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REALIZATION OF FERTILIZER PRODUCTION IN A DEVELOPING COUNTRY

The case of Bolivia

presented by

Ing. Juan Ayllon V.
Ing. Jorge Otero R.

YPFB La Paz, Bolivia

Mr. L. C. Axelrod
Mr. B. G. Mandelik

The M. W. Kellogg Company
New York

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/I. General

I. GENERAL

The countries of South America account for 6 per cent of the world population, cover 13 per cent of the area of the world, and include 5 per cent of the cultivated land in the world. However, only 2 per cent of the total fertilizers used in the world are used in South America. The countries that are covered in this study are the following South American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay and Venezuela. British and French Guiana and Surinam are not included as we were unable to obtain enough information covering their agricultural development, and at the same time, the agriculture in these three countries is fairly different from the rest of the countries of South America.

The food production in South American countries is at a lower level than desirable for the population residing in this area. The increase in the rate of production of food is slower than the rate of increase of the population, so that actually the per capita food production in the area decreased in the period 1951-61. It is therefore desirable to increase food production so that it would at least keep pace with the increase of population, and this can be achieved only by a planned use of fertilizers.

The amount of fertilizers used in the area in 1961 was about 128,000 tons of nitrogen. The ratio of NPK was 1-1.5-0.7. With the expected increase in the production and importation of fertilizers, it will also be necessary to provide adequate water supplies, means of transportation, farmers' credits, and agricultural consulting services to make the best possible use of the available resources in this area.

In the following paragraphs, we are presenting a review of the general features covering the individual countries of South America. We have selected for our discussion the factors that are most important in a feasibility study concerning production of fertilizers in a given area.

The review presented is the briefest outline of the work that is to be undertaken for the determination of the important factors that influence the production of fertilizers in a given country. How such a study is realized is shown in the subsequent paragraphs of this report dealing with fertilizer production in Bolivia.

II. CLIMATE AND GEOLOGY

The climate and geology can best be discussed by individual countries.

Argentina consists of four main geographical divisions: the Andes Mountains that are located in the western part of the country; the Chaco situated in the North, between the rivers of Parana and Uruguay with subtropical vegetation and woods; Patagonia, located in the southern part of the country, being an arid pasture land of a semi-desert nature; and the

/Pampas, in

Pampas, in the centre of the country which are naturally fertile and form the basis for the agriculture of the country.

Bolivia is a country situated in the Andes Mountains. It can be divided into three areas. The region of Altiplano is a plateau at an elevation of approximately 3,500 metres above sea level; as a result it has year-round cold nights that interfere with a great number of crops. The Valleys lying to the east of the mountains are situated at intermediate altitudes, and therefore, where the soil is suitable, offer good agricultural possibilities. The climate is mild and most of the crops can be grown in this area. The eastern part of the country is low-lying about 500 metres above sea level and is basically a tropical country suitable for crops generally grown in such climates.

Brazil has a great variety of climates. The greatest part of the country is situated in highlands at elevations between 200 and 900 metres. Forty per cent of the land consists of lowlands lying below 200 metres elevation and forms the basin of the Amazon River. The lowlands are nearly useless for agriculture and habitation because they are too hot and humid. The most important section of the country is the eastern coast where nearly all the population, agriculture and industry are concentrated.

Chile occupies the southwestern part of the South American continent between the Andes Mountains and the Pacific Ocean. It is distinguished by its mountains that extend along the entire 4,000 kilometre length of the country. The elevation is between 610-2,100 metres, with the climate ranging from subtropical desert in the North to the pasture regions in the South. The coastal parts of central and northern Chile have a temperate climate suitable for agriculture.

Colombia has basically three natural regions: in the west, there is a chain of the Andes Mountains consisting of three ranges and the intermediate valleys; in the north, there is a plain on the Caribbean coast which is flat and fertile, and is being rapidly developed; in the east, there is a level plain covered with grasslands and forests that slope down to the basins of the Amazon and Orinoco Rivers. This last plain covers 60 per cent of the country, but is practically uninhabited. There are only two seasons that occur twice each year: the wet season from March to May and from September to November, and the dry season in the remaining months of the year.

Ecuador is situated on the equator, but its climate is tempered by the cooling effect of the Humboldt Current; there is also a great variation in altitudes above the sea level. The country can be divided into three geographical areas: the coastal plain; the Sierra, which covers two mountain ranges of the Andes and the plain between them; and last, the forested eastern slopes, sloping down into the valley of the Amazon River. In the northern part of the country there is heavy rainfall, but it diminishes toward the South, and the extreme South is practically a desert.

/There are

There are three geographical zones in Peru: the Costa, the Sierra, and the Selva. The Costa covers about 10 per cent of the total area and is the narrow belt of land between the Andes and the Pacific Ocean. There is practically no rainfall in the area and it has the character of a desert, with the exception of a few belts of vegetation made possible by occasional fogs and drizzles. About 1/3 of the total area is the Sierra. This consists of the Andes Mountains arranged in three parallel ranges. The valleys between the ranges receive a full amount of rain and water from the rivers fed from the mountain snows. This is the area most suitable for agriculture although night frost is dangerous during most of the year. The low-lying areas in the east are called Selva and consist of jungles with subtropical and tropical climates. There is a heavy rainfall and high humidity persists throughout the year.

Paraguay lies between the rivers of Paraguay and Parana and has a subtropical climate. Most of the land is low-lying. In the northwest, the Chaco region is very sparsely inhabited and has a low rate of rainfall.

Uruguay lies between the Atlantic Ocean and the Rio de la Plata. It consists of grass-covered slopes, wooded ranges and broad valleys. The temperatures are moderate and the rainfall is rather low. Most of the area is covered by grassland and is suitable for agriculture.

There are four main geographical regions in Venezuela. South of the Orinoco River are the Guiana Highlands, which are not yet fully explored and practically uninhabited. The Andean Highlands lie on the Columbian border in the southwestern part of the country. Between them and the Orinoco River is the Llanos, the slow, gently sloping plain that is sparsely inhabited. The northwestern part of the country is called the Maracaibo Basin. The climate of the country is extremely hot with the exception of the highlands. Agriculture is concentrated in the highlands and in the Maracaibo Basin. There are no seasons of the year, and there is an adequate amount of rain available for agriculture.

III. AGRICULTURAL PRODUCTS AND YIELDS

The continent of South America is so large that there is necessarily a great variety of products cultivated in individual countries and in different climates.

It is impossible to draw any general picture for the whole continent, and it is even difficult to generalize for most of the individual countries because their climate changes according to the elevation above sea level and geographical position as was pointed out in the previous chapter. If there is any general conclusion that can be reached, it is that the yields of individual products are generally very low. This is due to the limited application of fertilizers and insufficient care of the soil, and resulting deterioration of soil conditions.

/The following

The following table summarizes some of the crops grown in the individual countries and yields obtained. (See Table 1.) It is obvious that a reasonably-priced supply of fertilizers would increase the yields in practically all instances and improve the standard of living of the farmers.

Where virgin land is cultivated, the crops bring very high yields for the first few years. Without fertilizers the soil, however, becomes exhausted very quickly and the yields drop fast.

In Argentina, the expansion of wheat production would provide a possibility to export a product that could earn foreign exchange and improve economic conditions. The land that is available for cultivation of crops is very suitable, and apart from wheat, many other crops could be exported and improve in this way the national economy. At present, there is rather a depression in the farming industry, and an over-all improvement in the farming activity is desirable.

In Bolivia, improved crops could be used to increase the standard of living of the inhabitants; it is certainly desirable to increase the production of cereals and meat to improve the diet. Because of the high cost of transportation from the sea coast to the inland areas, practically no fertilizers are being used at present.

The most important crop in Brazilian economy is coffee, followed by rice, corn, and cotton. The Brazilian economy depends to a large extent on the export of coffee. However, the supply of coffee is rather excessive and no increase in its production seems desirable. However, as far as other agricultural products are concerned, the increased rate of production of cereals would be of a definite benefit to the country.

The importance of agriculture in Chile is declining at present. The situation in Chile is quite different from that in other South American countries because of the availability of sufficient amounts of fertilizers in the form of mined nitrates. At the present time, however, the mining of the nitrates has become less and less competitive with fertilizers prepared from natural gas or oil, and it is difficult to predict the future development of this industry. It is desirable to increase the consumption of potassium and phosphorus fertilizers in the country to obtain maximum improvement of the national economy.

In Colombia, the agriculture depends to a large extent on the production of coffee. It is very hard to predict what importance the use of fertilizers would have on this crop because of the oversupply of this commodity. However, the other main crops of this country, that is bananas, sugar, potatoes, and cotton, could be produced advantageously in increased quantities, and this could be achieved by a better supply situation of fertilizers. The variety of products that are grown is great and the possibilities of improving the national economy and the standard of living in the country by an increased use of fertilizers are substantial.

/Table 1

Table 1

	Argentina		Bolivia		Brazil		Chile		Colombia	
	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha
Wheat	3 960	1 100	44	640	150	300	1 122	1 340	142	890
Rye	505	690					8	800		
Maize	4 850	1 770	290	980	8 500	1 250	145	1 960	733	1 000
Oats	843	1 100					132	1 220		
Barley	773	1 080	70	715			102	1 590	101	1 810
Cotton	124	250		250	429	135			70	470
Rice	149	3 240	50	1 260	5 315	1 690	100	2 630	470	2 070
Peanuts	266	1 400			488	1 450				
Potatoes	2 072	10 200	600	3 700	1 200	6 000	825	9 000	544	12 650
Sugar Cane	9 650	43 250	63	38 500						
Grapes	2 047	8 630					524	5 240		
Sunflower Seed	585	650					33	1 070		
Coffee					2 100	525			456	570
Beans			13		1 676	670	89	970		
Bananas					260	1 370			508	1 270

	Ecuador		Paraguay		Perú		Uruguay		Venezuela	
	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha	M Tons/Yr	Kg/Ha
Wheat	78	990		800	163	1 090	413	790		
Rye	4	510								
Maize	153	670		1 240	339	1 270	197	830	350	900
Oats							63	790		
Barley	70	760			207	1 040	49	730		
Cotton				170	130	520			6	118
Rice	163	8 400		2 220	308	4 350	54	3 450	81	1 390
Peanuts										
Potatoes	271	8 400		8 780	1 145	4 800	59	3 500	74	4 920
Sugar Cane	5 614	89 000		16 000						
Grapes					47					
Sunflower Seed							98	640		
Coffee					33	430			46.3	137
Beans					87	1 010				
Bananas	2 204	19 400								

/The main

The main crops in Ecuador are bananas, cocoa, coffee, and rice. Cereals and potatoes are grown for domestic consumption. It would again be desirable to increase the production of all products, with the possible exception of coffee, and create in this way a sound basis for the national economy.

