Summary of Projected Fertilizer Needs by Crop

(Unit: t P_2O_5)

Year	Soybean	Wheat	Tomato	Paddy	Sugarcane	Total
1985/86	4,212	7,031	210	44	86	11,583
1986/87	4,806	7,676	218	48	96	12,844
1987/88	5,454	8,385	227	52	105	14,223
1988/89	6,102	9,095	235	58	116	15,606
1989/90	6,804	9,804	244	62	128	17,042
1990/91	7,533	10,578	252	66	139	18,568
1991/92	8,289	11,352	260	70	150	20,121
1992/93	9,099	12,191	269	74	165	21,798
1993/94	9,720	13,029	277	80	176	23,282
1994/95	10,260	13,932	286	84	188	24,750
1995/96	10,800	14,835	294	88	203	26,220
Av. Growth (% p.a.)	9.9	7.8	3.4	7.2	9.0	8.5

The demand for phosphate fertilizers is calculated to increase at the annual rate of 8.5%/y, and reach 26,200 tons of P_2O_5, which amounts to 2.3 times the present figure, by 1995/96. Of this total demand, 98% will be generated by the soybean and wheat crops (57% for wheat and 41% for soybeans.)

The demand structure for individual of phosphate fertilizers is estimated as follows:

- DAP: 90% of wheat
- TSP: 10% each of wheat and soybeans
- NPK (5-30-10): 90% of soybeans
- NPK (12-12-17-2): tomatoes
- NPK (15-15-15): paddy and sugarcane

TSP is used in portions of both the wheat and soybeans, in amounts estimated to be around 10% of each. The actual projected demand for each type of fertilizer is listed in Table 4-7-12.

Table 4-7-12 Summary of Projected Fertilizer Needs by Type

(Unit: t)

Year	TSP	DAP	5-30-10	12-12-17-2	15-15-15	Total
1985/86	2,400	13,800	12,600	1,800	900	31,500
1986/87	2,700	15,000	14,400	1,800	1,000	34,900
1987/88	3,000	16,400	16,400	1,900	1,000	38,700
1988/89	3,300	17,800	18,300	2,000	1,200	42,600
1989/90	3,600	19,200	20,400	2,000	1,300	46,500
1990/91	3,900	20,700	22,600	2,100	1,400	50,700
1991/92	4,300	22,200	24,900	2,200	1,500	55,100
1992/93	4,600	23,900	27,300	2,200	1,600	59,600
1993/94	4,900	25,500	29,200	2,300	1,700	63,600
1994/95	5,300	27,300	30,800	2,400	1,800	67,600
1995/96	5,600	29,000	32,400	2,500	1,900	71,400

In 1995/96, the demand for DAP, TSP, NP and NPK fertilizers is estimated to be around 71,400 tons, about 2.3 times the present level (31,500 t/y). DAP and NPK (5-30-10) will account for 86% of the total demand.

4.7.7 Projected Total Demand for Fused Magnesium Phosphate Fertilizer

Japanese-Paraguayan farmers have an experience of using fused magnesium phosphate fertilizer (FMP) several years ago, but nowadays use of FMP has almost totally disappeared. Reasons for its disappearance can be conjectured as follows:

- FMP is difficult to obtain, and thus cannot be relied upon on a continual basis.
- FMP works on a delayed reaction basis.
- FMP is expensive in terms of a unit P_2O_5 nutrient as compared with other chemical fertilizers.

- FMP comes in a powdered form, and thus requires special machinery to spread. Although farmers do not have such machines, existing machines could be adapted to fit the purpose.
- No farmers other than the Japanese-Paraguayans have experience with FMP.

Despite these drawbacks, farmers who have tried FMP claim that they work well in restoring old, acidic soils, indicating that it could be useful as soil restoratives. Many of these farmers seem eager to use FMP if they could obtain a reliable supply at a reasonable price.

On the other hand, no systematic experiments are being conducted on the fertility and the soil restorative powers of FMP. At least several years of solid research and experimentation are necessary before FMP can be systematically introduced into Paraguay agriculture.

Under such conditions, a projection for future demand of FMP is difficult to arrive at. Based on the following three premises, however, Table 4-7-13 attempts to estimate demand for FMP over the next ten years.

- The analysis assumes that the necessary research and experiments will be carried out, the fertility and the soil resorative properties of FMP verified, and proper spreading techniques developed.
- In the absense of data from the above research, the analysis assumes a temporary standard dosage of 300 kg/ha.
- For the regions where FMP may possibly be introduced, the analysis is restricted to areas of the Japanese-Paraguayan Agricultural Cooperatives and the UNIDAS Agricultural Cooperative (total cultivated area of 120,000 ha).

Table 4-7-13 Projection of FMP Consumption

Year	FMP Consumption (t)
1985/86	-
1986/87	-
1987/88	-
1988/89	-
1989/90	5,000
1990/91	6,000
1991/92	7,000
1992/93	9,000
1993/94	11,000
1994/95	13,000
1995/96	15,000

The first few years will be devoted to research and experiments, and there is little expectation that actual use will occur during this preliminary period. After 1989/90, as results of the experiments become available, FMP will be introduced on a gradual basis. By 1995/96, use of FMP will be about 40% in the targetted areas, and the demand is estimated to be around 15,000 tons.

