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FERTILIZER MIXING PLANT FEASIBILITY STUDY

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by

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ABBREVIATIONS USED IN THIS REPORT

FERTILIZER FORMULAS

AS .....Ammonium Sulfate
DAP .....Diammonium Phosphate
GTSP ..Granular Triple Superphosphate
KCl .....Potassium Chloride
MAP .....Monoammonium Phosphate
TSP .....Triple Superphosphate

MEASURES

ha .....hectare (2.47 acres)
kg .....kilogram (1 pound = 0.454 kg)
km .....kilometer (1 mile = 1.61 km)
mg .....milligram
mt ..metric ton (2,204 pounds = 1,000 kg)
% .....percent
tdwt.....total dead weight tons

ECONOMIC AND MONETARY

$b .....Bolivian pesos
c.i.f. ..cost, insurance, and freight
ROI.....Return on Investment
CR .....Brazilian cruzeiros
f.o.b. .....free on board

LIST OF ORGANIZATIONS

AADAA .....Administracion de Aduanas
ASAR ..... Asociacion de Servicios Artesanales y Rurales
BAB .....Bolivian Agricultural Bank
CATIE .....Centro Agronomico Tropical de Investigacion y Ensenanza
CEPAL .....Comision Economica Para America Latina
CIAT .....International Center of Tropical Agriculture
CID .....Consortium for International Development
CROFOC .....Rotating Credit for the Development of Small Farmer Organizations
DPG .....Davy Powergas
ENAF .....Empresa Nacional de Fundiciones
ENAFER .....Empresa Nacional de Ferrocarriles de Bolivia
FAO .....Food and Agriculture Organization
GEOBOL .....Servico Geologico Boliviano
GOB .....Government of Bolivia
IBTA .....Instituto Boliviano Technologia Agropecuaria
IDB .....Interamerican Development Bank
IFDC .....International Fertilizer Development Center
INALCO .....Instituto Nacional de Cooperativas
MACA .....Ministerio de Asuntos Campesinos y Agropecuarios
MICT .....Ministerio de Industria, Comercio y Turismo
NFDC .....National Fertilizer Development Center
RTZ .....Rio Tinto Zinc
SAC .....Servicio Agricola Comercial
SNC .....Servicio Nacional de Carreteras
SNDC .....Servicio Nacional de Desarrollo de Comunidades
TVA .....Tennessee Valley Authority
UNESCO .....United Nations' Educational, Scientific, and Cultural Organization
UNIDO .....United Nations Industrial Development Organization
USAID .....U.S. Agency for International Development
YPFB .....Yacimientos Petroliferos Fiscales Bolivianos

FERTILIZER MIXING PLANT FEASIBILITY STUDY

RECOMMENDATIONS FOR BOLIVIA

Acknowledgment

The IFDC study team would like to thank Ing. Gover Barja, Director General of MACA, the USAID/Bolivia staff, especially Lic. Isaac Torrico, and the CID staff and field men for their assistance in collecting data and discussing problems pertaining to the Bolivian campesino and his needs.

Conclusions and Recommendations

Conclusions

Based on visits with the Bolivian campesinos, dialogue with the leaders of the business and agricultural communities, and the available literature concerning the fertilizer situation, the IFDC study team perceives the situation in Bolivia as follows:

1. The Bolivian campesino is relatively well versed in the use of fertilizers and in the economic returns which accompany fertilizer use. The potato growers in the altiplano and Cochabamba areas are rather sophisticated in their approach to crop fertilization. They indicated almost unanimously that they would use more fertilizer if the preferred material (DAP) were available.

2. The high price of fertilizers in Bolivia is not predominantly the result of low usage as has been previously stated. The high price appears to be due to several factors:

   a. Policies of the dealers,
   b. Imbalance of supply and demand,
   c. No integrated government programs concerning fertilizer,
   d. No government control over the importation of fertilizers by established dealers, and
   e. Lack of preferential treatment for fertilizer imports.

3. The overriding hindrances to increased fertilizer use are the lack of supply of the proper material when it is required by the farmers and the high prices charged for fertilizers.

4. Numerous actions can be taken to immediately decrease fertilizer costs to the farmer. In the short term the most important of these deals with the application of money-saving business tactics and negotiation methods when importing fertilizers. The immediate effect would be decreases which could be as high as US $140/mt for fertilizers delivered to the Bolivian campesino. This reduction would represent a savings of about 35% over the dealers' quoted price of US $400/mt for DAP.

5. In addition to short-term considerations, actions need to be taken which will render long-term, far-reaching benefits to the Bolivian farming community. These actions would include the initiation of an integrated agricultural program to be developed and administered by a central committee or agency.

6. The situation in Bolivia is such that, with immediate savings apparently realizable through direct fertilizer importation by organizations other than the established dealers, the economic volume for bulk blending becomes so low that blending could be started from the outset.

7. Short-term government programs providing agricultural credit and/or subsidies to farmers for fertilizer use would improve the economic situation of the small farmer. The subsidy could be in the form of support prices for commodities which the farmer sells.

Recommendations

The IFDC recommendations center about a six-phase program which moves from import of bagged materials into a mixed system of bulk handling, blending, and bagging with future incorporation of indigenously produced fertilizers. This approach is not unlike recommendations made for early development of local fertilizer industries in other countries (29, 45). One overriding consideration in this instance is the use of good business practices in tendering for fertilizers.

The program recommended by IFDC consists of these six phases:

1. Phase I provides for the import by cooperatives of only high-analysis "straight" materials in bags in the maximum quantities possible to serve the Bolivian market. Benefits result here from the use of purchase procedures which will reduce cost, as well as from the potential for lower markups by the cooperatives.

2. Phase II is the initiation of the import of phosphate materials in bulk for in-country bagging; urea would be purchased as bagged material.

3. Phase III consists of total conversion to a bulk-handling and bagging system for all materials and the initiation of blending operations. The material will be handled in bulk only from the port to the blending unit. Blended materials will be transported in bags to the use areas.

4. Phase IV involves the utilization of materials produced in country--urea from YPFB and phosphates from RTZ.

5. Phase V represents the expansion of blending facilities by placing additional units in high-use areas.

6. Phase VI involves incorporating locally produced potassic materials.

The implementation of these recommendations could lower the price of the fertilizer to the final user and result in increased fertilizer consumption in Bolivia. If supported and carried out through the integrated cooperative system, the resultant fertilizer use should increase by a minimum of 15% per year.

Introduction

Background of Study

In August 1978, USAID/Bolivia requested that IFDC prepare a feasibility study for a fertilizer mixing plant(s) in Bolivia. Emphasis, as requested by USAID/Washington, was to be placed on analysis of existing and potential demand for fertilizer among small farmers.

In 1970, the National Fertilizer Development Center (NFDC) of the Tennessee Valley Authority (TVA), Muscle Shoals, Alabama, prepared for USAID a report entitled "A Fertilizer Program for Bolivia." Numerous studies for large and broad-based projects incorporating fertilizers have been carried out and presented to the Bolivian government for consideration. Until mid-1978 no projects had been initiated for installation of fertilizer plants of any type or size in Bolivia. Since no action had been taken on any of the recommendations or projects since 1969, USAID/Bolivia requested assistance from IFDC in solving some of the problems of declining fertilizer usage and increasing fertilizer prices. Any agricultural programs involving rural development projects with inputs of fertilizer were almost impossible to justify economically due to the extremely high cost of the fertilizer inputs to these programs.

Objective

The objective of this study as outlined by USAID was to prepare a report on the technical feasibility of fertilizer bulk-blending facilities in Bolivia. After considering the present situation within this country, the IFDC study team expanded this objective to include the exploration of other alternatives for reducing the price of fertilizers.

Scope of Work

This work will include a study of the technical feasibility for one or more fertilizer facilities. Analysis will be based on present equipment and installation costs, prevailing raw material costs, and transportation charges. The study will be predicated on the best estimates of present fertilizer consumption and available projections of future fertilizer demands. Priority is to be given to investigating more effective methods for supplying lower cost inputs to small farmers.

Specific objectives include the following:

1. Recommend locations for facility or facilities, and
2. Describe equipment requirements and develop equipment specifications.

In addition to the scope of work delineated by USAID/Bolivia, the IFDC team enlarged the scope of the study to include three additional tasks:

1. Review the status of present fertilizer-related projects,
2. Report on indigenous fertilizer raw materials availability, and
3. Consider integration of <u>future</u> fertilizer manufacturing projects into the <u>short-term recommendations</u>.

Overview of Bolivia (Present Situation)

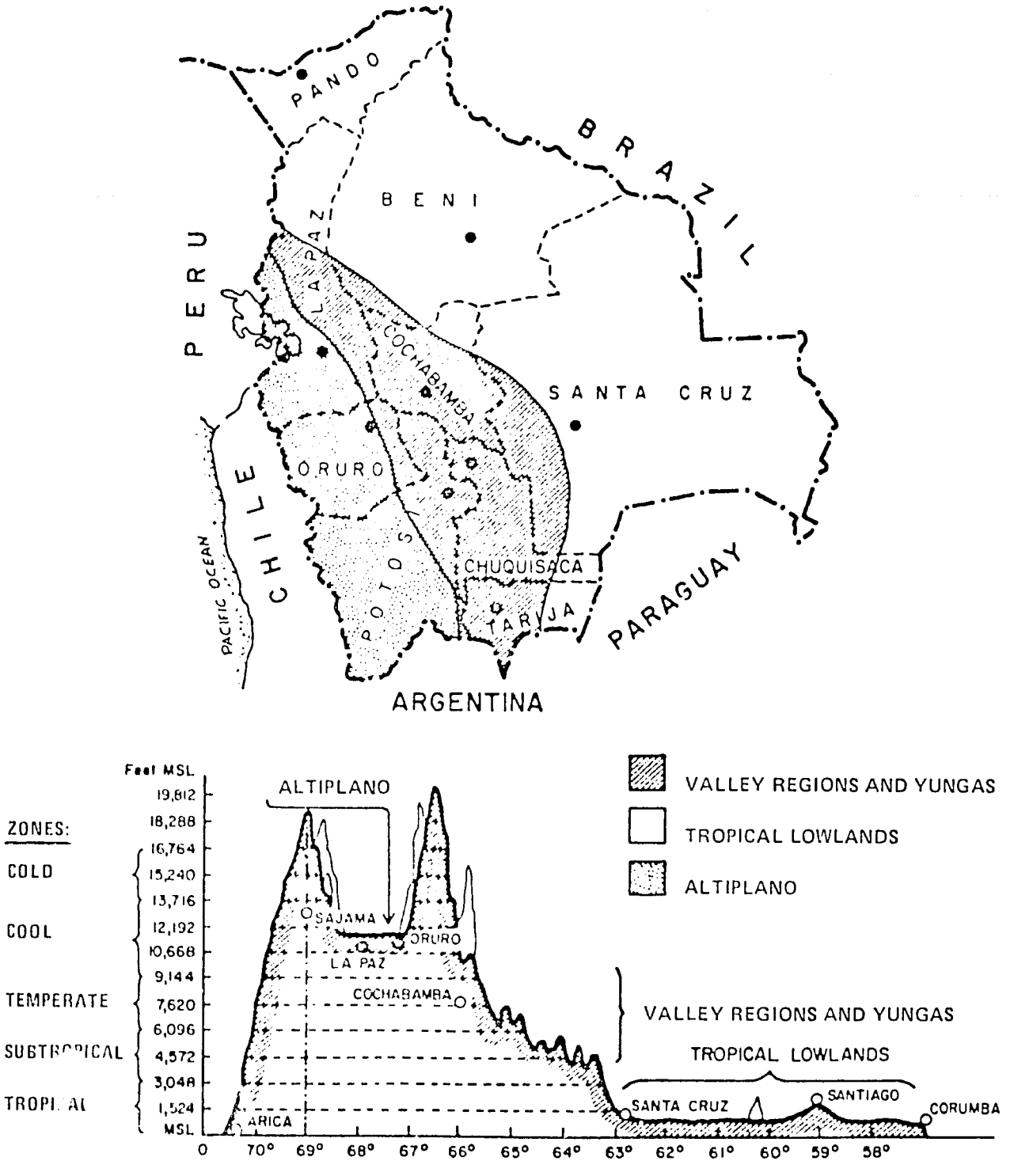
Bolivia's history is marked by political instability and a succession of governments. Almost all of the governments can be characterized by their brevity and the lack of continuity from one to the next. The average length of government over the past 150 years has been only 9 months. This governmental instability probably has been a major factor in the relatively slow economic development of this nation in comparison with that of its neighbors.

Bolivia is the fifth largest nation in South America and is completely landlocked, being bounded on the north and east by Brazil, on the southeast by Paraguay, on the south by Argentina, and on the west by Chile and Peru. The Andes cover approximately one-third of the total area of Bolivia running in a northwesterly to a southeasterly direction. The high mountain range divides Bolivia into three distinct topographical regions--the high-plateau region, which is known as the altiplano; an intermediate region with semitropical conditions on the eastern slopes (yungas of the Andes Mountains); and the drier valley regions and the flat Amazon-Chaco lowlands (llanos), referred to as the oriente (figure 1). Each of the regions is characterized by a complete difference in climate, vegetation, ethnic makeup, and population density. In general, population density ranges from less than one person per km^2 in the southeastern plains to about 10 per km^2 in the northern altiplano, yungas, and valley regions. The ethnic distribution of the population is approximately as follows: Indian, 65%; European, primarily Spanish, 5%-15%; and mixed or mestizo, 20%-30%. Most of the Indian population is found in the higher altiplano and yungas areas while the Spanish and mestizo population comprise the new settlers in the southeastern region.

The valley regions have labor productivity which is much higher than that in the lowlands or the altiplano. The yungas and valley regions have a long history of agricultural development and prosperity based on a variety of agricultural products. The valley regions, with about 33% of the rural population, produce almost 40% of the agricultural sector output. It is estimated that the agricultural production per worker averages twice as much in the valley regions as in the altiplano and over three times as much in the oriente as in the altiplano. Low fertilizer consumption per hectare and per capita compared to that of other countries in Latin America (table 1) clearly establishes the position of Bolivian agriculture as the second lowest fertilizer consumer in all of South America. In the Western Hemisphere only Paraguay and Haiti have lower fertilizer use rates. When the depleted nature of most cultivated soils is considered, one sees great potential for increasing crop yields and food supply through increased fertilizer usage.

