, 56

Draft For Discussion

THE PHOSPHATE FERTILIZER SECTOR IN COLOMBIA
SUPPLY ALTERNATIVES AND POLICY OPTIONS

A Report Prepared by

IFDC/CIAT Phosphorus Project
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Submitted to

International Development Research Center
Bogota, Colombia

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April 1987

INDEX

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List of Tables

List of Figures

ACRONYMS AND ABBREVIATIONS

ABOCOL	Abonos Colombianos
CIAT	Centro Internacional de Agricultura Tropical
COLPUERTOS	Empresa Colombiana de Puertos
CVC	Corporacion Autonoma del Cauca
ECOMINAS	Empresa Colombiana de Minas
ECOPETROL	Empresa Colombiana de Petroleos
FAO	Food and Agricultural Organization
FEDEARROZ	Federacion de Arroceros
FEDECAFE	Federacion Nacional de Cafeteros
FERTICOL	Fertilizantes Colombianos
FOSFOBOYACA	Fosfatos de Boyaca
FOSFONORTE	Fosfatos de Norte de Santander
FOSFACOL	Fosfatos Colombianos
IBRD	International Bank for Reconstruction and Development
ICA	Instituto Colombiano Agropecuario
IDRC	International Development Research Center
IFDC	International Fertilizer Development Center
IFI	Instituto de Fomento Industrial
IGAC	Instituto Geografico Agustin Codazzi
INCOMEX	Instituto Colombiano de Comercio Exterior
INCONTEC	Instituto Colombiano de Normas Tecnicas
INGEOMINAS	Instituto Geologico y Minero
MAG	Ministerio de Agricultura
MONOMEROS	Monomeros Colombo-Venezolanos
PRO-EXPO	Fondo de Promocion de Exportaciones
QB	Quimica Basica
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization

CURRENCY EQUIVALENTS

US $ 1 00 = $ 230 00

WEIGHTS AND MEASURES

1 hectare (ha) = 10,000 meters
1 hectare = 2 47 acres
1 metric ton (ton) = 1,000 kilograms (kgs)
1 kilometer (km) = 6214 miles

ABBREVIATION OF TERMS

CIF	cost, insurance and freight
DAP	Di-ammonium Phosphate
FOB	free on board
KCl	Potassium Chloride
km	kilometer
H_2SO_4	Sulfuric Acid
masl	meters above sea level
NE	North East
NPK	Multinutrient Fertilizer
PAPR	Partially Acidulated Phosphate Rock
RAE	Relative Agronomic Efficiency
REE	Relative Economic Efficiency
SSP	Single Super Phosphate
SW	South West
ton	metric ton
TSP	Triple Super Phosphate
VCR	Value-Cost Ratio
yr	year

THE PHOSPHATE FERTILIZER SECTOR IN COLOMBIA SUPPLY ALTERNATIVES AND POLICY OPTIONS

I INTRODUCTION

The population of Latinamerica has been increasing at an average rate of 2 3%/year during the past decade As population increases and countries strive to feed its population added pressure is placed on available resources, including crop land To meet the ever increasing need for food, countries can resort to increase productivity and/or to expand crop lands where available Increases in productivity can be achieved through the use of agro-chemicals and improved seeds, expansion of irrigated systems and the adoption of improved cultural practices Increases in total food production can also be achieved through the incorporation of new or marginal lands into the production process New or marginal lands are generally of lower fertility and located farther away from consumption centers than lands presently used The route that policy makers in a given country select to meet its own food needs depends on many factors, among them are the availability of new or marginal lands and the availability of agro-chemicals

In Latinamerica there are large areas of marginal low fertility lands, with agricultural potential However, lack of appropriate infrastructure and high transportation costs to densely populated urban centers preclude their fast incorporation into the agricultural production process Therefore, to meet the ever increasing demand for food, increases in productivity along with a systematic incorporation of new or marginal lands is necessary

According to Sanchez and Cochran[1], there are approximately 1 5 billion hectareas in tropical America (between 23 South and 23 North), of which 1 2 billion or 82% of the total exhibit phosphorus deficiencies Sanchez and Salinas[2] indicate that 822 million hectareas in Latinamerica are classified under Oxisols and Ultisols, soils which are characterized by their acidity and low fertility, but which can be incorporated into the agricultural production process once the fertility limitations have been removed through the use of amendments and fertilizers

Recent developments in the world economy have left most Latinamerican countries in a precarious balance of payment situation and in want of foreign exchange To avoid further drain in scarce foreign exchange, Latinamerican countries are now trying to substitute imports through the development of their domestic natural reserves In Latinamerica, with the exception of Brazil, all countries depend up to some degree on phosphate imports to supply their market needs[3] This is so, even though a large number of countries have phosphate rock reserves, which could be used to supply the need for phosphates The development of phosphate rock reserves is specially attractive since its represent savings in foreign exchange through the reduction and/or elimination

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[1] Sanchez, P A and Cochrane T T 1980 In Priorities for Alleviating Soil-related Constraints for Food Production in the Tropics P A Sanchez and L E Tergas, editors p 107-140, IRRI, Los Banos, Philippines

[2] Sanchez, P A and J G Salinas 1983 Suelos Acidos, Estrategias para su Manejo con Bajos Insumos en America Tropical" Sociedad Colombiana de la Ciencia del Suelo Bogota, Colombia

[3] IFDC 1986 Latinamerica Fertilizer Situation IFDC Muscle Shoals, Alabama, USA

of phosphate imports, and the potential increases in food production due to an increase use of readily available fertilizers

The Government of Colombia, country which is the subject of this study, has shown considerable interest in the development of its phosphate rock reserves During the past few years it has devoted a considerable amount of resources to the study of the phosphate rock reserves Studies carried out include geological surveys, and the feasibility studies for the development of phosphate fertilizer production complexes

Background

The International Fertilizer Development Center (IFDC), in cooperation with the Centro Internacional para Agricultura Tropical (CIAT), and with basic funding from the International Development Research Centre (IDRC) of Canada, started the so-called IFDC/CIAT Phosphorus Project in 1977 The overall objective of this project is to aid in the development of a fertilizer strategy for the acid infertile soils of Latinamerica using, where possible, phosphate sources indigenous to the region Research being conducted is aimed at identifying the agronomic efficiency and potential agricultural uses of Latinamerican phosphate rocks and of fertilizer products which could be manufactured from these ores Over the past years a series of laboratory, greenhouse and fields experiments have been conducted in pursue of project objective s

During early stages of this project fertilizer materials produced at IFDC s pilot plant have been tested at various agricultural research centers in Bolivia, Colombia, Costa Rica, Ecuador, Mexico, Peru, and Venezuela The agronomic response has been studied and measured on a variety of crops and under different agro-climatic conditions[4] Research conducted has allowed to make a classification of many of Latinamerican phosphate rocks according to their agronomic potential, as determined by their solubility and crop response[5]

Great progress has been made in the understanding of phosphate rock used as fertilizer in particular, and in phosphorus fertilization in general Research results obtained through work in this project have had implications and provided guidelines, not only for phosphorus research and phosphate fertilization management in Latinamerica, but also for other tropical regions of the world

Objectives

During the past few years throughout the development of the IFDC/CIAT Phosphorus Project and due to the nature of information available and gaps in phosphorus fertilization knowledge, special emphasis has been given to the agronomic aspects of different phosphate rocks and of products that could be manufactured from them The overall objective of this report covers a different research aspect, which is that of the identification and analysis of specific

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[4] See for example Leon L A and L L Hammond 1984 Efectividad Agronomica de las Rocas Fosforicas del Tropico Latinoamericano In La Roca Fosforica Fertilizante de Bajo Costo Grupo Latinoamericano de Investigadores en Roca Fosforica (GLIRF) Cochabamba, Bolivia, and Leon, L A and W E Fenster 1979 Management of Phosphorus in the Andean Countries of Tropical Latin America In Phosphorus in Agriculture ISMA No 76, September 1979

[5] Leon, L A , W E Fenster and L L Hammond 1986 "Agronomic Potential of Eleven Phosphate Rocks from Brazil, Colombia, Peru and Venezuela SSSA Journal Vol 50, May-June 1986 No 3 p 798-802

government fertilizer policies and of market, agronomic and deposits characteristics which will be conducive to the efficient use of indigenous phosphate rocks

Colombia has been selected as a case study because it is the country in which the current IFDC/CIAT Phosphorus Project has the largest amount of agronomic response and other needed data, and because of the interest of the pertinent government authorities in the development of domestic phosphate resources However, as the project progresses, studies similar are expected to be conducted in other Andean countries Government institutes in Ecuador, Bolivia and Peru have expressed interest in this kind of work

To accomplish this rather general overall objective, the following aspects of the Colombian agricultural and fertilizer sectors have been described and/or analyzed

1 Agricultural Sector
2 Fertilizer Use and Phosphate Demand Projections
3 Fertilizer Supply
4 Description of Domestic Phosphate Reserves
5 Agronomic and Economic Evaluation of Phosphate Sources
6 Potential Use of Phosphate Rock and of PAPR
7 Phosphate Supply Alternatives
8 Prices and Production Costs
9 Fertilizer Policy

Due to the nature of this report, the descriptions and analysis included in some of the sections are related to the major crop nutrients, namely N, P_2O_5 and K_2O However, where applicable and possible emphasis is given to phosphate fertilizers

II AGRICULTURAL SECTOR

Colombia is, and traditionally has been, an agricultural country As a fact, agriculture has been for many years, and is presently, the leading economic activity which during the 1982-84 period employed and average of 30% of the work force, and contributed to about 22% of the GNP[1] As can be estimated from table 1, agricultural products have accounted for 66% to 68% of the country exports during the 1982-84 period At the same time, agricultural imports of finished products and raw materials have accounted for 9% to 10% of all country imports during that same period

One important fact presented in table 1, is that Colombia has had an agricultural import-e port surplus balance during the period mentioned, whereas the country as a whole exhibits a deficit situation However, as shown in this table, the total deficit shows a decreasing trend

Agricultural Production

Colombia is well endowed with widely contrasting agroclimatic regions, which allow for the production of tropical crops as well temperate climate crops This situation has enable the country to be self sufficient for the supply of most agricultural products Table 2 presents the estimated area, production and yield, for the most important crops of the country

As table 2 shows, it is estimated that Colombia presently (1985) has about 4 1 million hectareas devoted to crop production This figure does not include land in pastures and graze lands, which alone, and depending on the data source used can, by far, exceed the total crop land area Of the 4 1 million has , about 25/ or 1 1 million has are devoted to coffee, the most important crop of the country

Coffee is followed in area by maize, rice, bananas and sugar cane, in that order As far as crop production, the production of bananas occupy the first place, followed by potatoes, and rice In terms of crop production value, coffee is by far the most important crop

With respect to crop yields, also shown in table 2, two of them deserve special attention rice and maize Rice because it has a very high yield (4 6 ton/ha), one of the highest in the world, and maize because it has a very low yield (1 4 tons/ha) The reasons for this are in part social and economic, and in part agronomic A large percentage of maize is planted in low fertility, steep lands by small farmers, while rice is usually cropped in well irrigated, fertilized and highly mechanized flat lands

Agricultural E ports

Colombian agricultural e ports have in recent times being dominated by coffee Traditionally, Colombia has been the second largest coffee exporter in the world, while Brazil has been the largest one As can be estimated from table 1, coffee has accounted for 73/ to 75/ of the total agricultural exports of the country during the 1982-84 period Table 1 shows that the value of the coffee e ports during this period has ranged from US $1 5 billion to US $1 7 billion Due to increases in international coffee

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[1] Statistics presented and discussed here have been obtained and/or estimated from data in Ministerio de Agricultura 1986 Anuario Estadistico del Sector Agropecuario OPSA Division de Informacion Proyecto FNUD/FAO/Col083/012 Bogota, Colonbia

prices during 1985 and 1986, the share of the total exports and the total coffee export value are expected to increase significantly during those two years

Bananas and fresh cut flowers are presently the second and third most important export crops of the country The export value of these two crops amounted to US $327 4 million during 1984 Production and exports of bananas have played an important role in the agricultural sector of the country, while the fresh cut flowers industry is a relatively new development of still increasing importance

Raw sugar, cotton and tobacco are also important export crops Raw sugar value has decreased lately due to decreases in international prices, while the reverse is true for cotton exports which have recently increased in total amount and value Exports of these two crops amounted to US $98 1 million during 1984

Agricultural Imports

Agricultural imports in Colombia are dominated by wheat, cooking oil and oil seeds As can be seen from table 1, imports of wheat amounted to US $119 2 million, while imports of cooking oil and oil seeds amounted to US $87 [illegible] million during 1984 With respect to wheat, imports are expected to slightly increase from present levels since the country does not have enough lands suitable for mechanized wheat production In the past Colombia has been able to produce only about 10 to 12% of their wheat needs The situation with respect to cooking oil and oil seeds is different, in the sense that recent developments in the oil palm industry have allowed the country to reduce its total oil import bill Present estimates indicated that sometime during the early 1990 s the country will become self sufficient in oil production

Table 1 also shows that other important agricultural imports into the country are barley, fresh fruits (peaches, apples and pears), maize and sorghum Imports of maize and sorghum show great inter-annual variation, and during certain years in the past they have not been necessary Imports of barley and fresh fruits are more consistent and uniform, since the country does not have large enough extensions of suitable lands for their production

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III FERTILIZER USE AND PHOSPHATE DEMAND PROJECTIONS

This section of the report deals with fertilizer use aspects in Colombia and with the development of demand projections for the 1987-2000 period It refers specifically to historical fertilizer consumption, to fertilizer use by crop, fertilizer use by product, use of phosphate rock for direct application, and to the development of P_2O_5 fertilizer demand projections and of fertilizer demand projections by product Due to the nature of this study, emphasis is given to the main phosphate using crops and to the different phosphate sources

Historical Fertilizer Consumption

The Ministry of Agriculture[1] reports that chemical fertilizers have been used in Colombia since 1925 when the Caja Agraria imported 50 tons for experimental trials Use of fertilizer on farms did not really started until 1948 when products imported by Caja Agraria (urea and NPK s) were used on potatoes and cereal crops in the Andes highlands During the 1948-1962 period, all fertilizers used in the country were imported mostly by Caja Agraria Domestic production started in 1963 with the opening of ABOCOL and FERTICOL plants ABOCOL produced Urea (90,000 tons/yr) and NPK s (120,000 tons/year), while FERTICOL produced Ammonium Nitrate (37,000 tons/yr of 26% N product) and Urea (15,000 tons/yr)

Until 1962 most fertilizers in the country were used on potatoes and cereal crops in high altitude areas (+2000

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[1] Ministerio de Agricultura 1978 La Productividad Agraria en Colonbia 1er Seminario Nacional sobre Productividad Agraria Tomo I Neiva, Huila, Colombia

masl) After ABOCOL and FERTICOL started fertilizer production and marketing, the use of fertilizer extended to other regions and crops in the country, specially for coffee, rice, cotton, bananas, sugar cane and tobacco During the late 1960 s and afterwards, use of fertilizers was common in all agricultural regions and crops in the country

As shown in table 3, during 1970, total nutrient use amounted to 82,000 tons of N, 48,400 tons of P_2O_5 and 30,600 tons of K_2O Figure 1 shows that during the 1970 to 1985[2] period reported here, the use of N, P_2O_5 and K_2O exhibited and upward but erratic trend Use of N reached and all time high in 1984 equal to 185,900 tons, while the highest consumption of P_2O_5 was equal to 89,600 tons during 1983 The highest consumption of K_2O occurred during 1985 and it was equal to 91,800 tons A semi-log function estimated average annual growth rates equal to 4 3%, 3 5% and 6 8% for N, P_2O_5 and K_2O, respectively for the 1970-85 period

The use of N has accounted, generally, for about 50% of the total nutrients used during the reported period Traditionally P_2O_5 has been the second most used nutrient, while K_2O has been in third place However, during recent years use of K_2O and of P_2O_5 has been in approximately the same amounts

Fertilizer Use by Crop

Table 4 presents the types of fertilizer products commonly used on different crops in the country, while Table 3 presents an estimate of the total amount of N, P_2O_5 and K_2O used by each crop during 1984 Table 4 presents the

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[2] Data for 1985 are preliminary

total crop areas, estimated rates of N, P_2O_5 and K_2O used per hectarea and the corresponding crop yields for 1985

Table 4 shows that, in general, crops can be classified according to the fertilizer products they use, as follows (1) crops fertilized mainly with NPK s, and (2) crops fertilized mainly with straight products Crops fertilized mainly with NPK s usually belong to small farmers (less than 20 has) with land devoted mostly to potatoes and coffee These farmers are located in the Andean mountains and are intensive users of agricultural inputs Crops fertilized with straight products, are usually produced in medium to large commercial farms (more than 20 has), located in the inter-Andean valleys, the Atlantic coast and in the eastern plains Among these crops, rice, sugar cane, sorghum, maize and cotton, are the most important Figure 2 shows the most important fertilizer user areas of the country, and the different crops to which they are applied

On Table 5, an estimate is presented of the total amount of N, P_2O_5 and K_2O used by each crop during 1984 This Table show that potatoes are the most important P_2O_5 users in the country, and that they used 39,800 tons of P_2O_5, or 44 2% of the total Potatoes are followed by coffee, which used 10,000 tons, equivalent to 11 1% of the total The top 4 crops users of P_2O_5, potatoes, coffee, sugar cane and rice, accounted for 63,900 tons of P_2O_5 or 70 8% of the total used in the country during 1984

Table 6 presents the crop areas and yields for 1984, as well as the N, P_2O_5 and K_2O use rates per hectarea With respect to P_2O_5, it can be seen that potatoes are by far, the most intensive user, with 155 kg/ha in 1984 They are followed by barley (51 kg/ha), fruit trees (37 kg/ha), sugar cane and cotton (27 kg/ha each)

The following paragraphs describe fertilizer use on crops which will feel the largest impact, should a large development of phosphate rock reserves occur These crops include potatoes, coffee, sugar cane and rice, or those crops which accounted for about 70/ of the total P_2O_5 used in the country during 1984 Also, a description of fertilization on pastures is included because they are an increasingly important user of P_2O_5

Potatoes are usually fertilized with NPK products with a relatively high P_2O_5 content i e 13-26-6, 10-30-10, 10-20-10 and basic slag Additional N is usually provided with applications of Urea Potato farmers are usually small (less than 20 has) and are located in the Andean mountains at altitudes ranging from 2000 masl to 3500 masl These farmers have traditionally been intensive users of agricultural inputs, specially fertilizers As shown in Table 6 during 1985 it was estimated that they used an average of 111 kg/ha of N, 249 kg/ha of P_2O_5 and 95 kg/ha of K_2O, on 139,100 has to obtain an average yield of 13 7 tons/ha The relative low yield, is apparently due to poor quality seeds and not to the inappropriate use of fertilizers or other agricultural inputs

Products used in the fertilization of coffee (a permanent crop) depend on the age of the crop During early stages 15-15-15 and 14-14-14 are used, while 17-6-18/2 is used on established crops and throughout the productive life of the trees Since most coffee plantations are already established, 17-6-18/2 is the most used product on coffee During 1985 a total of 126,800 tons of this product were used This figure increased to 142,200 tons during 1985, and it is expected to increase even more during 1986 and possible 1987, due to the crop diversification efforts of FEDECAFE

Like the potato farmers, coffee farmers are also small (less than 20 has) and are located in the Andean mountains at altitude ranging from 1200 to 1800 masl During 1985 it was estimated that coffee used an average of 41 kg of N/ha, 9 kg of P_2O_5/ha and 32 kg of K_2O/ha, on an estimated 1,100,000 has and farmers obtained an average yield of 660 kg/ha The use of fertilizers on coffee, is to a large extent influenced by the Federacion Nacional de Cafeteros (FEDECAFE), a cooperative type institute which subsidized fertilizers to its members FEDECAFE buys fertilizer directly from national and international companies, and sells it to its members at a discounted price

Sugar Cane is grown by two distinctive groups of farmers as follows (1) the small farmers which grow it on the Andean hill sides and use it for panela production, and (2) the sugar mill plantations which are highly technical and grow it on large farms in the inter-Andean valleys (Cauca, Risaralda and Zulia valleys) and use for sugar production

In the hill sides sugar cane is usually fertilized with NPK products , while the sugar mill plantations fertilize it with straight materials such as urea, DAP, KCl and TSP At the plantations, urea is usually applied several times throughout the life of the crop (12 to 18 months), while the P_2O_5 and K_2O sources are blended and applied at the beginning of the cycle During 1985, sugar cane in the country was fertilized with and average of 83 3 kg of N/ha, 31 8 kg of P_2O_5/ha and 25 4 kg of K_2O/ha A total of 93,400 has and 186,200 has with sugar cane for sugar and panela production were planted in 1985, which gave average yields of 12,608 kg of sugar/ha and 4,428 kg of panela/ha, respectively It should be noted that most of the fertilizer used on sugar cane is applied to the plantations crop

Rice in Colombia is grown entirely by commercial medium to large farmers, highly technical They are located in the inter-Andean valleys an in the eastern plains The fertilizer products they use the most are urea, DAP, and KCl, followed by AS, 15-15-15 Since the eastern plains soils are low in P, rice farmers there also use 10-30-10, basic slag and phosphate rock

Rice farmers usually apply the sources of P_2O_5 and of K_2O a few days before planting, and then after plant emergence they make the first application of the N source, usually urea, which is reapplied 3 to 4 times during the cycle of the crop During 1984, rice farmers used an average of 30 0 kg of N/ha, 6 3 kg of P_2O_5/ha and 6 2 kg of K_2O/ha, on an estimated 364,100 has and obtained an average yield of 4658 kg/ha

Pastures are grown mostly by commercial beef and milk producers Production of these commodities is characterized by their extensive nature i e low input use Most of the fertilized pastures in the country belong to milk production enterprises Pastures are grown throughout the country, but an area which has been gaining importance in recent years is that of the eastern plains

Pastures are usually grown associated with legumes which reduces N fertilizer needs For pastures establishment farmers usually apply PR, basic slag and KCl, broadcasted and incorporated with basic slag being the preferred fertilizer product Little, if any, fertilizers are used after pastures establishment FAO estimated that there are about 30 0 million has on permanent and annual pastures in Colombia (1980-82 average)

Fertilizer Use by Product

Table 7 shows the total amount of each fertilizer product used during 1981 through 1985 This table is divided into four parts, according to the names given to the fertilizer products in the country, names which are: (1) Straight products, (2) High P products, (3) Coffee products, and (4) Other products The straight product group includes all single nutrient fertilizers available in the country plus DAP Most of these products are used on commercial crops in medium to large farms The high P products are those with a 1-3-1, 1-2-1 or similar nutrient ratio These products are mainly used on potatoes and other crops in the Andean high lands, and in the low P soils of the oriental plains The coffee products are used almost exclusively by the coffee plantations in the Andes To the "Other" products group belong fertilizers used on a wide variety of crops in different agro-climatic regions of the country

From table 7, it can be seen that total fertilizer use in the country increased from 674,700 tons in 1981 to 836,900 tons in 1985 Of the total tonnage used NPK s accounted for 50% to 53 4% of the total during 1981 to 1983, for 48 7% during 1984 and for 50 4% during 1985 Presently, commercial farmers (specially rice, sugar cane, sorghum, cotton and oil palm farmers) are slowly shifting away from NPK s toward the use of more straight products Farmers have realized that by using straight products they can follow fertilizer recommendations, for rates and timing of application, more closely and often at a lower cost than by using NPK s This table also shows the increase in DAP and phosphate rock used during recent years The use of DAP has increased from 6,000 tons in 1981 up to 20,000 tons in 1985, while the use of FR for direct application has increased from 6,400 tons in 1981 to 16,100 in 1985

Table 8 presents the estimated amount and percentage of N, P_2O_5 and K_2O provided by straight products and NPK s during 1981-1984 It can be seen that most of the N (approx-imately 65/) has been supplied by straight products (mostly urea), while P_2O_5 and K_2O have been mostly supplied by NPK s Data presented here indicates that in recent years there has been a decrease in the percentage of N, P_2O_5 and of K_2O supplied by NPK s For N the percentage supplied by straight materials has decreased from 39 9/ during 1981 down to 34 4/ during 1985 For P_2O_5 this percentage has decreased from 82 5/ in 1981 to 79 1/ in 1985, while for K_2O it has decreased from 72 3/ in 1981 to 61 5/ in 1985 The straight products which have taken up the slack are Urea, AS, DAP, KCl, PR and TSP This trend is expected to continue into the future, as farmer become more educated and cost conscious

Tables 9 and 10 present the estimated amounts and percentages of P_2O_5 provided by different fertilizer prod-ucts during 1981-1984 It can be seen that the total amount of P_2O_5 provided by straight products has increased from 12,700 tons (or 17 5/ of the total) in 1981 to 17,300 tons (or 20 9/ of the total) during 1984 Of all products, 10-30-10, 13-26-06 and 15-15-15 are the most important suppliers of P_2O_5 These three grades supply from 50/ to 60/ of the total used in the country

From table 10, it can be seen that during the 1981 through 1985 period, only about 10/ of the P_2O_5 was supplied by fertilizer products containing phosphates only The other 90/ was supplied by NPK grades (about 80/) and DAP (about 10/) Farmers in Colombia do not have a large reliable supply of a phosphate only fertilizer Many farmers groups, specially rice and pasture farmers, have expressed their desired for a reliable supply of such a fertilizer, which will permit them to make a more efficient use on their crops

Use of Phosphate Rock for Direct Application

The use of phosphate rock for direct application has been gaining importance in the country during recent years Presently phosphate rocks from the Huila, Sardinata and Iza mines, are being used for direct application, with the Huila rock being the most popular Table 11 shows the amounts of Huila phosphate rock used by region during the 1981-86 period Figure 3 shows the areas of the country where most of this rock is used As table 11 indicates, since 1982 the Cundinamarca-Meta (the eastern plains) region is the largest rock user As a fact, the consumption in this area has increased from 563 tons during 1981 to 7,610 during 1986 Other important consuming areas in the country are the Valle-Risaralda-Quindio region and the Cauca-Narino region Consumption of phosphate rock has increased steadily in all areas of the country where it is used

The Sardinata phosphate rock, of which an estimated 2000 tons (32% P_2O_5) were used during 1985, was mostly applied to crops in the eastern plains During 1986, the Iza phosphate rock was being used in small quantities in the Cundinamarca and oriental plains regions

These domestic phosphate rocks are being used primarily on the acid, low fertility level soils of the oriental plains and the hilly areas of the Andes Crops in which these rocks are being used includes rice, pastures, sugar cane and potatoes Many farmers use Huila phosphate rock for its liming effect more than as a P source

Phosphate Demand Projections

There are many methods available to make fertilizer demand projections The selection of a method to be used in making demand projections depends, to a large extent, on the objective of the projections and on the degree of precision required Considering the objectives of this study, demand projections were made on a subjective basis and for phosphates and phosphate fertilizer products only For this, P_2O_5 demand growth rates were selected for different time lapses within the 1987 to 2000 period, considering the following factors

1 Colombia traditionally has been, and presently is, a country which produces enough food and fiber to meet its population demand Colombia export large quantities of coffee, flowers and sugar, while on the other hand import cereals (wheat, barley, oats) and cooking oil However the agricultural BOP of the country has been favorable in recent years

2 It is assumed that the agricultural sector growth will keep up with the population growth, as it has in the past Drastic changes in the basic structure of the agricultural sector are not anticipated The agricultural sector of the country grew at an estimated rate of 1 8/ in 1983 and 2 3/ during 1984

3 The population of the country is growing at a rate of between 1 8/ to 2 2/ during recent years It is expected that the agricultural sector will grow at a rate high enough to keep up with population growth

4 It is expected that the level of living of the popula-

tion will increase throughout the years, as it has in the past This represents and improvement in the nutrition and diet of the population, which will demand better quality products and consume more vegetables, poultry and beef, i e agricultural products which demand a more intensive fertilizer use

5 As crop area expand to meet food and fiber needs, marginal land will be brought into agricultural production These land require a more intensive use of fertilizer, as compared with lands presently under cultivation

6 A review of several studies containing fertilizer demand projections, made by different national and international institutes Projections made in these studies serve as guidelines for determining demand projection here The rates of growth used to make the projections and the initial and intermediate values are shown on table 12

As can be seen from table 12, growth rates to make projections have been used by many in Colombia The growth rates selected for each study have been selected according to conditions present and the outlook, at the time the projections were made

Table 12 indicates that there are variations in the growth rates selected to make the projections, but these variations are rather small As an indication, the lowest average growth rate for the 1985-2000 period was that used by the World Bank, which was equal to 3 7//year, while the largest was that used by Hansa-Luftbild, which was equal to 6 0/ On the other hand there are very large differences in the amounts of projected use of P^2O_5 Projected consumption for year 2000 ranges from 145,700tons/year from the World Bank to 272,700 by Hansa-Luftbild This large variation is due in great part to the base year used to make the projections, rather than the growth rates selected

On the basis of the above mentioned assumptions and premises, for this study the following growth rates were selected to make the projections: 5 5/ for the 1985-90 period, 4 0/ for the 1991-1995 period and 3 5/ for the 1996 to 2000 period This rates are very similar to the rates used by the World Bank, with the rates used in this study being slightly higher Utilizing these growth rates, and starting with a base consumption of 85,000 tons of P_2O_5 during 1985, the following projections were made 111,100 tons during 1990, 135,100 tons during 1995 and 156,600 during 2000 Projections obtained with this growth rates are presented on table 12 Figure 2 shows these projections and those made by the World Bank and Hansa-Lufbidt, which were the lowest and the highest of the projections analyzed