4.8 Estimated Product Mix and Fertilizer Supply

4.8.1 Product Mix

Enough fertilizer to almost completely meet the projected 1995/96 demand could be produced in a planned fertilizer plant. The 12-12-17-2 fertilizer used variously in Paraguay could be covered by 15-15-15 fertilizer. 15-15-15 fertilizer is distributed on a worldwide basis, and in Japan is commonly used with vegetables, including tomatoes. With the manufacturing process employed in this project, 6-30-10 could be produced in lieu of 5-30-10 (see Section 7.1.2).

Product mix for the fertilizer plant is outlined in Table 4-8-1. Production capacity of the plant is set to be 70,000 tons/yr. The individual fertilizer types shown in Table 4-8-1 are representative product mixes.

Table 4-8-1 Product Mix

(Unit: t/y)

Fertilizer	Product Mix
DAP (18-46-0)	29,000
TSP (0-46-0)	5,000
NPK (6-30-10)	32,000
NPK (15-15-15)	4,000
Total	70,000

If experimental results at the Estacions or elsewhere, however, show a different component of NPK fertilizers to be the most suitable, the product mix could be altered to produce such fertilizers although there would be some process restictions.

The FMP plant will have the capacity to produce 15,000 tons of fused magnesium phosphate fertilizer per year.

4.8.2 Estimated Fertilizer Supply

Table 4-8-2 lists the projected fertilizer supply for the next ten years. The fertilizer plant is expected to begin operation in 1992, and should be able to fill the entire demand from then until 1994/95. In 1995/96, 600 tons of TSP and 400 tons 6-30-10 of fertilizer will have to be imported.

Table 4-8-2 Supply and Demand Projection

(Unit:t)

	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96
Supply											
Import											
DAP	13,800	15,000	16,400	17,800	19,200	20,700	10,600	-	-	-	-
TSP	2,400	2,700	3,000	3,300	3,600	3,900	2,300	-	-	-	-
5-30-10	12,600	14,400	16,400	18,300	20,400	22,600	12,100	-	-	-	-
12-12-17-2	1,800	1,800	1,900	2,000	2,000	2,100	0	-	-	-	-
15-15-15	900	1,000	1,000	1,200	1,300	1,400	1,600	-	-	-	-
Sub-total	31,500	34,900	38,700	42,600	46,500	50,700	0	-	-	-	-
Production											
DAP	0	0	0	0	0	0	11,600	24,650	27,550	29,000	29,000
TSP	0	0	0	0	0	0	2,000	4,250	4,750	5,000	5,000
6-30-10	0	0	0	0	0	0	12,800	27,200	30,400	32,000	32,000
15-15-15	0	0	0	0	0	0	1,600	3,400	3,800	4,000	4,000
Sub-total	0	0	0	0	0	0	28,000	59,500	66,500	70,000	70,000
Supply total	31,500	34,900	38,700	42,600	46,500	50,700	54,600	59,500	66,500	70,000	70,000
Demand											
DAP	13,800	15,000	16,400	17,800	19,200	20,700	22,200	23,900	25,500	27,300	29,000
TSP	2,400	2,700	3,000	3,300	3,600	3,900	4,300	4,600	4,900	5,300	5,600
5(6)-30-10	12,600	14,400	16,400	18,300	20,400	22,600	24,900	27,300	29,200	30,800	32,400
12-12-17-2	1,800	1,800	1,900	2,000	2,000	2,100	0	0	0	0	0
15-15-15	900	1,000	1,000	1,200	1,300	1,400	3,200	3,400	3,600	3,700	3,900
Demand total	31,500	34,900	38,700	42,600	46,500	50,700	54,600	59,200	63,200	67,100	70,900
Balance (Supply-Demand)	0	0	0	0	0	0	0	300	3,300	2,900	(-)900

4.9 Agricultural Financing

Table 4-9-1 lists the total credit and agricultural credit figures for 1981 through 1985.

Table 4-9-1 Total Credit and Agricultural Credit

(Unit: million Gs)

Year	Total Credit	Credit for Agricultural Sector	
1981	253,185.9	29,148.9	(11.5%)
1982	248,940.2	38,365.0	(15.4%)
1983	264,548.8	32,327.9	(12.2%)
1984	341,111.9	54,877.2	(16.1%)
1985	393,488.7	77,045.5	(19.6%)

Source: MAC

The percentage of total outstanding loans held in agricultural credit rose steadily from 11.5% in 1981 to nearly 20% in 1985.

Agricultural financing is provided by the Banco Central del Paraguay (BCP), Banco Nacional de Fomento (BNF), Credito Agricola de Habilitacion (CAH), and Fondo Ganadero (FG), as well as by privately owned banks. Short term loans for purchase of fertilizer, seed and agricultural pharmaceuticals, however, are provided only by BNF, CAH and the private banks.