Climate

The climate of Bolivia can be divided into 10 major ecological zones with definite distinguishing characteristics as shown in table 2. The high altiplano can be divided into three zones, the north, central, and south, with decreasing rainfall (650-250 mm) and temperature averages (12°-8°C), respectively. All three can be characterized simply as cold, windy, and arid.



Source: USAID Mission to Bolivia, 1974, Agricultural Development in Bolivia, A Sector Assessment, La Paz, Bolivia

Figure 1. Geographic Profile of Bolivia

Table 1. Per-Hectare and Per-Capita Fertilizer Consumption in Latin America (1975) (50)

Country	Fertilizer, kg/ha Arable Land			N, P_2O_5, K_2O, kg/ha	kg (N, P_2O_5, K_2O) per Capita
	N	P_2O_5	K_2O		
Argentina	0.8	0.6	0.1	1.5	2.2
Bolivia	0.5	0.5	-	1.0	0.6
Brazil	11.2	25.0	16.1	52.3	17.4
Chile	6.7	8.1	1.5	16.3	9.2
Colombia	25.5	9.1	7.5	42.1	8.3
Ecuador	4.6	2.9	1.5	9.0	5.5
Guyana	20.3	8.3	0.8	29.4	14.1
Paraguay	0.3	0.5	0.3	1.1	0.4
Peru	25.4	3.6	0.8	29.8	6.3
Surinam	55.6	2.2	4.4	62.2	6.6
Uruguay	6.0	15.0	2.1	23.1	13.9
Venezuela	12.2	7.7	6.4	26.3	11.4
Average for Latin America	14.4	10.7	6.7	31.9	13.8
United States	44.9	22.6	22.6	90.1	88.1

Table 2. Distinguishing Characteristics of Bolivia's 10 Major Ecological Zones (3)

Zone	Altitude, ft	Average Temperature, °F	(°C)	Average Precipitation, in	(mm)	Principal Crops	Principal Livestock
North Altiplano	12,460-13,500	53	(12)	25.6	(650)	Potatoes Onions Quinoa Barley	Sheep Auchenidae Cattle
Central Altiplano	11,475-11,800	50	(10)	13.8	(350)	Potatoes Other Tubers Barley Quinoa	Sheep Auchenidae
South Altiplano	9,180-11,475	47	(8)	9.8	(250)	Potatoes Other Tubers Barley Quinoa	Sheep Auchenidae
Valley Regions	4,590-9,180	67	(19)	31.5	(800)	Horticultural Crops Corn, Wheat Deciduous Fruits	Cattle Sheep Poultry Swine
Yungas	1,150	73	(23)	41.3	(1,050)	Coffee Cacao, Rice Citrus Bananas	Mules Poultry Swine
Amazon Rain Forest	400-1,150	83	(28)	98.4	(2,500)	Brazil Nuts Rubber Yuca	Cattle Poultry
Beni Plains	590-820	79	(26)	70.9	(1,800)	Pastures Citrus Yuca	Beef Cattle

(Continued)

Table 2. Distinguishing Characteristics of Bolivia's 10 Major Ecological Zones (Continued)

Zone	Altitude, ft	Average Temperature, °F	(°C)	Average Precipitation, in	(mm)	Principal Crops	Principal Livestock
Santa Cruz	1,310-2,460	77	(25)	45.4	(1,150)	Cotton Sugarcane Rice Yuca	Cattle Poultry Swine
Brazilian Shield	655-2,460	75	(24)	37.4	(950)	Corn Pastures Yuca	Cattle Swine
Bolivian Chaco	1,150-1,475	82	(28)	29.5	(750)	Corn Sugarcane Yuca	Cattle Swine Poultry Goats

The valley regions and yungas have higher temperatures and a much higher rainfall than the high altiplano, with the rainfall being adequate for most horticultural and tropical crops. The average temperature varies from 17° to 23°C with a rainfall average from 800 to 1,050 mm distributed evenly throughout the year. The oriente, or tropical and subtropical ecological zone, is characterized by at least five distinguishable areas. This zone varies from the Amazon Basin tropical area with rainfall as high as 2,500 mm and a temperature average of 28°C to the semiarid region of the Chaco, with about the same temperatures but with a prolonged dry season of 7-8 months (April-November) resulting in an annual rainfall of only 750 mm (see figure 2).

Soils

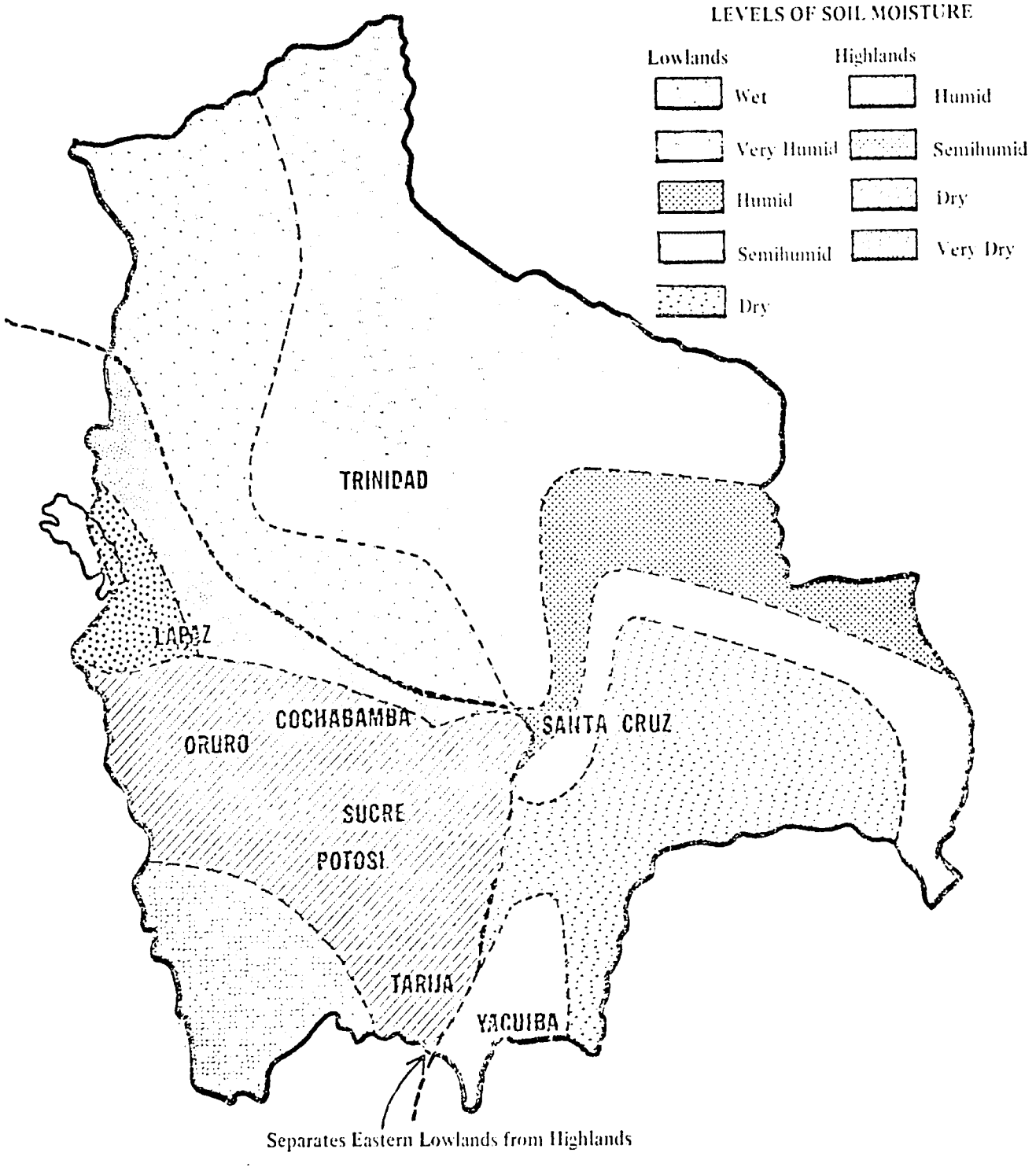
The tremendous variations in the topographical features of Bolivia have governed the agricultural practices more than the soil type or soil quality. Because of the topography, the soils have played a secondary role to the more variable climatic factors of rainfall, rainfall distribution, and temperature. All of these factors have been of primary importance in determining the type of agricultural activity that is now associated with the various topographical regions in Bolivia.

In general, the soils of Bolivia tend to be slightly acid, though a wide range of pH exists in all the agricultural areas as one would expect based on the variation of climate, vegetation, and parent material. Most of the soils are potentially responsive to phosphate fertilizers and nitrogen. There are indications that many of the soils have an adequate potassium level for most of the present cropping patterns. The soils of the newly cultivated areas of the oriente are not generally responsive to fertilizers in the first few years after initial clearing of the high forest. This is due to the indigenous organic matter and nitrogen buildup under the forest cover in these tropical and subtropical areas. Fertilizers are usually applied in ever-increasing amounts beginning with the third or fourth year after the new lands have been brought into cultivation.

The soils map of Bolivia (figure 3), adopted from FAO/UNESCO Soils Map, gives a representation of the soil types of Bolivia. A brief description of each soil type is included with the figure. "The Agricultural Land Use Potential of Bolivia--A Land Systems Map," a more detailed study by the Bolivian Ministry of Agriculture, is the most useful for persons concerned with agriculture on a technical basis. This system is based on the land-system method to describe and classify land areas using a concept whereby the characteristics of topography, vegetation, soils, and climate are related in identifiable repeated units. The methodology was developed and used in Australia by Christain and Stewart (1953), who defined the methods as "land area or groups of areas that have notable similarities in topography, soils, and vegetation" (26).

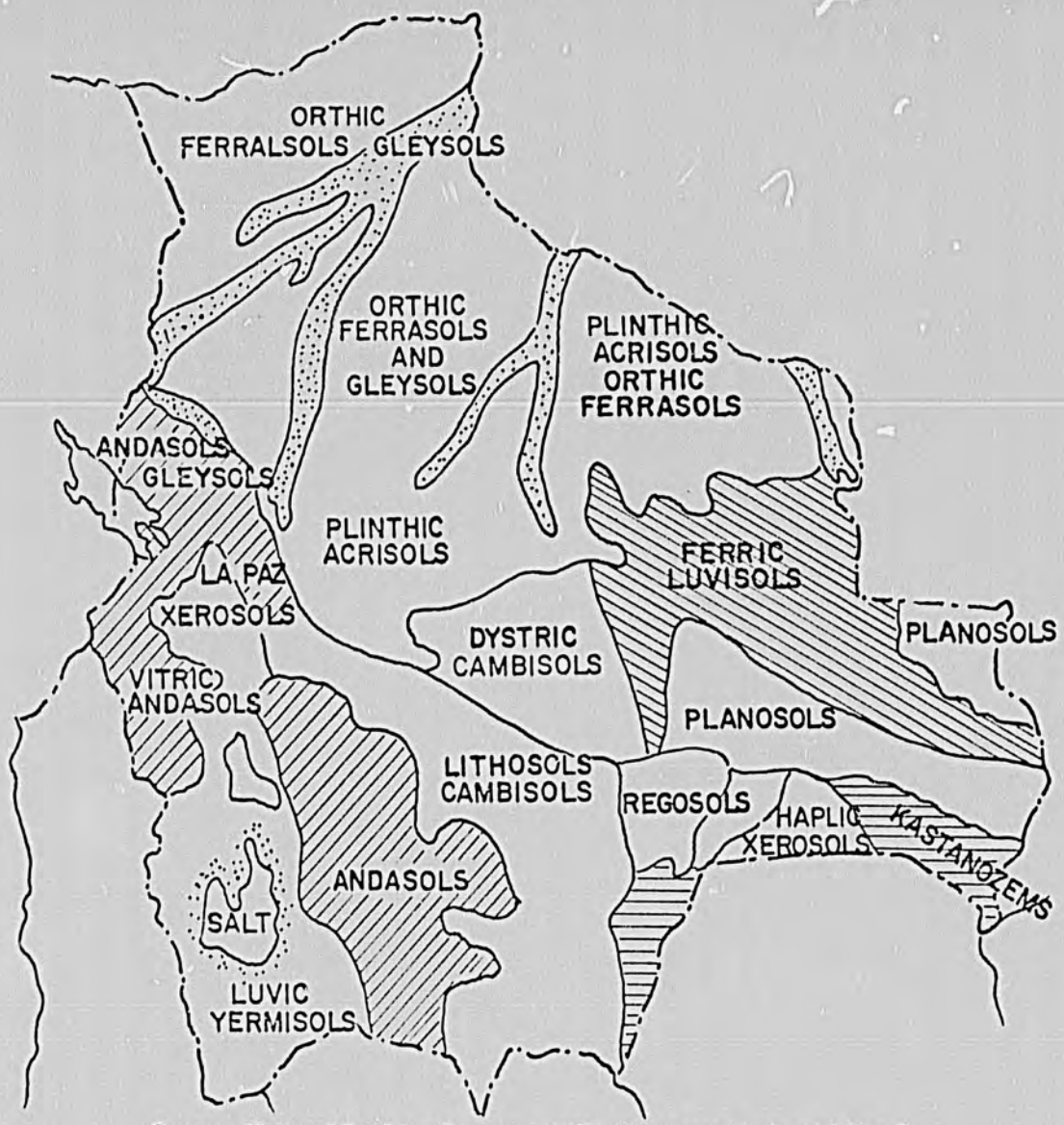
Crop Production

The climate and the elevation are the main limiting factors for agricultural production and livestock activities. The principal ecological



Source: Cochrane, Thomas T., 1973, El Potencial Agricola del Uso de la Tierra en Bolivia, un Mapa de Sistemas de Tierras, Don Bosco, Ed., La Paz, Bolivia

Figure 2. Levels of Soil Moisture



Source: National Smelting Company, 1977, "Integrated Industrial Plan," Technical Publication 4, La Paz, Bolivia

Orthic Ferralsols–Low natural fertility, mostly still covered by natural vegetation. First used generally for plantation-type cash crops, cotton, citrus, bananas, and cassava. Later converted to pasture because they lose natural fertility in a few years. Favorable physical properties and high structural stability. Dark red, well drained (Latosol).