Demand Projections by Product

Demand projections for phosphate fertilizers were made to evaluate the present production capacity of domestic manufacturers and the country needs, and to have basis for conclusions and recommendations with respect to the possible uses of domestic phosphate rock in agricultural production

Table 13 presents the projected consumption of NPK s for 1986 and 1987, and the 1985 actual (but preliminary) data These projection were made with the following assumptions

1 Total consumption of P_2O_5 is expected to be equal to

91,100 tons during 1986 and to 96,100 during 1987 This is equivalent to a 5 5/ increase per year, over the 86,300 tons used during 1985

2 The production an use of basic slag will be equal to 40,000 tons/year, with an average P_2O_5 content of 11/

3 The demand for phosphate rock for direct application will increase at a slightly higher pace than the overall demand for P_2O_5 This demand is expected to increase at a 6//year until 1990, at a 5//year from 1991 to 1995 and at 4 5//year for 1996 to 2000

4 The use on NPK products will continue to increase, as it has in the past However, it is expected that production and use of 17-06-18/2, the coffee grade, will increase faster than that of other grades

5 It is assumed that straight materials will provide 22/ and 23/ of the total P_2O_5 used during 1986 and 1987, respectively

As shown on table 13, the total NPK demand in the country is expected to reach 472,000 tons during 1986 and 500,000 during 1987 Projections were made only for these two years considering than the present domestic granular NPK production capacity is estimated to be equal to 500,000 tons/year It is projected that after 1987 the country s capacity to produce granular NPK products will not be enough to satisfy demand

Table 14 presents the demand projections for phosphate rock for direct application for 1986-1990, 1995 and 2000 Demand for phosphate rock is expected to increase at a slightly higher rate than for P_2O_5 because since it is a relatively new product in the market, and as farmers become familiar with its benefits will use more Also, as the agricultural frontier of the country expands in the eastern plains direction, more phosphate rock will be needed and used in those acid low fertility soils

As table 14 shows, the demand for phosphate rock is expected to increase from 16,400 tons in 1985 to 28,800 tons in 1995 and to 35,100 tons in 2000 Obviously, this trend projections assume that the price of phosphate rock relative to other phosphate fertilizers will be maintained

IV FERTILIZER SUPPLY

The fertilizer needs of a country can be met through domestic production and/or imports Furthermore, domestic production can take place using native resources or imported raw materials Colombia possesses N and P_2O_5 resources, but not known K_2O reserves

Table 15 presents the major manufacturing facilities of the country Of these, MONOMEROS is the largest one, with a production capacity[1] of 350,000 tons/yr of granular NPK products and 50,000 tons/yr of AS, followed by ABOCOL with a production capacity of 150,000 tons/yr of granular NPK products The FERTICOL plant has a production capacity of 10,000 tons/yr of urea and of 25,000 tons/yr of ammonium nitrate (Nitron 26-0-0) Presently Paz del Rio has a production capacity of 40,000 tons/yr basic slag with an average content of 11% of P_2O_5 In the past, basic slag has been a favorite fertilizer product among farmers However, starting in 1985 due to changes in the steel making process, the quality of basic slag has decreased considerably (from 16% P_2O_5 to 11%) It now has a high content of Fe_2O_3 (50%), which makes its use in some agricultural areas questionable

The MONOMEROS fertilizer production facilities were built in the early 1970 s in conjunction with a caprolactam manufacturing plant The facilities started production in late 1972 and early 1973 The fertilizer facilities utilize by-product AS solution from the caprolactam plant The principal fertilizer facility is a nitric-phosphate NPK granulation plant, in which nitric acid is used to dissolve

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[1] Production capacity may vary according to the mix of NPK grades manufactured

phosphate rock and the calcium nitrate is removed by reacting it with ammonium sulfate In addition to the granular NPK products, MONOMEROS produces, since mid 1982, about 50,000 tons/yr of crystallized ammonium sulfate

ABOCOL, though its wholly owned AMOCAR, produces ammonia and nitric acid Some of the ammonia (15% or about 16,000 tons/yr) and most of the nitric acid are used in ABOCOL s NPK granulation plant Excess ammonia is sold to MONOMEROS (50%), other domestic users and exported mostly to Europe

The FERTICOL urea plant utilizes a once-through (no recycle) process It has a rated capacity of 15,000 tons/yr, however, the plant is currently operated at about 10,000 tons/yr Off-gas from the urea plant is used to produced ammonium nitrate

As shown in table 15, three companies, FOSFOBOYACA, FOSFACOL and FOSFONORTE, have phosphate rock mining and grinding facilities Of these mines, FOSFACOL is actually operating and producing about 1,500 tons/month, while FOSFONORTE is producing about 800 tons/month The facilities at FOSFOBOYACA are presently being renovated

FOSFACOL production is used for direct application, while most of FOSFONORTE (75%) production is used by MONOMEROS and ABOCOL for the manufacture of granular NPK products FOSFOBOYACA is expected to start producing phosphate rock for direct application in mid-1987

In addition to the major fertilizer companies above mentioned, there are several minor fertilizer producers, which purchase their raw materials from the large companies

These minor companies produce blended, pelletized and/or liquid fertilizers

Table 16 shows the estimated quantities of N, P_2O_5 and K_2O supplied by domestic producers (using domestic raw materials resources) and through imports, during 1983 through 1985, while tables 17, 18 and 19 present the estimated quantities of imported N, P_2O_5 and K_2O as raw materials and finished products from 1970 to 1986 The P related information presented is analyzed in the following section of this report

From table 16 it can be estimated that about 75% of the N used during 1983 through 1985 was imported (mostly as urea) The 25% of the N provided from domestic resources came from ABOCOL NPK products, from MONOMEROS AS and NPK products, and from the urea and AN produced at FERTICOL For the P_2O_5, approximately 88% was imported, mostly in the form of raw materials for the manufacture of NPK products at MONOMEROS and ABOCOL, while about 12% came from domestic reserves All of the K_2O used in the country is imported, either as raw material (about 56%) or as a finished product (44%) in the forms of KCl and SOP

Phosphate Supply Situation

Table 18 shows the amount of phosphate raw materials and finished products imported into the country during the 1970 to 1985 period Many different P_2O_5 containing products have been imported Imports of phosphate rock, phosphoric acid and MAP have been used exclusively for the manufacture of granular NPK products, while imports of DAP and TSP are used in the manufacture of NPK s and for direct application

Imports of NPK s made during the early 1970 s were used for direct application

This table shows that the highest annual imports of P_2O_5 occurred during 1973 and 1974, the years of the energy and fertilizer crisis Imports decreased considerably on the two following years, and regained a normal" level after 1977 Presently, imports of P_2O_5 are at a level of around 70,000 to 80,000 tons/year, with an estimated CIF value of US $27 to 30 million, at 1985 prices

The consumption of P_2O_5 in Colombia, as shown in table 20, has increased steadily since 1970 It has increased from 48,400 tons in 1970 to 86,300 tons in 1985, or at an average growth rate of 3 9%/yr This consumption has been satisfied through domestic production and through imports of finished products and of raw materials Of the domestic sources, basic slag has been the largest and most reliable It has supplied from a low of 6,000 tons of P_2O_5 in 1985 up to high of 11,300 tons of P_2O_5 in 1976 SSP was produced utilizing Huila phosphate rock until 1976, year in which the plant closed Phosphate rock has been in the market place intermittently since 1970, and starting in 1980 its use has been increasing steadily to reach 5,900 tons of P_2O_5 in 1984

Consumption of P_2O_5 from phosphate rock is expected to reach 6,400 tons during 1986 Of this amount, it is estimated that about 3,800 tons of P_2O_5 (or 17,300 tons of phosphate rock) will be used for direct application, the remainder for the manufacture of NPK products at MONOMEROS and ABOCOL On the basis of granular NPK production during the last 5 years by MONOMEROS and ABOCOL, it is estimated that through NPK products these two manufacturers can supply 75,000 tons of

P_2O_5/yr[1] Of course this figures can vary depending on the mixture of grades produced by these factories This figure is expected to decline slightly in the immediate future, due to the up surge in demand for the coffee grade fertilizer 17-6-18/2

Table 20 shows that the P_2O_5 supply from domestic sources has remained relatively constant during the 1970-85 period (ranged from 8,800 to 13,700 tons), while its use (demand) has been increasing steadily This has created a situation in which the amount of imported P_2O_5 has increased from 39,500 tons in 1970 to 74,100 tons in 1985 P_2O_5 imports have been made in the form of raw materials and finished products Imports of straight products for direct application (TSP and DAP), have increased in recent years and during 1985 they were equal to 23,800 tons of product equivalent to 10,900 tons of P_2O_5

The P_2O_5 supplied by basic slag has decreased during the past 5 years, and it was equal to only 6,000 tons of P_2O_5 in 1985 Due to changes in the steel making process, it is expected that in future years production of P_2O_5 will remain at a volume of not more than 4,400 tons/yr

In summary, and not considering the production of native phosphate rock for the time being, it is estimated that the country has an established maximum production capacity of some 79,400 tons of P_2O_5/yr (granular NPK s plus basic slag) This capacity is not enough to meet present domestic needs, which already in 1985 amounted to 86,300

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[1] Average P_2O_5 content of granular NPK s produced by MONOMEROS and ABOCOL during past 5 years has decreased from 20 4% in 1981 to 15 5% in 1985 It is expected that the future average P_2O_5 content of NPK s will be of about 15%, which at a rated capacity of 500,000 tons/yr yields 75,000 tons/yr of P_2O_5

tons of P_2O_5 During the past few years, to satisfy this need some phosphate rock was mined and used for direct application, and imports of DAP and TSP were made, with the imported materials playing a more important role An alternative to these imported products is the use of domestic phosphate rock for direct application or to manufacture a more soluble phosphate product The selection as to what fertilizer should be produced using domestic reserves rest on the agronomic requirements of crops, the types of soils in the country, the fertility levels of the agricultural areas and the availability and quality of phosphate rock Subsequent sections of this report deal with these subjects

<u>The Future Supply of Phosphate Fertilizers</u>

As can be seen from table 15, there are presently si suppliers of P_2O_5 in the country, as follows MONOMEROS, ABOCOL, Paz del Rio, FOSFONORTE, FOSFOBOYACA, and FOSFACOL Of these, 5 are already in production, while FOSFOBOYACA is supposed to come on the stream shortly

Presently, MONOMEROS and ABOCOL do not have any major plans for expansion of their granulation facilities or for the establishment of any new plants[2] The same is true for Paz del Rio, the basic slag producer, and for FOSFACOL and FOSFONORTE FOSFOBOYACA is in a reorganization stage, and expected to start production during mid-1987

During recent years, considerable attention was given to the possible development of a large (100,000 tons of P_2O_5/yr) granulation complex, utilizing phosphate rock from

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[2] However, ABOCOL is considering de-bottlenecking its plant to increase production by some 50,000 tons/year of NPK s

the Pesca deposit After many studies, this project has come to a halt due to the uncertain quality and quantity of domestic reserves, which makes a project of this nature unfeasible

In view of the above stated facts, it is safe to assume that no new developments will come to impact the phosphate fertilizer sector, at least in the very short to short term

Table 21 presents the estimated projected supply for P_2O_5 for the 1986-2000 period This table includes a breakdown for domestic and imported phosphate It can be seen that with the present installed production capacity, up to 21,600 tons of P_2O_5/yr can be supplied from domestic deposits Imports of P_2O_5 raw materials for the manufacture of granular NPK products are estimated to be equal to 73,400 tons of P_2O_5/yr It is anticipated that the amount of imported raw materials for granular NPK production will remain at that level, and not be replaced by domestic production for two reasons 1) the transportation cost from the mines to the NPK manufacturers plants, and 2) quality problems with domestic phosphate rocks which makes them unsuitable for use in granular NPK production

In summary, the total installed production capacity for phosphate fertilizers in the country is estimated to be equal to 94,000 tons of P_2O_5/yr, and it is assumed to remain at that level for the foreseeable future

V PROJECTED SUPPLY/DEMAND BALANCE FOR PHOSPHATE FERTILIZERS

A comparison of the supply and demand projections for P_2O_5 for the 1986-2000 period is presented on table 22 This table shows that during 1986 an estimated deficit equivalent to 12,400 tons of P_2O_5 will exist This deficit will have to be met through imports of DAP and TSP for direct application The deficit in supply of phosphate fertilizers in the country is estimated to increase throughout the years as demand increases, as shown in figure 4, and to reach 65,100 tons of P_2O_5 during 2000 Table 22 shows that present installed capacity for phosphate fertilizers will increase up to 94,000 tons of P_2O_5 It is projected to remain at that level since there are not firm plans for expansion of present plants or for development of new ones

Of the total projected demand of 91,000 tons during 1986, it is estimated that 10,800 tons or 11 9% will be supplied through the use of domestic reserves The remainder will be imported as raw materials for the manufacture of granular NPK products, and as TSP and DAP for direct application For the remainder years of the projected period, supply from domestic sources is expected to increase to 21,600 tons, while imports of P_2O_5 are expected to increase from 80,200 tons in 1986 to 137,500 tons in 2000

A comparison of the data presented on this table with that of table 14 indicates that the country has a projected surplus capacity for production of phosphate rock for direct application This estimated surplus amounts to 9,700 tons of P_2O_5 during 1990 and to 6,900 tons in 2000 Therefore, for the country to be able to use this rock processing facilities at capacity scale, the phosphate rock would have to be transformed into a more soluble fertilizer Otherwise, imports will be even larger than here shown

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VI DESCRIPTION OF PHOSPHATE DEPOSITS

The Colombian government has been interested in the development of domestic phosphate reserves since the early 1940 s Extensive surveys for sedimentary deposits were conducted during the 1960 s at that time These surveys were conducive to the identification of deposits in Sardinata (Norte de Santander), and in Pesca (Boyaca) Subsequently, additional phosphate rock deposits were found

All of the phosphate deposits in Colombia are of sedimentary nature, and occupy and area of about 600 km in a NE to SW direction along the Cordilleras Central and Oriental All known deposits, as listed on table 23, belong to one of the following geologic formations La Luna, Monserrate and Guadalupe Superior These three formations, and the location of the most important deposits, are illustrated on Figure 6[1]

Presently, there are 18 known deposits of phosphate rocks with varying degrees of phosphate content and size of reserves In general all these deposits have low to medium grades of P_2O_5 Phosphates rocks which have a higher than 25% P_2O_5 content belong to calcareous deposits which have been weathered With the exception of Sardinata which can be mined open pit, all deposits require underground mining methods

As of mid-1986, of all deposits, only Sardinata in Norte de Santander and Tesalia in Huila were being exploit-

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[1] Mojica, P and F O Zambrano 1985 Los Depositos Fosfaticos de Colombia in Los Depositos Fosfaticos de Latinoamerica eds V Ricaldi and S Escalera Asociacion de Ciencias para el Desarrollo Internacional Grupo Latinoamericano de Investigaciones de Roca Fosforica Ed Geociencias Bolivia p 89-128

ed Works are in progress at the Pesca grinding plant in Boyaca to restart production using phosphate rock from de Iza deposit, while the Media Luna deposit in Huila in under study for possible utilization Presently there are no plans for development of other sites, the reasons for this being their inaccessibility and/or the inferior quality of the reserves, the low volumes of recoverable material, and/or the lack of adequate mining and geological studies of the reserves The following paragraphs present a description of deposits being exploited or with potential of being exploited in the near future Compared with presently exploited deposits located in throughout the world (USA, USSR, Morocco, and others), Colombian deposits are small

Sardinata This deposit is located in the Norte de Santander Department, approximately 35 km NW of Cucuta This area corresponds to the upper part of La Luna formation Access to mine site is by paved road and it takes approximately 45 minutes from Cucuta Total reserves are estimated to be 14 4 million tons of rock with a P_2O_5 content ranging from 15% to 37% The material with low P_2O_5 content is calcareous and hard, while the material with the highest P_2O_5 content has been weathered, is close to the surface and is soft These high P_2O_5 material is the one presently mined by open pit Phosphate rock veins are usually under soil layers of up to 10 m in thickness Once veins have been cleared of soil, the phosphate rock ore is easily removed and trucked to the beneficiation plant Phosphate rock layers with low P_2O_5 content are left in the field The presence of this calcareous material makes exploitation difficult and inefficient It is estimated that there are reserves of about 2 million tons of high P_2O_5 (>32%) content material, which can be mined open pit

At the mine site there is a beneficiation plant, where the phosphate rock ore is washed and scrubbed to remove organic matter and silicate, consequently increasing the P_2O_5 content The beneficiation process increases the P_2O_5 content from about 32/ to about 35-37/ This beneficiation is done to make the material suitable for use as a raw material at the MONOMEROS granulation plant Phosphate rock used in ABOCOL granulation plant does not need to go through this beneficiation process At the mine site, there is also a ball mill and a dryer which are used to prepare phosphate rock for use by MONOMEROS and ABOCOL

The capacity of the beneficiation plant is of about 40 tons/day (12,000 tons/yr) During 1985, a total of 8,500 tons were produced, of which 2,000 tons were used for direct application while the remainder was used by MONOMEROS and ABOCOL for the manufacture of granular NPK s

Tesalia, La Juanita This mine is located in the Huila Department, approximately 9 km north of Tesalia town This mine belong to the lower part of the Monserrate formation Access to mine is by paved road until 28 km before mine site, then a good dirt road serves the mine Total reserves are estimated at 6 million tons of phosphate rock with a P_2O_5 content varying from 20/ to 31/ However the economically exploitable reserves are estimated to be between 1 5 to 2 0 million tons This mine is presently exploited through conventional underground mining methods

Phosphate rock for direct application has been produced at this mine for several years Facilities at the mine consist of hammer mill, ball mill, dryer, conveyors, hoppers, screens and bagging facilities In 1986 a total of 14,822 tons were mined, ground and sold for direct application Current plans call for a production of 16,000 to 17,000 tons during 1987

Pesca and Iza Deposits These deposits are located in the Boyaca Department, in the neighborhood of Fesca and Iza towns This area corresponds to the middle section of the Guadalupe Superior formation Access to these mines is by paved road to Sogamoso, then by paved road to Iza and by a good dirt road to Pesca (last 8 km) Total reserves at Iza are estimated at 36 0 million tons while total reserves at Pesca are estimated at 30 6 million tons of phosphate rock The P_2O_5 content at these two deposits varies from 17/ to 25/ However, at present phosphate rock prices, the amount of economically recoverable reserves are estimated to be equal to only 6 5 million tons for Pesca and 13 0 million tons at Iza Due to the quantity, quality and location of these reserves, they offer the best potential for an economic development of a phosphate industry in the country

The Pesca mine has been exploited in the past through conventional underground mining methods Phosphate rock for direct application has been produced from the Pesca mine during the past few years During 1984-85 the mine was not exploited and there was a change in management at the grinding plant Presently plant equipment located about midway between these Fesca and Iza, with a capacity of 20 tons/hour, and consisting of a ball mill, conveyors, screens, dryer, hoppers and bagging facilities are being revamped It is expected that the plant will start production in late 1986 or early 1987 utilizing Iza phosphate rock exclusively Current plans are to produce about 20,000 tons during 1987 There are no current plans for utilization of phosphate rock from Fesca

Media Luna This deposit is located in the Huila department, about 10 km west of Aipe town Like the Tesalia mine, this deposit belong to the Monserrate formation Access to the mine is by paved road to Aipe and then by a good dirt road to the mine vicinity A road to the mine entrance is not developed yet Very little is known about the quantity of reserves at this site Table 22 shows that total reserves are estimated to be 22 million tons of material with a 18/ to 31/ However, the recoverable reserves are suspected to be much less

A few analyzed samples of material from this mine indicated that its quality is similar to that of Tesalia Therefore its agronomic behavior should also be similar

VII AGRONOMIC AND ECONOMIC EVALUATION OF P SOURCES

This section of the report presents in a summarized form, research results obtained by the 'IFDC/CIAT Phosphorus Project" related to the agronomic and economic evaluation of P sources The P sources included in the evaluation presented here are ground phosphate rock for direct application, sulfuric acid-based partially acidulated phosphate rock (PAPR), mixtures of ground phosphate rock with TSP, and soluble P sources (TSP)

Ground phosphate rock is the easiest fertilizer product to make from phosphate rock, it consist simply in the fine grinding of the rock PAPR is a phosphate rock treated with only a fraction of the acid (usually 30 to 50%) required to completely convert the insoluble phosphate to water soluble monocalcium phosphate or to make SSP or TSP Acidulation of the phosphate rock can be done with sulfuric, hydrochloric, phosphoric, or nitric acid In this report, however, acidulation refers only to the use of sulfuric acid, which is the most generalized form of doing it

The following paragraphs of this section present research results obtained by the project, which help identify areas, and crop fertilizer management practices where different P sources can be used effectively Research results presented refer to (1) the agronomic evaluation of phosphate rock, (2) the agronomic evaluation of PAPR, and (3) the economic evaluation of different P sources Research results presented were obtained from annual reports and technical publications that have been prepared as part of the project activities For simplicity, and in view of the massive amount of data and research results available, it was decided to select representative individual experiments and experiments pooled together to help illustrate concepts being discussed and research findings obtained

Research conducted by the project related to the use of phosphate rock as a P source, has indicated that crops respond similarly to phosphate rocks from Huila and Pesca The Iza and the Media Luna rocks which are very similar to the Pesca and Huila rock, respectively, but have not been field tested due to its unavailability, are estimated to behave similarly The phosphate rock from Sardinata, which has a higher P_2O_5 content, but less carbonates replacing phosphates in the apatite crystal structure, is less reactive, therefore its agronomic efficiency is inferior to the other rocks Therefore, recommendations made for the use of phosphate rocks for direct application refer to ground rock from Huila, Pesca Iza and Media Luna

With respect to PAPR from different sources, results presented include the field testing of products manufactured with the Huila and Pesca rock, which have similar properties The Iza and the Sardinata phosphate rocks acidulated to obtain the same amount of P soluble should possess similar agronomic properties Also included are results of mixtures of phosphate rock with DAP and TSP, which simulate PAPR products These mixtures were prepared to have the same amount of P in soluble form as a PAPR product

<u>Agronomic Evaluation of Ground Phosphate Rock</u>

One of the main overall objectives of the IFDC/CIAT Phosphorus Project has been the identification of soil, crops, agro-climatic conditions and fertilizer management practices under which indigenous phosphate rocks can be used effectively as fertilizers Research conducted by the project indicates that the use of ground phosphate rock for direct application is advisable only under specific conditions It has been found that the following factors play an important role in determining the agronomic effectiveness of phosphate rocks

(1) the chemical reactivity of the rock,
(2) the particle size of the rock,
(3) the soil properties and climate of the region,
(4) the timing and method of application,
(5) the crop and the farming system used,
(6) the residual effect of the rock, and
(7) the use of the rock as a soil amendment

The following paragraphs refer to research results obtained related to each one of the above mentioned factors

Chemical Reactivity of the Rock The reactivity of phosphate rocks can be evaluated by the amount of the total P they have soluble in neutral ammonium citrate, citric acid (2%), formic acid (2%), or acid ammonium citrate (pH=3) The relationship between the rock reactivity and crop response has been reported by Leon et al[1] in an article which classifies 11 Latinamerican phosphate rocks This article classifies phosphate rocks into four groups according to their agronomic effectiveness relative to that of TSP *Panicum maximum* was used as a test crop on an Oxisol from the Colombian eastern plains The 11 Latinamerican phosphate rocks were classified as Highly Effective (85 to 100), Medium Effectiveness (70 to 84), Low Effectiveness (40 to 69) and Very Low Effectiveness (<39) The number in parenthesis indicate the relative agronomic effectiveness for each grouping

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[1] Ibid Leon, L A and L L Hammond 1984

According to this classification, Colombian phosphate rocks were classified into the Medium Effectiveness (Huila and Pesca) and Low Effectiveness (Sardinata) groups The Iza rock was not included in that classification since it was not available at the time the experiment was conducted, but according to its chemical composition it should be classified similarly to the Pesca and Huila rocks Figure 1 presents the crop response obtained with several Latin-american phosphate rocks of different reactivity and with TSP

Particle Size of the Rock Experiments conducted by the IFDC/CIAT Phosphorus Project have shown that phosphate rocks are most effective when surface contact between the rock particles and the soil are maximized to promote dissolution of the rock[2] Experimental research results confirm that finely ground (<100 mesh) or mini granulated (-50+150 mesh) rock is more effective than coarser (granular) sizes Figure 2 presents the results of an experiment carried out in the Colombian eastern plains with three sizes of Huila phosphate rock

Properties of the Soil and Climate of the Region The chemical and physical properties of the phosphate rock are important factors in determining its agronomic effectiveness However, good characteristics of the rock alone do not guarantee a proper crop response Through research conducted by this project[3] and by others[4], it has been determined that the properties of the soil play a major role in the determination of the agronomic performance of phosphate rocks It has been found that, of all soil characteristics, the pH, the amount of available P or

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[2] Ibid Leon, L A and L L Hammond 1984
[3] Ibid Leon, L A and L L Hammond 1984

exchangeable calcium, and the P fixation capacity, play a major role in the effectiveness of phosphate rocks The estimated quantitative relationship between crop response and these characteristics appears on figures 3 and 4

In the case of Huila and Pesca phosphate rocks, it has been determined that they perform well in soils with a pH of around or less than 4 5, and with a P fixation capacity of of less than 45%, as measured by the Fassbender and IGUE method (1967) Also, these rocks have performed well in soils with a F content of less than 5 ppm (Bray I)

Results from experiment station and farmers fields with Huila phosphate rock, on the Andepts and Oxic Inceptisols of Cundinamarca, Boyaca, Cauca and Nariño, have shown the rocks to be less effective than when applied to Oxisols of the eastern plains (Meta) and Ultisols of Santander de Quilichao (Cauca) which are more acidic, lower in calcium and exhibit a lower P sorption capacity A representative example of experimental results obtained with potatoes, rice, cowpeas, maize and beans using this rock on these soils are presented on table 23 Results in this table and on following tables are presented in terms of the Relative Agronomic Efficiency[5] (RAE) of using TSP as reference This table also includes the crop yields of the control plots, which are useful to measure yield increases due to fertilizer use and to have an idea of the soil natural fertility

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[4] Hughes, J C and R J Gilkes 1986 "The Effect of Rock Phosphate Properties on the Extent of Fertilizer Dissolution in Soils Australian Journal of Soil Research Vol 24, pp 209-217

[5] RAE is defined as $\frac{\text{(Yield of Tested Product-Control)}}{\text{(Yield of Standard Product-Control)}}$

Experimental results presented on table 23 indicate that the agronomic performance of the phosphate rocks (Huila and Pesca) exhibits wide fluctuations This table shows that phosphate rocks are more effective on the acid, low fertility Oxisols and Ultisols than on the Andepts and Inceptisols In the Oxisols and Ultisols, phosphate rocks can be about 90/ as effective as TSP, while on the Andepts and Inceptisols their effectiveness can be as low as 5 to 10/

The Andepts soils in Nari o appear to contradict this statement, however, phosphate rock have performed consistently well in these soils which have a high P content This soils have been heavily fertilized with compound fertilizers for many years and are fertile soils, as opposed to the Andepts of Cundinamarca and Boyaca

Throughout the many e periments that have been conducted in pursue of the objectives of this project, it has been noted that climate (temperature and rainfall) influence crop response to phosphate rock application In the lowland and mid-altitude tropics (0 to 1000 and 1000 to 2000 masl, respectively) with temperatures of more than 24°C and between 18-24°C respectively, crops responded to phosphate rock applications, provided that the soil chemical conditions were adequate for rock dissolution In these two regions where the agronomic effectiveness of the phosphate rock was high, the climate was classified as sub-humid (1000-2000 mm/yr) The high temperature of the soil and the adequate amount of humidity favor rock dissolution

In the high and very high-altitude tropics (2000-3000 and 3000-4000 masl, respectively), mean annual temperatures range from 12 to 18°C and from 6 to 12°C, respectively In these two regions, where potato, wheat and barley are grown, mean annual rainfall is between 500 and 1000 mm Recent experiments performed by IFDC and ICA in these two regions with potatoes show that a better response to phosphate rock was obtained in the high altitude region than in the very high altitude Apparently the very cold temperature of the soil does not favor the dissolution of the rock

Time and Method of Application Research conducted at experimental stations and in farmers fields has shown that higher crop yields can be obtained applying TSP *in situ* at planting time When phosphate rock is used as P source, slightly higher yields can be obtained applying the rock broadcasted, incorporated, and preferably 30 days before planting time To illustrate this, table 24 presents the results of three experiments (beans, potatoes and maize) where the application method and the timing of application were tested This table shows that, as expected, the highest yields were obtained with TSP applied *in situ* at planting time The phosphate rock was slightly more effective when it was applied broadcasted, incorporated and 30 days before planting

Application of phosphate rock broadcasted and incorporated, 30 days before planting is not practical for steep lands subject to erosion In these areas, where minimum tillage is widely used, the phosphate rock can be applied to a reduced volume of soil Also, the application of fertilizers 30 days before planting promotes the development of weeds This two limitations on using phosphate rock should be carefully evaluated before specific recommendations are made