Table 4-9-2 arranges the agricultural credit figures according to individual financial agencies for 1981 to 1985. As can be seen, BNF accounts for 40% of the total, and is the most important financial agency for the agricultural sector. Following is a brief discussion of financial services supplied by BNF, CAH and private banks, the agencies most closely involved with financing fertilizer purchases.

Table 4-9-2 Agricultural Credit by Financial Organizations

(Unit: million Gs)

Year	Banco Central	B.N.F.	C.A.H.	Fondo Ganadero	Private Banks	Total
1981	3,057.5 (10.5%)	13,208.0 (45.3%)	358.1 (1.2%)	2,822.6 (9.7%)	9,702.7 (33.3%)	29,148.9 (100%)
1982	9,339.1 (24.3%)	13,532.6 (35.4%)	319.4 (0.8%)	3,699.5 (9.6%)	11,474.4 (29.9%)	38.365.0 (100%)
1983	2,277.6 (7.0%)	14,507.4 (44.9%)	311.9 (1.0%)	2,375.3 (7.3%)	12,855.7 (39.8%)	32,327.9 (100%)
1984	12,042.8 (21.9%)	24,780.8 (45.2%)	358.9 (0.7%)	1,820.1 (3.3%)	15,874.6 (28.9%)	54,877.2 (100%)
1985	16,692.6 (21.7%)	30,605.6 (39.7%)	411.6 (0.5%)	4,790.0 (6.2%)	24,545.7 (31.9%)	77,045.5 (100%)

Note: Banco Central: Central Bank
B. N. F. : Banco Nacional de Fomento, National Development Bank
C. A. H. : Credito Agricola de Habilitacion, Agricultural Credit of Financing
Fondo Ganadero : Livestock Fund

Source: MAG

4.9.1 Banco Nacional de Fomento (BNF)

Founded in 1961, BNF provides three main avenues of service, long and medium term loans for development in the agricultural and animal husbandry sectors, saving deposits for business, and short and medium term financing for the agricultural and animal husbandry sectors. 46 branch offices of BNF are located around the country.

For crops such as wheat and soybeans, BNF provides up to 70% of production costs through short term loans. The loan period is the same as the cultivation period (around 7 months), and repayment is due within 60 days after the harvest. The loans are subject to the following conditions:

- interest = 12%/yr
- borrowing charge = 1%
- stamp duty = 1.75%
- repayment fee = 0.5%/month
- mortgage: land

When agricultural cooperatives reissues the loans, there is an additional surcharge of around 1%, and the final rate to the farmers come to about 19% interest on loans for production costs. As some type of mortgage is required, small scale farmers are ineligible for these loans, and the annually based financing framework is insufficient to meet all needs.

4.9.2 Credito Agricola de Habilitacion (CAH)

CAH provides financing for small-scale farmers. Although the amount provided in each case is usually small, CAH services cover a wide area and reach a large number of small farmers. Loans are extended to members of small farmer cooperative groups called AUCA (regional credit associations). The AUCA function as intermediary organizations between CAH and the small farmers, accepting and repaying loans on their members behalf. Members also purchase production supplies and sell their harvest through these organizations. A land title deed is not usually required to be eligible for CAH loans, which reach 5,450 small farmers in 228 AUCA organizations served by 22 CAH regional branch offices.

4.9.3 Privately-owned Banks

Loans from private banks carry interest charges of 24% annually, and are thus rarely used by farmers to finance production costs.

4.10 Research and Extension Services

4.10.1 Research and Experimental Organs

At the level of national government in Paraguay, two research and experimental organizations, IAN (Instituto Agronomico Nacional) and CRIA (Centro Regional de Investigacion Agricola), exist under the supervision of MAG's Bureau of Agriculture and Forestry Research Extension.

IAN conducts a variety of experiments with important crops, and also basic research and experiments with soils, crop diseases and harmful insects. CRIA experiments concentrate on improving varieties of dry field crops such as soybeans, wheat and corn. In addition to these two, agricultural and soil research experiments are also conducted at the Agricultural Department of Asuncion University.

JICA's research and experimental facilities, the Estacion Experimental Agropecuaria en Paraguay, are located at Yguazu in the Department of Alto Parana. The main objectives of the Estacion are to promote and stabilize farm management among the Japanese-Paraguayan farmers, to help improve regional farm management in Paraguay, and to advance international cooperation. The most important activities being carried out at the Estacion are as follows:

- Experimental Research - concerning soybeans, wheat, corn, vegetables such as tomatoes and melons, soil fertilization, beef, pasturage, examination and treatment of livestock, etc.
- Farm Management Extention Services - collection of statistics and research materials, data analysis, reporting on experimental results, publication of farm management bulletins and other extension materials, introduction, propagation and distribution of seeds, seedlings and breeding stock, exhibits, hands-on lectures and demonstrations, farmers economic surveys, guidance of research groups, etc.
- Research Cooperation and Exchange - with CRIA, IAN, etc.
- Technical Cooperation - cooperation with various research groups, and management support for budding technicians.
- Planning of Agricultural Development in the Colonized Regions - standard farm management plans, farm management rebuilding programs, regional agricultural development, and agricultural cooperative restructuring programs.
- Leadership Guidance - for young people involved in agricultural development.
- Administration and Management of the Estacion.