The soils that are cultivated in Paraguay contain at present enough nitrogen for the crops that are grown for local consumption, but it would be desirable to supply potassium and phosphorus, which could improve the standard of living of the farmers to a large extent. There is no export of any agricultural products at present, and the improvement in the yields would be mainly an advantage for an increased standard of living for the farmers.

Agriculture is the most important industry in Peru. Two-thirds of the people are employed in agriculture, and one-half of foreign exchange is obtained by farm exports. The most important crops used for exportation are cotton and sugar. Some wool and coffee are also exported. At the same time, there is an increasing demand for agricultural products in the domestic market, and it is imperative to provide higher food production to feed the rapidly increasing population. Modern production of fertilizers is needed because the supply of guano is uncertain from year to year, and limited in quantity.

Most of the area where crops are cultivated in Uruguay is planted in cereals and oil seeds. In some periods wheat, meat, wool and oil seeds were exported, although at present there is difficulty in meeting the domestic demands for these products. Corn, barley, rice and potatoes are grown for domestic consumption, and it would be an advantage to increase their production as well as of the products that used to be exported to help develop the economy of the country. As there are no mineral deposits in Uruguay, agriculture is at present the dominant factor in the national economy. The main need is for phosphoric fertilizers and an increased consumption of these fertilizers would be of great benefit to the whole country.

The economy of Venezuela depends on oil and not much attention was given to agriculture in the country in the past. Recently, however, a good deal of effort has been expended to improve the conditions in agriculture and to raise the living standards of the farming population. At present, large amounts of cereals as well as other food products are imported. Coffee, cocoa, and sugar are exported. Fertilization of crops would benefit the farmers and increase their standard of living.

IV. RAW MATERIALS FOR FERTILIZERS

The over-all situation of raw materials for the production of the fertilizers can best be seen in the attached Table 2. The position varies from country to country, and is discussed below, for the individual countries concerned.

/Table 2

Table 2

Raw Materials	Argentina	Bolivia	Brazil	Chile	Colombia	Ecuador	Paraguay	Peru	Uruguay	Venezuela
Phosphate Rock	.....	.....	Ample	.....	.....	.....	.....	Ample	.....	Ample
Potash	.....	.....	Limited	Ample	.....	.....	.....	Ample	.....	.....
Sulphur	Limited	Ample	.....	Ample	Ample	.....	.....	Limited	.....	Limited
Limestone	Ample	Ample	Ample	Ample	Ample	.....	.....	Ample	.....	Limited
Coal	Limited	.....	Limited	Ample	Ample	.....	.....	Limited	.....	Limited
Hydrocarbon	Ample	Ample	Limited	Ample	Ample	.....	.....	Ample	.....	Ample

In Argentina, the main raw materials suitable for fertilizer production are petroleum and natural gas. The level of domestic production changes from year to year, but the reserves are such that there should be enough raw material available for any possible nitrogen fertilizer production in the country without the necessity of importation. There is some sulphur available, but local production is expensive, and it is not certain whether sulphur should be imported or whether domestic supplies should be used. The phosphate rock and potash would have to be imported into the country.

Bolivia has a sufficient supply of natural gas to cover all the requirements of raw materials for the production of nitrogen fertilizers. Although the natural gas fields are not yet in production, sufficient reserves are known to be available. There is ample supply of excellent quality sulphur which can be supplied at economical prices, to any selected plant location. There is no known source of potassium, but it seems that very little will be required in the near future. It is assumed that at present phosphate rock will have to be imported.

The main raw material available in Brazil is petroleum, and although the present production does not cover all the domestic requirements, the reserves are such that there should be ample supply of this raw material for the required production of nitrogen fertilizers. The natural gas in Bahia should be the most suitable raw material. There are also good deposits of phosphate rock, which should cover at least all the domestic requirements for fertilizers. There are also limited amounts of potassium available and further investigation of the resources will have to be made before a final appreciation of the situation can be made.

Chile has suitable resources of natural gas for the production of nitrogen fertilizers in Tierra del Fuego where there are also substantial supplies of crude oil available. This together with the available deposits of nitrates should not only cover all the necessary requirements for nitrogen fertilizers in the country, but also maintain a significant level of exports of nitrogen fertilizers. There are good reserves of sulphur in the northern part of the country. There are substantial amounts of potassium minerals in the form of potassium nitrate that should cover all domestic needs and maintain the country's export position. It is not yet certain whether it will be necessary to import any phosphate rock or whether domestic resources can be developed to such an extent that the country would be self-sufficient in this mineral. There is also some guano available. At present, some phosphate rock is imported for the production of phosphate fertilizers.

Colombia has a sufficient supply of oil to maintain a good level of production of nitrogen fertilizers, and satisfy all the country's need for oil products. There are significant reserves of sulphur, of volcanic origin, and substantial deposits of pyrites. There are no known deposits of phosphate rock or potassium salts. These two elements will have to be imported for the production of complete fertilizers.

/Ecuador has

Ecuador has no domestic resources of raw materials for fertilizers and all the supply for possible production will have to come from other countries. The same applies to Paraguay as far as the present state of exploration of the natural resources of the country is concerned.

Peru has an excellent supply of petroleum raw materials that can cover all the country's needs and produce all the nitrogen fertilizers that may be required. At present, there is a substantial export of oil products to other countries. The main raw material for phosphate fertilizers is guano of which there is an ample supply in the country. There are deposits of phosphate rock, but they are not being exploited at this stage. Some rock is imported from Florida. There are good deposits of potassium that will be able to cover all the country's requirements for fertilizers. At present, some guano is exported. There are limited deposits of sulphur; pyrites and other sulphur-bearing ores are also available for the production of sulphuric acid.

Uruguay has no known raw materials for the production of fertilizers. All raw materials for the production of fertilizers will have to be imported.

Venezuela has extremely large reserves of hydrocarbons and is one of the greatest exporters of oil products in the world. There is an excellent basis for the nitrogen fertilizer industry; the industry is being developed at present. There are phosphate rock deposits and the rock is produced in good quality suitable for the production of fertilizers. There are no deposits of sulphur, but enough sulphur from oil or natural gas is available for the production of sulphuric acid. There are deposits of pyrites that are being exploited. There are no known deposits of potassium minerals.

V. TRANSPORTATION SYSTEMS

The transportation systems vary from country to country and are a function of the geographical conditions and the history of the economical development of the country.

In Argentina, a basically sound network of railways is in existence. However, at present, the railways are plagued by economical difficulties, and they need replacement of a substantial portion of the rolling equipment. The system of roads is fairly extensive although most of them do not provide all-weather service. There are a number of deep-water ports and the facilities in the ports are good. The over-all transportation system would benefit from the development of agricultural production.

In Bolivia the railroad system has been geared to the needs of the mining industry, and therefore, the connexions to the area where the natural gas is found are not adequate. Although some transportation of

/products that

products that will be provided by an increased agricultural production could be made by railways, a great portion of this increased transportation will have to be made by roads. A system of roads is being developed, but it will need further improvements to provide access to the new agricultural areas from which a substantial amount of the increased production will have to come. The transportation system on the rivers is still in the early stages of development and only the navigation on Lake Titicaca is used at present to a considerable extent.

The transportation network in Brazil is concentrated in the eastern part of the country. Present development of the highway system around the capital, Brasilia, will provide connexions to the centre of the country. The railroad system still operates at a loss and an improvement would be desirable to speed up the transportation of agricultural products from one part of the country to another. A substantial part of the highways are passable only during dry weather and an improvement of the roads would facilitate the exploitation of the increased yields of agriculture that will result from the application of fertilizers. There are many sea ports and river ports that are well-developed and would be of great assistance in the expansion of agricultural production.

Chile has a well-developed railroad system although there is a need of replacement of some of the oldest equipment. The highways, however, need improving to allow access to places not serviced by the railways. The sea ports are numerous and would facilitate the development of the trade in fertilizers and agricultural products.

The transportation system in Colombia is not well developed because of the difficult nature of the terrain in the country. There is only a limited length of railway lines available and even where the railways are in existence, because of the steep gradients, there are limitations to the carrying capacity of the railway cars. The highways have been developed to a certain extent and would no doubt provide the main facilities for the increased transportation loads resulting from improved conditions of the agriculture. The sea ports and river ports are developed to a certain extent and would be used in the over-all transportation scheme.

VI. FERTILIZER REQUIREMENTS

At present, the consumption of fertilizers in South America is very low as has been discussed in preceding paragraphs. To achieve improvement of the economy in the countries that are reviewed in this paper, it will be necessary to plan an increased use of fertilizers. Some idea of what this increase might be can be seen in the following table:

/Expected requirements

Expected Requirementes of Fertilizers in South American Countries

Quantities in Thousands of Tons

	1966			1971		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Argentina	10	10	5	25	35	18
Bolivia	8	5	-	28	15	2
Brazil	100	200	150	150	300	200
Chile	30	85	15	65	145	25
Colombia	35	50	25	50	70	30
Ecuador	10	5	5	20	10	5
Paraguay	5	5	5	10	10	5
Peru	100	50	15	150	75	30
Uruguay	10	30	20	20	60	40
Venezuela	15	15	15	25	15	15

It is impossible to predict accurately what the development in the individual countries would be, but it can be expected that the over-all development of the industry will follow approximately the suggested outline.