Gleysols–Natural fertility usually high. Heavy clay soils, poor drainage. With intensive drainage systems are suitable for rice, bananas, and coffee. Grey to light grey color.

Plinthic Acrisols–Low base status with deficiencies in phosphorus, sodium, potassium, copper, and cobalt. Generally not used for farming. Covered by forests, Savannas (Cerrado), or grassland. Used for extensive grazing. Harden upon drying, which restricts root development.

Andasols–Common in the volcanic Andes with high rate of phosphate fixation. Topography often too steep to develop agriculture. Erosion very active under cultivation.

Vitric Andasols–Usually occur under dry climatic conditions. If soils are deep and topography level, irrigation can be supplied with good results, but high acidity and stoniness restrict their use. Potatoes and barley can be cultivated.

Xerosols–Restricted suitability for cultivation of a few short-season crops. Found in the driest parts of the semi-arid high regions. Extensive grazing is feasible, usually with llamas and sheep. Can be used for production of sisal or pineapples under better conditions relative to altitude and climate.

Haplic Xerosols–Brown sandy alluvium with Eolian sand patches. Mostly salty conditions exist, and grazing is restricted.

Luvic Yermisols–Receive less than 100 mm rainfall per year. In some years no rainfall is recorded. Severe frosts during all seasons. Broad, barren, salt plains are common. Plant cover scarce due to shallow, stoney soils with poor drainage. Agriculture mostly pastoral with llamas and sheep flocks.

Dystric Cambisols–Eastern slopes of Andes with a humid climate. Low fertility and high rainfall along with stoniness and ferruginous concretionary layers make these soils unsuitable for agriculture. Better suited and used for forests and pastures.

Lithosols–Soils rarely used for agriculture due to highly dissected, steep topography combined with rockiness and stoniness. Better used for forests, wild life, and recreation rather than agriculture.

Regosols–Sandy soils with low water retention make them difficult to develop agriculture. Susceptible to extreme erosion. Soils easily worked with machinery but need large amounts of fertilizer for most crops attempted. Better used for forests.

Planosols–Natural fertility usually medium to high with a deep impervious subsoil. Good soils for irrigated rice cultivation under both traditional and modern management.

Ferric Luvisols–Soils of medium to high fertility. Usually sandy top soils overlying impermeable subsoil at varying depths. Found in subhumid and semi-arid climates. Used principally for annual crops and grazing. Cotton, peanuts, sugarcane, corn, upland rice, and beans can be grown.

Kastanozems–Fertility usually high and fairly high in organic matter. On high elevations intensively cultivated to subsistence crops such as potatoes, wheat, barley, oats, quinua, and vegetables. Livestock grazed on shallow and stoney phases. Subject to extreme seasonal water deficiencies. In dry areas on fringes of pampean region, grazing on planted pastures is widespread. Irrigated soils produce vegetables, fruit trees, and grapes.

Source: FAO-UNESCO Soil Map of the World, Volume IV, South America, UNESCO-Paris 1971.

Figure 3. Soils of Bolivia

zones can also be related to the principal crops and livestock produced in each area. Table 2 shows the altitude, average temperature, average precipitation in millimeters, principal crops, and livestock of these major ecological zones.

Potatoes are, and have been for the past century, the major cash crop and subsistence agricultural product in Bolivia. Table 3 summarizes the major crops in Bolivia in 1975 and shows the importance of the potato among the various food crops. The yield of 6,532 kg/ha is an implication of fertilizer use on this crop. Through use of recommended application rates and procedures, yields of twice this amount have been achieved. Table 4, showing the production and value of principal crops and comparing the period from 1963 to 1965 to that of 1970 to 1972, clearly demonstrates the economic impact of the potato production. The total value of potato production (685,333 mt) is calculated at US $48,933,000 and highlights the important position of the potato crop to the Bolivian economy. Diversification into other crops has developed slowly. Table 5 shows average growth rates for several major crops. The largest growth (on a percentage basis) has been in plantation-type crops such as cotton, coffee, and sugarcane.

An estimated 80% of all agricultural output is from the small-farm sector. The modern sector of agriculture has only recently evolved and is found in the oriente where extensive new land areas are available. In this frontier area, land is relatively cheap and only waiting to be cleared and put into plantation-type agriculture. Cotton, sugarcane, and cattle (milk and beef) are the major agricultural activities in this expanding exploitation-type land development. Only in the past 10 years has development in this area attained proportions of national impact (see figure 4).

According to the most recent estimates of land use in Bolivia (table 6), there is 7.8 million ha of good agricultural land that can be utilized for cultivation of crops, a mere 7% of the country total. Of these 7.8 million ha it is estimated that only 14% or 1.1 million ha is actually in yearly use. There is 2.5 million ha of agricultural land which is lying fallow, due to a traditional method of cultivation that allows for resting and regenerating the fertility capability of the soils. The other 4.2 million ha, approximately 54% of the total, represents the potential agricultural land that is not being utilized at present. In many cases, the tremendous amount of fallow land is overlooked when calculations are being made of increased areas brought into cultivation or when calculating the yields per hectare from specific agricultural areas.

The crop yields (table 7), comparing the highest year yields for the years 1966-74 with the yields for 1975, indicate a decline in yields for all crops. Part of this decline could be attributed to the increasing amounts of fallow land not taken into consideration when calculating the yields per hectare.

Indigenous Raw Materials

All four major fertilizer raw materials--natural gas, phosphate rock, sulfur, and potassium salts--occur in Bolivia. Two of these raw materials, natural gas and sulfur, are being commercially exploited at the present time.

Table 3. Major Crops of Bolivia in 1975 (9)

	Acreage, ha	Yield, kg/ha	Production, mt
Potato	127,680	6,532	834,000
Corn	230,250	1,325	305,100
Sugarcane	52,010	45,501	2,366,500
Barley (bulk)	111,600	713	79,600
Barley (unpolished)	58,000	3,509	203,500
Wheat	78,420	882	69,200
Cotton fiber	47,800	443	21,200
Cotton seeds	-	-	48,000

Table 4. Production and Value of Principal Crops in Bolivia (1963-65 and 1970-72) (4)

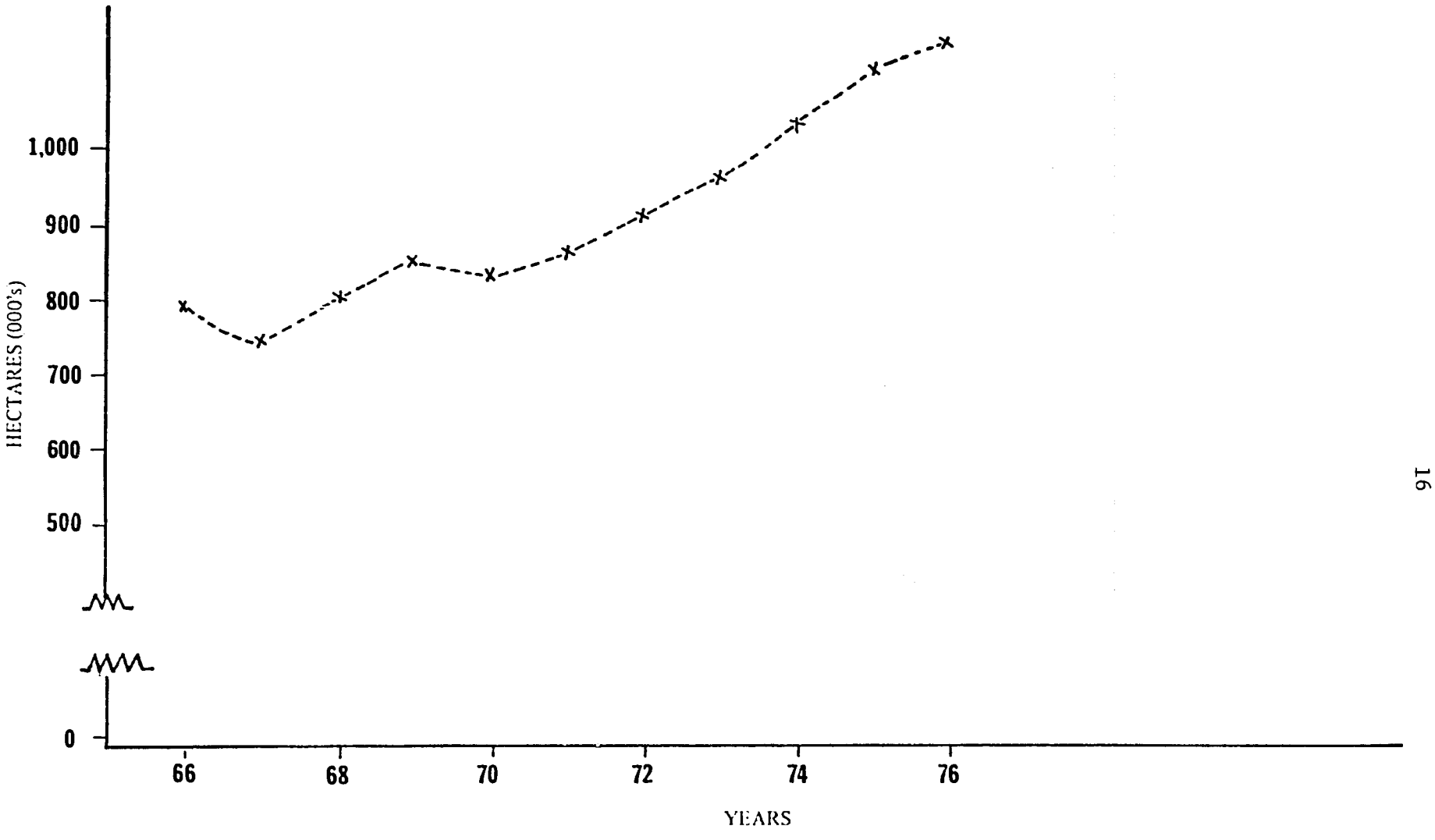
Crops	1963-65 Average Production, mt	1963-65 Total Value '000 U.S. $	1963-65 Rank	1970-72 Average Production, mt	1970-72 Total Value, '000 U.S. $	1970-72 Rank
Potatoes	560,667	35,233	1	685,333	48,933	1
Vegetables[a]	165,067	7,033	2	191,533	14,067	2
Corn (grain)[b]	275,933	5,400	3	280,167	8,933	3
Sugarcane	998,833	5,267	4	1,345,867	8,667	4
Wheat	56,033	3,770	5	60,067	5,133	8
Yuca	142,667	3,767	6	232,433	8,400	5
Rice (unhulled)	47,095	3,474	7	71,905	5,924	6
Barley	56,367	3,470	8	65,767	5,033	9
Other tubers[c]	43,033	3,200	9	51,167	4,700	10
Citrus fruits[d]	77,133	1,667	10	88,733	3,733	13
Bananas and plantains	212,600	1,633	11	327,133	4,100	11
Coffee	5,500	1,467	12	12,200	3,833	12
Quinoa	10,533	1,033	13	10,333	1,200	14
Cotton fiber	1,667	807	14	10,133	6,067	7
Dried beans	9,867	767	15	12,433	1,167	15
Oats	4,400	433	16	4,800	433	16

a. Includes sweet corn, onions, tomatoes, and green peas.
b. Includes hard corn for livestock consumption and soft corn for human consumption.
c. Includes sweet potatoes, oca, and papalisa.
d. Includes oranges, tangerines, lemons, grapefruit, and limes.

Table 5. Trends and Average Growth Rates in Production of Principal Crops in Bolivia (1963-72) (4)

Crops	Level of Production on Trend Line in 1963[a] (Intercept)	Average Increase in Production per Year (Slope)	Level of Production on Trend Line, 1972	Rank[b]	Average Annual Rate of Growth Along Trend Line
	mt				%
Quinoa	10,000	-51	9,542	1	-.52
Corn (grain)[c]	274,707	810	281,994	2	.29
Other tubers[d]	33,860	335	36,871	3	.95
Oats	4,127	57	4,639	4	1.31
Wheat	47,667	688	53,858	5	1.37
Vegetables[e]	173,013	3,341	203,084	6	1.80
Citr[illegible] fruits[f]	74,113	1,525	87,837	7	1.91
Bar	50,573	1,465	63,757	8	2.61
Potat	500,307	18,699	668,596	9	3.27
Dried beans	8,933	352	12,102	10	3.43
Sugarcane	862,380	55,633	1,363,075	11	5.22
Bananas and plantains	182,007	16,408	329,678	12	6.82
Rice (unhulled)	39,476	4,004	75,515	13	7.47
Yuca	116,847	12,897	232,919	14	7.97
Coffee	3,747	930	12,114	15	13.93
Cotton fiber	-1,947	1,245	9,257	16	g

a. Trend line calculated by regressing production against time in a linear form: $Y_i = a + bx_i$ where Y_i = production in year i, x_i = the year i, a = intercept, and b = slope.
b. Based on growth rates calculated along trend line and ranked in ascending order.
c. Includes hard corn for livestock consumption and soft corn for human consumption.
d. Includes sweet potatoes, oca, and papalisa.
e. Includes sweet corn, onions, tomatoes, and green peas.
f. Includes oranges, tangerines, lemons, grapefruits, and limes.
g. Cannot be calculated.