Information exchange between the various research and experimental organizations is not limited to cooperation on specific experiments, but includes working together in experiment design, and regular meetings such as discussion on results of experiments, the Paraguay Researchers Meeting, and the JICA Specialist's Research Communication Meetings.

4.10.2 Extension Service Organizations and Activities

The government of Paraguay is actively involved in agricultural extension services through the Servicio de Extension Agricola-Ganadero (SEAG). Financial organs such as BNF and CAH, as well as the Institute de Biemestar Rural (IBR), also cooperate with extension services through financing or colonization activities. In addition, there are several related organizations within MAG, such as the Cotton Research Extension Program (PIEA) and the National Tobacco Plan

(PRONATA).

When first founded in 1951, SEAG had only 22 regional offices, but now deploys 434 extension workers in 125 regional offices spread all over the country. The main office, located at San Lorence in the Department of Central, has a total of 69 administrative employees and specialists (see Table 4-10-1).

Table 4-10-1 Personnel of SEAG

	Head Office	Regional Office	Total
Agricultural Engineer (MS)	6	2	8
Agricultural Engineer	13	43	56
Agronomist	8	49	57
Agricultural Expert	-	128	128
Veterinarian	2	11	13
Economist (Dr.)	2	-	2
Personnel (graduated from junior high school)	2	17	19
Instructor etc.	36	184	220
Total	69	434	503

Source: SEAG, as of December, 1985

The activities of the regional offices concentrate on small farmers who cultivate 20 ha or less. Each office has one to three resident extension workers that provide on-the-farm guidance to individual farmers. One extension worker serves an average of 120 farmers.

Once or twice a year, meetings are held to announce the results of research at IAN and CRIA. At these meetings, SEAG extension workers and agricultural cooeprative technicians are informed of and given a chance to discuss the latest research developments.

Afterwards, the extension workers return to their districts and hold their own meetings to relay this information to the farmers. In addition, both research organizations send written reports of their results to the Representative Extension Office in each Department, and these are then forwarded to all the individual offices. CRIA also has a core technical training program aimed at extension workers.

Results of experiments at the Estacion Experimental Agropecuaria en Paraguay are conveyed directly to the Japanese-Parguayan farmers. Technical representatives are also dispatched to meetings staged by MAG, and through their reports results from the Estacion are communicated outward.

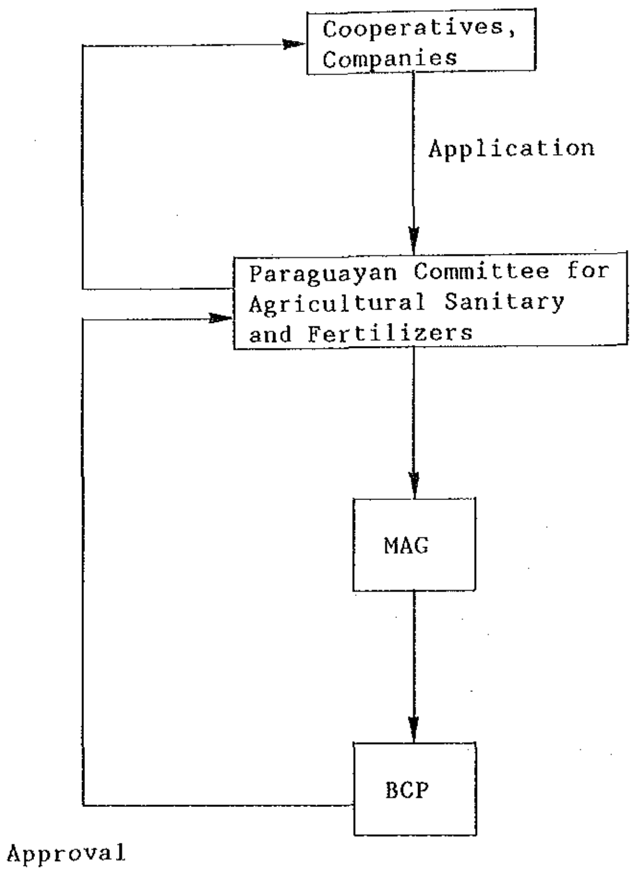
In addition to the above-mentioned government agencies, private fertilizer trading companies also provide advice and guidane to their customers. Generally speaking, however, extension activities provided by SEAG, IAN and CRIA are still insufficient, and should be upgraded in the future.

4.11 Fertilizer Distribution System

4.11.1 Import Procedures

Foreign exchange necessary for fertilizer import is calculated at the official exchange rate of 240 Gs/US$. Agricultural cooperatives or fertilizer and agricultural pharmaceuticals trading companies that wish to import it must file an application with the Banco Central del Paraguay (BCP).