VII. ECONOMIC LOCATION OF PLANTS

There are basically three factors that will influence the location of the plants for production of fertilizers. The first one is the necessity to regard the economies of the individual countries as a whole and decide whether it is an advantage to produce fertilizers in a given country or import them from a suitable source of supply. It is always necessary to maintain a balance between the import and export and see what influence a possible importation of fertilizers or raw materials for their production would have on the final exportation of agricultural products. It is impossible to make any general conclusions at this place whether any given country should produce fertilizers or import them.

Once a decision is made for an individual country or region to build such a plant, two factors have to be considered. One is the relative position of the production site to the area where fertilizers will be marketed, and the second is the influence of the supply of raw materials

/to the

to the plant site. It will be always an advantage from the point of view of the supply of the raw materials to locate the plant where these are obtained at the cheapest rate. Such a location will not be the same for all of the raw materials required because obviously it would be an advantage to locate the plant producing ammonia where the hydrocarbon source is available, and the phosphate and potassium fertilizer plants where raw materials for these are supplied at the cheapest rate. An economic balance must be made between these factors and combined or separate plant sites selected for the production of complete fertilizer to reach the optimum solution of the problem.

It is of course necessary to locate production facilities where the soil conditions are suitable, where cooling water is available, and where the problem of effluents can be handled.

Bringing all these factors into the picture and locating the plant so that the distribution of the products to the expected markets will be convenient will always require a thorough study before a decision for the location of a plant is made.

VIII. APPLICATION OF GENERAL PRINCIPLES TO THE CASE OF BOLIVIA

In the preceding six chapters, the most important factors that influence the establishing of a fertilizer plant in a given country were reviewed. These factors were studied, and their influence upon the possibilities of fertilizer production in Bolivia are reviewed in the following paragraphs.

Before going into the detailed study of the general conditions, we should review the general conditions concerning Bolivia. We would like also to make a very quick review of the work that has been done in the past in connexion with the problem of the supply of fertilizers to Bolivian agricultural enterprises.

Bolivia is a country well endowed with mineral raw materials.

In the middle ages the original production of great amounts of gold, later of silver, and in modern times of tin, gave the country its original riches. These riches, however, did not help to establish a well developed economical basis. The mining industry remained the only one with a broad base and offering wide opportunities for employment. Large quantities of food for the urban and mining population were imported, and the farmers lived off their land supplying only part of the food needed for the rest of the population. Only breweries, cotton mills and a few other consumer goods producing industries are established in the country at the present time.

The discovery of crude oil in the area of Santa Cruz provided the country with a domestic source of fuel and five refineries and a pipeline

/joining the

joining the refineries and sea port of Arica were built. When later natural gas was discovered, the government of Bolivia decided to use this raw material to develop a petro-chemical industry with an original stress upon fertilizers to modernize Bolivian agriculture and to start a soil conservation programme.

The possibilities of producing fertilizers were first studied by V.S. Debausset who, in his report commissioned by The Ministry of National Economy of Bolivia in March 1961, recommended construction of a fertilizer plant.

The subject was later discussed in "Estudio Sobre Fertilizantes", of the Organización de los Estados Americanos in 1961 and the importance of the erection of a fertilizer plant was stressed. An excellent report summarizing all the past work in the field was written by Messrs. Ing. Jorge Otero Reiche and Ing. Juan Ayllon Valle of the Departamento de Diseños y Proyectos of Yacimientos Petrolíferos Bolivianos in July 1963 under the title "Calculations for Petro-Chemical Plants in Santa Cruz". The present report is a deeper development of their work and was prepared with their collaboration.

VIII - II. SUMMARY

The M. W. Kellogg Company assisted personnel of Y.P.F.B. in collecting data supplementing those contained in the report previously compiled by Y.P.F.B.'s Department of Diseños y Proyectos.

Servicio Agrícola Inter Americano offered us their assistance, and several meetings were held with them and many private communications were received from them. Help was received from the Corporación Minera de Bolivia in the field of explosives requirements and sulphuric acid marketing. Departamento Nacional de Geología del Ministerio de Minas y Petróleo offered information concerning occurrence of phosphates in Bolivia and the availability of sulphur. The Ministerio de Hacienda y Estadística supplied information concerning importation and exportation of agricultural products, explosives and fertilizers. The Ministry of Agriculture offered data on colonization, irrigation and fertilizer experiments. The Director General of Meteorology of Bolivia supplied meteorological data. The Mining Institute of Bolivia helped by supplying data on mineral resources. The Ministry of Transportation released data on road and resources. The Ministry of Transportation released data on road and rail transportation systems in Bolivia. The Director General of Agricultural extensions provided information on experimental uses of fertilizers. The manager of the credit section of Banco Agrícola revealed information on financial help to farmers, and on the economical problems that face the farmers.

Direct information covering experimental work was obtained at the experimental agricultural station at Cochabamba. The Global Engineering Company supplied data concerning the irrigation projects. The Tippets-Abbett-McCarthy-Stratton Company gave information concerning the road

/improvement schemes.

improvement schemes. Members of the British Agricultural Mission to the Ministry of Economics supplied information concerning fertilizers most suitable to improve Bolivian agronomy. The Gulf Oil Company gave information concerning the natural gas available near Santa Cruz. At the Y.P.F.B. refinery at Santa Cruz information concerning the local geographical and labour conditions was received. Brief inspection of fields in the vicinity of La Paz, Cochabamba and Santa Cruz was made. The Angostura Dam was visited. The extensive information gathered was analyzed and used as the basis for the present report. The report evaluates data on the over-all economy of the country, the balance of trade, the exports and imports statistics, the geography on Bolivia, the influence of climate in individual locations and the crops that could be grown. Phytogeography of Bolivia is discussed and the individual crops that can be grown are reviewed. Availability of water is discussed. Distribution of the population through the country and their sources of income are reviewed. Economical integration of the country and the function of transportation system in it is evaluated. Agriculture in individual areas is discussed; the importance of teaching modern methods of agriculture is stressed. The properties of the soils are described and the available nutrients evaluated. The condition of the soil and the most suitable kinds of fertilizers are discussed. Improvement in the supply of water and irrigation products and the experimental work of the agricultural stations is described.

Raw materials which form the basis of the fertilizer industry are reviewed. Importance of using locally available raw materials is discussed. Existing marketing and distribution facilities are evaluated and future improvements suggested.

Future requirements of fertilizers and the probable development of their market is reviewed. Size of production facilities to best suit the needs is indicated.

The main fields of explosive uses in Bolivia are described. The size of probable market is discussed. Technological review of the production is given.

VIII - III. DISCUSSION

A. CURRENT ECONOMIC SITUATION

1. Gross National Product and its Distribution

The over-all picture of the composition of the national product can be seen from the following table: (1)

/Gross Domestic

Gross Domestic Product in 1962

(In million of dollars at 1958 prices)

Agriculture and Livestock	136.4
Mining	35.5
Petroleum	14.2
Manufacturing industry	48.1
Constructions	2.2
Commerce and Finances	45.6
Transport	37.0
Government	34.5
Other Services	43.5
Total	397.0

It is obvious that agriculture plays an important part in the economy of the country. In the past the mainstay of the economy was the mining industry, particularly the production of tin. This had the disadvantage that variations in the price of one metal had extremely deep repercussions in the economy of a whole nation. The present government of Bolivia is trying to broaden the basis of the economy. One of the ways to achieve it that is under consideration, a petro-chemical plant, would not only form a nucleus for a future chemical and plastics industry but also help to improve substantially the agricultural production upon which, more or less directly, 80 per cent of the population depend.

2. Balance of Trade and its Connexion to Agriculture

The over-all balance of trade in the years 1961 and 1962 was as follows: (1)

In Millions of Dollars	1961	1962
Exports (f.o.b.)	57.6	60.3
Imports (f.o.b.)	-75.2	-89.5
Invisibles (Monetary Transactions)	-13.3	-11.5
Balance of current account	-30.9	-40.7

As can be seen there is a need to rectify this situation, although no doubt some improvement in the situation has already occurred and is due to various factors. The details of exports and imports are given in the tables below (1)

Value of Exports In Millions of Dollars	1961	1962
Live Animals	0.1	0.1
Food and Beverages	2.4	2.5
Raw Materials	73.3	73.0
Manufactures	0.3	0.5
	76.1	76.1

/Main raw

Main raw materials		
Tin	50.5	54.0
Other Minerals	18.5	16.2
Petroleum	2.1	1.5

Details of the imports in 1960 and 1961 were as follows: (2)

	1960		1961 (First Half Only)	
	Tons	$US	Tons	$US
Cereals	81,578	6,663,000	72,412	6,585,000
Edible Oils & Lards	8,192	2,166,000	5,270	1,623,000
Vegetables & Roots	263	22,000	232	11,000
Sugar	25,815	2,284,000	11,195	1,009,000
Fruits	1,299	108,000	551	42,000
Coffee, Tea, Chocolate	309	260,000	166	153,000
Alcoholic Drinks	475	292,000	223	139,000
Meat & Eggs	164	91,000	118	58,000
Milk & Derivatives	3,823	1,588,000	2,711	992,000
Sea Foods	960	272,000	599	180,000
Spices	145	116,000	67	56,000
Other Foods	1,442	239,000	175	106,000
Vegetable Fibers	849	593,000	298	214,000
Animal Fibers	222	390,000	100	193,000
Leather, Furs, Bristles	27	62,000	5	28,000
Horses, Mules and Donkeys	556	11,000	278	11,000
Wood Products & By-products	382	90,000	679	69,000
Synthetic & Natural Fertilizers	1,343	121,000	426	48,000
Others not edible	1,227	620,000	675	307,000
Vegetable Raw Materials	772	155,000	301	60,000
Manufactured Goods	3,605	4,744,000	1,982	2,943,000

/Details of

Details of imports of food in 1959 and 1960 can be seen in the following table: (3)