Type of Crop and Farming System Used Research results indicate that even under appropriate soil conditions, phosphate rock is more effectively used by crops such as pastures, forage legumes, cowpeas, peanuts and rice, than by crops such as maize, beans and potatoes The reasons for this are partly related to the climatic conditions (temperature, rainfall and length of life cycle) where crops are grown and partly due to the plant ability to uptake P from the soil

Table 24 presents research results of experiments conducted with rice, cowpeas, cassava, pastures, maize and potatoes, in different agroclimatic regions of Colombia As this table shows, the RAE of the phosphate rock ranges from 120/ for rice in Carimagua to 13/ for maize in Pescador, Cauca and 7/ for potatoes in Tausa, Cundinamarca

Residual Effect of the Phosphate Rock Another factor to be considered in the agronomic evaluation of P sources is their residual effect Research conducted by the project using *Brachiaria decumbens* has indicated that phosphate rocks of medium reactivity, like Huila, increase their agronomic efficiency with time, and their residual effect equals that of TSP by the third crop In the case of rocks with slightly lower reactivity, like Pesca, their agronomic efficiency increases during the first three crops and reach a RAE of 82/ by then

Experiments carried out to measure residual effect of TSP and Huila phosphate rock, on crop rotations like beans/maize/wheat and potatoes/wheat/wheat have indicated that there are not differences in residual effect from these

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[a] IFDC/CIAT Phosphate Project 1986 "Annual Report 1985 Cali, Colombia (mimeo)

sources[5] What research results clearly indicate is that in places where the agronomic effectiveness of the phosphate rock is equal to that of TSP, this effectiveness remains constant through time, i e as TSP crops yields decrease in subsequent crops, so do phosphate rock yields Also in soils where the phosphate rock is not as effective as TSP during the first crop, the residual effect of the phosphate rock remains a fraction of that of TSP through time[6]

Use of Phosphate Rocks as Soil Amendment

Phosphate rock is presently used by farmers as soil amendment on low P and acid soils To measure the effectiveness of phosphate rock as soil amendment, experiments were carried out by the project to compare Huila phosphate rock (1 ton/ha), dolomitic lime (1 ton/ha) and a mixture of lime and phosphate rock (5 ton/ha of each) on beans in Pescador, Cauca

The results of these experiments appear on table 26 These results indicate that Huila phosphate rock used alone or in combination with dolomitic lime produces higher yield increases than dolomitic lime alone These results were consistent for the two crops seasons in which the experiments were carried out In one of the experiments the mixture of phosphate rock and lime gave the highest yield increases, while the Huila phosphate rock alone gave the highest yield in the other two

Agronomic Evaluation of PAPR

The low or poor performance of phosphate rocks in some soils and with some crops can be attributed to its low

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[6] Ibid Leon, L A and L L Hammond 1984

solubility, hence, its P is not available for crops uptake A common way to increase its solubility is to acidulate the rock totally to make SSP or TSP or partially to make PAPR By increasing the solubility of the rock, its agronomic efficiency increases, which results in higher crop yields Results presented here for PAPR correspond to phosphate rock acidulated at a 50% level Results obtained with project experiments have indicated that physical dry mixtures of phosphate rock with TSP or DAP, simulating PAPR products, give the same agronomic results as a PAPR product Therefore, results presented here also apply to those mixtures

Through research conducted in this project, it has been found that the best fertilizer management practices for the use of PAPR are the same as those for TSP This means that the best timing and method of application for TSP are also the best for PAPR

Table 27 presents experimental results obtained with PAPR and its RAE when compared with TSP These results show that PAPR can be, in some cases, as effective as TSP, but that its RAE most often ranges between 85% and 95% This holds true for a wide variety of soils, agro-climatic conditions and crops In the acid, low fertility Oxisols and Ultisols of the Eastern Plains, PAPR applied to pastures, rice and sorghum performed as well as TSP In the Andepts soils of Narino, PAPR can give higher potato and maize/beans yields than TSP On the other hand, in the Cundinamarca and Boyaca potato areas, yields obtained with PAPR are about 85% of those obtained with TSP

<u>Economic Evaluation of P Sources</u>

The economic evaluation refers to the estimation of net returns (or benefits) which accrue to the farmer from the use of fertilizers Net benefits due to fertilizer use are defined as the difference between the increased production value minus the cost of the fertilizer used To estimate the value of the increased production value, crop prices received by the farmer are used, while to estimate the cost of the fertilizer, prices paid by farmers are used[7] Since FAPR is a product not available in the market, its evaluation was done assuming that its price was equal to that of TSP on a P unit basis Therefore the economic performance of FAPR as compared to that of TSP, is directly related to the RAE of these two products as presented on table 26 It is worth noting that of the soluble P sources presently available to farmers in Colombia, TSP has the lowest value The highest prices, on a P unit basis, are for the NPK products Should in the future PAFR be available to farmers at prices higher/lower than those used for the evaluation here, the REE will be lower/higher in relation to TSP

Since the amount of net returns due to fertilizer use changes as crop and fertilizer prices change, Value/Cost Ratios (VCR), which measure the relationship between the increased value of production and fertilizer cost, are calculated VCR s are less subject to variation due to price changes, and do not change in situations where crop and fertilizer prices change at the same pace VCR s provide an indication of how safe to invest resources on fertilizer is To induce farmers to use fertilizers a VCR of at least 2 is needed A VCR lower than 2 indicates that the use of fertilizer is too risky to be acceptable

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[7] Prices used were: for TSP and PAPR s $200/kg of P, for HPR and PPR $125/kg of P, for Rice $42/kg, for Cassava $35/kg, for Maize $32/kg, for Potatoes $20/kg and for Beans $120/kg

The Relative Economic Effectiveness (REE) measures the economic effectiveness of FAPR and phosphate rock in relation to that of TSP The REE is simply the ratio of net returns obtained with FAPR and phosphate rock and the net returns obtained with TSP For the economic evaluation presented here, the estimation of all these economic parameters was made at the application rate which maximized net returns for each product tested

Table 28 presents selected examples of the economic evaluation of experimental results obtained This table includes several crops, which were cropped in different agro-climatic zones and in different soil types As can be seen from this table, the estimated REE of FAPR ranges from 80% to 113% The REE for FAPR is higher in the eastern plains soils (Oxisols) and in the Nariño soils (Andepts) Lower REE s for FAPR are observed in the soils of Caldono, Cauca (Inceptisols) and in the soils of the Cundinamarca--Boyaca region (Andepts)

Phosphate rock used for direct application had the lowest REE of the products tested The REE for phosphate rock was higher in the eastern plains soils (Oxisols) and in the Nariño area (Andepts) The lowest REE for phosphate rock were observed in the Cundinamarca-Boyaca soils (Andepts) and in the soils of Pescador, Cauca (Andepts) In some of these soils there was not a large enough crop response to applications of phosphate rock, so as to justify its application

Results here presented indicate that FAPR and phosphate rock produce a higher REE the same type of soils (Oxisols of the eastern plains and Nariño Andepts) In places where FAPR applications were not very effective, applications of phosphate rock were not effective at all

Table 29 presents the results of the economic evaluation of the phosphate rock used as soil amendment in three experiments conducted during two consecutive crop seasons The effectiveness of a phosphate rock as a soil amendment is determined by the amount of free calcium carbonates it has Therefore, results discussed here applied only to the Huila phosphate rock, which has the largest percentage of among the Colombian rocks

Table 29 shows that in all three experiments, either the Huila phosphate rock used by itself or mixed with lime, produced higher yields and had a higher REE than lime used alone According to the VCR obtained with these experiments it can be sated that the use of phosphate rock as soil amendment is a good investment for farmers Obviously, the higher yields increases obtained with the Huila phosphate rock are due to the P content of the rock and to its liming effect However, these finding are preliminary, and more research in this area is needed to better identify the soils where the rock can be used effectively as an amendment, the proper mi rock-lime and to determine yield increases due to the phosphate content and to the liming effect of the rock

VIII POTENTIAL USE OF PHOSPHATE ROCK AND OF PAPR IN COLOMBIAN AGRICULTURE

This section of the report presents a summarized description of the soils in Colombia, their F fertility status, and an estimation of the potential use of phosphate rock and of FAFR in different regions and crops of the country It includes the estimated degree of RAE from their use in different crops and homogeneous agroecological zones, and identifies some economically important food crops in which these products could be used Also included are maps which show the appro imate location of regions where phosphate rock and FAFR could be used effectively

Colombia is a country with an estimated total land area of 114,175,000 has As can be seen from table 30, only 10 9 million has are adequate for dry land annual crop production and 3 5 million has can be cultivated with aid of irrigation Thus, the combined irrigated and dry land agricultural area of the country amounts to 14 4 million has or only 12 7% of the total land area of the country Of the remainder area 19 2 million has , or 16 8% of the total, are adequate for e tensive and semi-intensive livestock production, while 67 1 million has or 58 7% of the total, are considered to be without agricultural possibilities

Colombian soils have been classified according to the U S soil classification system[1] The country presents a wide variety of soils but, as shown on table 31, it is dominated by Inceptisols, Entisols, Oxisols and Ultisols As a fact, it is estimated that 91 6% of the soils in the

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[1] Cortez, L A et al 1982 Mapa de Suelos de Colombia Ministerio de Hacienda y Credito Publico Instituto Geografico Agustin Codazzi Bogota Colombia

country belong to these soil orders Of these four soil orders, Inceptisols and Entisols are predominant in the presently cultivated areas of the country The O isols and Ultisols are most common in the eastern plains region, an area which is gaining importance through time, since it offers the best and largest potential for commercial agricultural production e pansion The eastern plains area is relatively close to important market areas, it has climatic conditions which favor agriculture and is formed mostly by flat lands easily mechanizable

The natural fertility of Colombian soils is very variable from one region to another In general, the P content of Colombian soils is considered to be low, and the use of phosphate fertilizers in commercial production is recommended[2] Table 32 presents the summary results of about 100,000 soil samples analyzed by ICA between 1965 to 1978[3] With respect to the P statu of the soils, table 32 presents the percentage distribution of soil samples by natural regions and levels of P availability As can be see on this table, of the 10 regions listed, in six of them more than 50% of the soil samples were considered to be low in P The Atlantic Coast and the Guajira regions were the only two where more than 50% of the samples were classified as having high P availability

Table 33 presents the percentage distribution of soil samples, for important food crops and by state, according to

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[2] Exceptions to this occur in the high fertility areas of the Cauca Valley, the Cundinamarca Highlands, the Atlantic Coast and the Zulia Valley

[3] Marin, G , J Navas, and J Henao 1982 La Fertilidad de los Suelos Colombianos y las Necesidades de Fertilizantes Instituto Colombiano Agropecuario Tibaitata, Colombia

specific crop requirements and the F availability status This table also includes the estimated (preliminary) area planted with these crops during 1986 As this table shows, for many of these crops and in many departments the low F soils are dominant (more than 50%), and in some cases, the low F soils accounted for more than 70% of the samples It appears that most of the soils were potato, cassava, beans and maize are grown have a low F availability Therefore, for sustained economical agricultural production of these crops in these areas, the use of P fertilizers is needed

Table 34 presents the estimated RAE for phosphate rock and for FAPR for different crops and on homogeneous agroecological regions of Colombia These table includes all those areas with agricultural potential for food crops, industrial crops and pastures, dry land and irrigated The homogeneous agroecological zones were determined considering the following factors (1) Climate altitude, temperature and rainfall, (2) Geomorphology slope and relief, (3) Parental Material sedimentary, igneous and metamorphic, and (4) Soil degree of evolution, effective depth, drainage, erosion and fertility The homogeneous regions are identified with letter codes, descriptions of which can be found in the original publication[4]

The RAE for phosphate rock and for FAPR has been estimated for crops currently grown in those regions, or crops which are recommended for those regions Due to the nature of this study, industrial crops such as coffee, tobacco, sugar cane for sugar production and cotton were not considered

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[4] Cortez L , A 1985 Zonificacion Agroecologica de Colombia" Ministerio de Hacienda y Credito Publico Instituto Geografico Agustin Codazzi Bogota, Colombia

As can be seen from the RAE estimates presented on table 34, a wide variation can be expected from the performance of phosphate rock and PAPR in different crops and agroecological regions For example in region Cg, Co and Cr for pastures, the RAE of phosphate rock is estimated to be 95%, while in regions such as Fa with potatoes and Fh with beans or maize, the estimated RAE for phosphate rock does not exceed 20% Obviously, in regions with a high RAE for phosphate rock, it is advantageous for farmers to use it, while in regions with a low RAE it is not recommended

With respect to the performance of PAPR, it can be noted that its RAE is higher than for phosphate rock, and that for some crops and in some agroecological regions it can be equal to 100% Even though some experimental results obtained by the project indicate that PAPR can have a higher than 100% RAE, for large areas, such as those on table 34, it is improbable that PAFR performs better than TSF and or a soluble P source The RAE for PAPR is estimated to be between 85 and 100% in the selected homogeneous agroecological regions of Colombia This indicated the suitability for use of PAFR throughout the country Figure 7 shows the approximate general areas of the country where phosphate rock is estimated to have a RAE of between 85 to 100% for pastures, and between 85 to 90% for rice Figure 8 presents similar information for PAFR, with estimated RAE s of pastures 95 to 100%, rice 90 to 95%, sorghum and maize 85 to 90%, potatoes 85 to 100%, and sugar cane for panela production 90 to 95%

From this analysis it can be safely concluded that PAPR could be effectively used as a P source in the country in a wide variety of crops and in the major agricultural regions On the other hand, phosphate rock could be used as a P source only in selected areas and in a few crops where its effectiveness has been proved. Phosphate rock from Huila can also be used as a soil amendment on vast country areas with acid, low fertility soils.

As far as determining the potential use of domestic phosphate rock for supplying the P needs of the crops in the country, and defining potential as possible as opposed to actual, it can be stated that through the use of ground phosphate rock for direct application and of PAPR most of the P needs of the country could be met. However, since these two products have in general a lower RAE and REE than TSP, their prices should be lower than that of TSP on a P basis, to entice farmers to use them. Prices can be made to be low enough so that the REE from TSP, phosphate rock and PAPR become equal.

Potential is sometimes also defined or equated with crop needs and/or with fertilizer recommendations. Table 35 presents an estimation of the P potential use by several crops and in different areas of the country. The potential P use was estimated multiplying the recommended amounts by crop, region and soil P fertility status by the areas with each crop. The areas with low and medium P content were estimated utilizing the percentages presented in table 32. Crops included in this table account for approximately 55% of the P use in the country (1985).

As table 35 shows, the estimated total potential P use of these crops amounts to 30,721 tons or 70,351 tons of P_2O_5 using area data from 1986. It is estimated that most of this P needed could be provided by PAPR's produced with domestic reserves. Also, phosphate rock for direct application could be used to provide the P needs in the low P status soils of

Meta (for rice, maize and cassava), Nariño (for potatoes) and in all low P status soils cropped with sugar cane for panela Not including pastures and other crops where it is estimated that phosphate rock can be used (i e oil palm, sorghum), phosphate rock could be used to supply 8,420 tons of P or 19,281 tons of P_2O_5 This is equivalent to about 87,600 tons of a phosphate rock with an average P_2O_5 content of 22%

Additionally, as was shown in the previous section of this report, phosphate rock can be used effectively as soil amendment in acid soils In this respect, agronomic response and economic benefits obtained from the use of phosphate rock and or phosphate rock mixed with lime exceeded those obtained with the use of lime alone There are several million has in the country with acid soils where phosphate rock can be effectively used as soil amendment

XI PHOSPHATE SUPPLY ALTERNATIVES

There are many possible fertilizer phosphate supply alternatives available to countries which posses domestic phosphate reserves The choice among possible alternatives depends ultimately on the production costs and on the agronomic suitability of the fertilizer products manufactured to soils/crops of the region under analysis In this section of the report, consideration is given to the supply of the phosphate needs of the country, utilizing indigenous materials to manufacture a standard soluble P fertilizer (i e TSP, DAP, NPK s), partially acidulated phosphate rock (PAPR) and ground phosphate rock

As has been shown under the agronomic evaluation section, PAPR can perform similarly to TSP or a soluble P fertilizer under a wide variety of soil and cropping conditions However, the production of PAPR can be accomplished at a lower production cost than the production of a soluble P source, primarily due to the savings in the amount of sulfuric acid needed[1]

Ground phosphate rock refers to the simply mining and grinding of the ore material In some cases, where possible, the rock may be beneficiated Production of phosphate rock for direct application is the most rudimentary way of supply phosphates to crops It is easy, requires little technology and can be economical at very low production rates

In selecting between the different phosphate supply alternatives that a country may have, there are four factors

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[1] More details on this subject can be found in: Schultz, J J 1986 Sulfuric Acid Based Partially Acidulated Phosphate Rock Its Production, Cost and Use IFDC Muscle Shoals, Alabama, USA

which should be carefully considered These factors are

1 Market Size
2 Quantity, Quality and Location of Phosphate Deposits
3 Availability of Inputs Needed for Fertilizer Production
4 Agronomic Response of Crops to Different Phosphate Sources

In addition to the above listed factors, consideration has to be given to the effect and impact that fertilizer government policies may have on different supply alternatives In view of this, and considering the general objectives of this report, government policy issues related to the fertilizer sector in general and to the development of the indigenous phosphate reserves in particular, are analyzed in detail in a subsequent section of this report

The selection as to which phosphate fertilizer or fertilizers should a country produce, should be made on the basis of the above mentioned factors The following paragraphs discuss each one of these factors and relate them to the existing situation in Colombia

(1) Market Size The phosphate market size is probably the first factor which should be considered when analyzing the different supply alternatives a country may have This includes a careful analysis of the potential domestic market, as well as the potential export market Economies of scale play a very important role in determining the type of fertilizer plant which can be justified for development

A recent report by FAO s Comission on Fertilizers [2]

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[2] FAO Comission on Fertilizers 1985 Investments and Production Costs for Fertilizers Fert 85/4 FAO Rome Italy

states that an analysis of newly built and of planned phosphate fertilizer plants, indicates that most of these plants will be located at a mine site and will have an average P_2O_5 production capacity of 165,000 to 296,000 tons/yr Due to economies of scale and technical considerations, plants of this size range can expect to have lower production costs than smaller sized plants According to the 'IFDC Fertilizer Manual [3] small SSP can be economical to serve small local market needs where suitable materials are available At the same time this manual indicates that for large scale production TSP plants are preferred to SSP plants

A section of this report entitled 'Projected Supply-/Demand Balance for Phosphate Fertilizers' indicated that by the year 2000, the total P_2O_5 demand in the country was estimated to be equal to 159,100 tons, of which 94,000 tons could be produced with currently installed capacity and with the planned utilization of the grinding plant at Pesca town Projected P_2O_5 deficits were estimated to be equal to 18,800 tons in 1990, 43,200 tons in 1995 and 65,100 tons in the year 2000 Therefore, to meet the phosphates requirements of the country until the year 2000, a fertilizer plant or plants with a total estimated production capacity of 60,000 to 70,000 tons of P_2O_5/yr will be enough This is equivalent to the development of an industry capable of processing 300,000 to 400,000 tons of phosphate rock annually

There has been increasing interest among government officials and private companies to develop domestic

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[3] IFDC 1979 Fertilizer Manual An IFDC-UNIDO publication IFDC Muscle Shoals, Alabama USA

phosphate resources to meet the ever increasing phosphate needs of the country In view of this interest, a feasibility study, completed in 1984[4], was done to study the possibility of developing a fertilizer complex utilizing phosphate rock in the vicinity of Pesca town This included phosphate rock from the Pesca and Iza deposits Results of feasibility the study indicated that to produce phosphoric acid based fertilizers at a competitive price, a plant with a capacity of 100,000 tons of P_2O_5/year and an estimated capital investment of an estimated US $190 million was needed This plant size is considered to be the minimum size for a plant of this nature, a smaller plant size would increase production costs considerably

To justify a fertilizer plant this size, the feasibility study assumed that MONOMEROS and ABOCOL will stop fertilizer production, and that the short- and medium-term phosphate needs of the country will be fully satisfied by the new fertilizer complex An improbable happening, considering that MONOMEROS and ABOCOL are well established fertilizer companies which expect to remain in the business

It is obvious that at present and projected domestic P_2O_5 consumption levels, and considering the existing phosphate supply of the country, an additional fertilizer complex to produce 100,000 tons of P_2O_5/year, is not justified

The possibility of exporting phosphate fertilizers from the country, is of little importance, given the fact that

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[4] Zellars-Williams Inc 1984 Estudio de Complementario de Factibilidad para un Proyecto de Fertilizantes en Boyaca, Colombia Prepared by Zellars-Williams, Inc for IBRD, UNDP and ECOMINAS Bogota, Colombia

MONOMEROS and ABOCOL, which have port facilities, have high production costs such that their products are not price competitive at present world market prices Their production cost are high partly because they depend almost exclusively on imported raw materials for the manufacture of fertilizers However, in the past, MONOMEROS has made sporadic and small exports of NPK s to Venezuela Should a large fertilizer plant be developed in Colombia to satisfy domestic phosphate needs, and should international fertilizer prices recover from their present low, exports from Colombia could become a viable alternative for MONOMEROS and ABOCOL, worth considering in a long-term basis or when present market conditions change The export potential for a newly proposed complex using domestic phosphate rock is minimal considering the location of the deposits and their distance to export ports

Therefore, considering the domestic market size, it can be stated that by the year 2000 there will be a need in the country for a phosphate plant with a production capacity of 60,000 to 70,000 tons of P_2O_5/year A phosphoric acid based plant designed for this capacity would be relatively small and would have high production costs However, to supply phosphates in the form of phosphate rock (which is already done) and of PAPR seems to be the best alternative to the country

(2) <u>Quantity, Quality and Location of Domestic Reserves</u>
After a careful analysis has been made of the phosphate market, an assessment of the domestic phosphate resources is required It has to be kept in mind that the mere availability of phosphate rock and size of the phosphate market, does not ensure the development of the phosphate industry Consideration has to be given to the quality,

quantity and accessibility of the phosphate rock

Table 23 presented a summary of the phosphate reserves of the country, as of 1986 This table will undergo changes as more is known about these deposits, and as new ones are discovered Of the 19 deposits there listed, only 4 have been studied and researched, to different degrees, so as to have reliable information These 4 deposits are known as Fesca, Iza, Huila and Sardinata Therefore the discussion presented here will be limited to these 4 deposits Table 36 presents the chemical analysis of representative samples from these 4 deposits This table shows that the Sardinata rock has the highest average P_2O_5 content equal to 26%, followed by Huila and Fesca with 22%, and finally Iza with 20% Of these rocks, Sardinata is the only one that can be economically beneficiated, to increase its P_2O_5 content to about 32% With respect to CO_2 content, an important factor when considering chemical processing of the rock, the Huila rock has the highest content, equal to 8 3%, The Fesca and Sardinata rock have considerably less CO_2, equal to 1 3% and 8% respectively, while samples from Iza indicate a variable CO^2 content (1 5 to 8 5%), depending on the depth of the sample

In view of the volume, quality and location of the deposits, Fesca is the one which has been mostly studied and researched It is considered that this deposit is the most promising with regards to the development of a relatively large fertilizer complex A feasibility study conducted in 1984[5] indicated that the production of TSP, DAP and NPK s was technically feasible using this rock However, the size of the estimated recoverable reserves, of only 6 5 million

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[5] Ibid Zellars-Williams Inc 1984

tons of phosphate rock with an average P_2O_5 content of 20% to 22%, were not enough to justify the investment needed This deposit has the advantage of being located very close to a large potential phosphate market area Even though this deposit is not large enough to support a large fertilizer complex, it has enough phosphate rock of suitable quality to support a small to medium scale development to produce phosphate rock for direct application and/or PAPR As mentioned earlier, production of this two products is a viable alternative in smaller sized plants

The Iza deposit which is located adjacent to Pesca, has been considered for development together with the Pesca deposit However, the feasibility study conducted[6] concluded that the Iza rock could not be used in the same plant with the Pesca rock This was due to the differences in chemical and metallurgical properties that exist between the two rocks This deposit is being exploited now in a small scale for production of phosphate rock for direct application As in the case of the Pesca deposit, it also has the potential to sustain a PAPR plant The proximity of the Iza and Pesca deposits to a large phosphate consuming area (the potato area of Cundinamarca and Boyaca) and the existence of the Pesca grinding plant give these two deposits a clear advantage for rapid development

The Huila phosphate rock deposit has been used during the past several years for production of phosphate rock for direct application It is presently the most popular of the rocks used by the farmers in the country, and the one that has received most the agronomy researchers attention This deposit has not been considered for a major fertilizer plant

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[6] Ibid Zellars-Williams, Inc

due to the low volume of its reserves, which at a level of 1 5 million tons of rock, with an average P_2O_5 content of 20/ are too small Obviously this mine, offers a good opportunity for continuing production of phosphate rock and a good potential for production of FAPR For the production of FAPR, this mine has the advantage of being located very close to a sulfuric acid plant, and also close to an important potential FAPR user agricultural area the rice area of Huila and Tolima

The Sardinata phosphate rock deposit has also been exploited in the past for production of rock for use by MONOMEROS and ABOCOL, which use it in the manufacture of NPK s This production has been limited to a few thousand tons per year, partly due to production constraints, and partly due to the high cost and usually lack of transportation from the mine to the fertilizer plants In recent years some of this rock has been used for direct application This rock has the advantage of its high P_2O_5 content, but major disadvantages are its distance to potential markets and its low reactivity The recoverable reserves of this mine, estimated at 2 million tons, make possible the development of a phosphate rock and/or FAPR plant there and the continued supply, in a small scale, of raw materials to MONOMEROS and ABOCOL The volume of reserves is not enough to support the development of a large fertilizer complex ECOMINAS is interested in developing a bicalcium phosphate (for animal feed) plant at this mine With respect to the possible production of FAPR, the sulfuric acid facilities of the country are located far from the mine, therefore the cost of bringing sulfuric acid to this mine will be higher than for other mines Due to the higher P_2O_5 content of the rock, a higher transportation cost could be affordable Also, of all domestic deposits, this one presents the lowest mining costs

Summarizing, considering the quantity, quality and location of the domestic reserves, it can be safely stated that there is not enough rock at any one place, of suitable quality, so as to support the development of a large fertilizer complex On the other hand, all four deposits considered have enough phosphate rock, of suitable quality and at accessible locations, so as to permit the development of a phosphate rock and/or PAPR industries

(3) Availability of Inputs Needed for Fertilizer Production Due to the role that sulfur and sulfuric acid play in the manufacture of fertilizers in general and phosphate fertilizers in particular, it is important to analyze their supply (availability) and demand (use) situation in the country

There are presently two sources of domestic sulfur production in the country, one is from the Purace mine in the Cauca department and the other one is sulfur derived as a by-product of the oil industry in Barrancabermeja, Santander In addition to the Purace mine, there are small sulfur deposits in the Nariño, Tolima and Cundinamarca departments[1] However, very little is known about these deposits, none of which is being exploited presently

The Purace deposit is located 50 km east of Popayan, in the neighborhood of Purace town, and has the largest estimated reserves of the country equal to about 2,000,000 tons During 1984-85, total sulfur production from the Purace mine

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[1] Paris Q , Gabriel 1979 El Azufre en Colombia in Suelos Ecuatoriales, Volume X, No 2, p 225-231

was equal to 35,000 tons, equivalent to 100% plant capacity Purace is in the study and planning stages for the expansion of their plant Depending on studies of the recoverable reserves, Purace plans to double production capacity ECOPETROL in Barrancabermeja, the other source of sulfur in the country, produces 15,000 tons/yr , from by product of the oil industry

The total sulfur needs of the country during 1986 are estimated at 75,000 tons/yr, of which 50,000 tons/yr are produced locally (Purace and ECOPETROL) and 25,000 tons/year are imported, mostly by MONOMEROS Should Purace expands its plant to de planned level, imports of sulfur will not be necessary

Table 37 presents a list of sulfuric acid producers, their location, rated capacity and total production during 1984-1985 This table shows that only one plant, that of Quimica Basica (QB) in Caloto, Cauca, is operating at full capacity This table also shows that the country has a total sulfuric acid production capacity 182,400 tons/yr and a demand for 121,200 tons, or only 67% of the installed capacity

Table 38 presents the 1984-1985 use of sulfuric acid by region It can be seen that MONOMEROS in Barranquilla is the largest user in the country followed by ECOPETROL and QB MONOMEROS produces 100% of what it needs for its caprolactam production, while ECOPETROL produces 95% of its needs QB, FQP and FAS produce sulfuric acid for sale to other industries The FQP, FAS and QB plants make sulfuric acid using sulfur from the Purace mine MONOMEROS uses about 21,500 tons/yr of imported sulfur and about 8,000 tons/yr of Purace material The ECOPETROL plant uses exclusively by-product sulfur from the oil industry

With respect to the possibility of available sulfuric acid in pro imity of the phosphate rock mines, the FAS factory, build in 1975, is about 40 km from the Huila (Tesalia) mine This plant was originally built with the intention of using the sulfuric acid production to acidulate Huila phosphate rock, to produce either PAPR or SSP There is presently the possibility of using the acid production from FAS to acidulate Huila phosphate rock The QB plant, at Caloto, Cauca, is located in the proximity of the Furace mine and about 200 km from the Tesalia PR mine This factory operates at full capacity and presently does not have surplus sulfuric acid to use in the acidulation of rocl However, QB is considering e/panding the plant in the near future to produce 10,000 tons/yr more, some of which could be used to acidulate rock The POP plant located in Bogota, and presently operating at about 50/ capacity, is the closest sulfuric acid source to the Pesca, Iza and Sardinata mines Acid from this plant is a possibility for acidulation of rock from any one of these mines