Source: H. Ossio, Draft report on Bolivian Agriculture, untitled, October 1978

Figure 4. Total Area Cultivated--Bolivia, 1966-1976

Table 6. Land Use in Bolivia (1976) (1)

Present Land Use	ha (millions)	% Total	% Agricultural Area for Exploitation
Forest	33.0	30	
Pasture/plains	65.9	60	
Total agricultural area (for exploitation)	7.8	7	
Agricultural lands (in actual use)	1.1		14
Fallow	2.5		32
Unused potential	4.2		54
Other land use (cities, lakes, salt flats, mountains, rivers)	3.1	3	
Total country	109.8	100	100

Table 7. Crop Yields, Bolivia (1)

Crop	Highest Yield, 1966-74 Year	Highest Yield, 1966-74 kg/ha	Yield, 1975 kg/ha
Potato	1971	7,196	6,532
Wheat	1972	833	803
Rice	1967	1,290	1,190
Quinoa	1970	795	790
Oranges	1968	17,500	16,515
Grapes	1972	6,667	5,980
Bananas	1971	16,000	14,907
Soybeans	1971	1,500	1,266
Peanuts	1968	1,580	1,500
Cotton	1968	616	411

Natural Gas

Most of the natural gas which has been discovered and exploited to date is located in the department of Santa Cruz. Reserves are estimated at about 4.5 trillion ft^3 (25). This wealth of natural gas as well as discoveries of crude petroleum has been the impetus behind the recent rapid expansion of the Santa Cruz region. An allocation of 100 billion ft^3 of gas has been designated for ammonia production during the next 20 years (25).

Even though the estimated reserve figure above sounds quite large, the actual petroleum and natural gas reserves are unknown. Vast regions of the oriente remain undeveloped and relatively unexplored. Hence, the possibility of discovery of new mineral and petroleum deposits remains ever present.

Phosphate Rock

Deposits of phosphate rock have been discovered throughout Bolivia. Many of the ore deposits which have been reported are of low quality and in strata which are quite thin for economic recovery (less than 50-cm thickness). The P_2O_5 content of most of these ores ranges from less than 1% to 26%. Most of these deposits have estimated reserves which are quite small. Various listings classify these deposits from "insignificant deposits" to reserves of 300,000 mt (13, 14, 15, 16).

The most promising area of phosphate rock occurrence is near Campinota. Its estimated reserves may be in the order of 300,000 mt, and the beds of ore are up to 1.6 m in thickness. When the area was studied by Davy Powergas (DPG) and Rio Tinto Zinc (RTZ), phosphate ores were found to occur in extremely faulted areas which made estimation of reserves difficult.

The analysis of this ore shows a high silica content, and it is reportedly a rock which would be difficult to beneficiate. Beneficiation tests have been limited to only crushing and grinding with no flotation tests being conducted although it is postulated that flotation could be marginally successful (5, 39). Local ores have been classified as unsuitable for production of superphosphates (10).

There are other factors which merit consideration when phosphate deposits in Bolivia are being studied. Factors of great importance are Bolivia's location and type of geology. With Bolivia bordering Peru and Chile (both having some minable phosphates), one might expect some occurrence of minable phosphates within Bolivia. There also exist several areas which are extensions of, or similar to, the Sechura desert of Peru where large phosphate deposits exist. If the similarities go beyond physical characteristics, there is a possibility that pockets of undiscovered minable phosphates do exist within Bolivia.

Sulfur

Minable deposits of volcanic sulfur are found along the Bolivia-Chile frontier region in the southwestern part of the country. There are reserves which are estimated at 7.8 million mt. There are also deposits of pyrites which

are estimated at 500 million mt of ore with 53% sulfur content. These deposits of pyrites are of little commercial interest since sufficient quantities of sulfur are available from the volcanic sources and the gases exhausted from smelters (25).

The volcanic sulfur is now being mined and used by COSSMIL in their sulfuric acid plant at Eucaliptus. A small portion is exported to neighboring countries.

Potash

There have been preliminary investigations of the occurrence of potassium salts in various areas of Bolivia, especially in the areas of Potosi and Oruro. Reserves of these deposits are reported to be 5,000 million mt of 0.8% potassium and 1,000 million mt of 1.5% potassium in the Potosi and Oruro areas, respectively (25). There are also reports of preliminary discoveries of potassium and lithium salts in the salars of southwestern Bolivia. The Salar Uyuni and smaller salars are being studied at present by the Lithium Corporation and Foote Chemicals to determine the extent of the deposits. Ericksen and Vine reported in 1976 the discovery of potassium and lithium salts in the brines of the Bolivian salars. The brines reportedly contain potassium concentrations of 4,000-24,000 mg/liter (17). A drilling program is now underway to determine the distribution and concentration of both the lithium and potassium. Speculation is that both of these minerals are economically recoverable at this time (17).

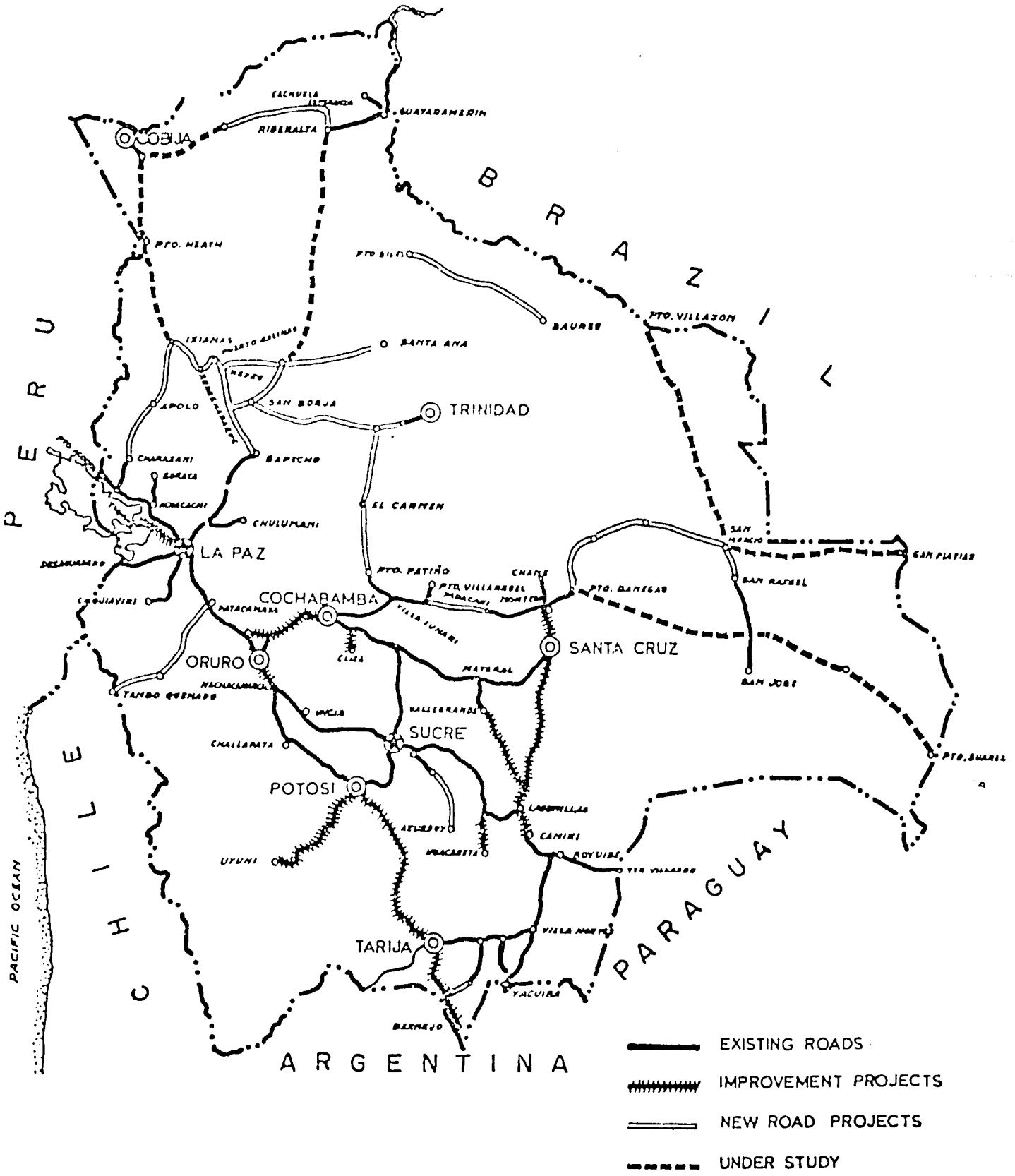
Infrastructure: Transportation System

The transportation system available to the agricultural sector in Bolivia consists mainly of rail and truck transport. The latter is of utmost importance to the farmer for internal transportation due to two problems with rail: (1) limited access and (2) the rail transporters' preoccupation with hauling of import products and servicing the mining industry. There is, however, some agricultural production being moved by rail.

Road Transport System

The GOB continues to upgrade transportation by extension of Bolivia's system of highways. The major areas of expansion are in connecting the areas east of Santa Cruz to major population centers in the altiplano. Even after extensive construction efforts, nearly 60% of the existing roads are impassable during the rainy season. Many more kilometers are only passable using high ground-clearance trucks or four-wheel drive vehicles.

The Bolivian road network consists of two major components. The system which handles the highest volume of traffic is the road network connecting the altiplano areas of Peru with the Lake Titicaca area, La Paz, Cochabamba, and Santa Cruz. The other major system links Potosi, Oruro, Sucre, and Tarija in the southwest with central areas of the altiplano (see figure 5) (3).



Source: USAID Mission to Bolivia, 1974, Agricultural Development in Bolivia, A Sector Assessment, La Paz, Bolivia

Figure 5. The Bolivian Road System

Several roads exist which are not connected with these major systems. Most of these relatively isolated roads/road systems are located in the eastern sector and have been only recently developed. The overall highway system would have to be evaluated as barely adequate. Even in the Santa Cruz area, a relatively well-developed region, some of the larger farms (greater than 1,000 ha) have only seasonally passable roads connecting them with the major road networks.

The existing road system can be classified into the categories of primary, secondary, and local access which can be further divided into the following types of roads: all-weather, difficultly passable during the rainy season, and impassable during the rainy season (table 8). Also listed are the condition and length of the roads.

From this table one can see that 56% of the total road system is only seasonally passable with another 20% requiring special vehicles (four-wheel drive or trucks) during the rainy season. This road system with trucks accounts for the primary transportation means available to the rural population. Buses are available, but the cost is relatively high. Space is also limited for hauling of livestock and commodities.

Railroads

The rail system of Bolivia was originally installed to support the mining industry. The predominant uses were the hauling of ores and ore concentrates to the smelters and ports, the backhauls of imported goods from the ports, and moving of supplies and machinery to the mines. Little consideration was given to Bolivia's internal transportation needs. For instance, even though both La Paz and Santa Cruz have rail access to ports, there exists no direct rail link between the two. As a result all direct traffic is carried between these two centers by truck.

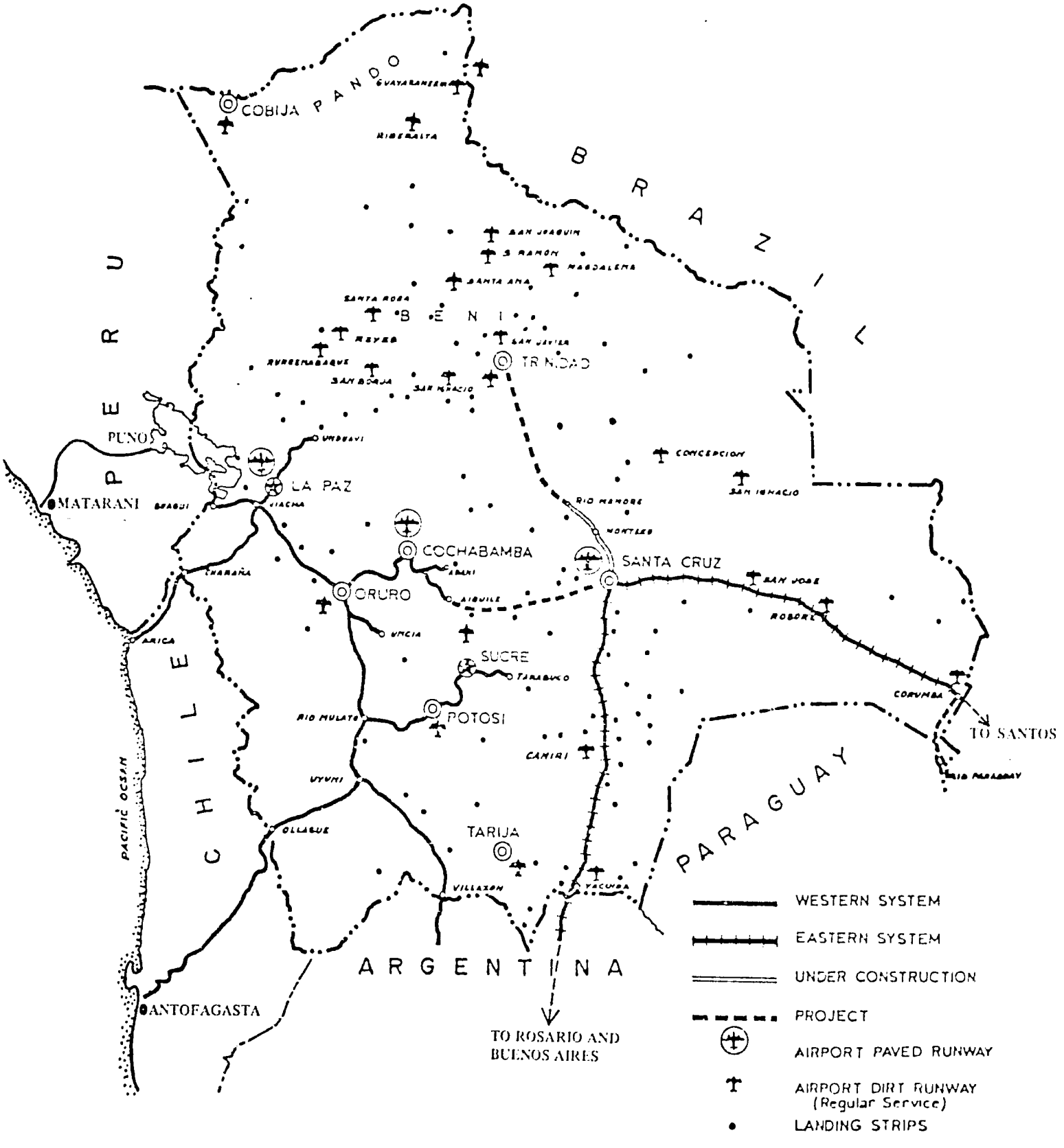
The rail system is composed of two segments, the eastern and western systems (see figure 6). The western segment is concentrated in the altiplano connecting the population and mining centers with the Pacific ports. This line connects with the Chilean ports of Antofagasta and Arica. The Peruvian port of Matarani is also connected via Guaqui using lake steamer to Puno then on to Matarani by the Peruvian rail system.