	1959		1960	
	Tons	$US	Tons	$US
Canned Meat	70	34,000	56	40,000
Horses and Mules	427	9,000	386	9,000
Fresh Meat	25	23,000	34	18,000
Cattle	139	8,000	56	6,000
Fresh and Dried Vegetables	1		6	1,000
Dry Fruits	40	17,000	15	3,000
Fresh Fruits	1,670	84,000	1,233	87,000
Olives	56	9,000	43	5,000
Vegetable Oils	80	29,000	78	32,000
Powder Milk	1,371	858,000	2,129	1,221,000
Oats	113	26,000	273	41,000
Tea	113	123,000	60	65,000
Barley	816	1,317,000	102	16,000
Tallow	301	47,000	116	20,000
Canned Milk	1,903	496,000	2,250	610,000
Edible Oils	2,930	769,000	2,286	680,000
Sugar	48,082	4,278,000	25,687	2,186,000
Wheat	14,536	1,108,000		
Lard	4,854	1,191,000	5,589	1,422,000
Rice	8,565	915,000	2,340	272,000
Wheat Flour	71,902	5,134,000	38,689	2,943,000

Imports of cereals, volumes and costs in 1962 are given in the table below:(4)

	Kg Tons	$US
Wheat for flour	21,487	1,705,000
Wheat for other foods	320	37,000
Barley	1	1,000
Oats	132	14,000
Corn	1	1,000
Rice	8,240	1,306,000
Other cereals	3	
Total	30,183	3,064,000

3. Distribution of Population and Industry

The composition of the Bolivian population according to 1963 statistics was as follows: (1)

/(a) Type

(a) Type of products:

The over-all production is shown in the following table: (1)

Agricultural Products in 1962

(In Thousands of Metric Tons)

Hulled Rice		24.0
Sugar Cane		1,056.0
Potatoes		576.8
Corn		234.1
Wheat		60.5
Refined Sugar		49.3
Produced at Guabira	19.8	
La Belgica	21.0	
La Esperanza	3.4	
San Aurelio	5.1	

Details of the production showing the areas cultivated and the department in which the individual products were grown can be seen in the following table: (5)

Department	Area Hectares	Production MT/Year
La Paz		
Wheat	1,700	850
Corn	12,000	9,900
Potatoes	34,500	156,000
Rice	800	
Quinua	7,500	
Barley	33,000	12,000
Papaliza	2,500	
Ocas	4,500	
Fruit	13,000	
Other Products	23,500	
Cochabamba		
Wheat	25,000	18,000
Corn	40,000	41,000
Potatoes	20,000	100,000
Barley	16,000	10,000
Alfalfa	5,500	
Fruit	4,000	
Vegetables	8,600	

The newly developed areas around Santa Cruz are basically tropical areas with relatively big farms and the possibilities of gathering more than one crop per year. The area is not too densely populated, and the newly cultivated lands have high fertility for a limited period. The land

/will need

will need mainly nitrogen fertilizers and originally the soil is acid enough to allow use of any generally accepted kind. The availability of phosphorus is limited, and small amounts of phosphoric fertilizers will be required. The main task in this area will be the maintaining of the present fertility of the soils so that it will not be necessary to colonize new areas and abandon the fields already under cultivation.

The area of the valleys around Cochabamba is the most intensely cultivated part of Bolivia. As the climate there is between moderate and sub-tropical, there is a great variety of crops that are grown commercially. The soils are more alkaline than the soils around Santa Cruz; therefore it will be necessary to supply fertilizers of an acid nature. The main need will be nitrogen, with a limited amount of phosphorus, while it is to be expected that potassium will not be required in the near future. The areas are the most thickly populated in Bolivia, and the task will be to improve the yields of the crops and grow enough fodder to allow the farmers to increase the amount of livestock that they have.

The area of the Altiplano will offer the greatest problem in the planned improvement of agriculture. The soil will require full amounts of nitrogen and phosphorus, while the utilization of the fertilizer will be limited by the generally low temperatures in this area. The fields have been in cultivation for such long periods that the soil is exhausted and needs urgently substantial amounts of fertilizers. The prevailing crop in this area is potatoes, and the improvement in the yields would benefit the farmers. They would raise their own actual standard of living by using the potatoes as cash crop. With very high yields they would then increase the number of domestic animals to which they would feed the excess potatoes. In this area, it would also be desirable to fertilize the pasture lands because they are very exhausted. The soils in this area are very alkaline and it will be necessary to supply fertilizers of an acid nature.

The over-all impression of the potentials and the present state of agriculture in Bolivia is illustrated on the economic map of Bolivia, Appendix 1.

Population and Population Density

Total Population (In thousands)	4,122.5
Urban	1,215.0
Rural	2,907.5
Active Age	2,241.8
Other ages	1,880.7
As percentages of Total	
Urban	29.5
Active Age	54.4
Density by km^2 Total	3.6
Altiplano and Valleys	6.4
Eastern Plains	0.8

/Rate of

Rate of increase of total population 1960-63 2.5 per cent

The employment of the population was:

Industry		16,218
Mining	Comibol	26,799
	Private	8,502
Petroleum		5,103
Construction		2,386
Commerce and Private Insurance		3,858
Railroads		6,670
Public Administration		42,092
Services		8,713
Universities and Private Education		1,763
	Total	122,104

The above figures actually cover only approximately 10 per cent of the total labour force as they show only the workers covered by the social security scheme.

Approximately some 80 per cent of the population are employed in agriculture; thus the vital importance of a prosperous agriculture is necessary for a healthy national future.

4. Agricultural Economics

This summary of the original document excludes the data on the economic aspects of Bolivian agriculture.

B. GEOGRAPHY

This summary of the original document excludes the data on the geography of Bolivia.

C. TRANSPORTATION

The system of transportation in Bolivia is in a relatively early state of development, and only a limited network of roads and railways is available. As a result of the limited development of the system of transportation, its cost is rather high and creates special problems in a country that is as sparsely populated as Bolivia. The main effort at present is made to improve the system of roads. It will be necessary to co-ordinate the available means of transportation, and improve several sections of it.

The development of the system of transportation in the past was geared to the requirements of the mining centres, and the agricultural products were transported mainly by locally available means. Only the biggest cities are supplied by food from other areas. At present, some parts of the country are accessible only by air or by primitive roads

/that can

that can be travelled only in dry weather. Transportation of goods in such conditions can never be economical. It is estimated that about 60 per cent of the total of the country should be made accessible by roads to make sure that a reasonable economical exchange of products and raw materials can be maintained.

1. Railroads

The system of railroads was designed primarily to connect the mining centres and the cities of Bolivia to sea ports. Separate lines connect Bolivia with the ports of Arica and Antofagasta in Chile. The line from Arica goes to La Paz and the line from Antofagasta goes to Oruro with connexions to La Paz, Cochabamba, Mizque and Sucre. There is a railway connexion to the port of Santos in Brazil leading to Santa Cruz, and a connexion to the railway system of the Argentine, with an ultimate connexion to the ports of that country. This line connects to the line from Brazil at Santa Cruz and at Uyuni to the line from Antofagasta to Oruro. There is also a railway connexion between La Paz and the port of Guaqui on the lake of Titicaca. The details of the railway system can be seen on the two maps of the railway network in Appendix No. 9 and 10. The length of the railways in the Altiplano and in the valleys is 2,890 km. This system has been erected mainly to transport the mined metals to the ports on the Pacific Ocean. These railways also serve for the importation of the essential machinery and food to the Country from the Pacific Ocean. The railway line from the Brazilian border at Corumba to Santa Cruz is 650 km long, and the railway line from Santa Cruz to the Argentinian border at Yacuiba is 530 km long.

As there is not enough traffic on these railroads, they are operating at a loss, and because of that, they are not able to compete well enough for the transportation within Bolivia with the trucking industry. There is no doubt that the increased economic activity that would arise with higher food production in the country and the possible exportation of some products to the Argentine and to Brazil, would improve the economic position of the railways. It is, however, impossible to predict their ultimate position in the revised pattern of communications of Bolivia.

2. Roads

The system of roads (15,16) consists at present, of 3,490 km of the basic system of the roads, with an additional 2,360 km classified as complementary, and approximately 10,000 km of roads linking individual departments, provinces and counties. The development of the road system has to be planned in such a way that it would achieve the economic integration of the whole country, that it would facilitate the colonization of the areas that are newly settled, that it would facilitate the establishing of industry and make possible easy connexions between the capitals of individual departments of the country. The system must provide connexion to an international system of communications, must include the access to all old and new centres of mineral resources of the country and connect these to the cities and to the areas of agricultural production.

/It will

It will be necessary to use efficiently the organizations for the maintenance of the roads that exist. State administration, as well as the administration in the localities should operate with a planned effort. The planning of the new roads should be done in such a way that wherever there are suitable railways at present, enough stress should be laid to using this means of communications, rather than building parallel roads that would compete economically with the railways. On the other hand, maximum importance should be attached to connecting river ports with the railroad system.

The Bolivian Government, through their Ministry of National Economy, have studied the situation of the available roads, and have decided to secure the services of Tippetts, Abbett, McCarthy, Stratton (TAMS) as consultants for the future important projects in the improvement of the system of roads in Bolivia. The over-all scheme is shown on a map as Appendix No. 10 prepared by TAMS. Eight projects that are in different stages of completion are shown on this map. The improved roads included in the eight projects will have an over-all length of 1,600 to 1,700 km. They were selected with three main points of view in the minds of the designers; to integrate the economy, to develop new areas, and reduce the cost of transportation within the country. These projects would improve substantially the over-all situation in Bolivia. A good picture of the present day condition of the Bolivian network of roads can also be found on this map.

Because of the history of the development of the Bolivian economy, original importance was attached to the mining industry, and therefore the system of roads is developed mainly in the areas where mining of minerals was done in the past. The road system is deficient mainly in the low lying areas, which are of great importance in the present day agricultural development. Nearly 40 per cent of the country is, at present, without adequate road access. The main towns that are in this category are the following: Apolo, Tipuani, Teoponte, San Borja, Reyes, Riberalta, Guayaramerin, Santa Ana del Yacuma, Trinidad, San Javier, Concepcion and San Ignacio.