The route of this application is diagrammed in Figure 4-11-1. The application is first submitted to the Paraguayan Committee for Agricultural, Sanitary and Fertilizers, where it is checked and sent on to MAG. MAG, which is responsible for regulating the total amount to be imported, then reviews the stated crop area and requested amount of fertilizer, and submits its decision to the BCP, where the import permit and letter of credit are finally issued. The results of this decision making process are relayed to the applicants through the Committee.



Remarks

MAG : Ministry of Agriculture and Livestock

BCP : Banco Central del Paraguay

Figure 4-11-1 Route of Application for Fertilizer Importation

The problem with this system is the length of time required between initial application and final approval, which is recent years has prevented farmers from obtaining the right type of fertilizer at the proper time. The reason for this delay in processing the application is insufficient foreign exchange capital, which must be carefully alloted among many potential user groups. In this connection, a policy which gives priority to importation of agricultural materials is a necessary step in correcting the problem.

4.11.2 Fertilizer Distribution Route

All fertilizer used in Paraguay is imported from Brazil and other countries. Most is transported by truck, from Foz do Iguacu to the border then across the Bridge of Friendship and on to Stroesner. Imported fertilizer landed on the Paranagua (Brazil) also is transported by truck along this route. In addition, fertilizer from Monte Video (Uruguay) and Buenos Aires (Argentina) comes by water up the Rio Parama or Rio Paraguay to Asuncion. Another route runs from Porto Alegre (Brazil) to Posadas (Argentina) by rail, then crosses the Rio Parana into Encarnacion.

Within Paraguay, fertilizer is transported almost entirely by truck, and delivered directly to the farmers and agricultural cooperatives that use it. The fertilizer dealers and transportation agents have no facilities for storing or warehousing the fertilizer.

A major problem with the present distribution system is that Paraguay is a landlocked nation with poor rail transportation. Long distance transport depends entirely on trucks, and is thus very expensive.

4.11.3 Fertilizer Distribution Network

Fertilizer and agricultural pharmaceutical trading companies participate either directly or indirectly in fertilizer import. They either import the fertilizer themselves and sell direct to the consumers, or import under consignment from agricultural cooperatives that have obtained an import permit.

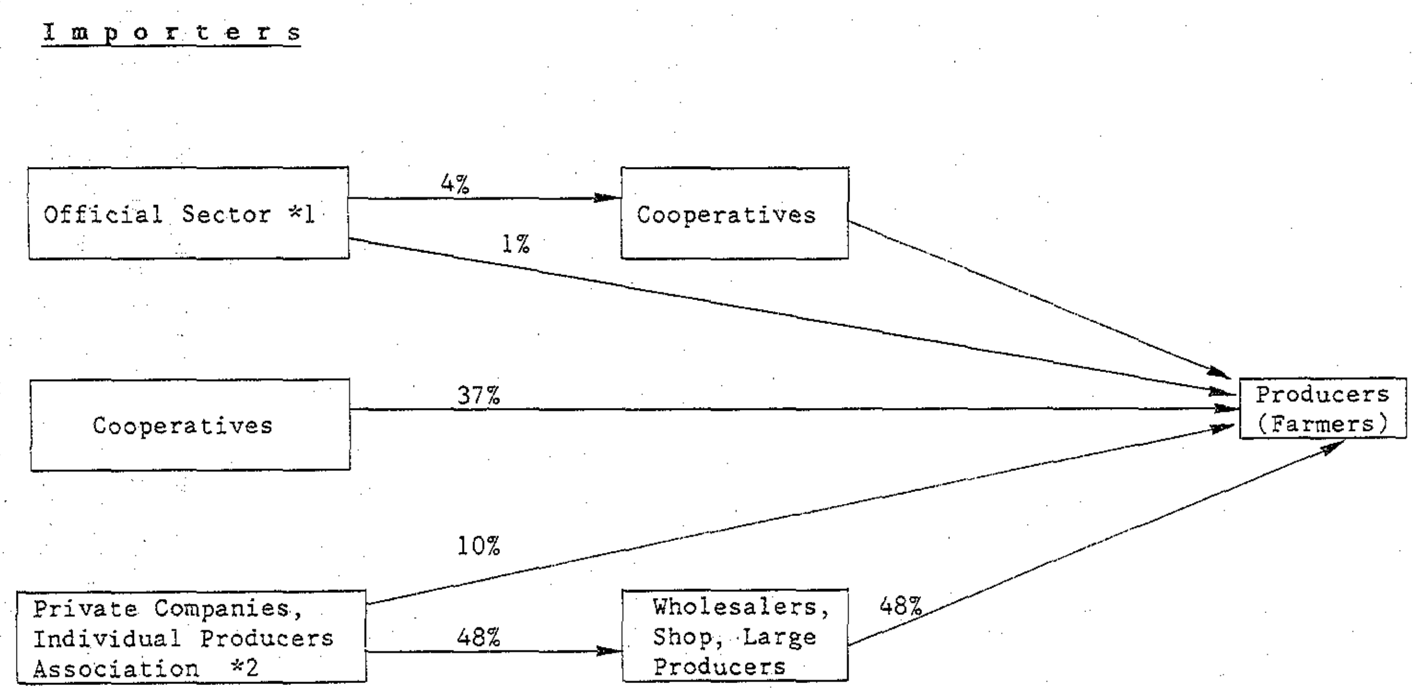
Fertilizer that is received by grant from abroad (such as The Second KR from Japan) is handled by MAG or the Credito Agricola de Habilitacion (CAH), and is sold below market price mainly to small farmers through the AUCA system, but also to some extent to agricultural cooperatives.