Therefore, the country apparently has enough sulfur reserves, and with the planned plant expansion capacity it should have enough finished material to become self sufficient With respect to sulfuric acid, the country now has excess production capacity, which if used will be enough to securely supply acid to an eventual small- to medium-scale development in the phosphate industry

(4) <u>Agronomic Response of Crops to Different Phosphate Sources</u> Previous sections of this report have shown that PAPR (or mixtures of TSP and phosphate rock simulating PAPR) can be used effectively as fertilizers on a wide variety of

crops and agroclimatic regions of the country It has also been shown that the use of phosphate rock as fertilizer is limited to a few crops and agroclimatic regions, and that Huila phosphate rock can be used as soil amendment in large areas

In view of these findings, it was stated that phosphate rock and PAPR could provide most of the P needs of the country The advantage of these two products over standard P soluble sources is their lower investment cost and lower production cost

Therefore, among the alternatives available to supply the country P needs using domestic reserves, it is evident that the production of phosphate rock for direct application and of PAPR offer the best potential This conclusion is reached after giving consideration to the four factors analyzed in this section of the report

X PRICES AND PRODUCTION COSTS

This section of the report discusses fertilizer prices in the country and presents a preliminary estimation of production costs for PAPR, including cost estimates for mixtures of PAPR and TSP which simulate PAPR products, including the transportation costs to main P using areas Also included is an estimation of fertilizer price elasticities which have implications for policy aspects However, aspects related to fertilizer policy are discussed in the following section of the report

Fertilizer Prices

Table 39 shows the average plant gate prices for major fertilizer products in the country, for the 1977-1987 period The P containing products shown on this table account for about 75/ of the P used To convert these prices to prices paid by farmers, an 8/ dealers margin plus the transportation cost to the farm have to be added As can be seen in this table, prices show yearly increases, with decreases occurring only occasionally These price variations reflect changes in international prices, and the ever present devaluation of the peso and inflation Large price increases can be observed during 1980 to 1981, and during the 1983 to 1985 period

Table 40 presents an estimation of the nutrient plant gate prices for N, P_2O_5 and K_2O for the 1977-1985 period These estimates are weighted averages of all fertilizer products sold in the country As can be seen on this table, and on figure 6, these prices show a steady increasing trend K_2O is the nutrient with the lowest unit price, while N and P_2O_5 alternate the highest During 1985, last year for which there were data available for this estimation, P_2O_5 had the highest price which was equal to $84 6/kg During the last two years, it is estimated that P_2O_5 had again the highest price, considering the decline in prices for Urea and the modest increases KCl prices

Prices and Transportation Costs

Fertilizer prices paid by farmers in different regions of the country vary widely due to differences in transportation costs Obviously farmers close to fertilizer factories are faced with lower prices Also, farmers buying from Caja Agraria are faced with the same prices throughout the country It is estimated that present transportation costs represent from 15/ to 25/ of the total cost of NPK s and straights For phosphate rock, since it is a product with a lower base price, transportation costs account for 30/ to 35/ of the selling price

Table 41 presents the estimated prices for the main P fertilizer products in the country at the plant gate (Barranquilla/Cartagena), in Bogota (Cundinamarca/Boyaca), Pasto (Nariño) and Villavicencio (eastern plains) Bogota and Pasto represent the two most important P using areas of the country, while Villavicencio represents the area with a large potential for increases in the use of phosphate rock for direct application and of PAPR

This table also presents the estimated prices for fertilizer products and an estimation of the P_2O_5 price from each product The price of the P_2O_5 was estimated discounting the value of N and K_2O, using the prices of Urea and KCl, also shown on the table P prices for DAP and TSP are the highest in the Villavicencio area, followed by

Bogota and Pasto For NPK s P prices are the highest at Pasto, followed by Bogota and Villavicencio The lower F prices for imported materials in Pasto, is due to the fact that these products can be, and sometimes are imported through the Buenaventura port, decreasing transportation costs

As table 41 shows, P_2O_5 is presently more expensive than N and that K_2O Among the P sources considered, Huila phosphate rock has the lowest price ($71 to $76/kg) while 15-15-15 has the highest price ($193 to $220/kg)

Table 42 presents the transportation cost from the main (present and potential) F supplying areas of the country to the three major P using areas, and an estimation of the potential transportation savings from the Tesalia (Huila phosphate rock) and the Pesca/Iza plant sites to the consumption centers As this table shows, considerable savings in transportation can be obtained by supplying P fertilizers from Iza/Pesca and Sardinata to the Cundinamarca/Boyaca area and to the eastern plains, and by supplying from Tesalia to the Nariño and eastern Plains areas, instead of bringing imported materials or NPK s from the Barranquilla/Cartagena plants Sardinata enjoys a small advantage in relation to the Atlantic Coast but has higher transportation costs, on a product basis, to market areas than products from other mines

To supply the Bogota area, products that could be manufactured at Iza/Pesca, enjoy an advantage of about $3400/ton over products from Tesalia, while Tesalia enjoys an advantage of about $1800/ton in the supply of products to the Nariño area With respect to the eastern plains area, Iza/Pesca enjoys an advantage of $1400/ton over Tesalia

Moreover, should the new road to the eastern plains be developed in the near future, as now promised, this advantage will increase

<u>PAFR Plant Size and Production Costs</u>

An attempt is made here to estimate the possible production cost of a PAFR product manufactured with ore material from either one of four mines considered, and located at either one of three possible sites Tesalia, Pesca and Sardinata Table 43 presents the results of these estimations The quantities of phosphate rock and of H_2SO_4 necessary to make one ton of PAPR are IFDC estimates For each product made, approximately 50% of its P_2O_5 is in water soluble form The phosphate rock mining and the H_2SO_4 costs were estimated with information provided by producers The conversion cost was assumed to be equal at all plant sites, and equal to 80% of that variable and fixed conversion cost estimated by IFDC[1] This was done considering domestic costs for utilities, construction and operation of a granulation plant of the same size (20,000 tons/yr of P_2O_5)

A PAFR granulation plant with a capacity of 20,000 tons of P_2O_5/year was selected considering the short- to medium-term potential use of this product As table 21 showed, it is estimated that during 1990 the country will need to import 91,200 tons of P_2O_5, while it will have a domestic production capacity of 21,600 tons Of the 21,600 tons to be produced, table 14 indicated that 4,600 tons will be used for direct application, the remainder or 17,000 tons will have to be acidulated and granulated to meet market acceptance Of the 91,200 tons to be imported, 72,400 tons

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[1] Ibid Schultz, J J 1986 Table 18, p 20

are expected to be used by MONOMEROS and ABOCOL for the manufacture of granular NPK s, while the rest will be TSP and DAP for direct application

It is believed that PAPR products con replace imports of DAP at least partially As was shown in the agronomic evaluation section, PAPR products can be as good as DAP and TSP on some soils and for some crops In soils and crops where the soluble fertilizers are better agronomically, the right price incentives will encourage farmers to shift Therefore, a plant to produce 20,000 tons of P_2O_5/year is estimated to be enough in the short- to medium-term In the longer term, as the PAPR market develops and as farmers get to know this PAPR, another plant of about the same size could be developed

Table 43 presents the estimated production costs for PAPR at four mine sites This table shows that the lowest product cost estimated is for acidulation of Pesca phosphate rock at Pesca ($17,256/ton), while the highest is for Huila rock at Tesalia ($18,070) With respect to the P_2O_5 content of the resulting PAPR product, Sardinata rock yields the highest content (21%), while Iza and Huila have the lowest (16 3% and 16 7% respectively As table 44 shows, the lowest P_2O_5 production cost is obtained with the Sardinata rock ($86/kg), followed by Pesca ($96/kg), Huila ($108/kg) and finally Iza ($110/kg)

Table 44 also shows the estimated product cost and P_2O_5 cost at the plant gate, and the estimated selling prices at Villavicencio, Pasto and Bogota, which represent the most important potential PAPR market areas These selling prices were estimated adding 8% dealers profit and the transportation cost to the estimated production cost On a P_2O_5 basis, the Pesca PAPR has the lowest price in the Bogota and Villavicencio areas ($126 and $109/kg, respectively), while the Sardinata PAPR exhibits the lowest price in Pasto ($145/kg) It should be considered that if a joint company between the rock and the acid producers is formed, the acid should be priced lower, since all profits will be made with the final product only Therefore, the production costs should be somewhat lower than here presented

From the above findings it can be stated that all four mines considered have somewhat similar production costs However, plants located at Tesalia and/or Pesca (using Iza and Pesca rock) have advantage over Sardinata, since they have better grinding, drying and bagging facilities already in operation Sardinata would require a higher capital investment Further more, there is a lack of transportation at the mine site, so probably, a premium price should be paid to obtain transportation as needed and not as available

As mentioned at the beginning of this discussion on production costs, estimates presented here are preliminary and a feasibility study is necessary to determine the best site or sites for PAPR(s) plant(s) An engineering study should also consider locating the PAPR plant(s) adjacent to the H_2SO_4 plants, to minimize the problems of transporting acid For this evaluation the H_2SO_4 plants located in Neiva, Huila (the FAS plant), Caloto, Cauca (the Quimica Basica plant) and Bogota (the PQP plant) should be considered

Market Competitiveness of PAPR Products

Table 45 presents the estimated prices of P_2O_5 from different sources at Villavicencio, Pasto and Bogota As this table shows the estimated prices for P_2O_5 from PAPR products are higher than the price from DAP, but lower than the price from NPK s The only exception to this is the price of PAPR from Pesca at Bogota ($109/kg) which is slightly lower than the price of DAP ($112/kg) P_2O_5 prices from the lowest priced PAPR s are 10% to 30% higher than DAP s in the Villavicencio area, 32% to 53% higher in the Pasto area, and from 3% lower to 28% higher in the Bogota area From this table it can be estimated that P_2O_5 prices from NPK s in the Villavicencio area are 21% to 37% higher than the price of Pesca PAPR, 12% to 52% higher than the price of Sardinata PAPR in the Pasto Area and 38% to 77% higher than the price of Pesca PAPR in the Bogota area

Finding here presented indicate that PAPR products can be a competitive source of P in the market place Since DAP is lower priced and of higher concentration, it will be a preferred fertilizer by farmers However, potato farmers, the most important P using group in the country, have had bad experience with the use of DAP on their crop (burning of seedlings), hence they do not use it in favor of NPK s Their aversion to the use of DAP has precluded the development of a bulk blending industry in the potato regions of the country

It is well known that present international fertilizer prices, including all P sources, are at their lowest level in many years These prices are expected to remain so for a short term, after that they will start increasing again As prices recuperate, DAP (and TSP) will loose some of its price advantage, and the PAPR products manufactured with domestic rock will become more competitive Should international phosphate prices (DAP and TSP) increase by about 20%, or reach their 1980-81 level, their estimated

P_2O_5 prices will be about equal to the PAPR price estimates presented here Therefore, it appears than in the medium- to long-term, PAPR will be able to effectively compete with imported DAP and TSP Also, since NPK s are manufactured with mostly imported materials, PAPR s advantage in relation to them should also increase

Estimated Costs of Phosphate Rock and TSP/DAP Mixtures

Table 46 presents the estimated cost to farmers of making a TSP or DAP plus Huila phosphate rock mixture Such mixture has been agronomically tested by the project and it has been noted to perform comparable to a PAPR product The mixture contains the same percentage (50%) of P_2O_5 water soluble as the PAPR products tested by the project Obviously, this table shows that the mixtures of Huila phosphate rock and TSP or DAP have lower costs at the three selected locations than TSP or DAP, and higher costs than the Huila rock alone Then, it can be stated that in places where this mixture is as effective as TSP or DAP, its use will save money to farmers

The mixture tested is a physical blend of products with similar granulometry (both powder), made right before application to the soil Therefore, farmers with access to cheap labor or with surplus labor at planting time may benefit from this practice

The idea of making a commercial product of this mixture does not seem to be attractive, since the TSP and/or DAP (or MAP) should be finely ground before mixing with the rock, thus adding to the cost of the product Costs will increase even more if this mixture is granulated Compaction is not recommended for products which contain phosphate rock and/or

TSP[2] However, a detailed engineering feasibility study for production of these mixtures should be conducted to evaluate alternative products which could be produced at different mine sites

Fertilizer Demand Elasticities

Fertilizer demand elasticities provide important guidelines related to the effect on fertilizer use, and hence on crop production, that government actions may have Table 47 presents the estimated fertilizer demand elasticities for nutrient prices, crop area and farm income Nutrient prices are the weighted average prices of N, P_2O_5 and K_2O, crop area is the area planted with crops and farm income is an estimate of the money earned by farmers per hectare during a given year Estimates were obtained through the use of multiple regression analysis Consistency of estimates was checked with the ridge regression procedure

As this table shows the nutrient price elasticities are the smallest calculated, and among them, the elasticity for P_2O_5 is the smallest, and equal to - 19 This figure means that a 1% increase (decrease) in the weighted average price of P_2O_5 will cause a decrease (increase) of 19% in the quantity of P_2O_5 used

From the estimated elasticities for N, P_2O_5 and K_2O, it can be inferred that colombian farmers in general make their fertilization decisions more in function of the crop area to be planted and on the expected income, than on fertilizer prices *per se* From this, it can be expected that government actions (policies) directed to influence crop prices and

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[2] Lupin, M S and N D Le 1983 Alternative Approach for Granular Fertilizer COMPACTION" IFDC T-25 Muscle Shoals, Alabama

crop areas will have more impact on fertilizer demand than fertilizer price actions

Since not enough data exists to estimate demand elasticities for phosphate rock and/or PAPR products, estimates for P_2O_5 can be taken as a proxy for estimation of effect of government policies on the use of phosphate rock and PAPR products

XI FERTILIZER POLICY

Given the strategic and important role that fertilizers play in the development of the agricultural sector of a country, governments usually elect to intervene in the performance of the fertilizer sector through legislation Fertilizer legislation takes the form of policies and/or regulations, whose ultimate objective is to attempt to achieve pre-established crop production levels through a reliable fertilizer supply at adequate prices There are many ways in which governments can affect the development and functioning of the fertilizer sector Considering that fertilizers are an input in the crop production process, government policies can be established to affect the fertilizer sector directly, through fertilizer policy as such, or indirectly through agricultural development policies This is illustrated on Figure 9

Fertilizer policies can be defined as those government actions whose implementation has a direct impact on the fertilizer sector To this group belong policies related to fertilizer production, fertilizer prices, fertilizer imports and exports, fertilizer marketing, fertilizer regulations, fertilizer research and extension, fertilizer credit, and fertilizer raw materials and domestic reserves Fertilizer price policy includes taxes and subsidies, while fertilizer marketing policy includes all government actions which somehow affect any of the fertilizer marketing components i e transportation, trading, storage, recommendations to farmers etc

Agricultural development policies which indirectly affect the fertilizer sector are all those governments actions which have an impact on the fertilizer sector through policies directed at the agricultural sector To this group belong policies related to crop prices, production input prices (other than fertilizers), agricultural development projects (i.e irrigation, drainage, conservation, reclamation), agricultural credit, land tenure and agrarian reform, agricultural imports and exports, foreign exchange restrictions

In Colombia, which is basically an agricultural country, the government has played an important role in the development of the agricultural and fertilizer sectors Through government policy, virtually all aspects which affect the development of these two sectors have been influenced Given the nature of this report, a description an analysis of those policies which have and have had the greatest impact on the development and performance of the fertilizer sector is made Special emphasis is given to fertilizer policies which are in effect or that could be taken to promote the development and use of the reserves of phosphate rock

During recent times, the Colombian government has concentrated most of its fertilizer policy efforts in the following areas fertilizer prices, and fertilizers and raw materials imports Also, in the strict sense of the word, there are fertilizer subsidies in the country but they are not an officially established government policy There are several government institutions responsible for the design and implementation of fertilizer policies A list of these institutions and their specific area of influence is presented on table 48

Price Policy

Fertilizer price policy is probably the most widely used and usually effective instrument with which governments can influence the fertilizer sector It consists in the establishment of maximum or ceiling prices for fertilizers The objective of a fertilizer price policy is usually the establishment of a fair price to farmers and manufacturers and/or importers

Given the nature of the fertilizer industry and the fertilizer market size in most developing countries, the fertilizer sector is usually characterized by a monopoly (one supplier) or an oligopoly (few suppliers) Economic theory indicates that under monopoly and/or oligopoly conditions, free market forces tend to establish a price higher than under a purely competitive regime This causes a relative reduction in quantity demanded (because of the higher price) and an excess of profits to manufacturers Therefore, through an effective price policy, governments can reduce effectively prices to farmers, thereby increasing demand for fertilizers and agricultural production and/or productivity, and guarantee fertilizer manufacturers with enough incentive to remain in the business

In Colombia, where the fertilizer sector is dominated by two companies i e MONOMEROS and ABOCOL, the government has had a well defined fertilizer price policy for many years As shown in table 48, the Ministry of Agriculture (MAG) is presently in charge of fertilizer price policy The prices of straight and NPK products produced domestically or imported did not have any price controls until 1967 During that year due to the importance that fertilizers were having in the development of the agricultural sector, accompanied by a temporary shortage of foreign exchange, the government decided to begin controlling fertilizer prices Initially this activity was carried out by the Superintendencia de Precios , which did so until 1975

Starting in 1976, the fertilizer price control function was transferred to the MAG, which implemented it until 1979 During 1979, the mechanism of fertilizer price control was changed to a system known as Libertad Vigilada , or a system where fertilizer prices are free to vary, but are closely overseen This system is presently in effect and it consists in the setting of maximun plant gate prices to wholesalers of domestically produced NPKs and Basic Slag To these maximun plant gate prices, the costs of transportation and a marketing mark-up (usually 8 to 12%) are added to obtain the final fertilizer price that farmers pay There is not a government established maximun price to farmers Also, there are not maximun prices set for imported fertilizers or for domestically produced straight fertilizers (except for BS) Fertilizer price regulations are enforced by the 'Superintendencia de Industria y Comercio

To determine maximun prices at which domestic manufacturers (MONOMEROS, ABOCOL and Paz del RIO) can sell to wholesalers, the manufacturers request to the MAG the approval of certain price They submit a formal request with documents (i e import bills, costs of raw materials, etc) and technical studies (i e production costs) to substantiate the case Manufacturers are required to do this for individual NPK products The MAG reviews these documents and at the same time conducts its own study, giving special atention to the costs of raw materials needed for the manufacture of each product Within 90 days following the request and submition of documents to the MAG by a producer, the Ministry has to make a desicion and either establish a new fertilizer price should the request be deemed justified, or leave the old price unchanged As a general rule, the MAG usually allows manufacturers of NPKs a profit of 8% above all production costs

Considering price fluctuations in international markets for raw materials and the domestic devaluation rate, the MAG and the manufacturers have agreed to revise prices quarterly Once the price of a given NFK product has been modified, the prices of other NFK s with similar nutrient content and ratios are also changed, so that at the end all of them have comparable prices This is done even in cases where the same (or similar) product comes from a different manufacturer

Presently, the government does not have an established price policy for imported fertilizers or for domestically produced straight materials, except for BS Fertilizer products excluded from MAG price regulations includes PR from Huila and Iza, urea and calcium-ammonium nitrate from FERTICOL, and ammonium sulfate from MONOMEROS The phosphate rocks, calcium-ammonium nitrate and urea prices are not controlled because of their relative low production volume and because of the competition they face from other products, specially imports The MAG is in the process of trying to start regulating the price of ammonium sulfate, which has been produced in large scale (50,000 tons/yr) by MONOMEROS during the past 3-4 years

Imports and E ports Policy

Fertilizer import policies are established with the purpose of guaranteeing a reliable supply of fertilizers to farmers and/or to protect domestic manufacturers from foreign competitors To guarantee a reliable fertilizer supply, governments in a number of developing countries set up fertilizer import companies To protect domestic manufacturers from foreign competitors, governments can impose taxes, tariffs or quotas on imported materials The amount of taxes, tariffs or quotas depends on the degree of protection that the government deemed necessary Having a fertilizer import control, domestic manufacturers can be protected against dumping practices which occur from time to time in the international fertilizer business

The Colombian government has intervened in the imports of fertilizers throughout the years mostly imposing taxes and by controlling the amounts of imports Table 48 shows the different government institutions involved in the establishment of import policies for fertilizer raw materials and finished products Table 49 show the taxes presently in effect (since mid-1986) charged for imports of different fertilizer materials For fertilizer raw materials which include phosphate rock, sulfur, phosphoric acid and ammonia, there is presently a 2/ tax[1] and the importer is required to obtain a license or import permit from the Ministry of Agriculture (MAG) For straight N, P_2O_5, and K_2O fertilizer products there is also a 2/ tax, except for Urea, for which the tax is 1/ As seen on table 48, licenses from MAG are required for imports of ammonium nitrate, ammonium sulfate, calcium nitrate, basic slag, di-calcium phosphate, and potasium-magnesium sulphate Before licenses for imports of these materials is given, the MAG ensures that domestic production of these products is insufficient to meet expected demand For all other straigth materials the MAG license is not required

The tax for imports of NPK products is 10/, and a MAG license is required The higher tax imposed on NPK s is in fact a protection for domestic NPK manufacturers (MONOMEROS and ABOCOL) As in the case with the straigth materials,

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[1] Taxes are charged on the basis of CIF values

licenses are not issued if there is enough product available from domestic producers

As it is the case with many government policies, the fertilizer import tax policy is revised frequently This is done attempting to make the ta policy reflect changing internal conditions, specially those related to foreign exchange availability and to the supply capacity of local maunfacturers

In addition to the taxes charged on fertilizer raw materials and finished products above mentioned, there is a 5/ tax called PRO-EXPO and a 2/ tax called FEDECAFE, assessed to all imports into the country This ta money goes into a special fund created to promote e ports Also 1 2/ Consular fees charge (on the basis of the FOB price) is assesssed on all imports When imports originate in a country member of the ANDEAN pact, the Pro-e po ta is reduced to 2/ In practice this only applies to urea from Venezuelan plants and sold e clusively to MONOMEROS The Ministerio de Hacienda charges a US $10/mt port tariff flat rate one all fertilizer products and raw materials imported

Summarizing, imports of straight fertilizers are subject to a 0 1/ tax, imports of raw materials to 2/ ta , and imports of NPK products to a 10/ tax Additionally, all imports are subject to a 7/ PRO-EXPO and FEDECAFE tax This yields and effective tax rate of 9/ for raw materials, 7 1/ for straight products and a 17/ for NPK products, of the CIF value Additionally, a 1 2/ consular fees tax on the FOB value and US$10/ton port tariff are charged on all imports

Once fertilizer imports arrive, they can enter the country through the docks of Empresa Colombiana de Puertos

(COLPUERTOS), located in Barranquilla, Cartagena, Santa Marta and Buenaventura, or through MONOMEROS and ABOCOL private docks Occasionally Urea has been imported from Venezuela, via Cucuta in trucks The cost of imports made through the COLPUERTOS docks are estimated to be from $6 to $16/mt higher than imports made through the private MONOMEROS and ABOCOL docks This is due to the higher COLPUERTOS operational costs

Fertilizer manufacturers in Colombia have, during the past few years, made sporadic exports of NPK products, mainly to neighboring Venezuela The government policy is to promote exports of all products produced in the country, including fertilizers, after domestic demand has been satisfied Exports of fertilizers and their volume are controlled through ICA exports licensing Exports of fertilizers have not prospered due to the high production costs of domestic producers

To promote fertilizer exports, the government has two export incentive programs which manufacturers can use One consists of a program in which the government issues documents known as Certificados de Abono Tributario , which are bonds equal to 5% of the CIF export value These bonds can be used for payment of income taxes The other program is a system whereby the Fondo Proexpo finances exports at a low rate of interest, presently equal to 16% per annum for a period of 180 days, and repayable in pesos This financing exists even though exporters are paid at the time of shipment by their customers This program results in the form of a loan at some 14% per annum below the current commercial interest rate of 30% per annum

Fertilizer Subsidies

Fertilizer subsidies, as an integral part of a nation s agricultural development policy, refer to the financial assistance given to farmers in buying fertilizers, or to individuals and organizations importing, manufacturing selling and/or distributing fertilizers The general objective of a fertilizer subsidy is to provide farmers with relatively cheaper fertilizer and thereby encourage use of fertilizer neede to achieve a greater agricultural production and/or productivity

The government does not have a defined policy on fertili-er subsidies However certain actions carried out by the government (and others) can be interpreted as subsidies The most important such government action is the loss incured by Caja Agraria, year after year, due to its fertilizer marleting In fact, latest data available indicates that during 1983, Caja Agraria lost $229 5 million, on the sale of 246,500 tons of fertilizer This is equivalent to an average subsidy of $1040/ton[2] Of all fertilizer distributors in the country, Caja Agraria traditionally has been the largest, and accounts for appro-imately 25/ to 30/ of all sales Caja Agraria losses in the fertilizer business are due mostly to the large inventory carry over e penses, to the operation of stores in remote areas where it is not profitable to do so, and to its overall inefficient operation Caja Agraria sells its fertilizers to farmers at prices which are competitive with those from others

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[2] Ministerio de Agricultura 1986 Politicas de Insumos Bogota, Colombia (mimeo)

The Federacion Nacional de Cultivadores de Cafe (FEDECAFE), a cooperative type organization, sells fertilizer to its members at discount (subsidized) prices FEDECAFE subsidizes fertilizer to its members, but it limits the amount it sells to each farmer accoprding to farm size During the 1979 to 1984 period, and considering the low international market coffee prices and large coffee stock in the country, FEDECAFE reduced the amount of fertilizer sold to each farmer and actively campaign to discourage its use, with the aim of reducing production However, starting in mid-1985, and considering the high international coffee prices this trend was reversed Latest available data indicates that during 1983 FEDECAFE sold to its members about 150,000 tons of fertilizer, with discounts equivalent to subsidy of $500 millions or about $3,300/ton[3]

Marketing Policy

The fertilizer marketing sector in Colombia, which comprises all those actions taken to deliver fertilizers from the plant gate to the farmer fields, is influenced by government actions In the Colombian fertilizer marketing sector participate government entities (Caja Agraria), private companies (ABOCOL and others), mixed companies (MONOMEROS), and farmers cooperatives (FEDECAFE, FEDEARROZ and others) These institutions compete with each other in the market place

The government, through the Institito Colombiano de Normas Tecnicas (INCONTEC) and the Instituto Colombiano Agropecuario (ICA), has issued a set of regulations for fertilizers, soil ammendments and inoculants of which the latest revision is the Resolucion 3601 of December 26, 1984

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[3] Ibid Ministerio de Agricultura 1986 <u>Politicas de Insumos"</u>

The main objective of these regulations is to bring order to the market place This is achieved by requiring trading licenses, product licenses, labels, bags, quality control etc The main objective of the regulations is to protect fertilizer users ICA is in charge of monitoring and enforcing regulations and has been given the authority to revoke licenses and impose penalties and fines to infractors

Contrary to what is common in many developing countries, where governments participate actively in fertilizer marketing, the government in Colombia does not have an established fertilizer marketing policy as such However through the operation of Caja Agraria, the government in a subtle way, influences the fertilizer marketing sector Caja Agraria is a government institute, which main function is to provide credit to small and medium farmers It also has about 400 agricultural inputs stores throughout the nation, where fertilizers are sold It is the largest fertilizer distributor of the country, and has stores even in very remote areas where it is not profitable to do so By selling fertilizers through Caja Agraria the government is effectively affecting the fertilizer marketing sector in mainly three ways 1) it is making fertilizer available to farmers (mostly small) in very remote areas, at a loss, therefore giving an effective subsidy, 2) by being the largest fertilizer distributor and having an adequate supply in all agricultural regions of the country, competitors always consider Caja Agraria prices when setting their own 3) It has enough financial resources to make its own fertilizer imports, a fact that is carefully considered by domestic suppliers (MONOMEROS and ABOCOL) when selling to Caja Agraria

Other than the influence that Caja Agraria has in the fertilizer sector and the ICA regulations, other aspects of the fertilizer marketing sector are not the subject of government policies That is the case for storage, transportation, advertisement and technical assistance, which are largely in private sector hands and free of government intervention

Production Policy

The nature of the fertilizer industry calls for large industrial complexes, which require high investments usually in foreign currency In most developing countries few private companies are willing to make large investments in the fertilizer industry, a strategic economic sector usually carefully and thoroughly regulated by governments Investments in the fertilizer business are considered to be very risky, to a large extent due to government intervention

The government s fertilizer production policy is concentrated in two areas (1) ownership, and (2) explotation of native resources As far as factory ownership, the GOC is part owner of MONOMEROS (47%), the other owners being the Venezuelan (47%) and the Dutch (6%) governments MONOMEROS was establish by IFI in the early 1970 s The IFI function is to make initial investments to develop industrial companies, which after being properly formed and profitable are to be sold to the public In the MONOMEROS case IFI has retained the company ownership

FERTICOL, a small company which produces Urea and CAN is wholly owned by Caja Agraria, a government institute Caja Agraria markets through its 400 stores the entirety of

FERTICOL production ABOCOL, the other major fertilizer producer of the country is privately owned

The phosphate rock producers in Colombia, FOSFACOL, FOSFONORTE and Abonos de Boyaca, are all privately owned It has been the governmet s policy to let private companies develop the phosphate rock deposits of the country