The incorporation of the newly colonized zones into the national economy would allow a better distribution of the population through the country. At present, 85 per cent of the population live in 30 per cent of the total area. This difficulty is increased by the fact that most of the thickly inhabited area is covered by soil of limited fertility, and with a restricted amount of rain available for cultivation of crops. The colonization of new lands will improve the standard of living of the population and increase the volume of the economic production in the whole of the country. The colonization of the new areas is fully dependent on the network of roads available. It can proceed only as fast as the construction of the access roads.

The decrease of the cost of transportation is of vital importance, mainly to those parts of the country that are at present served only by air transportation. The decrease of the cost of freight should be of the

/greatest importance

greatest importance in improving the standard of living. Next to these areas, there are those where the road construction has been done more than 30 years ago, and therefore present day trucks cannot operate on these roads economically. Either the loads are limited, or the life of the trucks is reduced by the condition of such roads and, therefore, the cost of transportation remains at a prohibitively high level.

3. Water Transport

Only a limited amount of cargo can be transported on ships to certain locations in Bolivia. There is no direct connexion between these sections and the sea. The greatest amount of shipping is made, at present, across Lake Titicaca between the Peruvian port of Puno and the Bolivian port of Guaqui. The shipping line on Lake Titicaca has been operated by a Peruvian company, and some improvement in the over-all picture is expected as a result of the Law No. 05982 of January 26, 1962, by which some national resources have been diverted for the improvement of this sector of communications.

The rivers of the Amazon Basin of Bolivia can be navigated practically over their entire length. The total length of these rivers is about 3,200 km, and forms sections of the rivers of Ichilo, Mamore, Itenez, Beni, Orton and Madre de Dios. There are, however, three waterfalls at Beni, Mamore and Madera which separate the navigable sections of the rivers. There is a primitive road connecting the ports of Guayaramerin and Riberalta. It will be necessary to provide connexions between the points separated by the waterfalls so that materials could be transferred from ship to truck and back again to ship. The tributaries of the La Plata River are not navigable at present, and there is no prospect that the Paraguay River will be made navigable outside of Bolivia in the foreseeable future.

4. Air Trasnportation

The air transportation in Bolivia has been developed to a large extent because, as has been mentioned previously, it is the only means of access to certain parts of the country. Both passengers and freight traffic contribute to the activity of the Bolivian Airlines. The Lloyd Aereo Boliviano is the only airline that flies between the individual airports in Bolivia. Only international connexions are shared by the Lloyd Aereo Boliviano with foreign companies. It will be necessary to improve both the existing airports, and build new ones, to improve the present system of transportation. The cost of this transportation however, because of its nature, is very high, and it cannot be expected that it can replace successfully other means of transportation.

/5. Economic

5. Economic Aspects of Development of the System of Transportation

The planned road projects should achieve the following: Connect La Paz to Rurrenabaque which could be developed into a very active port on the River Beni, and make accessible an important sector of North Bolivia. At present, the only access to this area is by air. The area around Reyes-San Borja can produce a substantial amount of meat for the market of La Paz, and as soon as roads are available, no doubt this industry could operate to the best advantage of the country. The present-day agriculture in Alto Beni is limited to the immediate requirements of the area. The area around Apolo has soil of very good quality, and a climate suitable for colonization by immigrants from Europe. The area north of Caranavi has, also, excellent soil. The whole area between Santa Ana and San Borja will be connected to Rurrenabaque. The reduction of the transportation costs would open up these areas to the markets of La Paz, and be of a great mutual benefit. Connexions between Quillacollo and Caihuasi will be improved. This will reduce transportation costs between Oruro and Cochabamba.

The road between Yapacani and Puerto Grether will be improved, connecting this area to Guabira, from where a good road to Santa Cruz already is provided. From Guabira, connexions to Chane and Puerto Banegas will also be constructed; this will allow the development of new agricultural areas that are required in the immediate future. As Guabira is already connected to the main network of Bolivian communications, the localities served by these roads would be immediately accessible from the main section of the country. Three hundred families have already been settled in the areas by the Corporación Boliviana de Fomento; further, 3,000 families could be settled in this area as soon as the road is finished.

Ultimately these roads should extend to San Javier and Concepcion. These two places are, at present, connected to the rest of the country only by air transportation and by tracks that are passable only in good weather. The area north of the River San Julian consists of excellent agricultural soil, and is highly suitable for colonization.

A road connexion of Cochabamba to the county of Chapare by Villa Tunari, making accessible the highly fertile soils situated between Villa Tunari and Rio Isoboro, and continuing to Puerto Villarroal, and to Puerto Guabira, will be constructed. The area around this road is suitable for agriculture. A preliminary time table indicates that the programme should be finished in 1971. Various distances by road between individual places in Bolivia are shown as a table, Appendix 12, and give details of present-day conditions of roads in various sectors of the country.

Typical costs of shipping various items within Bolivia and to seaports in other countries are shown below:

/(Information Based

(Information Based on Recent Personal Communications) (31)

Railroads	US$/Ton
Buenos Aires - Santa Cruz	
Fertilizers	26.15
Pipeline	41.53
Antofagasta - Cochabamba	
Bauxite, Aluminum Sulfate and New Tractors	25.90
Machinery in General	32.70
Steel Piping	25.80
Steel Plates	24.20
Arica - Cochabamba	
Fertilizers and Machinery in General	18.75
Mollendo - La Paz	
Machinery	24.70
Fertilizers	26.40
La Paz - Cochabamba	
Machinery in General	16.59
Potosi - Oruro	
Sulphur	11.66
Roads (by Truck)	
Santa Cruz - Cochabamba	
Oil Products	10.80
Sugar	14.70
Cochabamba - Sucre	
Oil Products	10.75
Cochabamba - Oruro	
Oil Products	9.17
Cochabamba - La Paz	
Oil Products	12.90
Santos (Brazilian Port) - Santa Cruz	60-65
Airlines (Lloyd Aéreo Boliviano)	
To any point within Bolivia:	
Less than one ton	108.00
More than one ton	58.30
International Railroads	
Mollendo - Cochabamba	28.20
Arica - Cochabamba	18.75
Antofagasta - Cochabamba	23.30

/The Port

	US$/Ton
The Port of Mollendo has an:	
Unloading Capacity	30 T.
Railroad Volume Capacity	15 x 5 x 3 Metres

The Port of Mollendo can serve Bolivia by means of a railway to the Port of Puno on the Titicaca Lake, and from there, either by road or by ship transportation to the railroad at Guaqui.

D. AGRONOMY*

1. Estimate of Fertilizer Requirement and Yield Increase

The National Secretariat of Planning and Co-ordination (Secretaría Nacional de Planificación y Coordinación) estimated the following optimum usage of fertilizers for Bolivia in 1962-1963, should these fertilizers have been available at reasonable prices.

Product	Area in Cultivation (Has)	Possible Areas for Fertilizer Usage (Has)	Application of Fertilizers in Kgs/Ha N	P_2O_5	K_2O	Total Quantity of Fertilizers in M.T. N	P_2O_5	K_2O
Potatoes	130,400	70,000	80	80	0	5,600	5,600	-
Wheat	89,400	50,000	45	45	0	2,250	2,250	-
Sugar Cane	16,000	14,000	100	0	0	1,400	-	-
Rice	26,000	20,000	100	0	0	2,000	-	-
Cotton	2,100	1,600	45	45	25	72	72	40
Pasture Land	52,000	220,000	45	45	0	9,900	9,900	-
Corn	215,400	80,000	80	80	0	6,400	6,400	-
Various	211,650	60,000	80	80	0	4,800	4,800	-
	742,950	515,600				32,422	29,022	40

It was estimated that the cultivated area will increase to 800,000 and 860,000 ha. in the agricultural years '63-'64 and '64-'65 respectively. These figures include the newly colonized areas. It is estimated that afterwards, in five to six years, the area in which fertilizers could be used would be increased by 60,000 ha. each year.

Other agencies show the following required fertilizer quantities:

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* This summary of the original document excludes data on the situation in respect of the various agricultural crops in Bolivia, and the results of tests on the effect of fertilizers on the yields of those crops.

FERTILIZERS NEEDED IN BOLIVIA (OEA, 1957)

Product	Present Production M.T.	Cultured Surface Has.	Pure nutrients: N M.T. Extr.*	N M.T. To inc.**	N M.T. Total	P_2O_5 M.T. Extr.	P_2O_5 M.T. To inc.	P_2O_5 M.T. Total	K_2O M.T. Extr.	K_2O M.T. To inc.	K_2O M.T. Total	Present yields Kg/Ha
Wheat	13 000	22 000	274	660	934	137	1 100	1 237	81	660	741	590
Corn	120 000	122 000	1 932	10 980	12 912	780	4 880	5 660	540	7 320	7 860	980
Sunflower, flax Oleagrinous	-	-	-	-	-	-	-	-	-	-	-	-
Barley, Oats, Rye	40 000	56 000	812	2 240	3 052	340	3 360	3 700	280	2 240	2 520	715
Cotton	-	-	-	-	-	-	-	-	-	-	-	-
Sugar Cane	500 000	13 000	7 400	1 820	9 220	4 000	1 495	5 495	20 000	715	20 715	38 500
Sugar Beet	-	-	-	-	-	-	-	-	-	-	-	-
Rice	23 000	15 000	796	1 125	1 921	285	600	885	465	-	465	1 530
Potatoes	170 000	115 000	544	9 200	9 744	204	16 675	16 879	969	14 375	15 344	1 480
Cassava	60 000	4 000	342	480	822	162	280	442	552	160	712	15 000
Sub-Total	926 000	347 000	12 100	26 505	38 605	5 908	28 390	34 298	22 887	25 470	48 357	
Pastures	1 015 000	11 323 000	43 017	566 150	609 167	28 744	339 690	368 434	4 059	452 920	456 979	
Total	1 941 000	11 670 000	55 117	592 655	647 772	34 652	368 080	402 732	26 946	478 390	505 336	

* Extracted.