The western system connects Santa Cruz with Corumba, Brazil, and ultimately with Santos. This line also connects Santa Cruz and Yacuiba continuing to Buenos Aires utilizing the Argentine line. The eastern and western systems are indirectly connected in Argentina with a spur line from the Buenos Aires-Yacuiba line connecting with the line which runs north and south through Villazon. This route has reportedly been used to ship fertilizers from Buenos Aires to Cochabamba.

The railroads are generally in poor condition and inadequately maintained. The tracks are narrow gauge, and cars are available in 20-, 32-, and 40-mt sizes (34). The effective maximum load is usually about 30 mt per car due to the condition of the equipment.

Table 8. Road Length and Condition (3)

	All Weather	Difficultly Passable During Rainy Season	Seasonally Passable	Total
	km			
Primary	4,875	2,832	-	7,707
Secondary	1,543	1,363	2,203	5,109
Local	1,288	3,444	19,765	24,497
Total	7,706	7,639	21,968	37,313



Source: USAID Mission to Bolivia, 1974, Agricultural Development in Bolivia, A Sector Assessment, La Paz, Bolivia

Figure 6. Ports, Railroads, and Airports in Bolivia

All fertilizer now entering Bolivia is imported as bagged material. The rail equipment which is currently available lends itself best to this type of operation. This is mainly due to the lack of modern bottom-unloading, covered gondolas for hauling of fertilizer in bulk. The equipment which is available consists of standard box cars, flat cars, and hinged-side gondolas. Tarpaulins are available for use when hauling moisture-sensitive cargoes (10).

The Empresa Nacional de Ferrocarriles de Bolivia (ENAFER) has suggested that, to afford maximum protection to bulk cargoes, standard box cars be used. This procedure would require box cars which could be loaded from the top and unloaded from one or both of the side doors or would require the loading through one side door utilizing payloaders. Possibly good results could be obtained by utilizing the hinged-side gondolas. The unloading operation could be accomplished utilizing a small front-end loader.

In recent years some of the materials which were traditionally carried by the rail systems are being handled more and more by trucks. The primary reason for this change is the relatively long shipping time required by rail. The average rail time required for transport from the ports to the nearest distribution centers is shown in table 9. The time required to move material from the port to a point within Bolivia can usually be cut in half by utilizing trucks instead of rail. There is, however, a steep premium involved when using trucks.

The eastern lines have increased in importance in recent years due to development of the oriente. Both lines have recently been used for importation of oil drilling and exploration equipment and exportation of sugar, cotton, and cottonseed to Brazil and Argentina. The lines are also used for the importation of consumer goods, including cars, tractors, trucks, other agricultural inputs, and manufacturing and transportation equipment for the nonfarm sector (3).

Ports Available to Bolivia

Bolivia is landlocked, having lost its access to the coast in wars with both Chile and Peru. As a result Bolivia must rely on the use of ports located in other countries. The major ports used to import and export goods are Matarani in Peru, Arica and Antofagasta in Chile, Santos in Brazil, and Buenos Aires in Argentina. In addition to these ports Bolivia has obtained from Argentina free port facilities at Rosario on the Parana River (figure 6).

The GOB has maintained as one of its major programs the securing, from either Chile or Peru, of a corridor to the Pacific. After the GOB reestablished relations with Santiago in 1976, negotiations were begun to trade some Bolivian territory for a narrow corridor to the sea. Peru has opposed the idea, and negotiations have been stalemated by the growing arms race between Peru and Chile (33).

Port facilities available for handling of bulk materials are generally proportional to the size of the port. Both Santos and Buenos Aires are classified as large ports while Puerto Rosario and Antofagasta are classified as medium sized; Arica and Matarani are considered small (28).

The capabilities of the Santos and Buenos Aires port facilities are quite extensive. Some equipment is specifically designated for bulk handling and storage of fertilizers (18). On the other hand, Antofagasta and Arica have

Table 9. Average Rail Time from Port to Nearest Distribution Center (34)

	Hours
Antofagasta-Ollague	48-72
Ollague-Cochabamba	48
Arica-Charana	24-48
Arica-La Paz	24
Matarani-Puno	72
Puno-Guaqui	24
Guaqui-La Paz	24
Corumba-Santa Cruz	20
Buenos Aires-Yacuiba	192
Yacuiba-Santa Cruz	20
Buenos Aires-Villazon	96-192
Villazon-Cochabamba	48-72

limited bulk-handling and storage facilities which are geared toward handling of grain and certain mineral ores. If the installed capacities of these systems are sufficient, there is a possibility that bulk fertilizers could be handled.

The GOB has negotiated agreements with all of these ports to provide certain concessions for their use. All provide a free storage period, usually 1 month, to enable arrangement of inland shipping. This "grace" period causes problems since cargoes of relatively low value are not moved out of the port areas promptly and are often damaged by excessive handling and abuse. Broken cartons and cans piled in warehousing areas are common. To enable the ports to handle these problems, higher rates are sometimes charged to cover the costs of cleanup operations (6). The free storage period also fosters inefficiency in placing of orders from within Bolivia and in transshipment once material is at the port. The result is double-handling, poor transportation scheduling, general inefficiency, and high monetary losses (2).

Under IFDC's Phase II and III recommendations, the handling and shipping of bulk fertilizers from the port areas into Bolivia must be highly efficient. These fertilizers are subject to degradation from moisture, and since they are in bulk form, they must be warehoused and reclaimed efficiently from the port area.

The costs involved with the use of each port vary not only with the quantity of material handled and distance traveled but also with differences in classification of various goods, the amount of handling involved, and differences in customs fees and labor costs. Because of these differences and the economic changes and renegotiation which cause these costs to fluctuate, no attempt will be made in this report to analyze the relative merit of using one transport route or port over another. This decision must be considered by the organization which will ultimately be importing fertilizers.

The following describes the various ports which are normally used to transport goods into Bolivia:

1. Matarani, Peru--Matarani is one of the three Pacific ports through which imports come to Bolivia. The facilities at this port are adequate for most materials. Since there is no direct rail connection from this port into La Paz, goods are normally transported by rail via Mollendo to Puno, then by lake steamer across Titicaca to Guaqui, and on to La Paz by truck. Materials can also be moved by truck directly from Puno to La Paz. The multiple handling, loading, and unloading involved causes this route to be relatively undesirable for most commodities, especially bulk fertilizers.

2. Arica, Chile--Arica is connected with Bolivia by both road and rail. The railroad goes directly to La Paz and is the most direct route to any port from the La Paz area. This rail link is for the exclusive shipment of Bolivian imports and exports. The Arica-La Paz railroad is under Chilean control to Charana on the Bolivian frontier and under Bolivian control from there into La Paz (6).

3. Antofagasta, Chile--This port is possibly of greatest importance because it has traditionally handled the highest volume of materials of any of the ports which serve the Bolivian market (see table 10). The major import items handled include equipment for mining and food, especially receipt of bulk shipments of wheat.

Table 10. Bolivian Exports and Imports at Various Locations (21)

	Antofagasta		Arica		Matarani		Yacuiba		Villazon		Corumba		Total	Total	
	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Exports	Imports	Total
								mt							
1973	87,442	43,220	39,020	31,480	166,149	69,150	40,277	35,080	10,732	59,295	55,360	28,801	398,980	267,026	666,006
1974	93,563	109,393	23,858	96,475	146,272	89,230	44,245	35,363	12,880	58,626	62,336	59,862	383,154	448,949	832,103
1975	106,508	165,916	20,000[c]	110,543	103,606	105,013	37,507	62,615	20,427	36,399	48,161	93,383	336,209	573,869	910,078
1976	114,423	123,064	22,493	81,173	113,074	84,636	30,693	65,235	16,656	47,843	90,057	114,666	387,396	516,617	904,013
1977	123,925	161,970	24,419	87,928	109,082	83,588	77,727	70,713	17,146	88,435	25,136	139,411	377,435	632,045	1,009,480
Totals 1977	285,895		112,347		192,670		148,440		105,581		164,547				
% of Imports 1977	25.6		13.9		13.2		11.2		14.0		22.1				
% of Exports 1977	32.8		6.5		28.9		20.6		4.5		6.7				
% of Total Traffic 1977	28.3		11.1		19.1		14.7		10.5		16.3				

Antofagasta is connected to Bolivia by both road and rail as is Arica. The Antofagasta-Bolivia railroad connects with Bolivia via Ollague with the section Antofagasta-Ollague being under Chilean control and the remainder being controlled by ENAFER. Unlike the Arica-La Paz railroad, this Antofagasta-Bolivia line is not for the exclusive service of Bolivia. It is also used for transportation of minerals and ores from the northern mining areas of Chile (8).

4. Puerto Rosario, Argentina--In 1976, the Argentine government agreed to give Bolivia a free zone in the port at Rosario on the Parana River (33). The Port at Rosario can handle oceangoing vessels of less than 10,000 tdwt (40). Since Puerto Rosario is located on a river, the depth is subject to seasonal fluctuation, but generally no problems are encountered during 9 months of the year (24). (A study of the facilities of the Bolivian Free Zone was completed in August 1978, see reference 24.)

   Rosario is connected by rail with both Villazon and Yacuiba. However, due to the distances involved, even with the free port status, there is probably little advantage in using Rosario instead of Buenos Aires.

5. Santos, Brazil, and Buenos Aires, Argentina--Both of these ports are large, with facilities to handle almost any type of cargo. Both are connected by rail to Santa Cruz with an alternative river barge plus rail connection from Buenos Aires. It is also possible to transport material by rail from Buenos Aires to the altiplano via Villazon. In fact, one fertilizer dealer in Cochabamba indicated that this route was available utilizing Argentine rolling stock for the total distance.

   These ports grow more important with the development of the oriente. Most of the imports at present are machinery and related equipment for the oil industry. Since little fertilizer is used in this area compared with that used in the valley regions and altiplano, (see section "Fertilizer Practice and Use"), this route has not been of great importance to the agricultural sector in Bolivia.

Port Usage--When considering the facilities available to Bolivia along with the possibility of obtaining port facilities on the Pacific through negotiations with Chile and Peru, one can see that with the present port arrangements Bolivia is not totally isolated. There is a certain charge added to all goods to cover duties and handling at the ports. This charge and even the transport costs involved are not responsible for the high fertilizer prices experienced by the Bolivian farmer. These factors will be considered at greater length in another report section.

Table 10 shows that total exports from Bolivia have remained relatively constant over the past several years while imports have been on the increase. This would indicate an ever worsening of Bolivia's balance of trade with the resulting grim implications for the economy.

It is also evident that the ports which are most important to Bolivian business are the two Pacific ports, Antofagasta and Matarani. Antofagasta handles the most followed by Matarani. In fact, the three Pacific ports handle nearly 60% of the total goods shipped into or out of Bolivia. In 1977 more than 20% of Bolivia's exports passed through Yacuiba, and a similar amount of imports came in through Corumba. This is indicative of the rapid growth taking place in the Santa Cruz region and in the oriente in general. A large quantity of the

exports from this area includes agricultural products such as sugar, soybeans, and cotton. Imports, however, are generally heavy machinery and other development equipment; large quantities of agricultural inputs are not usually handled.

Prices and Transport Costs--The actual cost involved in movement of fertilizers through the port areas to the ultimate user is dependent on numerous factors: port used, mode(s) of transport, and the handling procedures. To facilitate the description and analysis of the total cost involved, a "typical" example will be receipt of a shipment of fertilizer at Antofagasta and shipment to a user in Cochabamba. For clarity, the cost will be broken down according to the following categories:

1. Fertilizer cost, f.o.b. U.S. Gulf coast.
2. Freight charges for shipment to Antofagasta.
3. Port charges (to include duties, handling, warehousing, reloading, and other costs incidental to loading of the material for shipment).
4. Transportation cost for shipment into Bolivia.

The actual purchase price for fertilizers (f.o.b. source) is dependent on several factors. Most of these factors are related directly or indirectly to the market conditions prevalent at the time of purchase. Market conditions are considered the overriding factor governing fertilizer purchase price.

Other factors which impact on price include the following:

1. Shipment Size--The effect of shipment size on the contracted purchase price would be of more importance if specialty materials were being considered. When considering products such as urea, DAP, or MAP, the actual contract price is closely tied to prevailing market conditions (supply and demand). Shipment size would affect the shipping cost as would the registry of the vessel used, the availability of backhauls, and the contract conditions. Normally, shippers prefer to carry shipload quantities to a single destination; partial shipments usually incur increased shipping costs per ton of product delivered. Price quotes for ocean freight and unloading of vessels of various capacities increase by a factor of 2 on a cost-per-ton basis when comparing vessels of 40,000 tdwt with those of 10,000 tdwt (43).

2. The Nature of the Purchase--Purchasing on a "spot" purchase basis usually results in a higher price than purchasing under long-term contracts. Contracts usually are for a year or less with escalation clauses built in to protect the seller. In general, "spot" purchases of small amounts (less than 5,000 mt) would result in a comparatively high f.o.b. price per ton compared with negotiated contract prices.

3. Time of Purchase--The time of purchase is important because of the cyclical nature of the fertilizer market in the United States and Western Europe. If purchase tenders are let during the "off season" in Europe and North America, usually during the period May-July, quotes are generally at their lowest levels with resulting savings for the buyer.