As far as the government s policy for the exploitation of phosphate rock, ECOMINAS which is a non-profit government institution, has the jurusdiction over all mineral resources of the country ECOMINAS has the authority to lease out or grant permits for the exploitation of phosphate rock deposits, or it can elect to form joint companies with private individuals Presently ECOMINAS does not charge fees or royalties to the three phosphate rock companies in operation FOSFACOL is in private hands, while FOSFONORTE is partly owned by the Norte de Santander department, and FOSFOBOYACA is partly owned by ECOMINAS

Research and Extension Policy

Fertilizer research and extension activities have traditionally been carried out and financed by the government Fertilizer research, including phosphate fertilizer research, has been the responsability of ICA s 'Programa Nacional de Suelos which carries out activities related to fertilizer use, fertilizer recommendations to farmers, soil fertility, soil chemistry, soil physics and soil microbiology ICA has 22 research centers and experimental stations located in all representative agroecological regions of the country

As table 50 shows, in addition to ICA there are many national and two international institutions which also engage in fertilizer and soil fertility research The majority of the national institutes are commodity specific, with only ICA, CVC and the State Agricultural Secretariats having responsabilities with more than one crop The international centers have regional domain (more than one country) CIAT is a commodity oriented center and has in the past worked on fertilizers with rice, pastures, beans and cassava IFDC has worked in Colombia with a wide variety of crops located in different agroecological regions, mainly with phosphate fertilizers This report is prepared as part of the IFDC activities in Colombia Additionally, a number of state universities conduct research, on a limited and sporadic basis, related to the agronomic properties and to the engineering processing of domestic phosphate rocks

With the exception of the international institutions listed on table 50, all national institutes perform technical assistance activities ICA, through its Division de Desarrollo Rural', operates offices in all important agricultural areas of the country where technical assistance is provided to all kinds of farmers The commodity oriented institutions provide technical assistance to its members CVC is a regional organization which provides technical assistance to farmers in the Cauca valley and watershed area In addition to the institutions listed on this table, the fertilizer manufacturers (MONOMEROS, ABOCOL an FOSFACOL) provide technical assistance service to farmers throughout the country

ICA and CVC are financed by the government, while the other national institutes are financed by its members CIAT and IFDC are financed by international donor agencies

With respect to phosphate rock and PAPR research, ICA, IFDC and CIAT are the only institutions which are conducting research on a planned and systematic basis The "IFDC/CIAT Phosphorus Project is in charge of these activities, and it interacts very closely with ICA for conduction and execution of activities The CVC and the commodity specific research organizations are not presently conducting reserach in this area

XII POTENTIAL ECONOMIC IMPACT OF THE USE OF DOMESTIC PHOSPHATE RESERVES

As has been shown in this report, domestic phosphate reserves can be effectively used as fertilizers in the country Domestic reserves can be simply ground for direct application or acidulated to make a PAFR product This section of the report discusses the potential economic benefits that the use of domestic phosphate reserves may have on the fertilizer sector and the national economy

The development of the phosphate reserves will have repercussions at the national and at the farm level At the national level it will save foreing exchange by replacing imports, it will generate employment at the mines and plant sites and it will increase fertilizer self-reliance At the farm level it will improve phosphate fertilizer availability and it will reduce prices, or price increases in fertilizers Each one of this items is discussed in the following paragraphs

Foreign Exchange Savings

As table 20 showed, during 1985 a total of 86,300 tons of P_2O_5 were used in the country Of these total only 14 1/ or 12,200 tons were produced using domestic resources, of which 6,000 tons were provided by basic slag and 6,200 tons were provided by phosphate rock for direct application and for manufacture of NPK s If the P_2O_5 from phosphate rock is priced at US$165 5/ton (or Florida rock at CIF US$53/ton) the foreign exchange savings due to the use of domestic phosphate rock for direct application during 1985 were equal to US$1 02 million

Table 51 presents the estimated savings in foreign exchange that can be obtained through the use of domestic phosphate reserves during 1990, 1995 and 2000 Estimations presented on this table were made assuminig that NPK manufacturers will, in the future, continue importing P raw materials at the same level that they are doing it now, and will use only the equivalent of 2,600 tons of P_2O_5 from domestic mines (Sardinata rock) It is also assumed that the production of basic slag will remain constant and that all imports of DAP and TSP for direct application will be replaced by FAPR and phosphate rock This last assumption may be only partially correct, since it is improbable that these two products replace completely the imports of the soluble P sources, for direct application specially at the present low international prices However, as international prices recover from present lows, this assumption will become more and more realistic

The foreign exchange savings are estimated to be equal to US$11 7 million during 1990 and to increase up to US$27 3 million during 2000 Should international P prices increase in the future, as expected, this savings should also increase accordingly

Employment Generation

By substituting imports for locally manufactured products employment is being generated The production of PAPR and of ground phosphate rock for direct application will generate employment It is estimated[1] that a FAPR plant with a capacity of 20,000 tons of P_2O_5/yr will generate 48 full time jobs If the H_2SO_4 is to be produced at the same facility this figure increases to 74 A ground phosphate rock plant, with the same capacity, generates 29 full time

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[1] Ibid Schultz, J J 1986 p 30

jobs In addition to this 8 full time jobs will be needed for the mining of the rock

Fertilizer Self-Reliance

As mentioned earlier, Colombia now produces only 14 1/ of its P_2O_5 needs, the remainder being imported In today s world, countries are always trying to becomec self--sufficient in the needs of their societies Dependance on imports of strategic goods, such as fertilizers, are to avoided if possible As was experienced by fertilizer importing countries, during the 1974 oil crisis, dependance on imports can be very costly An increased level of self--sufficiency in fertilizers helps isolate the the country from drastic and unforeseen changes in international markets and from their detrimental effect on developing economies

Fertilizer Availability

It has been demonstrated in many countries that as the fertilizer supply increases and becomes stable through domestic reliable production, fertilizer demand also increases This increase in demand has a positive impact on crop production and on crop yields

In the fertilizer use section of this report, it was stated that during 1985, 23 8/ of the P_2O_5 used was provided by straight fertilizer products, i e TSP, DAP, basic slag and phosphate rock DAP, TSP and basic slag are usually in short supply and scarce in many areas of the country The supply of basic slag is determined by the steel industry and limited to only 4,400 tons of P_2O_5/yr, whereas the major suppliers of DAP and TSP (MONOMEROS and ABOCOL) prefer to sell their NPK products first, thereby they plan the imports of DAP and TSP accordingly

The phosphate rock industry which is in the developing stages, its making efforts to make its product available in all regions of the country where it is needed However, occasional shortages also occur Therefore, the further development of the ground phosphate rock industry and the development of the PAPR industry will help to alleviate shortages that occasionally occur In the fertilizer use section of this report it was mentioned that during recent years the consumption of K_2O had been approximately equal to that of P_2O_5, whereas a few year ago the consumption of phosphates was higher One of the reasons given for this to happen has been the inadequate supply of phosphate fertilizers

Some farmer groups in the country, specially rice and pastures farmers, have indicated the need for a better supply of phosphate fertilizers Rice farmers prefer to use TSP over DAP They feel that by applying DAP they are loosing some or all of the N in it since it is applied before planting Pastures in commercially oriented enterprises are usually grown in association with legumes, therefore the needs for N fertilization are minimized Rice and pastures farmers are avid users of basic slag and of phosphate rock They are estimated to be a good potential user of PAPR, considering that this product will also provide calcium and sulfur to their crops, which are located in many areas with defficiencies of these two elements Furthermore, rice farmers in sulfur defficient areas may be able to substitute the use of ammonium sulfate by that of urea, since the sulfur can now be provided by the PAPR

With respect to phosphate rock and PAPR use on potatoes, the main phosphate using crop in the country, the situation is slightly different since potato farmers are avid users of NPK products (10-30-10 and 13-26-06) As was shown in the fertilizer demand projection section, the demand for NPK s is expected to reach 500,000 tons during 1987, or equal to the country s installed production capacity After 1987, the additional growth in demand for NPK s will have to be met through the use of straight products either for direct application or for preparation of bulk blends On the other hand, should a PAPR plant be developed in the vecinity of the potatoe growing area (Pesca/Iza mines), its probably lower cost to the farmer and its availability may induce farmers to shift to PAPR, which can then be mixed with urea and KCl to make the needed grades

With respect to coffee, another important phosphate user in the country, the production of PAPR and of rock for direct application will probably not have much impact on the fertilization practices, since coffee is a crop which shows very little response to P applications Also, coffee farmers presently use 17-6-18/2, supply of which is guaranteed by NPK producers, and subsidized by FEDECAFE

Fertilizer Cost to Farmers

Farmers use fertilizers because they can derive economic benefits from them Therefore, other things being equal, farmers will prefer a cheap fertilizer over an expensive one In Colombia NPK fertilizer prices are fixed at the plant gate, while prices of straight products are open to free competition At the retail level, prices are monitored by the government to detect irregularities and to take action in case of need

The availability of a new fertilizer product in the market, like PAPR, or an increased supply of phosphate rock will exert forces to lower phosphate fertilizer prices and/or to put a check on price increases It is in the best interest of fertilizer producers, wholesalers and retailers to sell their products to farmers The high financing and storage costs makes high turn around rates highly desirable

The section on fertilizer prices and production costs showed that PAPR can have a lower selling price than other phosphate fertilizers in some areas of the country Therefore in farms where equivalent response can be obtained from the use of PAPR or another phosphate source, farmers will save money, and increase their net returns by using PAPR It was also shown that farmers can save money by simply mixing TSP or DAP with phosphate rock

If PAPR prices turn out to be as estimated on Table 45, then in regions such as Ipiales, Nariño and El Caibe, Meta, the use of PAPR will represent a lower fertilizer investment by farmers and, therefore, higher net returns

Economic Benefits to Farmers

Table 52 presents an illustration of potential benefits that farmers can derive from the use of alternative P sources In this table the use of 13-26-6 is compared with the use of urea, KCl and three different phosphate sources Huila PAPR, a mixture of TSP and Huila PAPR and TSP alone For this illustration, the Nariño potato area was selected since agronomic results there indicate that the same crop yields can be obtained from these three phosphate sources Products compared here are mixed to obtained the same amount of nutrients contained in one ton of 13-26-6, the recommended application rate for that area The mi ture of Huila PAPR and KCl can be done before planting, at a bulk blending facility, while the other two mixtures should be made right before application, at he farm site due to the urea-TSP blending incompatibility One problem, and probably a present constraint to the use of this mixture is the lack of product availability, specially TSP which is not widely used in the country

As this table shows, the application of one ton of 13-26-6 costs the farmer $61,000, while a ton of Huila PAPR, KCl and urea costs $53,910, a ton of TSP+Huila phosphate rock, KCl and urea costs $40,000 and a ton of TSP, urea and KCl costs $44,680 Since to provide the same amount of nutrients different volumes of these mixtures are required, an adjustment of $1 75/kg cost of application over 13-26-6 is discounted

Table 52 presents the savings that farmers can obtain per hectare of crop by using these mixtures instead of 13-26-6 The largest savings, equal to $20,550, are obtained with the TSP+Huila phosphate rock, urea and KCl mixture, followed by the TSP, urea and KCl mixture ($16,411) and the Huila PAPR, urea and KCl mixtures ($5,455) Considering that presently 18,000 has of potatoes, are planted per year in Nariño, and assuming that agronomic results so far obtained can be extrapolated to 90% of that area or 16,200 has, the aggregate savings that farmers can obtain range from $332,9 million/yr with the TSP and Huila phosphate rock, urea + KCl mixture, to $88 2 million/yr with the Huila PAPR, urea KCl mixture

Additionally Table 52 presents the estimated foreign exchange savings to the country that could be obtained should any of these mixtures be used in this relatively small area The largest foreign exchange savings would be obtained by using the mixtures with Huila PAFR, saving which would be equal to US$1 4 million Savings in foreign exchange by using the TSP+HPR mixtures would be equal to US$710,000, while no savings would be obtained with the TSP, KCl and urea mixtures, since the TSP is imported

An inconvenience that these mixtures made at the farm have, is that usually there is a shortage of labor at planting time Therefore, the mixture with PAFR, which can be made at a bulk blending facility enjoys a practical advantage

In summary, in this area of the country farmers could benefit by changing their fertilizer practices The advent of PAPR in the market would put pressure on the price of 13-26-6 In the short-to medium term, farmers can reap more benefits by using TSP in this fertilization practices However, it is expected that in the medium to long-term, as international fertilizer prices increase more benefits may be obtained from the use of Huila PAPR

It is believed that similar savings can be obtained by farmers in other regions and with different crops throughout the country, i e some rice farmers in the Eastern Plains, some Maize/Beans farmers in Nariño Areas and crops where these savings are posssible should be carefully identified, through confirmation trials before specific recommendations are given to farmers

XIII GOVERNMENT POLICIES TO PROMOTE USE OF DOMESTIC PHOSPHATE ROCK RESOURCES

This section of the report identifies and discusses government policies, which if properly implemented, will promote the use of phosphate rock resources Fertilizer policies included here correspond to those described in the fertilizer policy section, and which are represented under direct fertilizer policies of Figure Policies included here refer to fertilizer prices, taxes, subsidies, marketing, production and research/extension

Fertilizer Prices

Present fertilizer price policy in Colombia is concentrated in the fixing of plant gate prices for NPK s There is no government intervention for setting of fertilizer prices for imported finished products or for the prices of phosphate rock It is recommended that this practice of not intervining in phosphate rock prices be continued and should a PAPR plant starts productions, the non-intervention policy be extended to PAPR products It has been well documented worldwide, that government intervention in fertilizer pricing is the main reason discouraging investments in fertilizer production It is believed that phosphate rock for direct application and PAPR will have enough competition from imported materials and from domestically produced NPK s, so as to make government intervention unnecessary Such is presently the case for ammonium sulfate and for calcium-ammonium nitrate which are domestically produced These products face the competition of urea imports

Since production costs estimates, indicated that the price for a PAPR products will be in general, higher than DAP and TSP but lower than NPK's, it is believed that sufficient market competition will exist for phosphate rock and PAPR, so that they will be fairly' priced It will be in the best interest of producers to sell what they can to farmers

<u>Fertilizer Taxes</u>

Presently the Colombian government imposses a 7 1/ tax an straight fertilizers (DAP, TSP, KCl, etc), a 9/ tax on fertilizer raw materials and a 17/ tax on NPK s, on the CIF value of these products Additionally, a 1 2/ consular fee on the FOB price and a change of US$10/ton of part tariff are charged on all imports The higher tax on NPK products, is a protection to domestic NPK manufacturers Additionally, before NPK products are imported into the country a license is required These two measures effectively keep imported NPK s out of the country

Considering that NPK producers are receiving protection from exports, to accelerate the development of the phosphate rock industry and to make an investment in a PAPR plant more attractive, it is recommended that imported phosphate fertilizers to be used as finished products, be taxed at the same level as NPK s These will represent an increase from 7 1/ tax an straight phosphate fertilizers (TSP and DAP) to 17/ These increase in taxes will effectively increase the price of DAP and TSP for direct application, by approximately 10/

As for as taxes for imports of phosphate raw, it is recommended to have them at the present level Otherwise, the prices of NPK products will increase to a level which may be too burdensome to many farmers When implementing this policy recommendation, measures will have to be taken to avoid diverting MAP, DAP and TSP from raw materials to direct application

It is estimated that a 10/ increase in DAP and TSP taxes will increase fertilizer prices by about 10/ At present volumes of use of 20,000 tons of DAP and 4,500 tons of TSP, and at present plant gate prices of DAP $55,000/ton and TSP $45,000/ton this will represent an extra cash outlay by farmers of about $130 million Of this amount, the government will be collecting in taxes the equivalent of US$15 5/ton of TSP and US$19 0/ton of DAP (with a DAP CIF price of US$190/ton) or a total of about US$450,000/year

<u>Fertilizer Subsidies</u>

The Colombian government presently does not have a formal fertilizer subsidy policy However, its fertilizer business operations through the Caja Agraria, which result in a net loss of money, constitute a subsidy Also, FEDE-CAFE, a private growers association subsidizes fertilizers to its members, however, phosphate fertilization is not a concern to coffee growers

It is recommended that phosphate fertilizers manufactured with domestic raw materials be sold through Caja Agraria In this way, they will also benefit from Caja Agraria fertilizer subsidies With respect to FEDECAFE, since phosphate fertilization is not a priority for them, they will continue their present practices, and developments in the domestic phosphate industry will not affect their practices

Fertilizer subsidies are widely used by governments to promote fertilizer use[2], and hence to increase crop production Subsidies should be short term measures designed to attain specific objectives In the long term, fertilizer subsidies usually become expensive and they have to be terminated drastically In Colombia the phosphate rock for direct application industry has developed to its present level without any subsidies Furthermore, this industry is expected to continue its development without outside help The cost estimates presented for PAFR indicate that this product can compete, with domestically manufactured NPK s even at the presently low international market prices for phosphate raw materials As international prices increase in the short- to medium-term, the price advantage of PAPR will increase further

Should the possibility of establishing a subsidy for phosphate fertilizers manufactured from domestic reserves, the phosphate demand elasticities presented in this report sould be considered The low price demand elasticity estimated (- 19) indicates that a blanket subsidy directed to lower phosphate fertilizer prices will have little impact in increasing phosphate demand Rather, should a subsidy be established, it should be specifically directed to phosphate rock for direct application and to PAPR products manufactured with domestic reserves To subsidize the use of rocks for the manufacture of NPK s is not considered to be a very effective measure, in view of the small size of the rock reserves in Sardinata, and of the long distances which separate the other mines from the fertilizer plants

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[2] Harris G (Editor) 1984 <u>Fertilizer Subsidies in Developing Countries</u> IFDC SP-3 Muscle Shoals, Alabama, USA

If a subsidy is ever established by the government, its amount will have to take into consideration the prices of competing products Cost estimates presented indicate that PAPR can be competitive with NPK s, but it is at a disadvantage again imported DAP and TSP Should imports of these two products be taxed, as recommended, the competitiveness of PAPR will increase, and if an additional subsidy is given to PAPR, substantial increases in its use can be achieved Also a permant monitoring of international phosphate prices should be done, and set subsidies accordingly

Marketing Policy

In Colombia, the government participates in different activities related to fertilizer marketing, which include distribution, regulations and licensing For the distribution of fertilizers it carries out its duties through Caja Agaria, while regulations and licensing activities are conducted through ICA

It is recommended that the distribution of phosphate rock for direct application through Caja Agraria be continued and if possible increased This activities should be carried out only through those Caja Agraria stores located in areas when the effectiveness of phosphate rock has been demonstrated, or where grounds exist to suspect its effectiveness (see Figure) With respect to PAPR, a similar action by Caja Agraria should be taken to guarantee availability of product

The sale of PAPR and of phosphate rocks different from Huila will require modifications to present phosphate rock regulations Present regulations keep out of market phosphate rock which have a P_2O_5 content of less than 20% This regulation should be modified according to the reactiveness of the phosphate rock It has been shown that a Pesca rock with 18%, will give better agronomic results than a Sardinata rock with 32%, due to its differences in reactivity

Presently, there are not regulations related to PAPR This will have to be developed by ICONTEC jointly with ICA on the basis of agronomic results obtained so far by the IFDC/CIAT Phosphorus Project After regulations for sale of phosphate rock and of PAPR have been established, ICA should issue product licenses to those companies and individuals which meet requirements

<u>Production Policy</u>

The participation and inference of the government in the production of fertilizers in limited to the partial ownership of one of its NPK plants and to the administration of domestic resources Also, ECOMINAS is a shareholder of ABONOS DE BOYACA With respect to government policies recommendations related to production of phosphate fertilizers using domestic reserves, it is recommended that ECOMINAS continue serving as a catalistic and form joint or mixed companies with private investors Royalties presently charged by ECOMINAS to mine operators are nominal, and they should be kept, if only to have some degree of control and information about current operations

ECOMINAS should take the initiative for preparation of feasibility studies needed before plants are established For preparation of feasibility studies, technical assistance should be sought from IFDC s Fertilizer Technology

Division , which possesses a unique advantage in this field in general, and in the processing of colombian rocks in particular

As far as ownership of companies, it is desirable that ECOMINAS joins private investors, at least during the initial stages of plant operations Capital investments funds may be available through IFI

Should mines be allocated to private investors for development long term contracts would be needed for investors security

Research and Extension Policy

The bulk of agricultural research and extension in Colombia is carried out by ICA Regional and commodity oriented institutions conduct agricultural and extension on a crop or region specific basis With respect to phosphate fertilizer research, ICA is the leading research institution in the country It has been conducting phosphate rock research since 1968

Research on use of phosphate rock and of PAPR has been conducted during the past 10 years by the IFDC/CIAT Phosphorus Project , with the close collaboration of ICA It is recommended that ICA with the continued close collaboration and assistance from the IFDC CIAT Phosphorus Project incorporates into its present work plans the following specific activities

1 Development of specific recommendations for the use of phosphate rock and of PAPR by farmers in different agroecological zones of the country

2 Incorporate phosphate rock and PAFR recommendations into ICA fertilizer publications on this subject

3 Detailed identification of areas and crops where phosphate rock and FAFR can be used effectively by farmers

4 Determine and measure effect of calcium (or liming effect) from phosphate rock and of calcium and sulfur from PAFR on crop production

5 Conduct long term studies to measure and monitor the effect of phosphate rock and PAFR on Colombian soils

6 Conduction of verification and demonstration trials on different crops and agroecological regions of the country

7 Train technical assistance personnel so that they can assist farmers on the use of these two products adequately

8 Incorporate into existing ICA extension service activities phosphate rock and FAFR recommendations to farmers

The conduction and implementation of these activities will help fertilizer farmers to understand the benefits of these two, relatively new to them, fertilizer products in the market, therefore promoting their use Since ICA operates with an already tight budget, funding will be needed to carry out these additional activities

XIV CONCLUSIONS AND RECOMMENDATIONS

As this report has shown, Colombia now depends on imports of phosphates to satisfy 85% of its demand The planned development for the phosphate industry will have little impact on this situation As a fact, imports of P_2O_5 are projected to continue indefinitely

Agronomic studies conducted by the IFDC/CIAT Phosphorus Project have indicated that phosphate rock for direct application and PAPR manufactured from domestic reserves can play an important role in supplying the country needs Even more, vast general areas and crops had been identified where these two sources can be effectively used by farmers in crop production

A preliminary estimation of production costs for PAPR indicate that it can be a cheaper source of phosphates than NPK s, but more expensive than imported DAP and TSP However, it is expected that in the medium- to long-term, as international phosphate prices recover from their present slump, PAPR will become a more attractive alternative

Throughout the past few years and in light of the ever increasing phosphate imports, the colombian government has shown and increasing interest in the development of domestic resources An effort has been made here to analyze domestic deposits in view of their possible alternative uses as fertilizers In doing this, four factors were taken into account (1) phosphate market size, (2) quantity, quality and location of deposits, (3) input availability, and (4) agronomic response After due consideration was given to these factors, it was concluded that production of phosphate rock for direct application and production of PAPR offer the best potential to the country The country does not have large enough phosphate reservess to sustain the development of a large phosphate fertilizer complex Moreover, considering the present fertilizer supply and demand structure, a large phosphate fertilizer comple is not warranted

Considering the present supply and demand structure of the country, it is recommended that a detailed fesibility study for a PAFR plant with a capacity of 20,000 tons of P_2O_5/year be conducted This study should evaluate the utilization of phosphate rock from several deposits, at plants located at differant mine sites or close to sulfuric acid manufacturing facilities

The use of phosphate rock for direct application is reaching a market saturation point In the near future, increases in use of phosphate rock will be mostly dependant in increases in crop areas, and into low fertility lands Therefore, to use the presently installed rock grinding facilities, some of this rock has to be acidulated (and granulated) to enjoy market acceptance

It was found that the country now has enough sulfuric acid capacity to meet the needs of an eventual development of a PAPR plant of the above mentioned capacity However, should the sulfur production capacity remain at its present level, an increase in imports of sulfur will be necessary

It was estimated that the country could save up to US $ 27 3 million during the year 2000 in foreign exchange, due to the use of its domestic phosphate reserves Also, it was estimated that at present phosphate fertilizer prices and PAPR estimates, farmers can increase their net returns by shifting from their current practice of using NPK products, to a bulk blended mixture of urea, FAFR and KCl

The development of the domestic phosphate fertilizer industry will generate employment at plant sites and mines, increase fertilizer self sufficiency, increase fertilizer availability at the farm level, and increase the competence to imported phosphate fertilizers

The general objective of this report is the identification of government policies which would promote the development of domestic reserves Presently, the colombian government has fertilizer policies related to prices, finished products and raw materials imports, marketing and research/extension These policies were described and analyzed, and the following specific policy actions were identified as those which, if implemented, will promote the use of domestic phosphate reserves

1 Fertilizer Pricing It is recommended that the government do not intervene in price setting for phosphate rock for direct application, phosphate rock to be used as raw material or for PAFR products, produced with domestic reserves

2 Fertilizer Taxes It is recommended that a tax on imports of phosphate fertilizer for direct application, i e DAP and TSP, be impossed This tax which should be equal to the tax now impossed on imports NPK s, should raise DAP and TSP prices by about 10% Also, it is recommended that taxes for imports of phosphate raw materials remain at the present low level

3 Fertilizer Subsidies It is recommended that phosphate fertilizers produced from domestic resources be marketed through Caja Agraria, so that they can enjoy the subsidies offered to other fertilizers Direct government fertilizer subsidies are not recommended It is believed that if the domestic phosphate fertilizer industry is going to develop, it should do so on solid grounds, and not become a burden to other sectors of

the economy
In view of the low demand elasticity for phosphate fertilizers in Colombia, should the government decide to grant subsidies, they should be a short-term measure and given directly to producers so as to lower their production costs, and hence make product available to farmers at a lower price

4 <u>Fertilizer Marketing</u> Phosphate rock for direct application and PAFR should be made available to farmers through Caja Agraria stores in those areas of the country where their effectiveness has been established
Present phosphate rock marketing regulations should be modified to allow more products in the market Regulation related to the marketing of PAFR should be developed
Licenses should be issued to phosphate rock and PAPR producing companies which meet government requirements

5 <u>Production Policy</u> ECOMINAS should continue playing the role of catalist between the government and private investors Royalties charge to producing companies should be kept at their present low level
Mines should be assigned to able investors on a long term basis, so as to guarantee returns on investment ECOMINAS, with IFDC assistance, should take the initiative in the development of engineering feasibility studies for PAFR products

6 <u>Research and Extension</u> Several recommendations are made to ICA in this respect The following activities should be incorporated into ICA s work plans and carried out with close collaboration from the 'IFDC/CIAT Phosphorus Project

a Development of specific recommendations for the use of phosphate rock and of PAFR by farmers in different agroecological zones of the country

b Incorporate phosphate rock and PAPR recommendations into ICA fertilizer publications on this subject

c Detailed identification of areas and crops where these two products can be used effectively by farmers

d Determine and measure effect of calcium (or liming effect) from phosphate rock and of calcium and sulfur from PAPR on crop production e Conduct long term studies to measure and monitor the effect of phosphate rock and PAFR on Colombian soils

g Conduction of verification and demostration trials on different crops and agroecological regions

f Train technical assistance personnel so that they can assist farmers on the use of these two products adequately

h Incorporate into existing ICA extension service activities phosphate rock and PAFR recommendations to farmers

It is believed that implementation of these policies will accelerate the development of domestic reserves Otherwise, the phosphate industry will continue developing at the slow pace it has in the past In the short term, policy actions here recommended will make products from domestic sources more competitive in the market place However, in the medium- to long-term, as international phosphate prices increase, the domestic industry will become more competitive and some of the policy actions recommended here will not be necessary

This study places into perspective the potential uses of the Colombian phosphate reserves The bulk of the agronomic research activities of the IFDC/CIAT Phosphorus Project" have been directed towards understanding the properties of different phosphate rocks in the Andean countries For this report, Colombia was selected as a case study due to the amount of data available and the desire of local authorities for this undertaken This report implicitly identifies the primary and secondary data, and methodological analysis needed for a study of this nature An evaluation of data available from other andean countries is needed before a study of this nature is carried out

Table No 1 Value of Total and of Agricultural Exports and Imports 1982-84

Items	1982	1983	1984
	---000 US $---		
Total Exports	3095 0	3080 9	3483 1
Total Imports	4905 8	4478 0	4492 4
Balance	(1810 8)	(1397 1)	(1009 3)
Agricultural Exports			
Coffee	1561 5	1506 2	1764 5
Bananas	151 1	147 1	197 9
Flowers	111 5	120 6	129 5
Raw Sugar	54 7	68 9	28 6
Cotton	26 5	23 1	48 1
Tobacco	21 6	22 9	21 4
Others	182 6	163 0	173 6
Total	2109 5	2051 8	2363 6
Agricultural Imports			
Wheat	92 7	113 4	119 2
Oils and Oil Seeds	113 6	73 4	87 3
Barley	22 4	17 1	19 3
Maize	14 9	9 5	1 4
Sorghum	7 3	23 3	6 6
Fresh Fruits	11 1	11 5	7 0
Others	229 4	230 5	181 4
Total	491 4	478 7	422 2