** To incorporate.

FERTILIZERS NEEDED IN BOLIVIA (SAI, 1959)

Product	Present Production M.T./Year	Cultivated Surface Has	Recommended			Pure nutrients			Total Pure Fert. Needed M.T./Year	Type of Fert.	Present Yields Kg/Ha
			Needed Produc. M.T./Year	Needed Surface to Fert. Has.	Deficit of Produc. M.T./Year	N M.T.Y To inc.*	P_2O_5 M.T.Y To inc.	K_2O M.T.Y To inc.			
Wheat	64 000	92 700	134 000	60 000	70 000	2 700	2 700	-	5 400	45-45-0	690
Corn	-	216 300	-	10 000	-	800	800	-	1 600	80-80-0	-
Cotton	450	1 800	2 354	10 000	1 904	450	450	250	1 150	45-45-25	250
Sugar Cane	250 000	19 500	550 000	20 000	300 000	900	-	-	900	45-0-0	1 800
Rice	18 000	18 000	25 000	20 000	7 000	900	-	-	900	45-0-0	1 000
Potatoes	674 000	112 400	1 000 000	80 000	400 000	6 400	6 400	-	12 800	80-80-0	6 000
Others	-	100 000	-	5 000	-	400	400	-	800	80-80-0	-
Sub-Total	1 007 070	560 700	1 711 354	205 000	778 904	12 550	10 750	250	23 550		
Pastures	-	-	-	200 000	-	9 000	9 000	-	-	45-45-0	
Total	1 007 070	560 700**	1 711 354	405 000	778 904	21 550	19 750	250	23 550		

* To incorporate.

** Without pastures.

FERTILIZERS NEEDED IN BOLIVIA (FAO, 1963 TO 1971)

Product	Needed Production M.T.	Needed Surface Has	Approx. per cent of total area	N M.T. Total Kg/Ha	N M.T. Total Needed	P M.T. Total Kg/Ha	P M.T. Total Needed	K M.T. Total Kg/Ha	K M.T. Total Needed	Yield Kg/Ha
Wheat	175 000	175 000	17.50	71	12 425	36	6 300	60	10 500	1 000
Corn	393 000	262 000	26.50	128	33 536	48	12 576	140	36 680	1 500
Sunflower	21 000	70 000	7.00	130	9 100	55	3 850	210	14 700	300
Cotton	16 950	11 300	1.13	84	949	34	384	87	983	1 500
Sugar Cane	1 375 000	25 000	2.50	85	2 195	60	1 500	190	4 750	55 000
Rice	72 900	48 600	4.86	65	3 159	20	972	75	3 645	1 500
Potatoes	745 000	106 500	10.65	103	10 969	47	5 005	211	22 471	7 000
Beans, Vegetables	-	95 000	9.50	250	23 750	90	8 550	300	28 500	-
Onions, Citrus Fruit	-	80 000	8.00	105	8 400	22	1 760	145	11 600	-
Bananas	600 000	20 000	2.00	63	1 260	16	320	207	4 140	30 000
Coffee	9 970	17 500	1.75	30	525	6	105	45	787	570
Cacao	1 400	2 800	0.28	14	39	8	22	12	33	500
Others (10 per cent)	-	91 300	8.70	100	9 130	50	4 565	50	4 565	-
Sub-Total	3 410 720	1 004 200	100.00		115 357		45 909		143 354	
Pastures	-	-	-	-	-	-	-	-	-	
Total	3 410.720	1 004 200	100.00		115 357		45 909		143 354	

/PRESENT CONSUMPTION

PRESENT CONSUMPTION OF FERTILIZERS IN BOLIVIA AND OTHER COUNTRIES

Country	"Tilling" lands Has	Nutrient consumption in M.T.			Nutrient consumption Kg/Ha		
		N	P205	K20	N	P205	K20
Bolivia (SAI EST)	560 000	225	200	50	0.4	0.36	0.09
Argentina	30 000 000	8 805	3 319	2 276	0.29	0.13	0.08
Brasil	19 095 000	30 000	73 000	59 000	1.72	3.83	3.09
Paraguay	517 000	10	10	10	0.02	0.02	0.02
Peru	1 730 000	62 500	33 000	5 800	36.13	19.36	3.35
Chile	5 516 000	10 000	40 000	6 500	1.81	7.25	1.19
Uruguay	2 244 000	3 000	7 000	3 000	1.33	3.12	1.33
United States	188 309 000	2 183 309	2 100 000	1 979 000	11.59	11.15	10.51
Mexico	19 928 000	75 000	40 000	5 300	3.76	2.00	0.27
Japan	5 048 000	609 500	358 500	423 600	120.02	71.02	83.91

/It is

It is obvious from the statistics shown above that the fertilizer consumption in South American countries is limited. The establishing of a cheap fertilizer source in Bolivia would be a great stimulus to the agriculture of the country. Even a modest amount of fertilizers would improve the yields substantially, but it would be necessary to produce the fertilizers at a price that would allow them to be paid for out of the improved income of the farmers.

E. FERTILIZER RAW MATERIALS

1. Natural Gas

The production of Nitrogen fertilizers will be based on natural gas, which is available in the vicinity of Santa Cruz. The gas will be purchased from the Bolivian Gulf Oil Company, and will, most probably, come from the Caranda Field.

Economic utilization of the natural gas available in the vicinity of Santa Cruz has been described in two YPFB reports. (22,23) Three approaches to the usage of the gas were considered: power generation with a fertilizer plant, petrochemical plant, and a generator only. The gas from the Colpa field has a high content of methane and a relatively high content of hydrocarbons above C_4, and could be very easily used for liquification of the higher hydrocarbons and usage of the lowest components in the production of ammonia.

A list of various analyses of the gas has been sent to YPFB by the Gulf Oil Company on March 16th, 1964 with methane ranging between 61.36 and 85.4 per cent. It is not yet certain whether this gas will be delivered to the YPFB at the Caranda field, or in Santa Cruz, and it is not yet certain what the available pressure of the gas will be. It is not certain yet at what date, at what price, at what conditions, and in what amount, this gas will be available.

2. Sulphur

It is found (24) in practically limitless amounts in the area of Potosi about 300 miles from Santa Cruz. It is found as 97-98 per cent S and is available refined as 99.6 per cent S free of As and Se. At present it is exported to Chile by truck or rail and sold at $25/ton FOB Bolivian border town of Ollaque. (25) Most of the mines are privately owned and

/operated at

operated at a limited scale. (26) Supply of sulphur to plant at any possible location in Bolivia would present no problems.

3. Phosphate Rock

There are no known deposits of Phosphate Rock of a grade normally used for the manufacturing of commercial fertilizers. (24,25,26) There are deposits of Phosphate containing minerals near Oruro, but they contain only 4.25 to 8.3 per cent of P_2O_5 and are unsuitable for fertilizer production. The shipping costs of Rock are mentioned in paragraph C_5, Page 36 and would be about $24/ton to Cochabamba with another $10 to Santa Cruz. This makes the P_2O_5 fertilizer component an extremely expensive one. There is a possibility that some 20-30 TPD of Rock containing 20-25 per cent of P_2O_5 could be found near Potosi. Extensive Geological study of the area is under way at present. (24)

4. Electrical Power

There is no power generation in Bolivia that would be important enough to allow the connexion of an industrial plant to a network. A complete power generation system must be included in every new plant. Natural gas or oil are the possible fuels.

5. Water Resources

The rivers in the vicinities of any possible plant location that may be selected for the production of fertilizers are not big enough to provide enough water for a once through cooling system. Water cooling towers with wells to replace the losses of evaporation must be incorporated in the design of all the plants.

F. EXPLOSIVES REQUIREMENTS

Use of Ammonium Nitrate for Explosives

Prilled Ammonium Nitrate can be used successfully in a mixture with fuel oil as an explosive when it is initiated by a suitable primer. The usual composition of an explosive mixture is 94.2 per cent of ammonium nitrate and 5.8 per cent of fuel oil. It is important to produce the ammonium nitrate prills in such a way that they would absorb the correct amount of oil.

/The regulation

The regulation of the physical properties of the prills is made by the concentration of the solution entering the prilling tower, by the falling height and cooling during solidification of the droplets, and by regulating the pH of the solution entering the prilling tower. It is also necessary to dry the prills in the correct way, and make sure that the fines are eliminated from the final product. The coating agent has to be of a suitable grade to allow the propagation of the explosion wave through the nitrate.

Ammonium Nitrate Explosives can be prepared either in the factory, or at the ultimate place of usage by mixing the prills with fuel oil and enclosing them in a suitable container. It is probable that the greatest part of the Ammonium Nitrate used for explosives will be mixed by the large mines on site and blown directly into the bore holes, but a certain market, no doubt, will exist for the explosive in the form of a finished product suitable for use with a blasting cap and a primer. The mixing with oil and filling of containers has been described extensively in literature, and is well known. The actual operation will be described in this report, in a section concerning the production of Ammonium Nitrate. Table included as Appendix 13 shows the importation of explosives into Bolivia in years 1950-1961. As there is no production of explosives at present, these figures show, at the same time, the approximate consumption in the country. According to the information received from various employees of the Comibol Company, and found in literature, approximately 80 per cent of the amounts of imported dynamite could be replaced by explosives based on Ammonium Nitrate. The following table shows the figures for importation of explosives in 1952-1963 (28) with details for 1962 and 1963.

Year	Tons	U. S. $
1952	2,817	1,316,000
1953	3,082	1,123,000
1954	3,153	1,229,000
1955	2,013	793,000
1956	1,658	724,000
1957	3,353	1,318,000
1958	4,087	1,605,000
1959	3,485	1,413,000
1960	5,163	1,867,000
1961	4,300	1,580,000
1962	6,438	2,278,000
First Semester 1963	2,227	740,000

Road construction is expected to require 7,200 tons in the 6 years beginning with 1965. Apart from the mines and roads, there will be some additional amounts of explosives used in other construction fields. It seems, therefore, that some 6,000 tons of Ammonium Nitrate will be required for use in explosives as soon as the product becomes available. There will be no necessity of developing a market, as will be the case in marketing of fertilizers.