Figure 4-11-2 charts the distribution system for officially imported fertilizer. *In addition, there is also the fertilizer inflow not shown in* the statictics. Although the system is not clearly understood, in some cases the consumers journey directly to Brazil to make their own purchases, and in other cases dealers bring the fertilizer in and sell it.

4.12 Considerations

1) The government needs to conduct extensive statistical research on importation of fertilizer. A thorough knowledge of the supply and demand conditions is necessary for drawing up plans for a fertilizer development program. The amount of officially imported fertilizer needs to be accurately verified, and it is equally important to find out more about the inflow not shown in the statistics. The government should take necessary measures for making sufficient quantities and desired types of imported fertilizer available on a timely basis and at a reasonable price.

2) *The use of fertilizer by Paraguayan farmers has a relatively short* history, only about 10 years or so. In the future, research and experimental organizations like CRIA and the Estacion Experimental Agropecuaria en Paraguay should concentrate on developing a fertilizer utilization technology well suited to Paraguay's soil and farming practices.



Remarks

*1: CAH and MAG. CAH sells fertilizer to AUCA.
*2: Member of Paraguayan Committee for Agricultural Sanitary and Fertilizers

Source: MAG

Figure 4-11-2 Fertilizer Distribution Channels (1984/85)

3) Although the present levels of fertilizer use are low, VCR shows these dosages to be the most economically effective at this time. The reason for this is that while fertilizer prices are high, crop value is comparatively low. Under the prevailing fertilizer/crop price structure, individual farmers already using fertilizer are unlikely to increase their dosages, but as even low levels of fertilization clearly produce results, farmers who have not yet to employ fertilizer can be expected to pick up the practice.

4) Considering the types of fertilizers for future use, NPK (5-30-10) and DAP are now used respectively for soybeans and wheat, and experimental results confirm these to be the most effective fertilizers. There should be some demand for TSP as a simple fertilizer, and NPK fertilizers of 12-12-17-2 or 15-15-15 will be used with tomatoes.

5) Demand for NP, NPK and phosphate fertilizers is expected to reach 71,400 tons in 1995/96. Using this figure as a base, a fertilizer plant with productive capacity of 70,000 tons/yr would be suitable. In 1995/96 supply and demand would be almost equal, but afterwards demand would increase beyond the capacity of the plant. Plans should thus be made to meet this increased demand through import or by expanding the capacity of the plant.

6) As experimental data on fused magnesium phosphate fertilizer (FMP) has not yet to be completed, plans for facilities to produce FMP should await experimental confirmation of their effectiveness.

7) As fertilizer purchase depends on agricultural financing programs, these should be upgraded and expanded. BNF, which plays the major role in agricultural financing, should consider such options as widening the scope of its lending policies, lightening the mortgage procedures and requirements, and reducing the interest on short term loans. Such improvements would allow agricultural financing services to reach a greater number of farmers, which is a necessary prerequisite for future development.

8) Communication between CRIA and the agricultural extension offices needs to be improved, with a consistent and dependable system for relaying the results of CRIA experiments through the extension offices to the farmers.

9) Until fertilizer plant is established in Paraguay, in order for farmers to obtain the types and amounts of fertilizers they need in a timely manner, the procedures for import permit applications should be streamlined, and fertilizer import given priority in terms of the foreign exchange allocation.

CHAPTER V PRODUCT MIX AND CAPACITY

5.1 Basic Conditions

The fundamental questions concerning production at the Paraguayan fertilizer plant are what types of fertilizers, and in what quantities, would be most beneficial to Paraguay. Below is a list of potential types, and following will be a comparison of these in terms of production possibilities. Market analysis will be used to determine which types are most desirable, and in what quantities they should be produced at the Paraguayan plant.

Product to be considered

1) TSP (Triple Superphosphate)
2) FMP (Fused Magnesiumphosphate)
3) MAP (Monoammonium Phosphate)
4) DAP (Diammonium Phosphate)
5) APP (Ammonium Polyphosphate)
6) NPK (NPK compound Fertilizer)

5.2 *Production Factors for Various Fertilizer Types*

1) Raw materials

Table 5-2-1 shows the raw materials required for production of all six fertilizer types. As can be seen, all except FMP utilize *phosphoric acid*. The *phosphoric acid, however, is required as an* intermediate product, which can be manufactured by either the "dry" or "wet" process.