Source 1986 Anuario Estadistico del Sector Agropecuario OPSA Bogota

[1] All prices are FOB

Table No 2 Estimated Area, Production and Yield for Selected Crops 1985

Crop	Area	Production	Yield
	000 ha	000 tons	kg/ha
Coffee	1,100 0	677 9	616
Potatoes	139 1	1,900 4	13,662
Sugar Cane			
Hills	198 1	1,429 3	4,400*
Plantation	113 5	887 8	12,600*
Rice	386 4	1,798 2	4,654
Cotton	196 0	339 6	1,733
Maize	540 6	762 6	1,411
Vegetables	123 0	1,550 2	12,603
Sorghum	192 3	499 4	2,597
Cocoa	95 4	42 6	447
Fruit Trees	37 7	662 6	17,671
Barley	30 5	60 4	1,980
Wheat	44 5	76 1	1,710
Beans	131 8	99 5	755
Bananas/Plantain	383 8	3,214 1	8,374
Tobacco	18 3	17 5	956
Other Crops	337 1		
Total	4,068 1**		

* Kgs of sugar
** Does not include land in pastures and/or graze lands

Table No 3 Estimated Consumption of N, P205 and K20 in Colombia 1970-1985

Year	N	P205	K20	Total
	-------------	-----000	tons-----	--------
1970	82 0	48 4	30 6	161 0
1971	91 0	64 7	42 3	198 0
1972	131 7	59 0	40 5	231 2
1973	124 0	63 8	50 2	238 0
1974	118 2	60 6	46 9	225 7
1975	106 2	57 8	39 8	203 8
1976	129 6	64 7	50 5	244 8
1977	144 0	76 3	72 1	292 4
1978	130 3	80 0	78 0	288 3
1979	142 6	81 7	79 7	304 0
1980	151 2	81 0	80 3	312 5
1981	136 5	74 1	72 8	283 5
1982	153 0	85 4	75 0	313 4
1983	167 9	86 9	77 2	332 0
1984	185 9	89 6	91 0	366 6
1985	184 7	86 3	91 8	362 8

Source ICA Oficina de Insumos, MONOMEROS, ABOCOL

Table No 4 Fertilizer Products Used on Different Crops 1986

Crop	Fertilizer Products Used
<u>Small Farmers</u>	
Potato	13-26-6, 10-30-10, 10-20-10, 15-15-15, B Slag, Urea
Coffee	17-6-18/2, 15-15-15, 14-14-14/2, 14-14-14
Maize (Ladera)	10-30-10, 15-15-15, 14-14-14, 13-26-6
Sugar Cane (Ladera)	10-30-10, 15-15-15, 13-26-6,
<u>Medium to Large Farmers</u>	
Rice	Urea, DAP, KCl, AS, 15-15-15, 10-30-10, PR, B Slag
Sugar Cane (Commercial)	Urea, DAP, KCl, 15-15-15, TSP
Cotton	Urea, AS, KCl, 15-15-15
Tobacco	AN, 14-14-14/2
Banana	Urea, DAP, KCl
Maize (Commercial)	Urea, AN, 15-15-15, 14-14-14, 10-30-10, 13-26-6
Sorghum	Urea, 15-15-15, AS, DAP, KCl
Oil Palm	Urea, DAP, KCl, PR
Pastures	Urea, AN, B Slag, P Rock

Source ICA Oficina de Insumos, MONOMEROS and ABOCOL

Table No 5 Estimated Consumption of N, P205 and K20 by Crop 1985

Crops	Nitrogen		P205		K20	
	000 mt	%	000 mt	%	000 mt	%
Potato	15 5	8 4	34 6	40 1	13 2	14 4
Coffee	44 7	24 2	10 0	11 6	35 0	38 1
Sugar Cane	23 3	12 6	8 9	10 3	7 1	7 7
Rice	31 8	17 2	6 7	7 8	6 6	7 2
Cotton	10 4	5 6	5 3	6 1	3 5	3 8
Maize	4 9	2 7	3 1	3 6	2 6	2 8
Vegetables	3 7	2 0	3 2	3 7	2 9	3 2
Sorghum	5 2	2 8	1 4	1 6	1 2	1 3
Cocoa	3 8	2 1	1 4	1 6	1 6	1 7
Fruit Trees	2 0	1 1	1 2	1 4	1 4	1 5
Barley	1 8	1 0	1 5	1 7	0 9	1 0
Beans	0 5	0 3	1 0	1 2	0 7	0 8
Wheat	0 5	0 3	0 8	0 9	0 4	0 4
Banana	10 8	5 8	0 6	0 7	9 8	10 7
Tobacco	0 5	0 3	0 5	0 6	0 5	0 5
Others	25 3	13 7	6 1	7 1	4 4	4 8
Total	184 7	100 0	86 3	100 0	91 8	100 0

Source ABOCOL

Table No 6 Crop Areas, Estimated N, P2O5 and K2O Use Rates by Crop and Yields 1985

Crop	Area	N	P2O5	K2O	Yield
	000 ha	----------kg/ha----------			mt/ha
Potatoes	139 1	111 4	248 7	94 9	13 7
Coffee	1100 0	40 6	9 1	31 8	0 6
Sugar Cane		83 3	31 8	25 4	
Hills	186 2				4 4
Plantations	93 4				12 6
Rice	386 4	82 3	17 3	17 1	4 7
Cotton	196 0	53 1	27 0	17 9	1 7
Maize	540 6	9 1	5 7	4 8	1 4
Vegetables	123 0	30 1	26 0	23 6	12 6
Sorghum	192 3	27 0	7 3	6 2	2 6
Cocoa	95 4	39 8	14 7	16 8	0 4
Fruit Trees	37 7	53 1	31 8	37 1	17 7
Barley	30 5	59 0	49 2	29 5	2 0
Wheat	44 5	11 2	18 0	9 0	1 7
Beans	131 8	3 8	7 6	5 3	0 8
Banana (exports)	23 1	467 5	26 0	424 2	44 5
Tabacco	18 3	86 2	86 2	86 2	1 0

Source Ministerio de Agricultura Direccion de Agricultura

* Yield of panela and sugar, respectively

o

Table No 7 Fertilizer Use by Product 1981-1985

Products	1981	1982	1983	1984	1985
	-----	-----	000 mt	-----	-----
Straights					
Urea	142 0	161 4	185 3	226 0	223 9
Ammonium Sulfate	20 0	25 0	28 7	36 2	41 9
Ammonium Nitrate	22 5	25 0	26 0	18 8	21 7
Di-ammonium Phosphate	6 0	20 0	17 7	20 6	19 4
Triple Super Phosphate	3 1	1 0	2 3	3 0	4 4
Basic Slag	52 5	55 0	42 4	50 8	50 1
Potassium Chloride	39 2	40 0	43 1	58 3	54 6
Potassium Sulfate	0 0	1 0	1 7	3 6	3 1
Phosphate Rock	6 4	10 4	12 2	13 4	16 4
Total Straights	291 7	338 8	359 4	430 7	435 5
High P Products					
10-30-10	52 5	55 0	68 0	47 7	41 2
13-26-06	68 2	69 2	73 0	79 0	66 8
10-20-20	22 5	14 2	9 3	23 7	17 0
10-20-10	0 2	4 6	2 8	0 0	5 4
08-30-12	0 0	5 7	2 9	1 2	0 9
12-18-06	5 7	0 0	0 0	0 0	0 0
Coffee Products					
17-06-18/2	117 0	105 1	107 0	122 0	138 9
14-14-14/2	5 6	3 4	2 7	5 9	5 4
Other Products					
14-14-14	0 2	8 9	11 4	13 6	13 9
15-15-15	88 3	107 9	104 2	101 0	117 3
25-15-00	0 0	3 2	10 4	16 9	17 5
Total NPK s	360 2	377 2	391 7	411 0	424 3
Grand Total	651 9	716 0	751 1	841 7	859 8

Source ICA Oficina de Insumos, MONOMEROS, ABOCOL

Table No 8 Amount and Percentage of N, P205 and K20 Provided by Straight Products and NPK s 1981 1985

Nutrient Product		1981		1982		1983		1984		1985	
		000 mt	%	000 mt	%	000 mt	%	000 mt	%	000 mt	%
N	Straights	76 5	56 0	89 6	58 6	101 2	60 3	120 2	64 6	120 9	65 5
	NPK s	60 1	44 0	63 4	41 4	66 7	39 7	65 8	35 4	63 8	34 5
P205	Straights	14 0	18 9	20 7	24 3	18 7	21 5	21 9	24 5	20 6	23 8
	NPK s	60 1	81 1	64 7	75 7	68 3	78 5	67 7	75 5	65 7	76 2
K20	Straights	23 5	32 3	24 5	32 7	26 7	34 6	36 8	40 4	32 8	35 7
	NPK s	49 3	67 7	50 5	67 3	50 5	65 4	54 2	59 6	59 0	64 3

Table No 9 Total P2O5 Supplied by Different Products 1981-1985

Product	1981	1982	1983	1984	1985
	----------	----------	000 mt	----------	----------
Straights					
Di-ammonium Phosphate	2 8	9 2	8 1	9 5	8 9
Triple Super Phosphate	1 4	0 5	1 1	1 4	2 0
Basic Slag	8 4	8 8	6 8	8 1	6 0
Phosphate Rock	1 4	2 3	2 7	2 9	3 6
Total Straights	14 0	20 7	18 7	21 9	20 6
High P Products					
10-30-10	15 8	16 5	20 4	14 3	12 4
13-26-06	17 7	18 0	19 0	20 5	17 4
10-20-20	4 5	2 8	1 9	4 7	3 4
10-20-10	0	0 9	0 6	0 0	1 1
08-30-12	0 0	1 7	0 9	0 4	0 3
12-18-06	1 0	0 0	0 0	0 0	0 0
Coffee Products					
17-06-18/2	7 0	6 3	6 4	7 3	8 3
14-14-14/2	0 8	0 5	0 4	0 8	0 8
Other Products					
14-14-14	0	1 2	1 6	1 9	1 9
15-15-15	13 2	16 2	15 6	15 2	17 6
25-15-00	0 0	0 5	1 6	2 5	2 6
Total NPK s	60 1	64 7	68 3	67 7	65 7
Grand Total	74 1	85 4	86 9	89 6	86 3

Table No 10 Percentage P205 Supplied by Different Products 1981-1985

Product	1981	1982	1983	1984	1985
	---000 mt---				
<u>Straights</u>					
Di-ammonium Phosphate	3 7	10 8	9 4	10 6	10 3
Triple Super Phosphate	1 9	0 5	1 2	1 5	2 3
Basic Slag	11 3	10 3	7 8	9 1	7 0
Phosphate Rock	1 9	2 7	3 1	3 3	4 2
Total Straights	18 9	24 3	21 5	24 5	23 8
<u>High P Products</u>					
10-30-10	21 2	19 3	23 5	16 0	14 3
13-26-06	23 9	21 1	21 8	22 9	20 1
10-20-20	6 1	3 3	2 1	5 3	3 9
10-20-10	0 1	1 1	0 6	0 0	1 3
08-30-12	0 0	2 0	1 0	0 4	0 3
12-18-06	1 4	0 0	0 0	0 0	0 0
<u>Coffee Products</u>					
17-06-18/2	9 5	7 4	7 4	8 2	9 7
14-14-14/2	1 1	0 6	0 4	0 9	0 9
<u>Other Products</u>					
14-14-14	0	1 5	1 8	2 1	2 3
15-15-15	17 9	19 0	18 0	16 9	20 4
25-15-00	0 0	0 6	1 8	2 8	3 0
Total NPK s	81 1	75 7	78 5	75 5	76 2
<u>Grand Total</u>	100 0	100 0	100 0	100 0	100 0

Table No 11 Use of Huila Phosphate Rock by Region 1981-1986

Region	1981	1982	1983	1984	1985	1986*
	mt					
Valle/Risaralda/ Quindio	2576	2545	2781	1620	2492	2922
Cauca/Narino	1542	2606	2298	2562	2151	2278
Huila/Tolima	1697	1053	1342	1204	625	704
Meta/Cundinamarca	563	3103	4109	5246	7627	7610
Antioquia	0	1088	871	959	585	1193
Others	28	40	80	80	74	115
Total	6406	10435	11481	11671	13554	14822
Total P_2O_5	1409	2296	2526	2568	2982	3261

Source FOSFACOL

* Preliminary

Table No 12 Phosphate Demand Projections 1986-2000

Year	IFDC(80)[1]	H L[2]	Z W[3]	M M P[4]	W B[5]	IFDC(87)
	Growth rates (/)					
1986-1990	7 6	6 3	8 8	5 0	5 5	5 5
1991-1995	2 9	5 4	3 3	4 7	3 5	4 0
1996-2000	1 9	4 2	2 2	3 9	2 0	3 0
	000 mt of P_2O_5					
1985	149 5	125 0	92 0	114 7	85 0	86 3
1990	206 7	170 5	133 0	143 3	111 1	112 8
1995	236 6	225 0	155 0	177 3	131 9	137 2
2000	258 7	272 7	170 0	212 1	145 7	159 1

Sources [1] IFDC 1980 Market Survey of Phosphate Fertilizers

[2] Hansa-Luftbild 1980 Phosphate Market Survey

[3] Zellars-Williams 1984 Estudio de Factibilidad Complementario para un projecto de Fertilizantes Fosfatados en Boyaca, Colombia

[4] Mejia, Millan and Perry 1984 Estudio sobre Transporte y Distribucion de Fertilizantes en Colombia

[5] World Bank Communication to Ecominas April 11/1985

Table No 13 Phosphate Fertilizer Product Demand Projections 1986-87

Products	tons of P_2O_5			tons of Product		
	1985*	1986	1987	1985	1986	1987
	---000 tons---					
Straight Products						
DAP	8 9	9 7	11 4	19 4	21 1	24 8
TSP	2 0	2 1	2 3	4 4	4 6	5 0
Basic Slag	6 0	4 4	4 4	50 1	50 1	50 1
P Rock	3 6	3 8	4 0	16 4	17 3	18 2
Total Straights	20 6	20 0	22 1			
High P Products						
10-30-10	12 4	14 0	14 2	41 2	46 7	47 3
13-26-6	17 4	14 7	17 8	66 8	68 1	68 5
10-20-20	3 4	3 6	3 7	17 0	18 0	18 5
10-20-10	1 1	1 3	1 4	5 4	6 5	7 0
Coffee Products						
17-6-18/2	8 3	10 2	11 4	138 9	170 0	190 0
14-14-14/2	8	1 0	1 0	5 4	7 1	7 1
Other Products						
14-14-14	1 9	2 0	2 1	13 9	14 3	15 0
15-15-15	17 6	18 3	18 8	117 3	122 0	125 3
25-15-0	2 6	2 9	3 2	17 5	19 3	21 3
Total NPK s	65 7	71 0	74 0	424 3	472 0	500 0
Grand Total	86 3	91 0	96 1			

* Actual

Table No 14 Estimated Demand Projections for Phosphate Rock for Direct Application (1986-2000)

Year	Product	P_2O_5
	--------000 tons	-------
1985	16 4	3 6
1986	17 3	3 8
1987	18 2	4 0
1988	19 7	4 3
1989	20 9	4 6
1990	22 1	4 9
1995	28 2	6 2
2000	35 1	7 7

Table No 15 Major Fertilizer Manufacturing Facilities 1986

Company	Plant Location	Product	Rated Capacity[1]
ABOCOL	Mamonal, Bolivar	Granular NPK s	150,000[2]
MONOMEROS	B/quilla, Atlantico	Granular NPK s	350,000[3]
		AS	50,000 (84%)
FERTICOL	B/bermeja, Santander	Urea	15,000 (100%)
		AN	29,000 (90%)
Paz del Rio	Belencito, Boyaca	Basic Slag	50,000 (44%)
		AS	3,000 (100%)
FOSFOBOYACA	Pesca, Boyaca	Phosphate Rock	50,000 (0%)
FOSFACOL	Tesalia, Huila	Phosphate Rock	18,000 (90%)
FOSFONORTE	Sardinata, N Santander	Phosphate Rock	10,000 (100%)

[1] 300 days at 100%

[2] Production capacity for ABOCOL can also be expressed as

10-30-10	600 mt/day
17-06-18/2	400 mt/day
14-14-14	450 mt/day
10-20-20	500 mt/day

[3] Production capacity for MONOMEROS can also be expressed as

13-26-06	1,200 mt/day
17-06-18/2	900 mt/day
15-15-15	1,100 mt/day
14-14-14/2	1,000 mt/day

[4] Numbers in parenthesis represent the estimated percentage of plant utilization during 1985

Sources Fertilizer Producer companies

Table No 16 Estimated Quantities of N, P_2O_5 and K_2O Supplied from Different Sources 1983 1985

Source	1983			1984			1985*		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	----000 tons----								
Domestic									
ABOCOL and MONOMEROS	37 3	0	0	35 2	0	0	36 5	0	0
FERTICOL	9 1	0	0	10 6	0	0	10 2	0	0
Paz del Rio	0	6 8	0	0	8 1	0	0	6 0	0
FOSFACOL	0	2 7	0	0	2 9	0	0	3 6	0
FOSFONORTE	0	1 3	0	0	1 6	0	0	2 6	0
Total	46 4	10 8	0	45 8	12 6	0	46 7	12 2	0
Imports									
Raw Materials	26 2	64 8	53 4	21 6	66 1	54 1	36 1	63 2	57 5
Finished Products	97 2	11 3	27 5	102 9	10 9	37 3	101 9	10 9	34 3
Total	123 4	76 1	80 9	134 5	77 0	91 4	138 0	74 1	91 8
Estimated Consumption	169 8	86 9	80 9	180 3	89 6	91 4	184 7	86 3	91 8

* Preliminary

Table No 17 Estimated Imported Quantities of N Raw Materials and Finished Products 1970-85*

Year	AA[b]	Urea	AS	AN	MAP	DAP	NPK	Total Product	Total N
	---000 tons---								
1970	0	25 0	26 3	0	28 8	0	0	79 3	19 8
1971	0	18 9	28 5	0	15 8	0	15 0	78 2	18 1
1972	50 0	71 0	18 2	0	33 2	0	27 2	199 6	53 1
1973	60 3	144 2	31 2	2	38 8	24 3	148 8	447 8	110 4
1974	36 5	123 6	14 6	1 4	0	1 3	191 7	369 1	90 8
1975	29 8	0	3 7	0	0	0	43 3	76 8	12 0
1976	17 9	23 3	25 0	0	22 6	0	0	88 8	21 8
1977	22 8	83 2	8 7	0	18 8	2 8	0	136 3	58 0
1978	33 7	185 0	8 0	0	20 6	40 4	0	287 7	123 7
1979	27 6	175 0	0	0	26 0	30 7	0	259 3	111 3
1980	6 0	174 0	6 9	0	30 4	30 1	0	247 4	94 9
1981	24 1	141 1	16 8	0	30 6	34 3	0	246 9	97 4
1982	5 5	167 0	6 0	0	27 8	44 0	0	250 3	93 3
1983	6 9	190 0	0	24 7	80 6	46 4	0	348 6	114 4
1984	14 0	225 0	0	0	63 7	51 2	0	353 9	130 6
1985*		230 0	0	0			0		138 0

[a] The N content for each imported product was as follows 82% for AA, 46% for Urea, 21% for AS, 20% for AN, 10% for MAP, 18% for DAP and 12% for NPK

[b] From 1972 to 1976 imports were in the form of Aqua Ammonia (20% N) In 1977 1 031 tons of N as Aqua Ammonia and 14,477 tons of N as Anhydrous Ammonia were imported For the remainder years only Anhydrous Ammonia was imported

* Preliminary

Source ICA Oficina de Insumos

Table No 18 Imports of Phosphate Raw Materials and Finished Products[1] 1970-85

Year	PR	PA	TSP	MAP	DAP	NPKs	Total Product	Total P_2O_5	CIF Value
	000 tons								10^6 US $
1970	12 2	0	36 5	28 0	0	0	76 7	34 7	
1971	16 3	41 1	28 7	15 8	0	15 0	116 9	51 2	
1972	35 9	20 0	20 0	33 2	0	27 2	136 3	53 0	
1973	37 5	41 5	54 3	38 8	24 3	148 8	345 2	115 9	
1974	156 9	53 3	23 3	0	1 3	191 7	426 5	124 9	
1975	28 8	24 6	0	0	0	43 3	96 3	30 4	
1976	10 9	14 8	5 9	22 6	0	0	54 2	25 4	
1977	54 4	17 8	15 0	18 8	2 8	0	108 8	44 6	
1978	64 7	23 0	21 1	20 6	40 4	0	169 8	71 7	
1979	42 8	19 7	16 4	26 0	30 7	0	135 6	58 0	
1980	53 1	22 9	16 5	30 4	30 1	0	153 0	64 8	23 4
1981	35 7	19 1	11 6	30 6	34 3	0	131 3	56 9	21 6
1982	47 4	7 3	11 8	27 8	44 0	0	138 3	57 6	20 4
1983	52 6	5 6	7 5	80 6	46 4	0	192 7	81 7	30 5
1984	41 9	3 3	8 8	63 7	51 2	0	168 3	72 1	27 4
1985*						0		77 4	29 4

[1] The following P_2O_5 contents and prices were used in estimations PR 32/ and US $53/ton, PA 54/ and US $268/ton, TSF 467 and US $155/ton, DAP 46/ and US $197/ton, MAP 46% and US $197/mt and NPI s 18/

* Preliminary

Source ICA Oficina de Insumos

Table No 19 Estimated Imported Quantities of K_2O Raw Materials and Finished Products 1970-84*

Year	MOP	SOP	PSM	NPK	Total Product	Total K_2O
	-----------------000 tons					
1970	74 8	15 8	5	0	91 1	52 9
1971	72 7	20 5	2 5	15 0	110 7	56 2
1972	26 5	29 5	16 5	27 2	99 7	37 5
1973	83 1	40 2	14 7	148 8	286 8	90 3
1974	6 2	37 3	13 8	191 7	249 0	48 4
1975	0	17 6	18 8	43 3	79 7	18 1
1976	21 0	0	0	0	21 0	12 6
1977	97 3	30 4	0	0	127 7	73 6
1978	106 3	21 5	12 5	0	140 3	77 3
1979	94 1	7 2	3 0	0	104 3	60 7
1980	141 4	5 5	10 5	0	157 4	89 9
1981	99 8	5 0	0	0	104 8	62 4
1982	96 8	2 2	2 8	0	101 8	59 8
1983	123 7	2 0	3 9	0	129 6	76 1
1984	135 6	6 6	8 6	0	150 8	86 7
1985*	144 6	6 1	9 0	0	159 7	91 8

* The K_2O content for each imported product was as follows 60% for MOP, 50% for SOP, 22% for PSM and 12% for NPKs

* Preliminary

Source ICA Oficina de Insumos

Table No 20 Estimated Total Use, Domestic Production, Balance, and Total Imports of P_2O_5 in Colombia 1970-1985

Year	Domestic Use	Domestic Production					Balance	Imports	
		BS	SSP	PR	TOTAL	%		NPK[1]	Straight
	-------	---- 000 tons----			------- ---	%	---- -000 tons		--- - -
1970	48 4	7 7	0 4	0 8	8 9	18 4	-39 5	39 5	0 0
1971	64 7	8 5	0 2	1 0	9 7	15 0	55 0	55 0	0 0
1972	59 0	6 1	0 1	1 4	7 6	12 9	-51 4	51 4	0 0
1973	63 0	9 3	0 1	4 3	13 7	21 7	49 3	49 3	0 0
1974	60 6	9 3	0 0	1 6	10 9	18 0	-49 7	49 7	0 0
1975	57 8	8 8	0 0	0 9	9 7	16 8	-48 1	48 1	0 0
1976	64 7	11 3	0 1	0 5	11 9	18 4	-52 8	52 8	0 0
1977	76 3	9 2	0 0	0 4	9 6	12 6	66 7	65 4	1 3
1978	80 0	8 8	0 0	0 0	8 8	11 0	-71 2	67 0	4 2
1979	81 7	9 0	0 0	0 0	9 0	11 0	72 7	69 1	3 6
1980	81 0	9 0	0 0	0 9	9 9	12 2	-71 1	68 5	2 6
1981	74 1	8 4	0 0	1 4	9 8	13 2	-64 3	60 1	4 2
1982	85 4	8 8	0 0	2 3	11 1	13 0	-74 3	64 7	9 7
1983	86 9	6 8	0 0	2 7	9 5	10 9	77 5	68 3	9 2
1984	_89 6	8 1	0 0	4 5	12 6	14 7	-77 0	66 1	10 9
1985	86 3	6 0	0 0	6 2	12 2	14 1	74 1	63 2	10 9

[1] Imports of raw materials to manufacture the granular NPK products

Table No 21 Projected Supply of F_2O_5 1986-2000

Year	Domestic				Imports	Total
	BS	PR[1]	PR[2]	Total	NPK[3]	
	---000 tons---					
1986	4 4	3 8	2 6	10 2	68 4	78 6
1990	4 4	14 6	2 6	21 6	72 4	94 0
1995	4 4	14 6	2 6	21 6	72 4	94 0
2000	4 4	14 6	2 6	21 6	72 4	94 0

[1] Phosphate rock for direct application, produced from the Huila, Iza and Sardinata mines

[2] Phosphate rock for the manufacture of granular NPks, produced from the Sardinata mine

[3] Imports of raw materials for manufacture of granular NPKs

Table No 22 Projected Supply/Demand Balance of Phosphate Fertilizers (P_2O_5) 1986-2000

Year	Projected Demand	Projected Supply NPKs	B S	P R	Total	Balance	Domestic Supply	Imports
	000 tons							
1986	91 0	70 0	4 4	3 8	78 6	-12 4	10 8	80 2
1990	112 8	75 0	4 4	14 6	94 0	-18 8	21 6	91 2
1995	137 2	75 0	4 4	14 6	94 0	-43 2	21 6	115 6
2000	159 1	75 0	4 4	14 6	94 0	-65 1	21 6	137 5

Table No 23 Summary of P Reserves in Colombia 1986

Location: Departament	Location: Municipio	Mine Name	Thickness	P_2O_5	Total Reserves[1]
			m	%	10^6 ton
Huila	Palermo	Llano Verde	6-2 0	15-25	35 0
	Palermo	La Guagua	5-1 6	19-28	12 0
	Aipe	Media Luna	6-1 2	18-31	25 0
	Teruel	La Juanita	9-2 2	15-24	15 0 (2 5)[2]
	Tesalia	Tesalia	8-1 2	20-31	6 0
	Yaguara	Monserrate	7-2 4	13-31	15 0
	Baraya	Pinos/Andes	6-2 0	11-26	30 0
N Santander	Sardinata	Sardinata	5-3 5	15-37	14 4 (9 0)[3]
	Sardinata	Lourdes	5-1 5	10-30	10 0
	Mercedes	Tibu-Oru	1 0-5 4	8-19	13 0
	Gramalote		5-3 8	10-27	7 7
Santander	Azufrada	Azufrada	7-2 0	10-29	32 7
Boyaca	Sogamoso	P Negra	5-1 6	11-27	39 0
	Sogamoso	Siscuenci	7-1 0	15-20	20 0
	Sogamoso	El Pilar	8-1 6	17-26	15 0
	Iza	Iza	6-2 4	10-23	36 0 (13 0)
	Cuitiva	Cuitiva		8-23	
	Pesca	Conejera	1 0-4 2	17-25	30 6 (6 5)
Tolima	Pandi	Tolima	1 6-2 7	16-23	10 0

Source Communication from INGEOMINAS and ECOMINAS

[1] Total Reserves are the sum of proven, probable, possible and inferred reserves They are expressed in mt of Phosphate Rock

[2] Number in parenthesis refer to recuperable reserves under present economic conditions

[3] It is estimated that only about 1 5 to 2 0 million tons of ore material have a P_2O_5 content >28%

Table No 24 Relative Effectiveness of Huila (HPR) and Pesca (PPR) Phosphate Rocks on Different Crops and Soil Types

P Source	Location	Soil Type	Crop/Rate[1]	Yield	RAE
				kg/ha	%
TSP	Tausa, Cund	Andept	Potatoes	24033	100
HPR			150 kg/ha	2700	7
Control				1066	
TSP	Ipiales, Narino	Andept	Potatoes[2]	24628	100
HPR			180 kg/ha	22321	76
Control				15003	
TSP	Ipiales Narino	Andept	Maiz/Beans[3]	7315	100
HPR			60 kg/ha	7135	92
Control				4863	
TSP	C/magua, Meta	Oxisol	R F Rice	4819	100
HPR			40 kg/ha	4795	99
Control				1172	
TSP	V/cencio, Meta	Oxisol	Irr Rice	5510	100
HPR			25 kg/ha	4929	51
PPR				4996	57
Control				4314	
TSP	C/magua, Meta	Oxisol	B Decumbens	32400	100
HPR			44 kg/ha	31750	96
PPR				35950	120
Control				14400	
TSP	Q/chao, Cauca	Ultisol	Maize	4491	100
HPR			87 kg/ha	3370	40
Control				2617	
TSP	Pescador, Cauca	Inceptisol	Maize	872	100
HPR			50 kg/ha	111	13
Control				0	
TSP	Pescador, Cauca	Inceptisol	Beans	1089	100
HPR			140 kg/ha	308	27
Control				45	
TSP	Caldono, Cauca	Inceptisol	Cassava[3]	23232	100
HPR			82 kg/ha	12631	18
Control				10300	

[1] Application rates are in kgs of P/ha

[2] Average of 5 Experiments

[3] Average of 9 Experiments Yield expressed in maize equivalents

[4] Average of 3 Experiments

Table No 25 Effect of Method and Timing of Application of Huila Phosphate Rock (HPR) and TSP