/It is

It is also probable that certain amounts of ammonium nitrate for use in explosives could be sold in the north of Argentina and Chile to the mines that are located reasonably near the future plant of YPFB. This amount may be quite substantial under favourable circumstances, and even exceed domestic requirements for the explosive. This possible market will be considered in the plant design, so that, should it be possible to develop it commercially, it will be possible to produce the required amounts of ammonium nitrate in the proposed plant.

G. PROSPECTS OF FERTILIZER PRODUCTION

The preceding sections of this report indicate that a definite demand for the application of fertilizers will exist once the industry is established in Bolivia.

As, however, a lot of work was done in the past by many different agencies utilizing various sources of information, several desirable levels of the production of fertilizers were mentioned. All reports, however, fully agree upon the necessity of producing fertilizers in Bolivia. In this report, an attempt is made to summarize the recommendations of the various agencies, and suggest a production level that seems most desirable at present day conditions.

To determine the minimum requirement of fertilizer for the original one or two years, we have used the data included in a table prepared by the National Secretariat of Planning and Co-ordination. According to our interpretation of data and conditions, we feel that this table should be modified as follows:

	Area Suitable for Fert'g Ha	MWK Estimated Factor for 1st Year Application	Estimated Hectares Fertilized	TYP of "N" Using 50 Kg/Ha
Potatoes	70;000	.5	35;000	1;750
Wheat	50,000	.5	25,000	1,250
Sugar Cane	14;000	1.0	14,000	700
Rice	20;000	1.0	20;000	1,000
Cotton	1;600	1.0	1;600	80
Corn	80,000	.4	32,000	1,600
Fruit, Vegetable and Various	60;000	.4	24;000	1;200
Subtotal	295;600		151;600	7,580
Pastures	220;000	.04	8;400	420
Total	515,600		160,000	8,000

A table prepared by SAI in 1955 for the nitrogen requirements and cited above shows a total consumption of 21,550 tons per year of nitrogen. This figure should probably be reduced by one half of the amount that has

/been included

been included for the requirement of fertilizing pasture lands as the full amount required for this purpose will no doubt be used only at a relatively late date, and therefore the corrected amount of nitrogen required would be 17,050 TPY. The estimated requirements of fertilizers by FAO cited on Page 31 of this report indicated a total amount of 115,000 TPY that may be decreased in the following manner:

Wheat	50 per cent	6,200	TPY "N"
Corn	50 per cent	16,200	TPY "N"
Cotton	100 per cent	900	TPY "N"
Sunflower	20 per cent	2,000	TPY "N"
Sugar Cane	100 per cent	2,200	TPY "N"
Rice	50 per cent	1,600	TPY "N"
Potatoes	50 per cent	5,500	TPY "N"
Vegetables	20 per cent	4,500	TPY "N"
Fruit	20 per cent	1,200	TPY "N"
Miscellaneous	10 per cent	1,000	TPY "N"
Total		41,100	

This probably is as high an estimate as need be considered for the next 10 years. The amounts of fertilizers shown by the FAO will be reached at a period which is beyond the scope of the present study.

For the period following immediately the initial period the information gathered from various sources listed previously could be summarized in the following table, showing the amounts of nitrogen required yearly.

	OEA	SAI	FAO	MWK
Wheat	660	4,170	12,420	3,000
Corn	10,980	17,300	33,540	9,000
Sunflower			9,100	
Barley	2,240			1,000
Cotton		450	1,180	500
Sugar Cane	1,820	870	2,120	2,000
Rice	1,120	810	3,160	1,100
Potatoes	9,200	8,990	10,970	9,000
Vegetables	280		2,380	200
Fruit			970	200
Coffee & Cocoa			560	100
Various		8,000	9,130	1,600
Total	26,300	40,590	85,530	27,700

Nitrogen consumption is considered to be primary in this report because natural gas is a raw material available in Bolivia, while phosphate rock has to be imported. However, the situation of the phosphate rock has not been fully clarified, and should a discovery of phosphate rock be made

/in Bolivia

in Bolivia a complete change in the economic picture of the fertilizer production would occur. For the time being, it must be assumed that it will be necessary to import the rock, and therefore minimize the requirements of P_2O_5. The requirements of this fertilizer component may be presented as follows:

	SAI	MWK Estimate 1st Year	MWK Estimate 3rd Year
Wheat	2,700	1,250	1,500
Corn	800	800	4,500
Cotton	450	450	500
Potatoes	6,400	1,750	4,500
Others	400	350	2,100
	10,750	4,600	13,100

The tables shown were used as a basis for the selection of the fertilizer requirements that should be provided by the new plant. There seems very little doubt that at least 6,000 tons per year of ammonium nitrate will be required for use in explosives; it is not probable that the rate of consumption in Bolivia will change drastically; it is, however, possible that exports of explosives to one of the neighbouring countries could have a far reaching influence upon the production of ammonium nitrate. The quantity of nitrogen corresponding to the 6,000 tons of ammonium nitrate is 2,100 tons.

As a result of the facts described above it is recommended that the plant that will be erected should be capable of producing 20,000 to 30,000 TPY of "N". The corresponding amounts of P_2O_5 are 9,000 and 15,000 TPY, respectively. The relatively low figures for P_2O_5 are used because of the high price of the imported rock caused by the expensive shipping from the seaport to the plant site.

It probably is not advisable to produce urea at this stage, because ammonium nitrate is needed for explosives and thus offers an outlet that is of a stable nature and ready to absorb the product as soon as it is available. Urea has the advantage that it contains a higher amount of nitrogen (46 per cent) which is of great importance in a country with high costs of transportation; further there is no doubt that some of the nitrate nitrogen will be leached out by rain before it can be used by the crops. However, the above advantages of urea do not justify production at this stage because only a very small quantity could be produced; as the products will have to be in solid form the cost of the installation would be too high. Too small a size of a production plant increases the cost of the product too much. Should, at a later date, an expansion of the plant be considered, the question of urea should be reexamined at that stage.

The possibility of producing a 20-20-0 fertilizer by reacting the rock with nitric acid was considered. The fertilizers produced in this way require an acid soil and there is every reason to believe that they would

/not be

not be suitable for Bolivian conditions; with this fertilizer a substantial amount of P_2O_5 could be unused and because of the high price of this component and the necessity of importing the rock, it seems imperative to make sure that all of it will be available immediately to the crops.

The bulk of the fertilizers should be produced in granulated form with substantially all the P_2O_5 present in soluble form. The analysis of the products could be for instance 30-15-0, 31.5-10.5-0, 26-26-0, and 21-42-0. The production of the individual components could be varied according to market requirements in respective areas of the country.

The requirement for high P_2O_5 contents could be taken care of by the 21-42-0 product, while the areas requiring nitrogen only could be supplied with ammonium nitrate. The production facilities would consist of ammonia, nitric acid, ammonium nitrate, sulphuric acid, phosphoric acid, and a granulation plant.

It would also be possible to produce a fertilizer with a 19-9-0 analysis; in this case superphosphate would be supplied when P_2O_5 only would be needed; for the areas requiring nitrogen only, ammonium nitrate would be available. The advantage of this scheme is that low priced ammonium nitrate could be produced. Granulated fertilizer with other analysis than the 19-9-0 could be supplied by varying the amounts of ammonium nitrate and superphosphate introduced into the granulation equipment. The production facilities would consist of ammonia, nitric acid, ammonium nitrate, sulphuric acid, superphosphate and a granulation plant. The advantage of the first scheme is a high nutrients concentration in the end product; the second scheme has a lower investment and operating cost.

It would, of course, be possible to sell, should there be a demand, any of the intermediate products.

The size of the plant will have to be selected according to the possibility of marketing the fertilizers in the initial stages of production. It should be realized that the bigger the production, the cheaper the final product. It is probable that the future cost of fertilizers would be less than half of the present one once the production has been fully established. The farmers would be able to buy it out of the improved yields of their farms. The successful establishing of the fertilizer industry followed by increased farm production would bring the maximum benefit in the overall economic situation of the country.

VIII - IV. CONCLUSION

The Bolivian economy depends on agriculture, not only because approximately 1/3 of the net national product is derived from it, but mainly because as far as the employment situation is concerned some 80 per cent of the population depend upon agriculture. Therefore, it is easy to see that benefits of utmost importance could be derived even from a small increase in the farm income. In spite of the high ratio of population active in agriculture, it is still necessary to import some cereals and other foods. Eliminating these imports would improve the balance of trade and benefit the overall national economy. Even a moderate application of fertilizers would assure far reaching economic advantages for the whole country. As a result of the geography of Bolivia agronomical conditions and crops vary markedly between well defined regions. However, the agricultural nutrients do not differ markedly; hence the selection of the production facilities is relatively straightforward. Cultivated soil is everywhere very poor in nitrogen; only in a few places is there enough phosphorus; however, everywhere enough potassium is available, so that at the present time this element need not be supplied.

Availability of fertilizers is however not the only factor required to bring an overall prosperity to agriculture. Water supply must be assured, education of farmers realized, transportation be available to allow easy marketing of the products, and credits forthcoming to provide the initial impetus for the increased productivity.

Of the raw materials required in the production of fertilizers, two are found in abundance: natural gas and sulfur. Natural gas fields are located in the vicinity of the city of Santa Cruz. No pipe line for the gas exists. Sulfur is found in the department of Potosi near the Chilean border. The grades and amounts of phosphate containing minerals in the area between the town of Oruro and Potosi are under investigation. It is possible that some commercially valuable deposits may be discovered; the grade may be such that a definite process to utilize it would offer overwhelming advantages. As at present no information on this subject is available, use of imported high grade rock was assumed in this study.