Table 5-2-1 Raw Materials Required for Fertilizer Production

Product Mix / Raw Material	TSP	FMP	MAP	DAP	APP	NPK
Phosphate Rock	o	o				
Phosphoric Acid	o		o	o	o	o
Ammonia			o	o	o	o
Muriate of Potash						o
Serpentine		o				

An outline comparison of the wet and dry process is presented in Table 5-2-2. The wet process has low energy requirements, and is thus normally used in production of phosphoric acid for fertilizers. This method, however, requires sulfur or sulfuric acid as a raw material. In Paraguay, there are neither sulphur deposits nor sulphuric acid plants, but energy in the form of electric power is abundant and relatively inexpensive. Thus the dry process employing an electric furnace will be adopted for the Paraguayan fertilizer plant.

Table 5-2-2 Comparison of Phosphoric Acid Production Processes

	Wet Process	Dry Process (Electric Furnace Process)
Raw Material Required	Phosphate rock Sulfur or sulfuric acid	Phosphate rock coke, silica gravel, and, electric power
Product Acid	Main usage for fertilizers	High quality usage for food grade chemicals and also fertilizers

2) Production process

An outline of the production process for fertilizers is described below:

(1) TSP

This fertilizer is produced through the following reaction by crushed phosphate rock and phosphoric acid.

$$Ca_3(PO_4)_2 + 4H_3PO_4 \rightarrow 3\ [Ca(H_2PO_4)_2]$$

According to the conditions under which this reaction occurs, two processes are available, the den process and the slurry process. The den process allows the reaction to occur in a temperature controlled "den" containing a mixture of phosphate rock and phosphoric acid, producing powdered TSP fertilizer. The slurry process, on the other hand, involves drying and granulating "slurry" produced by the reaction in to a granular product.

(2) FMP

Phosphate rock and serpentine are mixed and melted in a furnace, then quenched and cracked with water. This process can be accomplished with either an electric furnace or an open hearth furnace using fuel oil. The Paraguayan project would employ the electric furnace option due to availability of abundant electricity.

(3) MAP

Phosphoric acid and ammonia are reacted according to the equation listed below. The resultant slurry is granulated and dried as in (1) above.

$$H_3PO_4 + NH_3 \rightarrow NH_4H_2PO_4\ (MAP)$$

(4) DAP

This process is the same as that described in (3) above, except for the reaction equation, which is as follows.

$H_3PO_4 + 2NH_3 \rightarrow (NH_4)_2HPO_4$ (DAP)

(5) APP

This process is fundamentally the same as that in (3) and (4) above, but the reaction temperature is higher.

(6) NPK

P_2O_5 in the NPK is in the form of ammonium phosphate. This product can be produced by the process (3) and (4) above adding potash and urea feeding facilities.

In summary, as can be seen from the above brief description, TSP, MAP, DAP, APP and NPK fertilizers can all be produced by a similar process based on the slurry process. FMP fertilizer, on the other hand, requires a totally different production process using an electric furnace.

3) Characteristics of the various fertilizer types

The major characteristics of the six fertilizers are described below.

(1) TSP

This is a quick-acting fertilizer with monocalcium phosphate ($Ca(H_2PO_4)_2H_2O$) as the main ingredient. The total phosphoric acid content (P_2O_5) is about 50%, of which approximately 90%

is water soluble. Although chemically acidic, TSP is physiologically neutral, and does not lower the soil pH level even over extended use. In fact, when spread in strongly acidic soils, the plants absorb the phosphoric acid but leave the calcium in the soil, which tends to neutralize the pH level.

(2) FMP

This is a slow-acting fertilizer with no water soluble phosphate. The total P_2O_5 content is between 18 and 21%, of which over 17% is citric acid soluble (soluble in 2% citric acid). Aside from phosphate, FMP fertilizers also contain 20-30% calcium (CaO), 15-18% magnesium (MgO) and 23-27% silica (SiO_2), and as such can also be expected to produce results as a soil restorative.

(3) MAP

This quick-acting fertilizer is a stable product consisting of chemical compounds of the nitrogen and phosphoric acid necessary for plant growth. Nitrogen and phosphoric acid content is high, for example, 11% nitrogen and 55% phosphoric acid (P_2O_5). Although chemically acidic, MAP is physiologically neutral, and there is thus no danger of soil acidification due to its use.

(4) DAP

Similar to MAP, this fertilizer is a quick-acting stable product of chemically compounded nitrogen (18%) and phosphoric acid (46% as P_2O_5). The effectiveness of DAP is equal or slightly higher than that of MAP, and as this fertilizer chemically neutral, it does not acidify the soil.

(5) APP

This is a concentrated fertilizer with a combined nitrogen and phosphoric acid content between 70 and 77%. The content of phosphatic nutrient (P_2O_5) is 60% and is exceptionally high. The main components are ammonium phosphate (MAP) and tri-ammonium pyro-phosphate ($(NH_4)_3HP_2O_7$). The effectiveness of APP fertilizer compares favorably with DAP, but as results do not appear until the fertilizer is dissolved by the action of microorganisms in the soil, the effects tend to be slightly delayed and also influenced by the temperature of the soil.