P Source	Location	Application Method	Crop/ Rate	Yield	RAE
				kg/ha	%
TSP	Tausa, Cund	Placed	Potatoes	24033	100
HPR		Broadcasted	150 kg/ha	2700	7
HPR		Placed		2600	7
Control				1066	
TSP	Pescador, Cauca	Placed	Beans	1203	100
TSP		Broadcasted	100 kg/ha	1141	95
HPR		Placed		384	28
HPR		Broadcasted		508	39
Control				68	
TSP	Pescador, Cauca	Placed	Maize	872	100
TSP		Broadcasted	50 kg/ha	710	81
HPR		Placed		87	10
HPR		Broadcasted		111	13
Control				0	
TSP	Pescador, Cauca	At Planting	Beans	1101	100
TSP		30 days BP	100 kg/ha	856	78
HPR		At Planting		487	44
HPR		30 days BP		502	46
Control				0	
TSP	T/rres, Narino	Placed	Potatoes	46013	100
HPR		Broadcasted	150 kg/ha	41951	56
HPR		Placed		41193	47
Control				36837	

Table No 26 Agronomic Effectiveness of Huila Phosphate Rock Used as Soil Amendment on Beans, Pescador, Cauca

Amendment	First Crop		Second Crop	
	Yield	RAE	Yield	RAE
	kg/ha	%	kg/ha	%
HPR	344	100	230	100
Lime	101	27	157	68
Lime+HPR	314	91	184	80
Control	10		0	
HPR	311	100	341	100
Lime	85	3	99	
Lime+HPR	205	55	300	78
Control	78		151	
HPR	585	100	808	100
Lime	561	94	774	95
Lime+HPR	707	129	915	115
Control	159		109	

Table No 27 Relative Agronomic Effectiveness of PAHPR and PAPPR as Compared to TSP Soils and Crop Types

P Source	Location	Soil Type	Crop/Rate[1]	Yield	RAE
				kg/ha	%
TSP	M/vita, Boyaca	Andept	Potatoes	24300	100
PAHPR			150 kg/ha	20640	80
Control				5610	
TSP	Ipiales, Narino	Andept	Potatoes[1]	24628	100
PAHPR			150 kg/ha	23914	113
Control				15003	
TSP	Ipiales, Narino	Andept	Maize/Beans[2]	7315	100
PAHPR			60 kg/ha	7435	105
Control				4863	
TSP	Pescador, Cauca	Inceptisol	Beans	1248	100
PAHPR			100 kg/ha	1151	88
Control				454	
TSP	Pescador, Cauca	Inceptisol	Maize	1580	100
PAHPR			150 kg/ha	1448	92
Control				0	
TSP	V/cencio, Meta	Oxisol	Irr Rice	4793	100
PAHPR			25 kg/ha	4743	92
Control				4178	
TSP	El Caibe, Meta	Oxisol	Sorghum	2331	100
PAHPR			100 kg/ha	2336	105
PAPPR				2340	109
Control				2228	
TSP	Caldono, Cauca	Inceptisol	Cassava[3]	23232	100
PAHPR			82 kg/ha	20876	82
Control				10300	

1 Average of 5 Experiments

2 Average of 9 Experiments Yield expressed in maize equivalent

3 Average of 3 Experiments

Table No 28 Economic Evaluation of Different P Sources

P Source	Location	Soil Type	Crop	Application Rate	Yield	VCR	REE
				-----kg/ha-----			
TSP	Tausa, C/marca	Andept	Potato	150	24033	15 3	100
HPR				0			0
Control					1066		
TSP	Ipiales, Narino	Andept	Potato[1]	180	24628	5 3	100
PAHPR				180	25914	6 1	116
HPR				180	22321	6 5	79
Control					15003		
TSP	Motavita, Boyaca	Andept	Potato	150	24300	12 5	100
PAHPR				150	20640	10 0	79
Control					5610		
TSP	Pescador, Cauca	Inceptisol	Beans[1]	104	841	4 4	100
PAHPR				92	738	4 4	86
HPR				39	142	2 3	5
Control					71		
TSP	Pescador, Cauca	Inceptisol	Maize	150	1965	2 1	100
PAPR				100	1428	2 3	78
HPR				0			0
Control					0		
TSP	Caldono, Cauca	Inceptisol	Cassava	82	23232	27 6	100
PAHPR				82	20876	22 6	81
HPR				82	12631	8 0	16
Control					10300		
TSP	V/cencio, Meta	Oxisol	Irr Rice[2]	29	4819	4 6	100
PAHPR				39	4819	3 5	91
HPR				32	4658	5 0	77
PPR				24	4650	6 6	80
Control					4178		
TSP	C/magua, Meta	Oxisol	R F Rice	40	4436	16 1	100
HPR				40	4458	26 6	101
Control					1172		

[1] Average of 5 Experiments
[2] Average of 4 Experiments

Table No 29 Economic Analysis of Phosphate Rock Used as Soil Amendment Beans, Pescador, Cauca

Amendment	Yield		VCR[1]	REE
	1st Crop	2nd Crop		
	kg/ha			%
Phosphate Rock	344	230	4 1	100
Lime	101	157	2 1	41
Mixture	314	184	5 3	91
Control	10	0		
Phosphate Rock	311	341	2 8	100
Lime	85	99	-	-
Mixture	205	300	2 4	61
Control	78	151		
Phosphate Rock	585	808	8 6	100
Lime	561	774	20 9	101
Mixture	707	915	15 5	127
Control	159	109		

[1] Prices used were phosphate rock $12,000/ton, lime $5,000/ton, and beans $120/kg Second crop discounted at i=30/

Table No 30 Land Classification in Colombia

Type of Land	Area	
	10^3 has	%
<u>Agricultural Lands</u>		
Irrigated Agriculture	3,499	3 1
Dry Land Agriculture		
Flat Lands-Annual Crops	2,693	2 4
Hills-Annual Crops	190	2
Permanent Crops	7,981	7 0
Sub-Total	14,363	12 7
<u>Livestock Lands</u>		
Extensive and Semi-Intensive Livestock Production Annual and Permanent Crops	8,343	7 3
Extensive Use Livestock Production	4,942	4 3
Very Extensive Livestock Production	5,966	5 2
Sub-Total	19,251	16 8
<u>Forestry Lands</u>		
With Agricultural Possibilities	11,208	9 8
Without Agricultural Possibilities	67,093	58 7
Sub-Total	78,301	68 5
<u>Other Lands</u>		
Urban Areas, Marshes, Rivers, etc	2,259	2 0
Total	114,175	100 0

Source Cortez L A et al 1985 <u>Zonificacion Agroecologica de Colombia</u> Ministerio de Hacienda y Credito Publico Instituto Geografico Agustin Codazzi Sub-direccion Agricola Bogota Colombia

Table No 31 Distribution of Major Colombian Soils

Soil Order	Area	
	10^6 has	7
Entisols	23 5	21 0
Inceptisols	15 9	14 2
Entisols/Inceptisols	18 6	16 6
Oxisols	12 8	10 7
Oxisols/Inceptisols	18 6	16 6
Oxisols/Ultisols	6 2	5 5
Oxisols/Entisols	5 5	4 9
Ultisols/Inceptisols	3 5	3 1
Total	104 6	91 6
Total Country Area	114 2	100 0

Source Estimated from Mapa de Suelos de Colombia 1982 Instituto Geografico Agustin Codazzi

Table No 32 Percentage Distribution of Soil Samples by Natural Regions and Levels of P Availability

Natural Region	P Availability		
	Low	Medium	High
	------------/------------		
Andean Region	68	14	18
Bogota Savanna	45	25	30
Upper Magdalena Valley	46	17	37
Lower Magdalena Valley	59	16	25
Cauca Valley	52	21	27
Pacific Coast	80	11	9
Atlantic Coast	27	13	60
Guajira	25	15	60
Orinoquia	69	15	16
Amazonia	77	11	12

Source Marin, G , J Navas and J Henao 1982 "La fertilidad de los Suelos Colombianos y las Necesidades de Fertilizantes Instituto Colombiano Agropecuario Tibaitata, Colombia

Table No 33 Percentage Distribution of Soil Samples by Crop, Department and Level of P Availability

Crop	Department	Area[1]	P Availability		
			Low	Medium	High
		10^3 has	------------/----------		
Rice	Meta	67 5	65	22	13
	Tolima	75 3	38	26	36
	Huila	31 8	36	15	49
Maize	Antioquia	105 2	70	16	44
	Cundinamarca	70 8	59	14	27
	Boyaca	42 0	44	18	38
	Narino	39 9	66	17	17
Beans	Antioquia	31 1	83	13	4
	Boyaca	42 0	47	16	37
	Cauca	2 2	81	9	10
	Valle del Cauca	5 2	55	23	22
	Huila	30 0	56	29	15
Potatoes	Boyaca	39 0	74	7	19
	Cundinamarca	53 0	66	10	24
	Narino	18 0	59	19	22
	Antioquia	15 8	84	11	5
Cassava	Cauca	2 8	96	3	1
	Meta	4 5	83	7	10
	N de Santander	7 6	55	18	27
	Valle del Cauca	3 0	70	14	16
Sugar Cane (Panela)	Boyaca	18 1	74	15	11
	Cundinamarca	40 5	43	26	31
	Antioquia	37 7	84	9	7
	Narino	20 0	70	12	18
	Santander	25 4	56	24	20
Pastures	Antioquia		77	14	9
	Boyaca		61	15	24
	Cundinamarca		49	25	26
	Meta		75	8	17
	Valle del Cauca		69	16	15

Source Ibid Marin, G , J Navas and J Henao 1982

[1] Estimated 1986 cropped area Preliminary

Table No 34 Estimated RAE of Phosphate Rock and of Partially Acidulated Phosphate Rock in Different Crops and Homogeneous Agroecological Regions of Colombia

Region Id	Area	Crop	RAE	
			P Rock	PAPR
	has		------%------	
0-1000 masl, Temperature>24°C, Rainfall 500 to 2000 mm/yr				
Cg	114,500	Pastures	95	100
Cj	3,171,925	Rice	55	85
		Maize/Sorghum	25	85
Co	3,139,350	Pastures	95	100
		Cassava	85	95
		Peanuts	85	95
		Sorghum	55	90
Cq	453,875	Rice	85	95
Cr	681,600	Pastures	95	100
Cs	5,038,400	Pastures	85	95
0-1000 masl, Temperature>24°C, Rainfall 2000 to 8000 mm/yr				
Kd	1,433,750	Rice	65	90
		Cassava	65	85
		Maize/Sorghum	45	85
Ke	238,500	Pasture	85	100
		Cassava	85	95
		Maize	45	85
Kf	1,089,500	Pastures	85	95
		Rice	85	95
		Maize	55	85
Kk	915,175	Pastures	85	100
Kr	1,742,625	Pastures	85	100
		Maize	45	85

Table No 34 (Cont)Estimated RAE of Phosphate Rock and of Partially Acidulated Phosphate Rock in Different Crops and Homogeneous Agroecological Regions of Colombia

Region Id	Area	Crop	RAE	
			P Rock	PAPR
	has		------%------	
1000-2000 masl, Temperature 18-24°C, Rainfall 500 to 1000 mm/yr				
Ma[1]	76,325			
1000-2000 masl, Temperature 18-24°C, Rainfall 1000 to 4000 mm/yr				
Me	409,150	Beans	25	85
		Cassava	65	90
		Sugar Cane	65	90
Mf	1,129,175	Sugar Cane	65	90
		Pastures	75	95
2000-3000 masl, Temperature 12-18°C, Rainfall 500 to 1000 mm/yr				
Fa	221,750	Potatoes	20	85
		Wheat	20	85
		Maize/Beans	80	100
Fc	132,150	Pastures	65	90
Fg	38,625	Pastures	75	95
		Potatoes	20	95
Fh	188,750	Potatoes	15	90
		Beans	5	90
		Maize	5	90
Fk	699,125	Pastures	55	90
3000-4000 masl, Temperature 6-18°C, Rainfall 500 to 2000 mm/yr				
Pa	45,500	Potatoes	75	95
Total Area	20,959,750			

[1] This region includes soils with high fertility and where fertilization with phosphate rock or PAPR is not recommended

Table No 35 Potential P Use by Selected Crops

Crop Potential	Department	Recommendation		Areas		
		Low	Medium	Low	Medium	
		kg of P/ha		10^3 has		tons of P
Rice	Meta	33	22	43 9*	14 9	1777
	Tolima	18	9	28 6	19 6	691
	Huila	18	9	11 4	4 8	248
Maize	Antioquia	44	22	73 6	16 8	3608
	Cundinamarca	22	11	41 8	9 9	1029
	Boyaca	22	11	18 5	7 6	491
	Narino	44	22	26 3	6 8	1307
	Meta	33	22	7 6*	2 1	297
Beans	Antioquia	33	22	25 8	4 0	939
	Boyaca	33	22	19 7	6 7	798
	Cauca	33	22	1 8	2	64
	Valle del Cauca	22	11	2 9	1 2	77
	Huila	22	11	16 8	8 7	465
Potatoes	Boyaca	130	110	28 8	2 7	4054
	Cundinamarca	130	110	35 0	5 3	5133
	Antioquia	130	87	10 6	3 4	1674
	Narino	130	87	13 3*	1 7	1877
Cassava	Cauca	44	22	2 7	1	121
	Meta	44	22	3 7*	3	169
	N de Santander	44	22	4 2	1 4	216
	Valle del Cauca	33	22	2 1	4	78
S Cane	Boyaca	44	22	13 3*	2 7	645
	Cundinamarca	44	22	17 4*	10 5	997
	Antioquia	66	33	31 7*	3 4	2204
	Narino	66	33	14 0*	2 4	1003
	Santander	44	22	14 2*	6 1	759
	<u>Total kgs of P</u>					30721
	<u>Total kgs of P_2O_5</u>					70351

* Areas and crops where ground phosphate rock for direct application can be used

Table No 36 Chemical Characteristics of Major Colombian Phosphate Rocks

Mine Name	P_2O_5	CaO	Fe_2O_3	Al_2O_3	MgO	CO_2	F	SiO_2	Na_2O	K_2O	SO_3
						%					
Pesca	22	28	1 0	1 4	15	1 3	2 1	40 3	14	15	45
Iza	20	31	4	4	12	1 5			-	-	-
Huila	22	40	6	1 7	17	8 3	2 7	23 6	16	09	95
Sardinata	26	33	1 9	5 0	22	8	2 6	25 3	10	15	-

Source IFDC Files and Communication from ECOMINAS

Table No 37 Sulfuric Acid Manufacturing Facilities 1985-86

Company	Location	Rated Capacity	Production 1985-86
		ton/yr	ton/yr
MONOMEROS	Barranquilla	86,400	47,400
PQP	Bogota	28,800	13,800
FAS	Neiva,	12,000	9,000
ECOPETROL	Bucaramanga	25,200	21,600
Quimica Basica	Caloto, Cauca	30,000	30,000
	Total	182,400	121,800

Source Personnal Communication from Quimica Basica

Table No 38 Use of Sulfuric Acid by Region 1985-1986

Region	Supplier	Use
		ton/yr
Atlantic Coast	MONOMEROS and others	36,600
Antioquia	MONOMEROS, PQP, QB	18,000
Bogota	PQP and FAS	13,200
Barrancabermeja	ECOPETROL and MONOMEROS	22,800
Valle	QB	26,400
Neiva	FAS	4,800
	Total	121,800

Source Personnal communication from Quimica Basica

Table No 39 Plant Gate Prices for Major Fertilizers in Colombia

Year	Urea	DAP	KCl	10-30-10	13-26-6	15-15-15	17-6-18
1977	7400		5600	7800	8600	6700	
1978	10700		7800	7800	8600	6700	
1979	11300	11900	7800	8500	9900	7400	10100
1980	15300	16800	9100	14800	14800	11230	12500
1981	18600	19500	16800	19400	17100	15200	15900
1982	21000	21500	17600	20000	18200	15700	16100
1983	19500	21500	18500	20900	19500	17500	18000
1984	27600	33700	23200	27000	25800	22400	19100
1985	36300	43500	26500	36000	37600	30900	29200
1986	34000	48000	28000	46500	44600	38900	39200
1987	30000	55000	28000	48200	46300	40400	40700

Source ABOCOL files

Table No 40 Average Nutrient Prices in Colombia 1977-1985

Year	N	P_2O_5	K_2O
	----------$/kg----------		
1977	16 1	18 7	10 2
1978	23 1	15 9	9 6
1979	24 5	18 4	10 9
1980	33 6	33 9	19 8
1981	40 6	37 9	31 7
1982	45 7	37 3	29 5
1983	42 8	43 1	35 1
1984	59 8	56 5	36 2
1985	79 4	84 6	48 2

Table No 41 Estimated Fertilizer and P_2O_5 Prices at the Plant Gate and at Major Consumption Centers March 1987

Product	Plant Gate		Villavicencio		Pasto		Bogota	
	Product	P_2O_5	Product	P_2O_5	Product	P_2O_5	Product	P_2O_5
	$/ton	$/kg	$/ton	$/kg	$/ton	$/kg	$/ton	$/kg
DAP	55000	94	68900	114	65400	110	67400	112
TSP	45000	98	58100	126	54600	119	56600	123
10-30-10[1]	48200	123	61600	153	63100	162	60100	150
13-26-06[1]	46300	135	59500	168	61000	179	58000	165
15-15-15[1]	40400	157	53100	197	54600	220	51600	193
Huila P R	10300	47	16700	76	17200	78	15700	71
Urea	30000	65	41900	91	38400	83	40400	88
KCl	28000	47	39700	66	36200	60	38200	64

Source MONOMEROS, ABOCOL, FOSFACOL and ECOMINAS Personal communications

[1] The N and K_2O value has been substracted using the price of Urea and KCl at the different locations

Table No 42 Estimated Fertilizer Transportation Costs to Main P Using Markets March 1987

From	To	Cost	Advantage over A C	Advantage over Tesalia
		---------------$/ton---------------		
A Coast	Bogota	8,000		
A Coast	Pasto	11,000		
A Coast	V/cencio	9,500		
Tesalia	Bogota	4,400	3,600	
Tesalia	Pasto	5,900	5,100	
Tesalia	V/cencio	5,400	4,100	
Pesca	Bogota	1,000	7,000	3,400
Pesca	Pasto	8,000	3,000	(2,100)
Pesca	V/cencio	4,000	5,500	1,400
Sardinata	Bogota	4,500	3,500	(100)
Sardinata	Pasto	11,000	0	(5,100)
Sardinata	V/cencio	7,500	2,000	(2,100)

Table No 43 Estimated Production Costs for PAPR Products

Rock	Quantity[1]		Costs[2]		Sub-Total	Conversion Cost[3]	Total Cost	P_2O_5
	Rock	H_2SO_4	Rock	H_2SO_4				
	--kg/ton---		--------------$/ton--------------------					/
Huila	758	210	1516	5250	6766	11304	18070	16 7
Pesca	816	144	1632	4320	5952	11304	17256	18 0
Iza	817	167	1634	5020	6644	11304	17948	16 3
Sardinata	810	181	405	6335	6740	11304	18044	21 0

[1] Quantities of rock and H_2SO_4 (93/) to make one ton of PAPR are IFDC estimates

[2] Estimated using the following costs of mining and tranportation of unground rock to plant site

Huila, Pesca and Iza $2,000/ton
Sardinata $500/ton

H_2SO_4 (93/) costs are equal to	at Huila	$25,000/ton
	at Pesca/Iza	$30,000/ton
	at Sardinata	$35,000/ton

[3] Conversion costs were estimated from Schultz, J J 1986 Sulfuric Acid Based Partially Acidulated Phosphate Rock Its Production Cost and Use IFDC T-31 Muscle Shoals, Alabama USA , table 18

Table No 44 Cost of PAPR Products at Different P Market Areas

PAPR Product	Plant Gate		Villavicencio		Pasto		Bogota	
	Product	P_2O_5	Product	P_2O_5	Product	P_2O_5	Product	P_2O_5
	$/ton	$/kg	$/ton	$/kg	$/ton	$/kg	$/ton	$/kg
Huila	18070	108	24916	149	25415	152	23915	143
Pesca	17256	96	22636	126	26636	148	19636	109
Iza	17948	110	23383	143	27383	168	20383	125
Sardinata	18044	86	26988	129	30488	145	23988	114

Table No 45 Estimated P_2O_5 Prices from Different Fertilizer Sources at Selected Locations

Product	Villavicencio		Pasto		Bogota	
	Price	%	Price	%	Price	%
	$/kg		$/kg		$/kg	
DAP	114	100	110	100	112	100
TSP	126	111	119	108	123	110
10-30-10	153	134	162	147	150	134
13-26-06	168	147	179	163	165	147
15-15-15	197	173	220	200	193	172
Huila PAPR	149	131	152	138	143	128
Pesca PAPR	126	111	148	135	109	97
Iza PAPR	143	125	168	153	125	112
Sardinata FAPR	129	113	145	132	114	102
Huila Rock	76	67	78	71	71	63

Table No 46 Estimated Costs of Inputs to Make a Phosphate Rock/TSP Mixture

Product	Villavicencio		Pasto		Bogota	
	Product	P_2O_5	Product	P_2O_5	Product	P_2O_5
	$/ton	$/kg	$/ton	$/kg	$/ton	$/kg
Huila Rock	16700	76	17200	78	15700	71
TSP	58100	126	54600	119	56600	123
Mixture	30072	101	29280	98	28911	97
DAP	68900	114	65400	110	67400	112
Mixture	33560	95	32769	94	32399	92

Table No 47 Estimated Fertilizer Nutrient Price Elasticities

Nutrient	Elasticity		
	Price	Crop Area[1]	Farm Income
Nitrogen	- 56*	1 31**	69+
P_2O_5	- 19+	1 07**	17
K_2O	- 41**	1 38**	1 61**

+ Significant P < 10
* Significant P < 05
** Significant P < 01

[1] For estimation of elasticities for N and P_2O_5 includes area cropped with potatoes, rice and sugar cane For K_2O includes the above plus the coffee area

Table No 48 Governemt Institutions Involved in Fertilizer Policy and Areas of Influence

Institution	Area of Influence
INCOMEX	Imports and Exports of Raw Materials Imports and Exports of Fertilizers
Ministerio de Agricultura	Imports of Fertilizers Fertilizer Prices Imports of Raw materials Extension
ICA	Quality Control Trading Licenses Imports of Fertilizers Imports of Raw materials Technical Assistance
INCONTEC	Quality Control Regulations
ECOMINAS	Mineral Reserves
Ministerio de Minas	Natural Gas
Instituto de Fomento Industrial	Fertilizer Production
Ministerio de Hacienda	Fertilizer Taxes Port Tariff

Source Communications from ECOMINAS, ICA and Ministerio de Agricultura

Table No 49 Present (since mid-1986) Taxes for Fertilizer Raw Materials and Finished Products Imports

Item	Tax	Regimen
	%	
Fertilizer Raw Materials		
Sulfur, Phosphate Rock, Phosphoric Acid and Ammona	1	License
Nitrogen Fertilizers		
Sodium Nitrate	1	Free
Ammonium Nitrate	1	License
Ammonium Sulfo-nitrate	1	Free
Ammonium Sulfate	1	License
Calcium Nitrate	1	License
Calcium-Magnesium Nitrate	1	Free
Calcium Cianamide	1	Free
Urea	1	Free
Phosphate Fertilizers		
Basic Slag	1	License
Calcium Phosphates (Thermo Phosphates)	1	Free
Super Phosphates (SSP and TSP)	1	Free
Di-calcium Phosphate	1	License
Potash Fertilizers		
Natural Potassium Salts	1	Free
Potassium Chloride	1	Free
Potassium Sulfate	1	Free
Fotassium-Magnesium Sulphate	1	License
Other Fertilizers		
Sodium Potassium Nitrate	1	Free
MAF and DAP	1	Free
NPKs	10 0	License
NPs	10 0	License
NI s	10 0	License
Other Multinutrient Fertlizers	10 0	License
Fertilizer sold in tablets or in bags of not more than 10 Kgs	15 0	License

Source Arancel de Aduanas LEGIS Chapters 25 and 31 June 30, 1985 (Envio 89), and 'El Tiempo , April 28/86, p 2D

Table No 50 Institutions Engaged in Fertilizer Research, Soil Fertility Research and Technical Assistance

Institution	Area of Work
National	
ICA	All crops, all areas
CVC	Regional Crops, Cauca Valley
FEDEARROZ	Rice
CENICAÑA	Sugar Cane for sugar production
CENICAFE	Coffee
COLTABACO	Tobacco
FEDETABACO	Tobacco
FEDECACAO	Cocoa
FEDEREALGODON	Cotton
FENALCE	Cereal crops (except rice)
UNIBAN	Bananas
INDUPALMA	Oil Palm
IGAC	Soil Fertility Maps
State Secretariats	All crops, satewide
International	
IFDC	Phosphate Fertilizers
CIAT	Rice, Pastures, Beans, Cassava

Table No 51 Potential Foreign exchange Savings from Use of Domestic Phosphate Reserves

Year	Projected Demand	Supply		Balance	CIF Value
		NPK[1]	Basic Slag		
	---000 tons---				000 US
1990	112 8	72 4	4 4	36 0	11 7
1995	137 2	72 4	4 4	60 4	19 9
2000	159 1	72 4	4 4	82 3	27 3

[1] Imports of P_2O_5 needed for manufacture of NPK s

[2] 2,600 tons valued at US$165 5/ton (Florida rock at CIF US$53/ton), the remainder valued at US$337/ton (TSP at CIF US$155/ton)

Table No 52 Estimated Aggregate Economic Benefits to Potatoes Farmers in Narino

Fertilizer Products	Fertilizer Cost	Quantity Nutrient	Quantity Product	Cost Savings[1]	Savings in F Ex[2]
	$/ton	---------kg---------		$/ton	000 US$
13-26-6	61,000		1,000		0
Huila PAPR	39,520	260	1,557		
Urea	10,790	130	283		
KCl	3,600	60	100		
Total	53,910	450	1,940	5,445	1,400
TSP	15,470	130	283		
Huila PR	10,140	130	591		
Urea	10,790	130	283		
KCl	3,600	60	100		
Total	40,000	450	1,257	20,550	710
TSP	30,940	260	565		
Urea	10,140	130	283		
KCl	3,600	60	100		
	44,680	450	948	16,411	0

[1] Includes extra charges for increase in application costs
[2] Total on an estimated 16,200 hectareas