4. Form of Product--As one can see from table 11, bagged fertilizers command a premium over bulk materials. Generally, for U.S. material this premium is $25-$35/mt depending on market factors and the other factors listed here. Transport costs for bulk are also lower than for bagged materials resulting in still greater savings with bulk.

5. Freight Considerations--The freight rate charged by U.S. carriers is usually higher than that charged by vessels of another registry. This rate can at times be three times as high for U.S. vessels than for others.

   These rate differences compounded by the small shipment size could result in higher-than-normal freight charges. However, freight rates for shipping Florida phosphates for 10,000-mile distances were in the range of US $10-$30/mt during the period 1971-75. The highest rate occurred in 1974 (44).

Table 11 shows prices for urea, DAP, and MAP quoted as f.o.b. U.S. Gulf coast (Tampa or New Orleans). These prices should be representative of negotiated prices for delivery in November or December, 1978, and are IFDC estimates based on the current market conditions and information supplied by manufacturers and brokers.

Specific estimates of shipping costs are more difficult to obtain. Costs reported for recent fertilizer shipments to Antofagasta from the United States ranged between $18 and $19/mt for bagged materials and $15 and $16 for bulk fertilizers (vessels of non-U.S. registry). Due to the distances involved, the cost of shipping to any of the ports serving Bolivia (Matarani, Arica, Antofagasta, Santos, Buenos Aires, or Rosario) would probably fall within these ranges. Shipments of less than 15,000 mt would command a premium which would probably amount to about $4/mt (IFDC estimate, see item no. 1).

Port Charges--When the fertilizer arrives at the port, it is subject to a myriad of additional charges for handling, storage, reclaiming, loading, duties, and tariffs. These charges are port specific and subject to change or renegotiation. As a result, the charges listed are included for discussion and comparison only and are not intended to be the actual port charges in effect.

Generally, the materials entering the ports are classified by type (machinery, food, etc.) and physical characteristics (bagged, bulk, containerized). These classifications are used at the port to calculate duties and handling, loading, and storage charges. The railroads use similar classifications to determine rate structures for freight charges. Tables 12, 13 14, and 15 contain examples of the merchandise classifications as well as many of the incidental charges levied at the ports.

The apparent costs involved in importing small quantities of fertilizers are enumerated in table 16. The total price of $281.55, shown in table 16, would represent the price paid by the distributor to purchase the fertilizer and have it delivered in Cochabamba. A profit margin would be added to this cost, and the actual price paid by the consumer would therefore be in excess of the $281.55 shown.

Table 11. Current Fertilizer Prices (f.o.b. U.S. Gulf)

Material	Costs			
	Bagged (US $)	per kg Nutrient	Bulk	per kg Nutrient
MAP (granular)	187	.312	155	.258
MAP (nongranular)	172	.286	140	.233
DAP (granular)	187	.292	155	.242
Urea (prills)	162	.352	130	.283

Source: IFDC estimate; for delivery November-December 1978.

Table 12. Cost of Loading and Unloading of Merchandise in Transit to Bolivia (Arica) (6)

Name	Cost per Ton			
	Unloading Ship		Loading Train or Truck	
	Direct	Indirect	Direct	Indirect
	US $			
1. Animals (on foot)(each)				
a. Large	1.40	3.15	0.42	1.17
b. Small	0.35	2.10	0.11	0.86
2. General cargo				
a. Packed	8.50	10.25	2.55	3.30
b. Semi-packed	9.25	11.00	2.78	3.53
c. Not packed	10.25	12.00	3.08	3.83
d. Palletized	7.75	9.50	2.33	3.08
3. Food, fertilizers, cement				
a. Packed or bagged	3.20	4.95	0.96	1.71
b. Palletized	3.00	4.75	0.90	1.65
c. Bulk				
1. Mechanized	2.85	4.60	0.86	1.61
2. By other means	2.40	4.15	0.72	1.47
4. Machinery, motors, etc.				
a. Crated	10.00	11.75	3.00	3.75
b. Not crated	12.50	14.25	3.75	4.50
5. Containers				
a. Loaded	9.60	11.35	2.88	3.63
b. Empty	5.00	6.75	1.50	2.25
6. Metallic minerals and ores				
a. Bagged	5.20	6.95	1.56	2.31
b. Palletized	4.40	6.15	1.32	2.07
c. Bulk				
1. Mechanized	3.35	5.10	1.01	1.76
2. By other means	2.70	4.45	0.81	1.56
7. Primary metals (all forms)				
a. Ingots	7.00	8.75	2.10	2.85
b. Crated	6.10	7.85	1.83	2.58
8. Raw materials for industry				
a. Bagged	8.00	9.75	2.[illegible]0	3.15
b. Not bagged	9.50	11.25	2.85	3.60
c. Crated	7.20	8.95	2.16	2.91
9. Bulk solids				
a. Mechanized	3.70	5.45	1.11	1.86
b. By other means	3.00	4.75	0.90	1.65
10. Bulk liquids	1.50	3.25	0.45	1.20

The unit of collection is 100 kg; the minimum invoice is US $1.50.

Table 13. Price of Additional Services (Arica) (6)

1. Location and weighing of crates	US $1.00/mt
2. Weighing of cars or trailers	0.10
3. Spotting the railcars	0.14
4. Moving into the Bolivian site	3.00
5. Other operations	2.20
6. Repair and installation	20% of net cost
7. Cleaning (for each work group)	10.00/hr
8. Food	1.50/man
Materials loaded or unloaded are affected by the following charges:	
a. Sacks larger than 80 kg	5.20/mt
b. Crates of 10 mt or greater	3.50/mt
c. Bulk materials with lumps or caked	0.50/mt

Table 14. Charges in Effect by EMPORCHI at Antofagasta (8)

1.	Handling charge of 10% of invoice	-
2.	Charge for offloading to warehouse	$1.75/ton
3.	Spotting of railcars	0.14
4.	Moving material to Bolivian warehouse	3.00
5.	Warehousing--varies with material and time	-

Table 15. Duties Charged (7)

	Basic Soles (US $)	Additional (Dollars)
a. Nonspecific cargo	78 (1.11)	0.84
b. Solid cargo in bulk moved to terminal installations		
1. Wheat (by pneumatic tower)	100 (1.43)	0.28
2. Minerals (by belt conveyor)	70 (1.00)	0.24

US $1.00 = 70 soles, International Monetary Fund data, late 1976.

Table 16. Apparent Cost of Moving Fertilizers into Bolivia

Item		Cost US $/mt	% Value Added
1. Fertilizer (DAP) bagged f.o.b. U.S. Gulf		187[a]	-
2. Ocean freight and insurance		22[b]	10.5
3. Port charges[c]			
a. Unloading	4.95		
b. Other charges	7.00		
c. Reloading	1.71		
		13.66	6.1
4. Duties and tariffs[d]			
a. Port	3.10)	7.10	3.1
b. Bolivia (2%)	4.00)		
5. Freight, Antofagasta-Ollague		9.02[e]	3.8
6. Freight, Ollague-Cochabamba		40.27[e]	14.4
7. Incidental costs including unloading warehousing, etc.		2.50	1.0
Total Delivered Cost		281.55	

a. See table 11.
b. Includes $4.00/mt premium for partial shipment.
c. See tables 12, 13, 14.
d. Estimate.
e. Table 18.

Import of fertilizers in the past in Bolivia has been undertaken by one of a number of "distributors"; the large ones have been affiliated with a major producer or broker either in the United States or Europe. For the analysis here and in other sections, the dealers' markup will be omitted to avoid confusion. Normally, the distributor adds a markup, and then any local dealer adds his markup. Values added in these cases are generally in the 15%-20% range, resulting in as much as a 40% increase in the fertilizer's cost over the actual landed price. In this instance, the selling price to the farmer could be well over $390/mt. This point is substantiated by the cost figures presented in table 17 which show selling prices of $400 and $380 for DAP and urea, respectively. In fact, when local merchants open fertilizer bags and sell partial bags, the price for DAP can be as much as $700/mt. (Prices in this range were observed by the IFDC team at local fairs in the altiplano north of La Paz.)

From tables 16 and 18 it is evident that the charges for transportation within Bolivia are responsible for the largest percentage of added value to the delivered cost of the fertilizer. In the case of the shipment being moved to Cochabamba, this within-country cost is actually higher than the combination of both the ocean freight from the U.S. Gulf to Antofagasta and the rail freight charge to Ollague. By the same token, we can see from table 19 that the use of trucks as opposed to rail would result in an even higher cost. In the instance of the first two entries in table 19 (Antofagasta-La Paz by rail versus Matarani-La Paz by truck), the cost of rail and truck results in US $0.0254/mt/km and US $0.0538/mt/km, respectively.

The cost figures and shipping analysis developed will be used later as a base point for comparison of methods for importing fertilizers (see section, "Phases for Implementation of Cost-Reducing Recommendations").

Future Fertilizer Manufacturing Plans Within Bolivia

At present Bolivia has no fertilizer industry with the exception of the informal "industry" of the supply of organic fertilizers. In fact, it has been stated that sheep manure is as valuable to the sheep grower as wool. There also exists an industry of sorts dealing with the importation of finished chemical fertilizers. The major suppliers function as importers only, with little regard for distribution or any service activities. There appears to be no presale or aftersale services available to farmers. Extension-type services are supplied by the public sector through IBTA and SNDC or through the cooperatives' and growers' associations.

Discussions have been going on in Bolivia for many years concerning the development of a local fertilizer industry. The first recommendation to build a fertilizer production facility was made in a report to the Bolivian Ministry of National Economy in 1961 by V. S. Debausset. This suggestion was considered and expanded in various later reports resulting in the 1964 proposal for an ammonium nitrate facility prepared by M. W. Kellogg (37). This is the same project which was used as a basis for the 1970 TVA report (10).

Table 17. Present Fertilizer Prices in Bolivia

Material	Grade	Selling Price $/mt
DAP	18-46-0	400[a]
Urea	46-0-0	380[a]
Ammo-Phos	16-20-0	316[b]
Ammo-Phos	12-24-12	334[b]
Nitro-Phos	12-12-17-2	227[c]
Nitro-Phos	15-15-15	220[c]
Nitro-Phos	20-20-0	225[c]
Ammonium Sulfate	21-0-0	140[c]

a. Data from CID, Cochabamba - from Grace, quoted purchase price, Cochabamba.
b. From British Mission on Tropical Agriculture, quoted c.i.f. at border.
c. From British Mission on Tropical Agriculture, quoted c.i.f. at Buenos Aires, actual c.i.f. price at Santa Cruz would be $100-$125/mt more.

Table 18. Charges per mt for Transport of Fertilizer in Full Railcars[a]

		15-19.9 mt	20-24.9 mt	25-28.5 mt	28.6 mt or More
Antofagasta/Ollague		180.40 (9.02)	-	-	-
Ollague/Cochabamba		805.32 (40.27)	729.58 (36.48)	694.42 (34.72)	660.96 (33.05)
Arica/Charana		189.60 (9.48)	-	-	-
Charana/La Paz		371.24 (18.56)	336.32 (16.82)	320.12 (16.01)	304.69 (15.23)
Guaqui/La Paz		277.25 (13.87)	256.18 (12.81)	246.40 (12.32)	237.09 (11.85)
Santos/Corumba		CR 710.00 (38.78) approximation			
Corumba/Santa Cruz		745.44 (37.27)	675.34 (33.77)	642.79 (32.14)	611.82 (30.59)
Buenos Aires/Pocitos	$arg.	28,294.00 (35.13)	24,032.00 (29.83)	21,860.00 (27.14)	20,721.00 (25.72)
Pocitos/Yacuiba	$arg.	39,411.00 (48.93) By railcar			
Yacuiba/Santa Cruz		625.70 (31.29)	566.85 (28.34)	539.54 (26.98)	513.54 (25.68)

a. Prices are in $b/mt followed by US $/mt, exchange rates: $b 20 = US $1, CR $18.31 = US $1, arg. $805.50 = US $1.

Table 19. Distances and Cost of Transport (25)

	km	By	$b/mt (US $/mt)	$/mt km
Antofagasta-La Paz	1,296	R	658 (32.90)	0.0254
Matarani-La Paz	610	T	656 (32.80)	0.0538
La Paz-Oruro	239	T	166 (8.30)	0.0347
Oruro-Cochabamba	197	T	136 (6.80)	0.0345
Cochabamba-Santa Cruz	500	T	338 (16.90)	0.0338
Oruro-Potosi	335	T	228 (11.40)	0.0340
Cochabamba-Sucre	366	T	248 (12.40)	0.0339
Potosi-Matarani	1,184	T	1,190 (59.50)[a]	0.0503
Santa Cruz-Arica	1,243	T/R	1,126 (56.30)[a]	0.0453
Santa Cruz-Corumba	-	R	1,112 (55.60)[a]	-

a. Estimated in case of future export.

Note: R--Railroad
T--Truck

For several years within Bolivia there has existed the need to provide lower priced fertilizers and make them available to the farmers on a timely basis. The previously proposed Bolivian fertilizer projects were based heavily on a large export market. In other words, up to 90% of a proposed factory's production would have to be exported during the first 5 years or so of operation. The relatively large project approach and the requirement of joint ventures among Bolivia, Brazil, Argentina, and Paraguay have resulted in difficulties in obtaining outside funding for these projects.

For several years there were proposals and studies pertaining to production of single superphosphate utilizing the sulfuric acid from the COSSMIL plant at Eucaliptus. Due to the requirement to use imported phosphate rock and the high cost of sulfuric acid from the COSSMIL plant (reportedly $50/mt ex-gate), this project was abandoned.

YPFB now has a plan to utilize the natural gas of the Santa Cruz region for production of ammonia and urea. The planned capacity of this facility is to be 160 mtpd of ammonia and 200 mtpd of urea as urea prills (9). At an operating factor of 90%, this complex would produce about 60,000 mtpy of urea. The present consumption of nitrogen in Bolivia is less than one-tenth of this amount. Even with the increase in use which is anticipated with the lowering of urea prices, it is still doubtful that the internal consumption in Bolivia during the next 5 years would account for as much as 60% of the total production (a number which has been used previously to determine production feasibility) (10). Using an integrated agricultural program, there exists the opportunity, with the integrated cooperatives as a base, to begin market development activities to increase fertilizer use to levels supportive of this and other indigenous fertilizer production projects.