At present only very small amounts of fertilizers are used, mainly for the cotton and sugar cane fields near Santa Cruz. Whenever subsidized fertilizer distribution was made by USAID at about 50 per cent of the present day fertilizer cost, all the offered fertilizer was quickly purchased by the farmers, and used. The area around Cochabamba is highly developed agriculturally, but most farms are of a very small size. Because of the climate, very good response to fertilizers should be obtained. As means of transportation are relatively good, it should be easy to supply the local farmers with fertilizers from any acceptable location of the future fertilizer plant.

/The area

The area of Santa Cruz is the centre of the development programme. To avoid depletion of the land, newly colonized areas will require fertilizing. As a result of the colonization scheme, distribution of fertilizers should be easy. This area also contains the relatively big farms, where the farmers will be anxious to buy reasonably priced fertilizers. The area can be reached easily from Cochabamba, and is close to the natural gas wells.

The soil in the Altiplano has been depleted extensively by many centuries of cultivation. There is frequent occurrence of soil erosion. The farms are small, the climate cold, irrigation schemes limited. The pasture land is in very poor condition and needs urgently good supply of nitrogen fertilizers. Only limited response can however be expected as a result of the climate; at the same time, the urgency to stop soil erosion and improve the standard of living of the farmers should be considered strong motives to provide domestic fertilizers at a very early date. The area is not connected directly to Santa Cruz by railway. Therefore, locating the plant further west than Santa Cruz would make the shipping cheaper.

To satisfy the immediate need for fertilizers as described in detail in Chapter III with references to original sources, the following amounts of basic nutrients should be available:

	Nitrogen	Phosphorus Pentoxide	Granulated complete fertilizers (excluding explosives)	
	TPY	TPY	TPY	TPD
1st year	8,000	4,000	27,000	80
2nd year	20,000	9,000	55,000	160
5th year	30,000	15,000	85,000	240

As also was discussed previously, the immediate need for fertilizers will not be the same in all parts of the country but will be influenced by local conditions, such as the kind of crops cultivated, cost of transportation, size of the farms and availability of agricultural credits. Therefore, the following consumption by regions may be expected (as shown in Appendix 14):

Year	1st	3rd	5th
La Paz	10	12	14
Potosi	10	12	16
Oruro	3	3	3
Chuquisaca & Tarija	20	20	19
Cochabamba	28	26	24
Santa Cruz	29	27	24
Total	100	100	100

/The type

The type of fertilizer that we believe is best suited for the local conditions is a high strength granulated product. Two typical schemes are proposed one with a 30-15-0 main product, the other one with a 19-9-0 product. The first scheme allows not only the production of the 30-15-0 grade with the ratio of $N:P_2O_5$ of 2:1 but of other grades as well. The 2:1 ratio is the best suited ratio in the overall application in Bolivian conditions. There will, however, be certain crops where other ratios will be needed. The plant is flexible and the ratio can be easily varied from 3:1 to 1:2. In the last case the product would be a 21-42-0 fertilizer. It would be used in such applications where high amounts of P_2O_5 are required, but not too much nitrogen.

In the second scheme the main product with the 19-9-0 analysis is again at the approximate 2:1 N to P_2O_5 ratio. Here for higher N to P_2O_5 ratios, ammonium nitrate would be added to the main product. Where more P_2O_5 and less N is needed, superphosphate would be used beside the main product. Superphosphate contains P_2O_5 only and can be described as a 0-20-0 fertilizer. Here again, by combining the three products, granulated 19-9-0, superphosphate and ammonium nitrate, all possible ratios of application of N and P_2O_5 can be made, allowing a complete flexibility. Because the soils have generally a high alkalinity, rock decomposition by nitric acid to obtain a 20-20-0 type fertilizer is not recommended.

The requirements of nitrogen are too low to allow a parallel production of urea and ammonium nitrate; as prilled ammonium nitrate must be produced to supply the needs of the mining industry for explosives, the selection of ammonium nitrate as the desired product seems imperative.

The location of the plant could be chosen near any one of the main communication centers of Bolivia and a study of the costs of transportation of raw materials and products was made for plant locations at La Paz, Potosi, Oruro, Sucre, Cochabamba, and Santa Cruz. Of all the locations considered, two are most attractive. One is to locate the complete production facilities at Santa Cruz. The advantage of having a centralized plant is quite obvious. On the other hand, there would be the necessity to transfer the phosphate rock from railway cars to trucks at some point, to reach the production facilities. Also, practically all the shipping of the produced fertilizers would have to be made by road. The second solution is to produce ammonia at Santa Cruz, ship it by truck to Cochabamba and make all the other products there. Phosphate rock could go by rail to the plant, and fertilizers to many destinations could also be shipped in the same way. Currently available figures were used in estimating the respective costs; details are shown in the Appendix clearly demonstrating the advantages. As it seems probable that the final pattern of fertilizer consumption will cover the whole of the country, it is advisable to locate the fertilizer plant so that all means of transportation would be used in its exploitation.

/It does

It does not appear economical to build a natural gas pipeline to Cochabamba, or any other of the places mentioned above.

A well defined market for 6,000 TPY of ammonium nitrate, to be used in the preparation of explosives, seems to be assured.

Long term expansion possibilities indicate a steady growth of local requirements of fertilizers, with the possibilities of reaching 200 TPD of ammonia production at a not too distant date. In the first expansion step, urea production should be evaluated. It may be possible to develop an export market for fertilizers and explosives in some areas of neighbouring countries and thus further expand the production.

The cost factors used for the evaluation of plant location are shown in the Appendix.

VIII - V. RECOMMENDATIONS

The study of the Bolivian conditions indicates that there is a definite need of domestically produced fertilizers, and therefore, it is adviseable that the plant for fertilizer production be erected as soon as practically feasible.

This plant should be based upon the utilization of the natural gas available in the area of Santa Cruz. This will allow substantial upgrading of this domestic raw material and will increase considerably the value of the national economic production. Therefore, Phases II and III of the present study should be completed and the following variations of possible plants should be considered:

Products: Granulated 30-15-0 fertilizer based on producing phosphoric acid as an intermediate product or granulated 19-9-0 fertilizer with the production of superphosphate.

Capacities: 20,000 TPY of nitrogen with 9,000 TPY of phosphorus pentoxide or 30,000 TPY of nitrogen with 15,000 TPY of phosphorus pentoxide.

Location: All production at or near Santa Cruz, or NH_3 production at or near Santa Cruz, with other facilities at Cochabamba.

Explosives: Product: ammonium nitrate or mixtures with fuel oil.
Capacity: 6,000 tons per year
Location: At the facilities for ammonium nitrate or at or near Oruro.

/While the

While the work on the study will be in progress, it would be advisable that Y.P.F.B. continue the study of marketing and distribution possibilities so that any changes that might occur during the preparation of the study could be considered in the final presentation of the report.

The success of the production of fertilizers is tied intimately to parallel development of means of transportation, credit availability, education and training of farmers, and development of markets for agricultural products.

/APPENDIX

APPEMDIX

Basis for calculating optimum plant location:

Cost of shipping one ton of material.

To	From	U.S.$/ton
La Paz	Mollendo	25
	Cochabamba	12
Potosi	Oruro	11
Oruro	Cochabamba	9
Sucre	Cochabamba	10
Cochabamba	Antofagasta	23
	Arica	24
	Mollendo	28
	Santa Cruz	10
Santa Cruz	Buenos Aires	40

Local shipping U.S.$ 4/ton

Raw materials shipped:	Phosphate rock	46,000 TPY
	Sulphur	14,000 TPY
	Fertilizers	85,000 TPY
	Ammonia	40,000 TPY

Fertilizers used in individual areas:

La Paz	14 per cent	TPY at 85,000 Total	11,900
Potosi	16 per cent		13,600
Oruro	3 per cent		2,600
Chuquisaca & Tarija	19 per cent		16,100
Cochabamba	24 per cent		20,400
Santa Cruz	24 per cent		20,400

As explained on page 2 of this Appendix.

Cost of pipeline estimated at U.S.$ 30,000/Mile.

These costs do not include the cost of building a gas pipeline. Neither do they include any handling within the plant.

This table has been computed from the information covering the production of individual crops in various departments (5) and from the table of the expected fertilizer requirement shown on page 26.

/The figures

The figures shown indicate the percentage of the crop shown in the department.

Crop	Department					
	La Paz	Potosi	Oruro	Chuquisaca & Tarija	Cocha-bamba	Santa Cruz
Wheat	2	40		20	30	8
Corn	5	13		38	18	26
Barley	18	51	7	10	14	-
Cotton						100
Sugar Cane						100
Rice						100
Potatoes	30	30	8	12	20	-
Vegetables & Pastures	28	12	6	15	20	19
Fruit	-	-	-	25	25	50
Coffee	-	-	-	-	-	100

These figures would indicate the following percentages of nitrogen fertilizers.

La Paz	14 per cent
Potosi	20 per cent
Oruro	3 per cent
Chuquisaca & Tarija	19 per cent
Cochabamba	24 per cent
Santa Cruz	20 per cent

These figures were adjusted slightly to values shown above to include marketing and other influences.

Yearly shipping costs were computed as follows:

Tons Shipped	La Paz	Potosi	Oruro	Sucre	Cocha-bamba	Santa Cruz
11,900	48,000	120,000	120,000	120,000	144,000	192,000
13,600	136,000	54,000	136,000	136,000	136,000	218,000
2,600	31,000	24,000	10,000	24,000	29,000	42,000
16,100	193,000	193,000	161,000	97,000	193,000	258,000
20,400	245,000	204,000	245,000	245,000	82,000	204,000
20,400	326,000	286,000	326,000	326,000	204,000	82,000
46,000	920,000	1,104,000	1,104,000	1,104,000	1,058,000	1,518,000
14,000	168,000	168,000	112,000	168,000	168,000	224,000
40,000	800,000	800,000	800,000	800,000	400,000	-
	$ 2,867,000	2,953,000	3,014,000	3,020,000	2,414,000	2,738,000

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