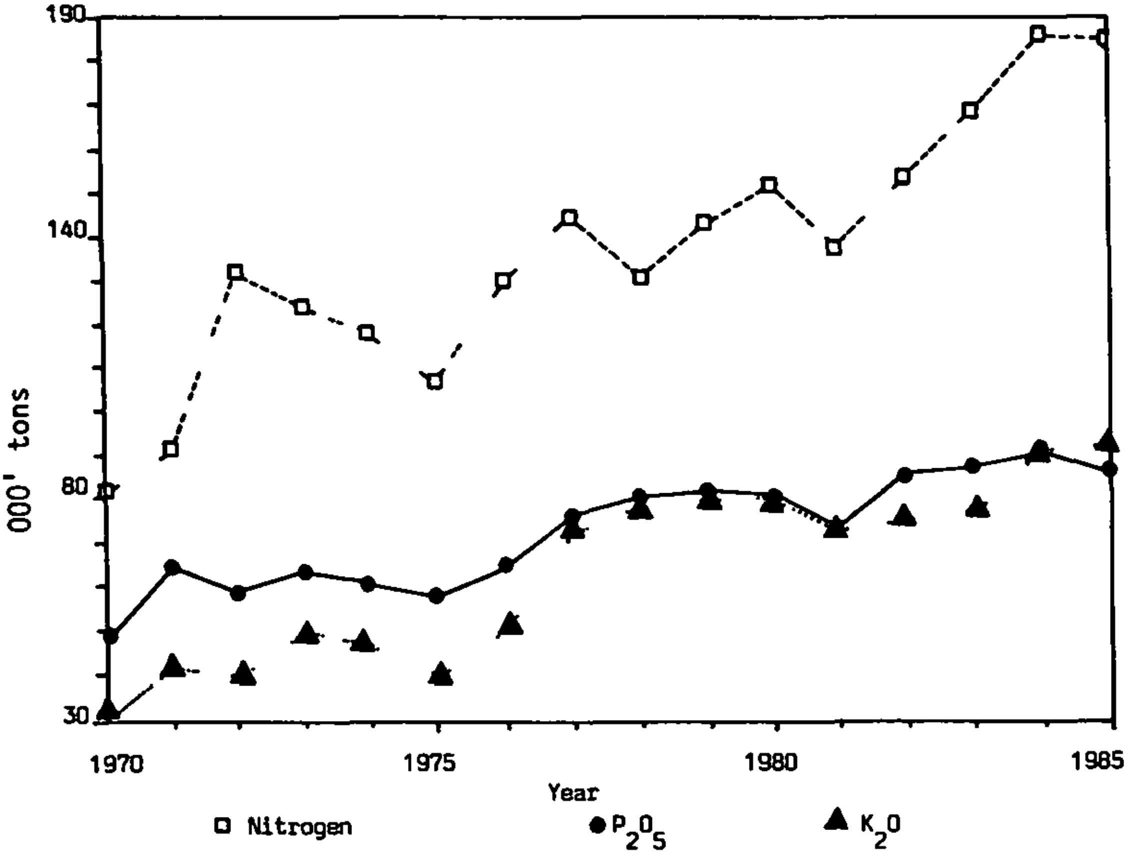


Figure 1 Nutrient use in Colombia 1970–1985

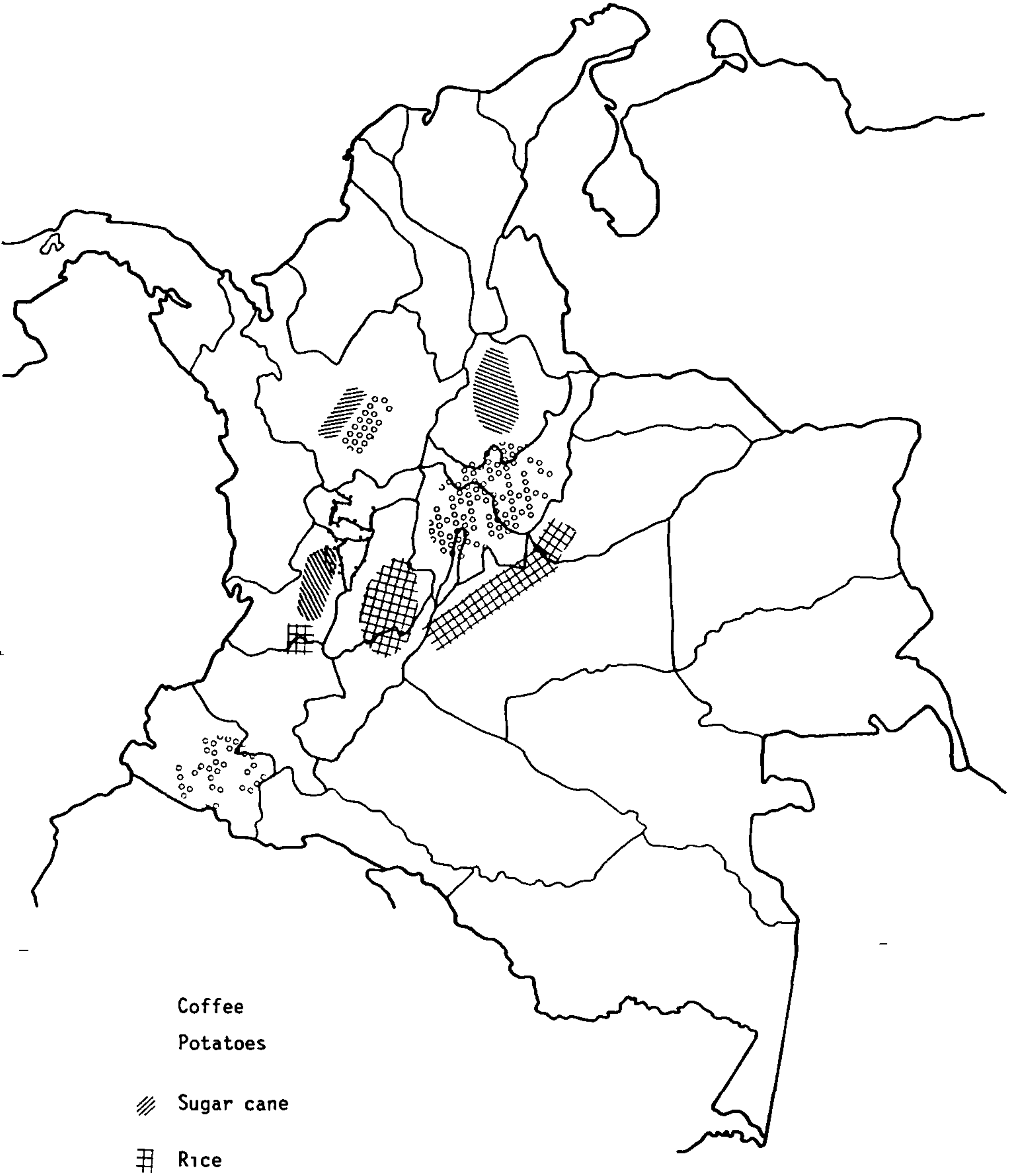
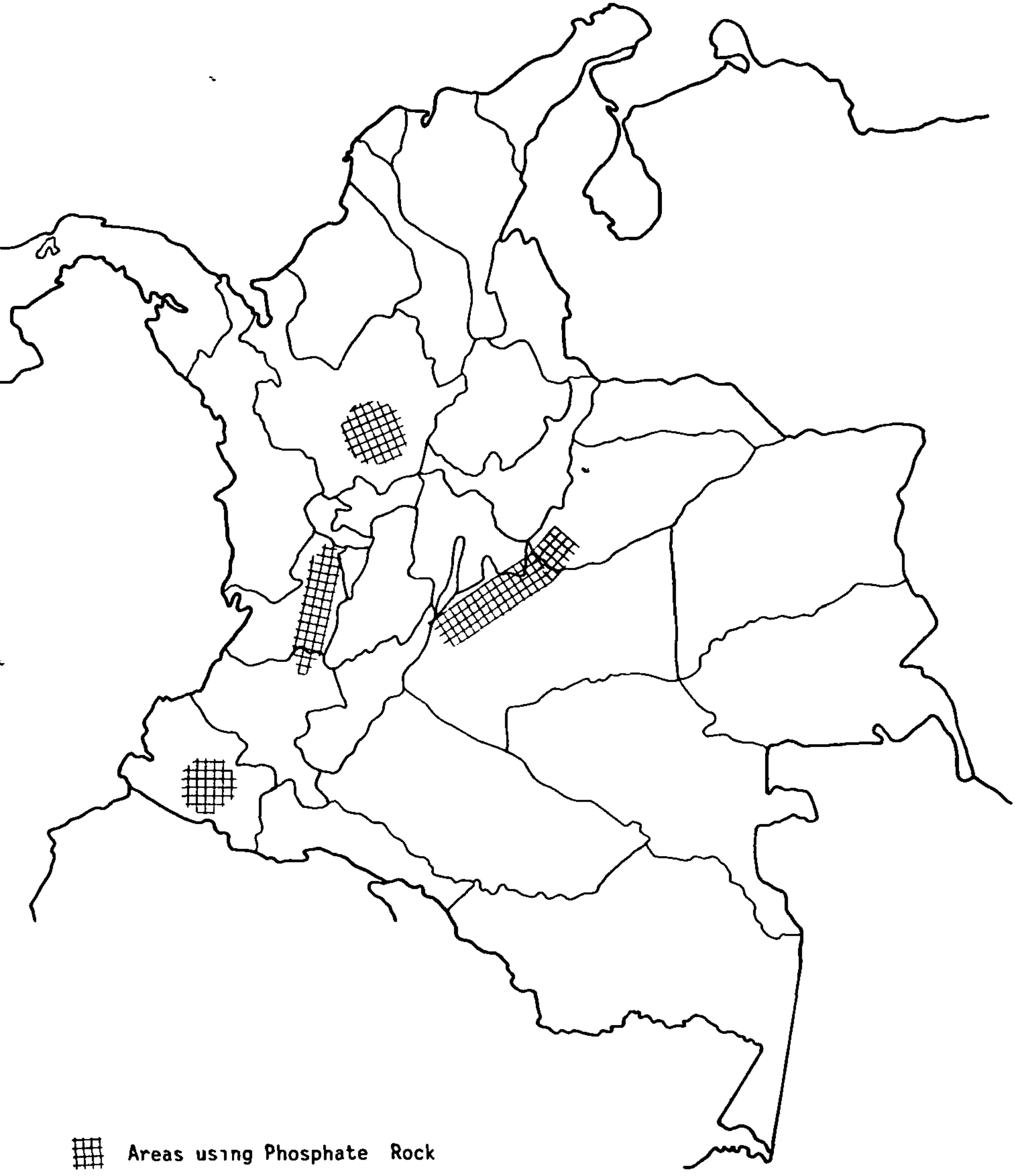


Figure 2 Major P_2O_5 consuming areas and crops 1986



Areas using Phosphate Rock

Figure 3 Location of major phosphate rock consuming areas 1986

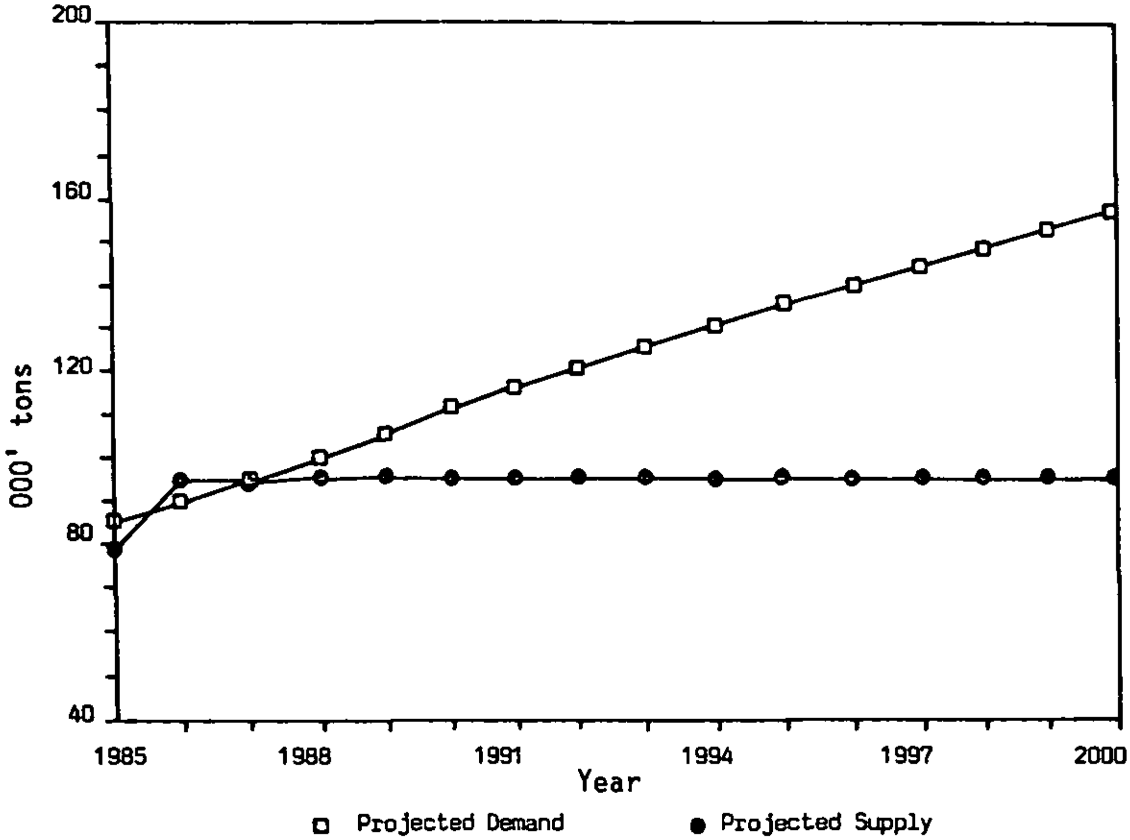


Figure 4 Projected demand and supply for P_2O_5 1986-2000

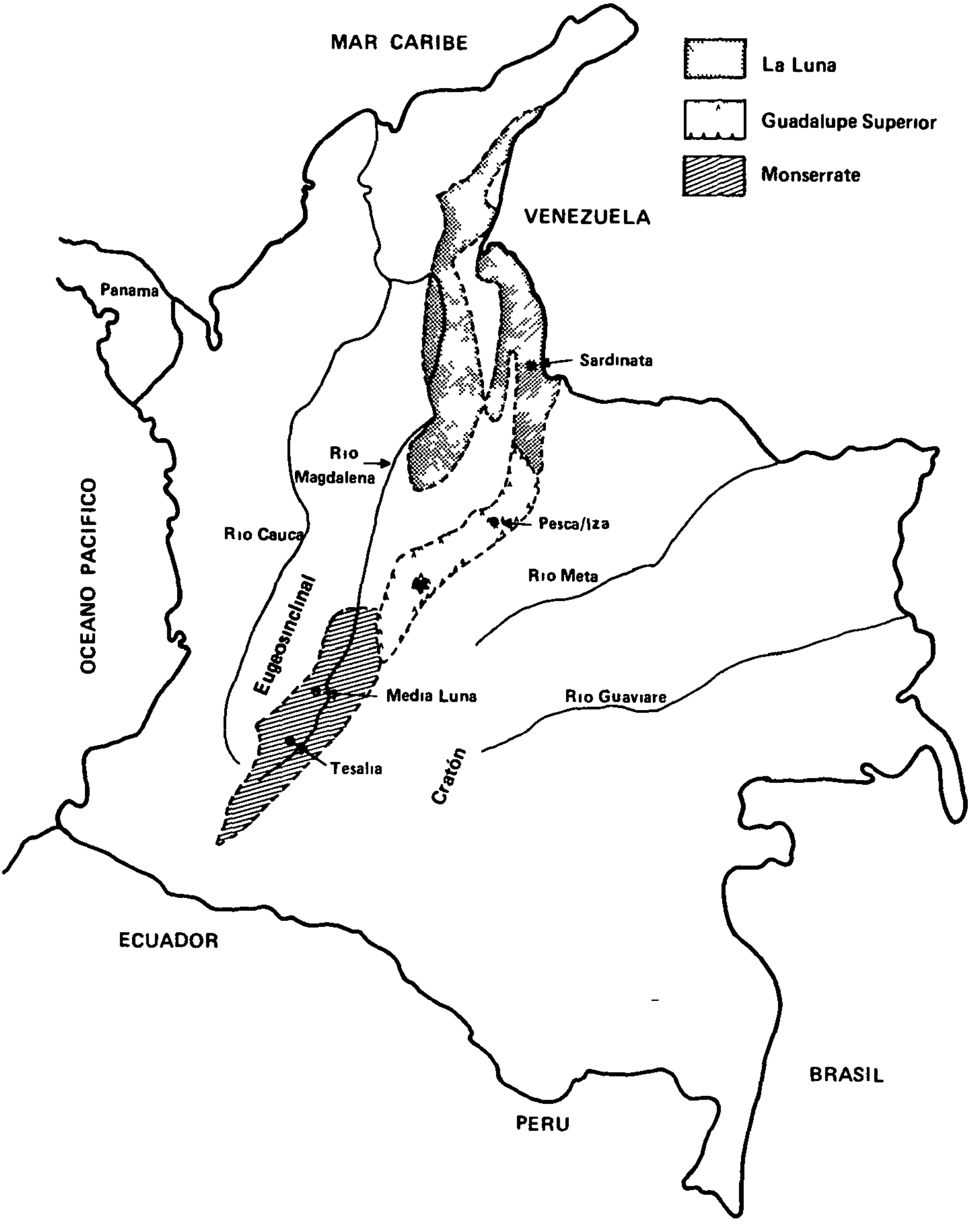


Figure 5 Location of major phosphate rock formations and deposits

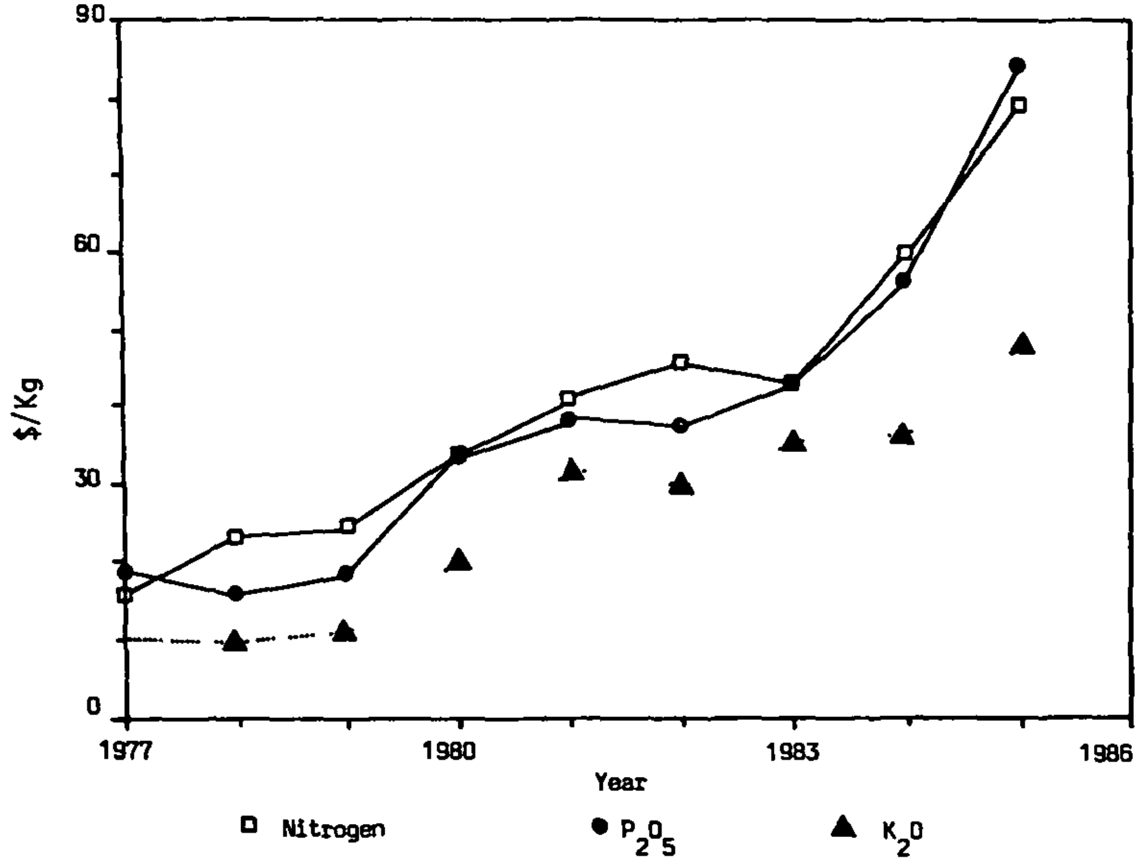


Figure 6   N, P_2O_5 and K_2O prices in Colombia   1977–1985

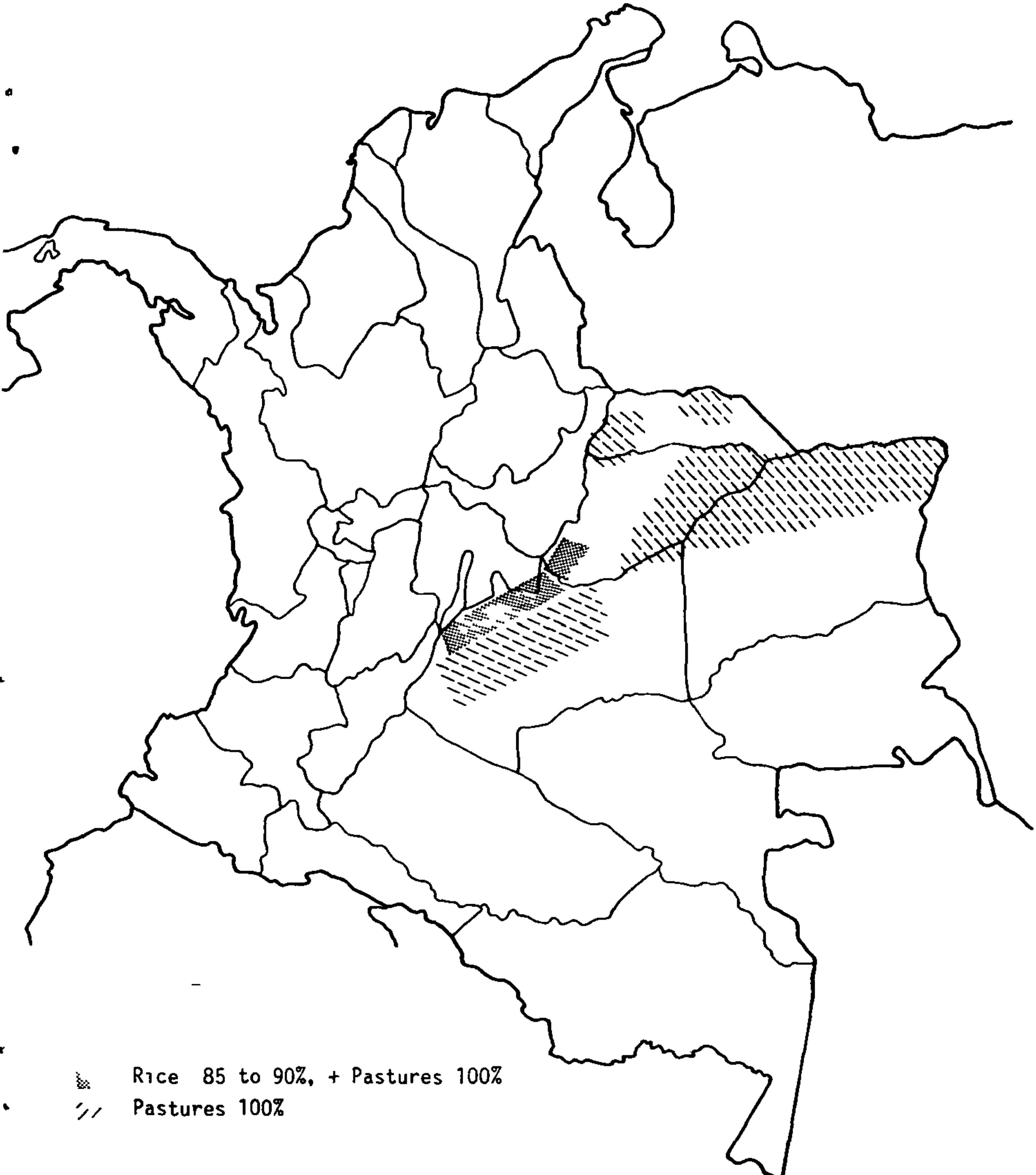


Figure 7 Potential areas crops and RAE for phosphate rock

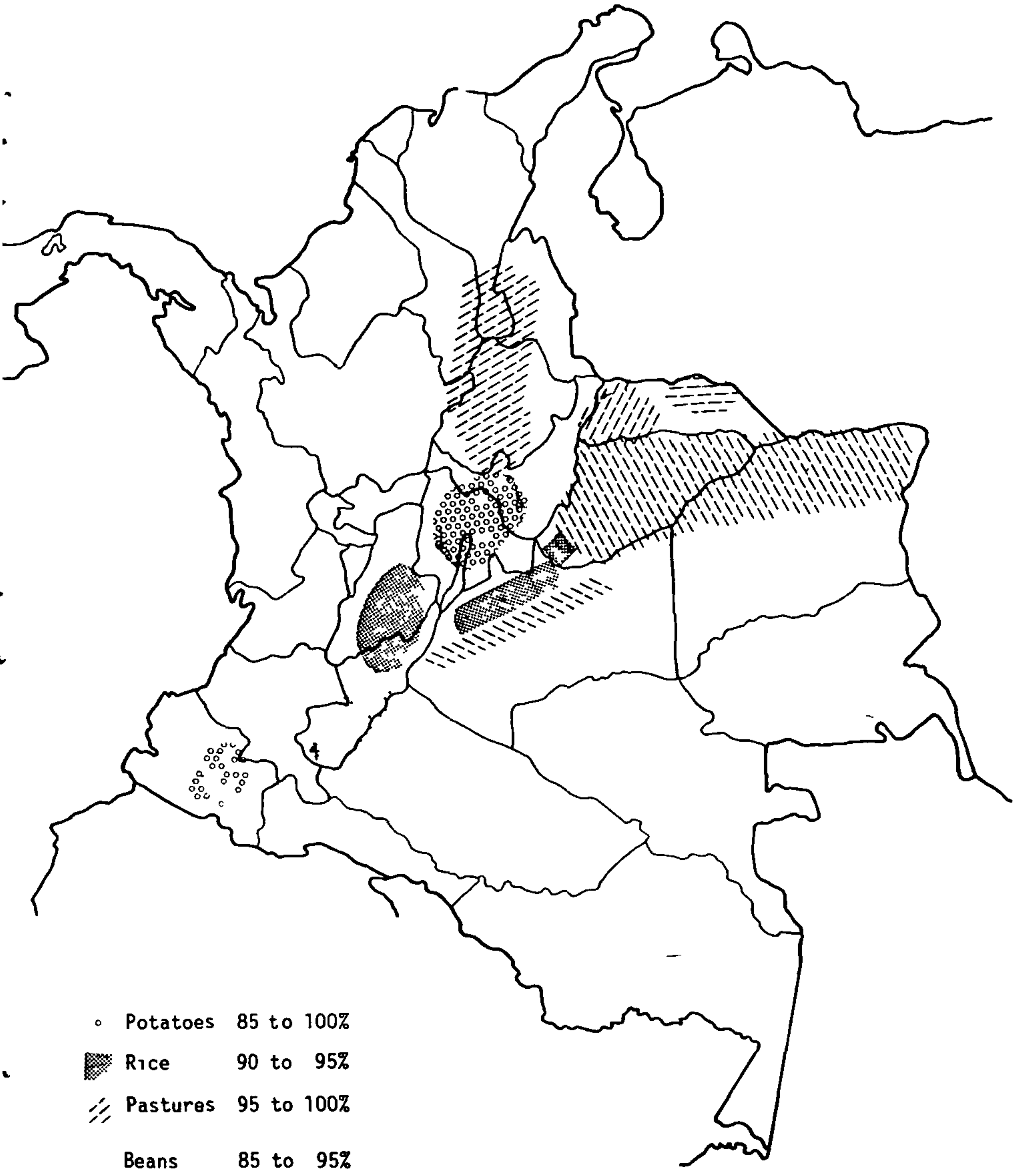


Figure 8 Potential areas, crops and RAE for PAPR

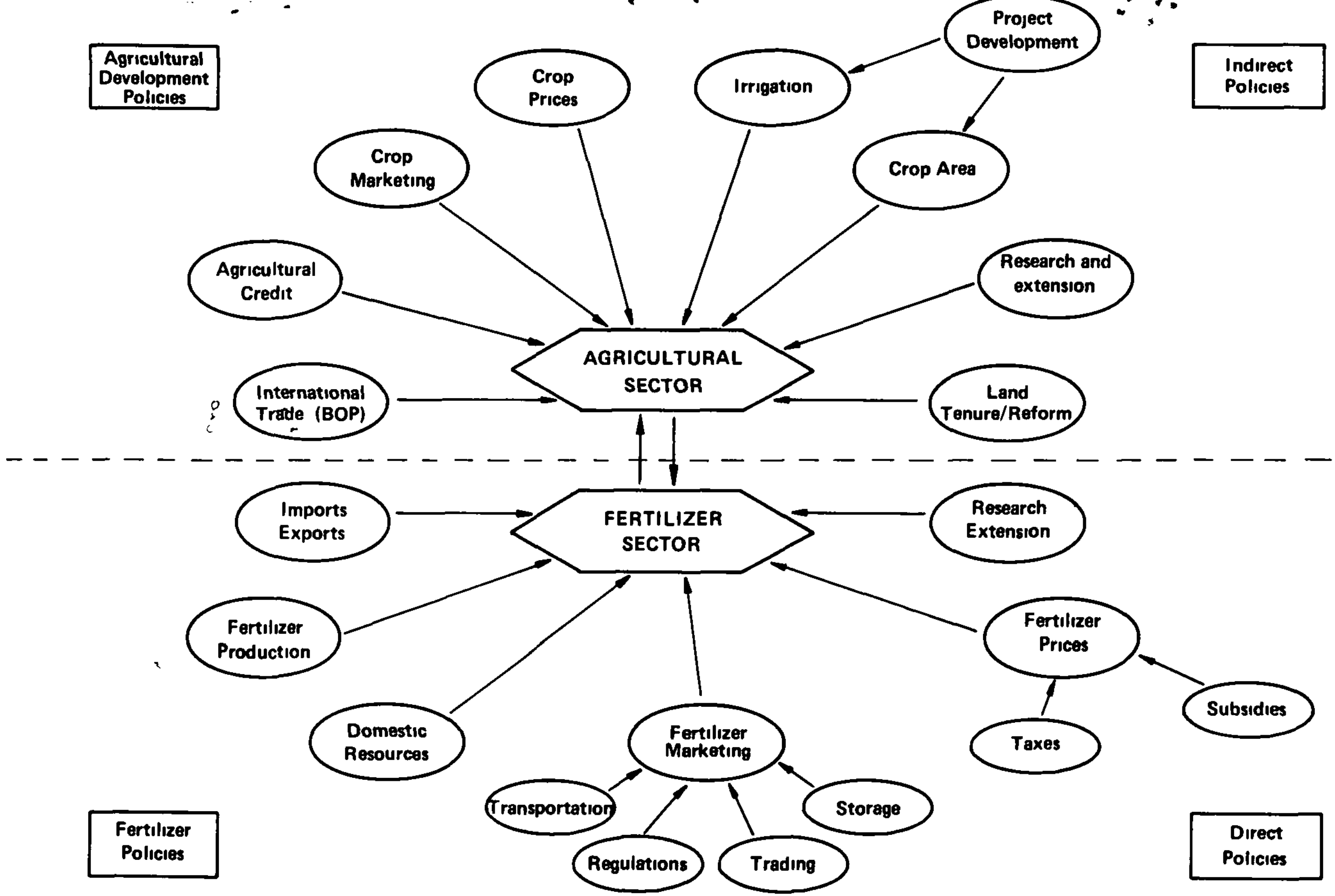


Figure 9

Representation of direct and indirect government policies as they relate to the fertilizer sector