In addition to this YPFB project, another large ammonia/urea complex has been proposed for Puerto Suarez (by YPFB). This project would utilize a portion of the natural gas now being sold to Brazil for the production of 545 mtpd of ammonia and 940 mtpd of urea. The total output of this plant would be aimed at the export market, primarily for the western portions of Brazil (25). This project seems to be more tentative than the smaller project at Santa Cruz.

The National Smelting Company (ENAF) is considering a phosphate production project in conjunction with a proposed zinc refinery for construction in the Potosi area. The related phosphate project is being studied by DPG based on prefeasibility reports prepared by DPG and RTZ. The project is based on production of TSP with the possibility for production of MAP or DAP at a later date. Production of MAP and DAP has not been under serious consideration due to the requirement for transporting ammonia from the Santa Cruz or Puerto Suarez areas. In the event that availability of ammonia is secured at a later date, the phosphoric acid plant could be expanded to produce powdered MAP (25, 5). This project is initially based on imported phosphate rock with the hope that current DPG investigations in the Campinota area will result in discovery of commercially exploitable deposits of local phosphate ores.

If the phosphoric acid plant and the YPFB nitrogen facility are built, the IFDC team suggests that utilization of the excess ammonia from Santa Cruz (~40 mtpd) be considered for the production of MAP. A study to compare the relative costs of MAP and GTSP would provide interesting results.

Studies are underway to determine how best to utilize the potassium and lithium salts which have been discovered in the salars. At this time there exist no firm plans for projects to extract potash for use as a fertilizer raw material. Such projects should be forthcoming based on the optimistic outcome of studies underway at present.

The IFDC recommendations for providing lower cost fertilizers to the Bolivian farmers are not dependent upon any of the above projects. The plan recommended by IFDC complements these projects if they materialize, and any success achieved in market development improves the economic viability of the larger projects.

Fertilizer Practice and Use

The small farmer from the altiplano has been applying fertilizer for centuries in the form of animal manure. Chemical fertilizers were almost completely unknown as agricultural inputs prior to the revolution of 1952. After that date, when they were finally freed from the feudal obligation of delivering all of their animal manure to the hacendado (landowner), the campesinos began to apply manure to their own fields.

The economic returns were so easily measured that increasing purchases of animal manures from herdmasters in the mountain areas increased the value of these manures out of proportion to their actual nutrient value. Even so, the price of the locally available organic fertilizers and the uncertain supply of imported chemical fertilizers often left the campesino with no alternative other than paying the high price for animal manures to fertilize his most important crop, potatoes. This potato crop was important not only as the basic staple food in his family's diet but also as the prime source of income from the farm.

The use of chemical fertilizer had a late start in Bolivia, yet there have been large volume increases since 1952. The period of 1973-75 reflects the increased cost of fertilizer due to the energy crisis (figure 7). At the present time, between 80% and 90% of all imported fertilizers goes into the production of potatoes, which are grown in the altiplano and valley regions. Over the past 10 years, the altiplano and valley regions have accounted for 91.4% of total fertilizer used (table 20). Studies show that, on the average from 1966 to 1976, 70% of all fertilizer imported was applied to potatoes (1, 4). While most of the fertilizer is used on potatoes, there are increasing amounts being applied to the citrus fruit plantations and garden-type vegetables, which command fairly reasonable prices in the urban sectors. The mechanized commercial or plantation type of agricultural operations, such as sugarcane and cotton, does not account for a very large proportion of fertilizer consumption. In the tropical areas, it has been found to be more economical to take advantage of the original fertility of the soil resulting from its high organic matter and mineral content. The normal operation is to clear the land and plant 2-3 years of sugarcane and then rotate the land into cotton, corn, or pastures as the available nutrient level begins to decline.

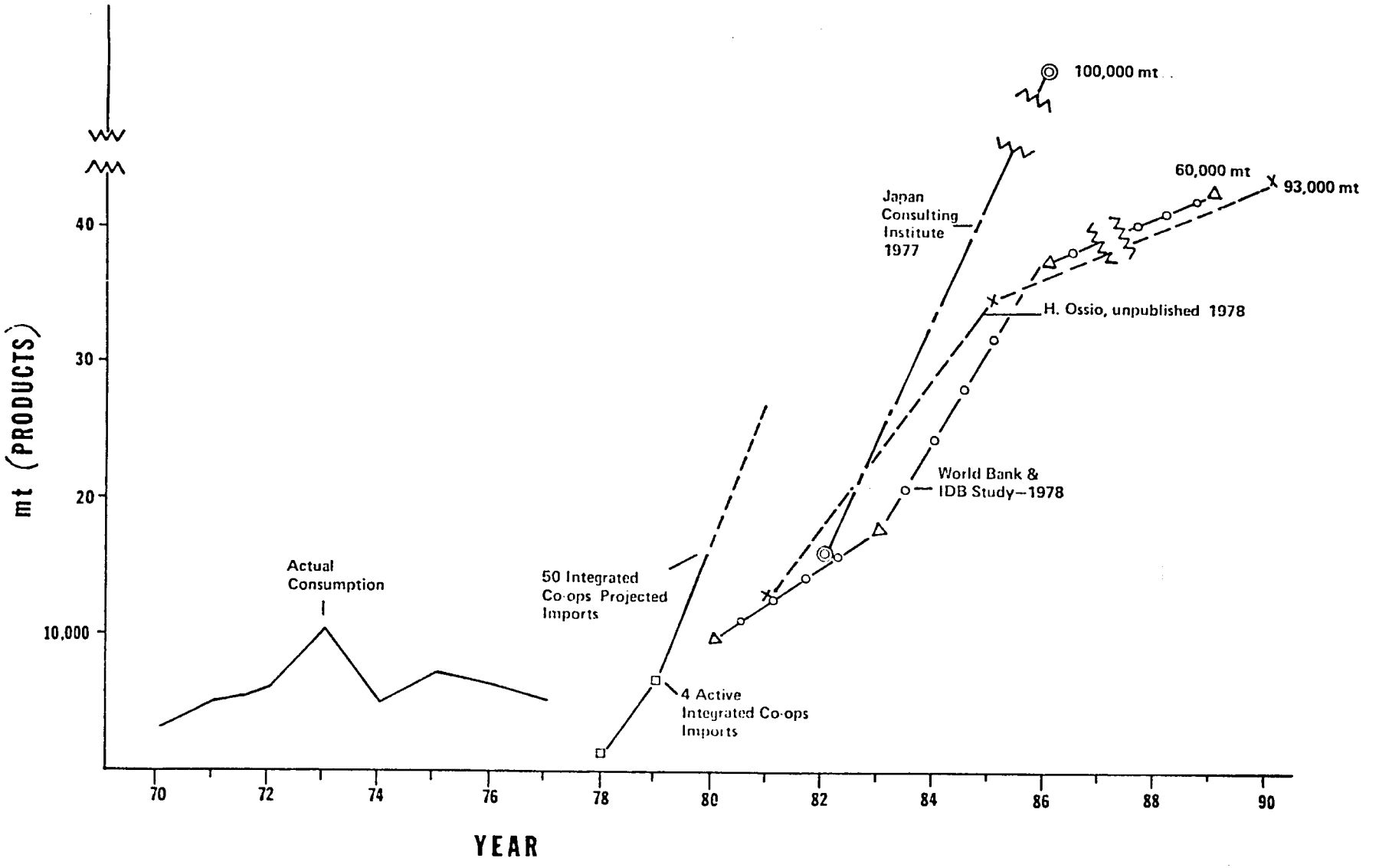


Figure 7. Actual and Projected Fertilizer Consumption in Bolivia

Table 20. Bolivia Regional Fertilizer Consumption (1)

Year	Regions			
	Altiplano	Valley Regions	Oriente	Total
	mt			
1966	1,085	1,503	155	2,743
1967	1,413	2,005	279	3,696
1968	2,152	3,012	356	5,520
1969	1,616	2,229	214	4,059
1970	1,276	1,910	415	3,601
1971	2,039	2,916	439	5,394
1972	2,290	3,258	466	6,014
1973	4,119	5,844	811	10,774
1974	1,692	2,605	669	4,966
1975	2,749	4,037	766	7,552
1976	2,272	3,334	630	6,236
Average	2,064	2,968	473	5,505
% of total	37.5	53.9	8.6	

The amounts of fertilizer now being applied to wheat and corn are negligible and reflect the fluctuating demand for these products in the marketplace. The domestic production of wheat has not developed as was projected by a number of previous investigators (10). This has been due to the fluctuations of international trade in grain and partly to the benefits of a number of foreign aid programs for imports of wheat and flour. The availability of imported wheat, coupled with a low price and higher quality, has resulted in greater consumer acceptance of the foreign wheat over any of the domestic varieties. It is always possible that a program to meet the country's wheat needs will be developed; this should be coupled with the proper agricultural inputs for economic production at the local level.

Quinoa (Chenopodium quinoa) is a crop that is well known and extensively cultivated in Bolivia and could benefit from a fertilization program (52). This grain crop is produced at higher elevations on small farms. It is very popular with the campesinos and has many advantages over other small grains. Quinoa is produced even more for the on-farm consumption than the potato crop (2, 4). One of the advantages of this crop is its adaptation to poor soils and the inclement and variable climate of the high agricultural areas in the altiplano. It is higher in protein and vitamin content than wheat and could represent an improvement in the diet of the Bolivian consumer. It is now being used for on-farm consumption as a part of the rotation with potatoes.

The new agricultural areas of the oriente are not realizing their full potential of fertilizer consumption. The land, once cleared of its forest cover, is a virgin soil with high fertility which is systematically drained by planting sugarcane crops, and only in later years are rotations introduced to include cotton, corn, or rice. These other crops in the subsequent rotation are fertilized only to bare minimum amounts. The exploitation of these lands indicates that farmers are moving to new areas rather than investing in fertilizers in the already cleared land areas. This can continue for only a finite time since there is a limit to the amount of virgin land available close to the centers of market facilities and with farm-to-market road transportation.

Extension Services

Background

A modern form of agricultural extension services, patterned after those of the United States Department of Agriculture, was established in Bolivia around 1947. During the period of 1950-60, there were many extension programs and youth programs (4-S) along with bulletins, field demonstrations, and radio programs to bring the most modern and up-to-date practices to the Bolivian rural population. During this same period the research work began to falter from lack of funds and proper management and the extension service suffered from the same problems. Most of the past problems have been heightened by the lack of funding for normal operating and maintenance costs.

Even though the extension service is not as active today as it has been in the past, the results of the heavy commitment to the agricultural extension

service in the late 50's and early 60's are still very evident in the agricultural community and with the campesino. The small farmer is aware of fertilizer as an input requirement and of the benefits to be derived from the organic- or commercial-type fertilizers; he is also aware of the commercial names of imported fertilizers and the nutrient content of various materials. He knows, in descending order of purchase preference, the different types of fertilizers available on the market. He is able to make intelligent decisions as to the plant varieties that he will use--early-maturing varieties or late-maturing varieties--depending on the rainfall and soil moisture content at the time of planting. He also has knowledge of available pesticides and is up-to-date on their latest costs.

The capabilities and sophistication of the Bolivian small farmer are considerably more advanced than what is generally recognized by some government officials and foreign assistance program personnel.

Research Stations

Table 21 shows the location of the 15 experiment stations now in operation. All have been established since 1946; several were developed after 1960. The discontinuity of research programs and the lack of impact on the agricultural sector are reasons for minimal results. Most of the disruptions have resulted from the changes in management due to the various transfers of the research program responsibility within the GOB.

Community Development Program

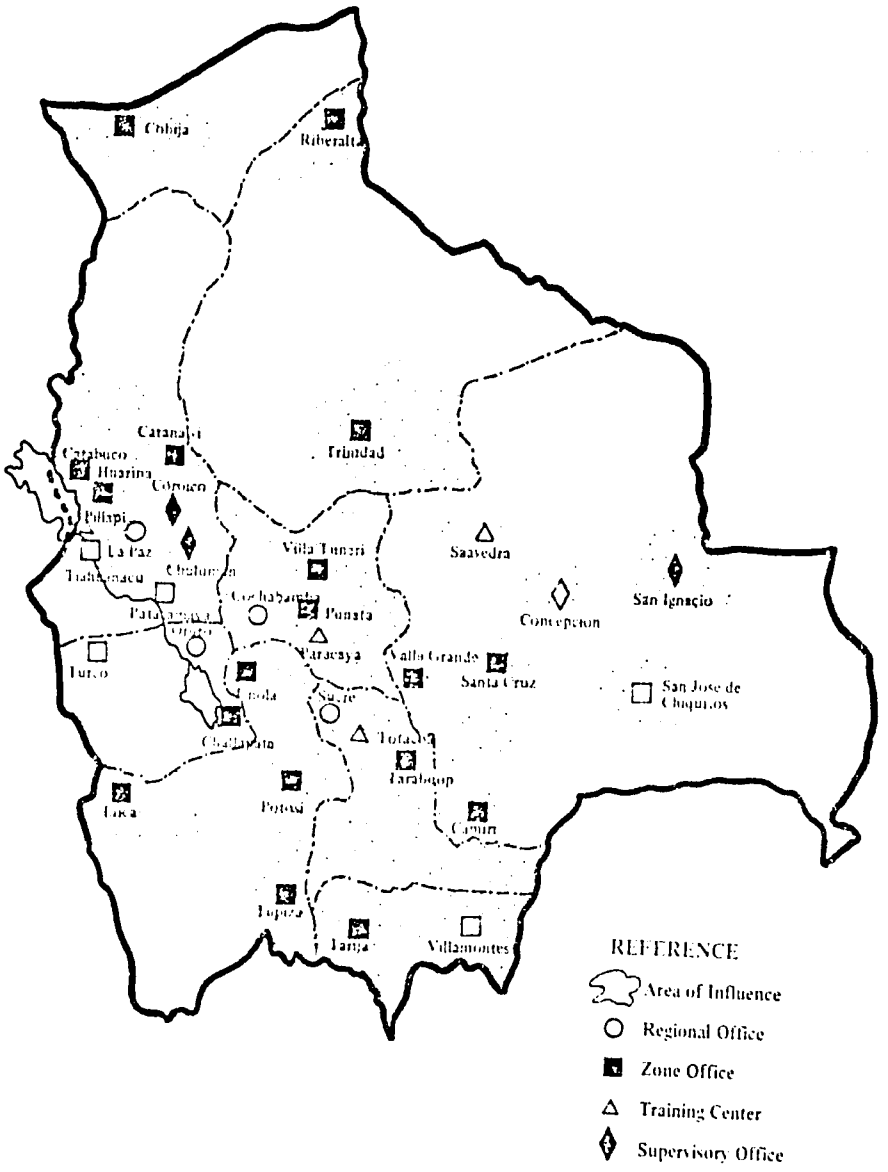
Community development programs, started in the Ministry of Agriculture in the late 1950's, led to the development of the National Community Development Service (SNDC) in 1967. Most of the activities of the SNDC are programs focused on small farmers in the altiplano and the valley regions. The stated objectives of the SNDC are to integrate the campesino into the process of economic development, foster social and political awareness, and organize the community to enhance agricultural production and standard of living (21).