(6) NPK

The phosphate in these fertilizers is in the form of ammonium phosphate, and the combined content of nitrogen, phosphoric acid (P_2O_5) and potassium (K_2O) is over 35%. The ratio of these three components can be freely adjusted, enabling production of a nutrient ratio ideally matched to particular crops and soil conditions. While the phosphate is all in the form of ammonium phosphate (MAP or DAP), the nitrogen is contained in the form of ammonium phosphate, ammonium sulfate or urea. Nutrient potassium is present in as potassium chloride, but chemically the dominant components exist as complex salt or solid solution with ammonium phosphate and ammonium sulfate.

NPK fertilizers, which contain all three essential nutrients, are far easier to spread than single fertilizers, one each for nitrogen, phosphorus and potassium. This advantage is particularly important in large scale agriculture where machines can be used for spreading.

NPK fertilizers can be produced in a nutrient ratio appropriate to local situations, and as all three nutrients can be supplied to the soil simultaneously, the effect is multiplied. These fertilizers are water soluble, but come in granulated form. They are thus easy to handle and can be expected to work over a period of time.

5.3 Consumption Trends for the Phosphate Fertilizer Types

World and regional figures for consumption of phosphate fertilizer products are shown in Table 5-3-1. Consumption of the types of fertilizer depends on regional characteristics such as main crops and soil conditions. On a worldwide basis, however, NPK and ammonium phosphate fertilizers such as DAP and MAP are the top movers, with TSP in a secondary position. Of the six fertilizers considered for production at the Paraguayan plant, APP and FMP are specialized phosphate fertilizers outside the mainstream of world consumption.

Table 5-3-1 Phosphate Fertilizer Consumption by Product, 1974/75 - 1984/85

(Unit: 1,000tP_2O_5)

REGION	YEAR	BASIC SLAG	GROUND ROCK	SINGLE SUPERPHOSPHATE	TRIPLE SUPERPHOSPHATE	OTHER STRAIGHTS	AMMONIUM PHOSP.	COMPOUNDS NP/NPK	COMPOUNDS PK	TOTAL
WEST EUROPE	1984/85	196	59	245	396	66	90	3532	998	5080
	1974/75	721	54	477	108	62	8	2618	970	5018
EAST EUROPE	1984/85	47	816	2098	2216	50	2929	1861	7	10030
	1974/75	62	964	2864	1412	140	624	976	18	7060
NORTH AMERICA	1984/85	-	-	17	353	35	4534	included in ammonium		4941
	1974/75	7	1	35	587	18	4024	Phosphates figures.		4671
LATIN AMERICA	1984/85	5	42	523	565	101	675	528	-	2440
	1974/75	18	131	327	461	28	432	221	2	1623
OCEANIA	1984/85	-	-	724	77	-	135	167	46	1149
	1974/75	-	1	731	37	-	23	32	6	831
AFRICA	1984/85	-	-	94	107	9	163	502	6	923
	1974/75	1	19	75	93	22	30	374	10	687
NEAR EAST	1984/85	-	-	129	434	-	708	327	2	1600
	1974/75	-	-	152	83	-	198	282	2	491
SOUTH ASIA	1984/85	-	34	298	201	-	1101	654	-	2288
	1974/75	-	4	123	46	-	282	170	-	626
EAST ASIA	1984/85	-	79	65	499	140	62	976	-	1821
	1974/75	-	38	61	197	146	49	783	-	1274
SOCIALIST ASIA	1984/85	-	300	2000	300	750	1300	350	-	5000
	1974/75	-	200	1138	-	465	17	89	-	1906
W O R L D	1984/85	248	1330	6195	5148	1151	11697	8897	1059	35725
*********	1974/75	809	1413	5983	3025	880	5690	5545	1007	24352

Source; IFA

5.4 The Most Desirable Product Mix

Product mix to be produced at the Paraguayan fertilizer plant is based on market research and on the comparisons presented in Section 5.2. The product mix for this project, also discussed in Section 4.8, is listed in Table 5-4-1. All these fertilizer types can be produced economically using common facilities located in a single plant complex.

In addition, the Paraguayan fertilizer project should consider the option of producing FMP as well. This, however, would have to be produced in an entirely separate plant.

5.5 Plant Capacity

Table 5-4-1 also presents production capacity for the product mix of fertilizer, based on the estimates of demand discussed in Section 4.7. The capacities meet the demand for 1995/96, and the implementation of the project is assumed to started in 1987 and full production reached in 1994/95.

Table 5-4-1 Product Mix

(Unit: t/y)

Fertilizers	Product Mix
DAP (18-46-0)	29,000
TSP (0-46-0)	5,000
NPK (6-30-10)	32,000
NPK (15-15-15)	4,000
Total	70,000
FMP (0-20-0)	15,000