The community development program lists 633 technicians who are located throughout the country. There are 132 central offices, 119 regional offices, 331 zonal offices, 35 training centers, and 16 production centers (figure 8). Over 80% of all personnel work permanently in the rural areas. The supervisors, technicians, and promoters, both male and female, comprise a dedicated group of people who live in the outlying districts and meet with their local community groups on a daily basis. This practice helps to dispel some of the criticism of the sporadic operation of the former extension service organization.

USAID/Bolivia is one of the major technical advisors to the development of the organization for small farmers. Much of the funding from USAID has been used in training and for financing the purchase of vehicles and office equipment. USAID/Bolivia has underwritten the costs of the technical contract through Robert R. Nathan & Associates, Inc., working as consultants for the economic and social development within the SNDC.

Table 21. Agricultural Research Stations in Bolivia (1974) (4)

Station	Location	Year Developed	Principal Focus
Belen	North Altiplano	1946	Potatoes, sheep, vegetables
La Tamborada	Valley Regions-Cochabamba	1947	Wheat
Reyes	Beni Plains	1948	Beef, cattle, pastures
Saavedra	Santa Cruz	1948	Rice, sugarcane, corn
Riberalta	Amazon Rain Forest	1952	Rubber
Muyurina	Santa Cruz	1953	Cattle
Patacamaya	Central Altiplano	1953	Sheep, forages, wheat
Trinidad	Beni Plains	1961	Beef, cattle, rubber
Chinoli	South Altiplano	1962	Potatoes, wheat
Toralapa	Cochabamba	1962	Potatoes
Chipiriri	Yungas-Cochabamba	1964	Citrus, rice
San Benito	Valley Regions-Cochabamba	1970	Fruit, wheat
Villamontes	Bolivian Chaco	1970	Oilseeds
COTESU-Cochabamba	Valley Regions-Cochabamba	1974	Dairy cattle
COTESU-Todos Santos	Santa Cruz	1974	Beef, dairy cattle



Source: Annual Report 1977, National Community Development Service, MACA, La Paz, Bolivia

Figure 8. National Community Development Services Office Locations

The strategy for the implementation of the SNDC goals is both innovative and effective. The plan makes use of a first contact by a group of dedicated individuals, mostly women, who are called "promoters." These promoters make the first contact in selected small, isolated villages with the local women. Programs range from nutrition, child care, and vegetable gardening to raising poultry for home use. Once these promoters have gained the confidence of the village women, they bring in associates to discuss the advantages of organizing a small cooperative. Along with the explanation and demonstration of the advantages of forming the village cooperative which will be a part of the overall cooperative program, the promoters can call on other specialists for specific programs and meetings. Formerly, the extension service technicians could not develop the working confidence with the local people that the promoters have demonstrated. The promoters develop this confidence by actually living and spending the major portion of their time in the communities that they are assigned. They walk as do the campesinos from one community to another or use the local rural transportation. There are very few vehicles or motorbikes available for use by the promoters. Initially, this seems to be a disadvantage, but the effectiveness of spending major portions of their time in the communities is a great advantage. The overall importance of the integrated cooperative and the organization of small farmers are shown in figure 9. The Agricultural Bank of Bolivia, the National Community Development Program, the Agricultural Extension Service, and other institutions working through the integrated cooperatives bring the technical assistance, the credit, the inputs, the sale of the commercial products, small industry, and other benefits to the campesino.

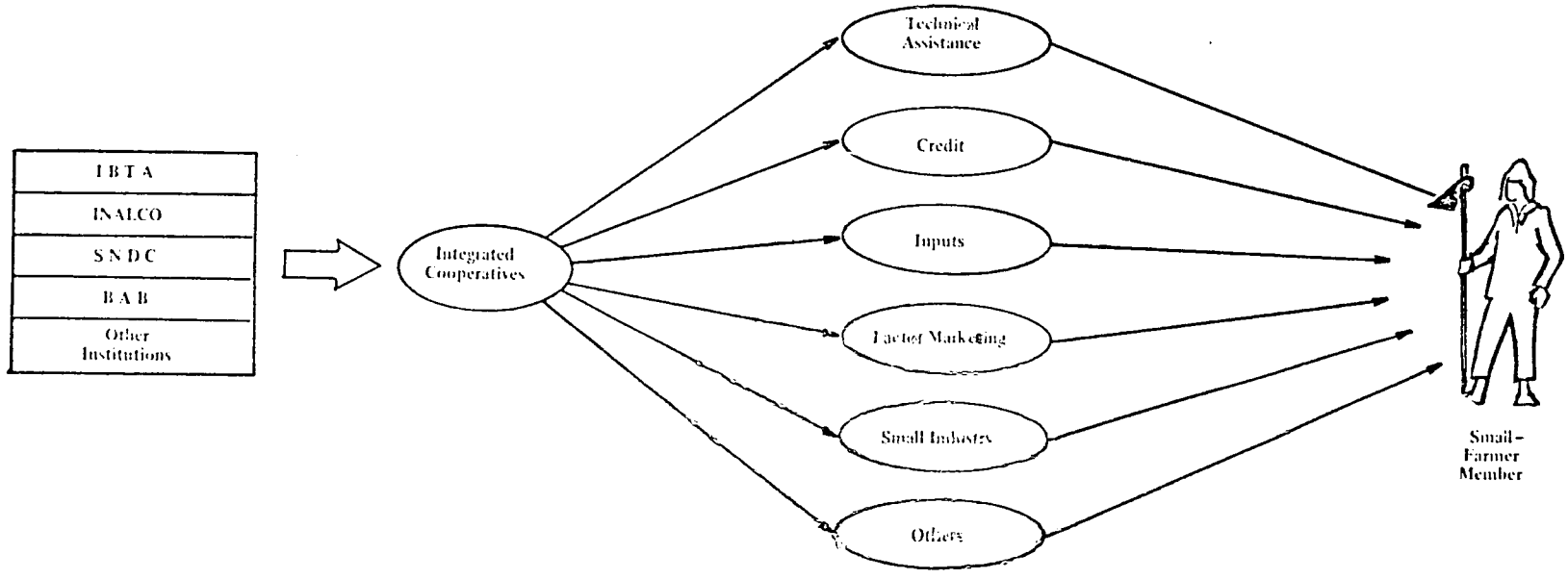
The Rotating Credit for the Development of Small Farmer Organizations (CROFOC) is the organization through which loan funds are channeled to assist the integrated cooperatives and to import fertilizers and other inputs required for the small farmer. The credit is underwritten by donations from both the USAID program and the GOB (for technical assistance). In 1976-77, funds totaling $b 9,504,000 (US $475,200) were approved for use in the program. In 1977, the amount was increased to $b 26,500,000 (US $1,325,000), based on the activity and results of the first year's program. The number of participating members in 1976 was 1,145, compared with 2,272 in 1977. In 1977 two integrated cooperatives were formed with each having approximately 1,500 members. In 1978, two more integrated cooperatives were organized, each having between 1,500 and 2,000 members. Two more integrated organizations are planned for development in 1979 which makes a total of six integrated cooperatives with a membership of 10,000-12,000.

Soil Testing Laboratories

One of the most evident deficiencies of the agricultural program in Bolivia is the lack of an effective soil testing program or a network of soil testing laboratories. There is an active soil testing laboratory under CIAT administration located in Santa Cruz, but this is several hundred kilometers removed from the center of demand for fertilizers.[1] Normally, the time and the

1. CIAT is a local Bolivian organization not associated with the Centro Internacional de Agricultura Tropical (CIAT) in Colombia.

SERVICES PATHWAY FOR INTEGRATED COOPERATIVES



Source: Annual Report 1977, National Community Development Service, MACA, La Paz, Bolivia

Figure 9. Services Pathway for Integrated Cooperatives

variancies of transport and mailing system work contrary to the utilization of this laboratory. The laboratory was established by North Carolina State University and uses their methods of analysis. The Santa Cruz Soil Testing Laboratory ran most of the soil tests for the British Tropical Soils Mission team that developed the extensive soil map of Bolivia which was recently published (26).

The organization ASAR in Cochabamba has gone to the extreme of sending soil samples to both Europe and the United States in order to have a representative check on analyses made at Santa Cruz. The results of all samples were within the limits accepted for these types of analyses.

Present Consumption and Projected Consumption of Fertilizer

The previous studies on the actual and projected Bolivian fertilizer consumption have usually tried to develop recommendations for specific programs which would justify and validate their future projections (2, 4, 10). As an example, the projections that were developed by the TVA study included a basic program to raise domestic wheat production that could have been a major factor in increasing the overall size of the fertilizer market (10). The study assumed that wheat would absorb more of the nitrogen and phosphorus than potatoes, which currently account for 80%-90% of the fertilizer used. These projections were not realized due to the failure to implement the recommended wheat program. In other studies the developing and expanding area of the tropical oriente, with its large plantation crops such as sugarcane and cotton, was projected to be a large consumer of fertilizer (9). This projection has not materialized. It was also estimated that corn production in all parts of the country would develop into a large consumer of fertilizers; this has not happened (9).

Most of the increase is to be in the fertilization of corn and wheat. Tables 22 and 23 show an expected 15-fold increase in use for both N and P on corn. Wheat fertilization is projected to increase from 1,900 mt of nutrient in 1982-83 to 14,000 mt by 1985-86. Significant increases have also been predicted for the remainder of the major crops (tables 22 and 23). To date, these projected increases have not been tied to existing programs or organizations but based on development of future increased fertilization brought about through unknown methods.

Present consumption as shown by figure 7 is about 6,000 mt of fertilizer products (N3,000 mt nutrient). The data in table 22 predict a 300% increase to 9,000 mt by 1982-83. The recent success shown by the system of integrated cooperatives in fertilizer importation and projections by SNDC (figure 7) would substantiate a prediction of rapid growth of fertilizer use over the next several years.

The following projections of fertilizer imports planned by the cooperatives were based on the actual number of members and the loan funds already reserved for this purpose. The 10-year average consumption of fertilizer (1966-76) was 5,504 mtpy with consumption declining since 1975 (1). In 1978 the integrated cooperatives imported and distributed 1,500 mt of fertilizers. The projection for 1979 is 6,800 mt to be imported only by integrated cooperatives in operation at the end of 1978 (figure 7) (51). These projected purchases are as firm as can be developed in today's fertilizer market.

Table 22. Forecast of Fertilizer Consumption by Crop and by Region in 1981-82 (9)

		Potato	Wheat	Corn	Sugarcane	Cotton	Others	Total
		'000 nutrient mt						
La Paz	N	0.6			0.1			0.7
	P	0.5			-			0.5
	K	0.1			-			0.1
Cochabamba	N	0.7	0.5	0.1			0.1	1.4
	P	0.6	0.2	-			0.1	0.9
	K	0.2	0.2	-			-	0.4
Chuquisaca	N	0.5	0.4	0.1			0.2	1.2
	P	0.4	0.2	0.1			0.2	0.9
	K	0.1	0.1	-			0.1	0.3
Santa Cruz	N			0.2	0.5	0.4		1.1
	P			0.1	0.1	0.1		0.3
	K			0.1	-	-		0.1
Others	N	0.3	0.2				0.1	0.6
	P	0.2	0.1				0.1	0.4
	K	-	-				0.1	0.1
Total	N	2.1	1.1	0.4	0.6	0.4	0.4	5
	P	1.7	0.5	0.2	0.1	0.1	0.4	3
	K	0.4	0.3	0.1	-	-	0.2	1

Table 23. Forecast of Fertilizer Consumption by Crop and by Region in 1985-86 (9)

		Potato	Wheat	Corn	Sugarcane	Cotton	Others	Total
		'000 nutrient mt						
La Paz	N	1.7		0.3	0.4		0.3	2.7
	P	1.9		0.2	0.2		0.3	2.6
	K	0.3		0.1	0.1		0.1	0.6
Cochabamba	N	2.2	3.9	1.2			0.8	8.1
	P	2.6	1.7	0.6			0.8	5.7
	K	0.3	0.5	0.2			0.2	1.2
Chuquisaca	N	1.3	3	1.4			1.3	7.0
	P	1.5	1.3	0.7			1.3	4.8
	K	0.2	0.3	0.2			0.3	1.0
Santa Cruz	N			2.5	2.6	2.0	0.5	7.6
	P			1.2	0.8	1.0	0.5	3.5
	K			0.4	0.4	0.5	0.1	1.4
Others	N	0.8	2.1	0.6			1.1	4.6
	P	1.0	1.0	0.3			1.1	3.4
	K	0.2	0.2	0.1			0.3	0.8
Total	N	6.0	9.0	6.0	3.0	2.0	4.0	30
	P	7.0	4.0	3.0	1.0	1.0	4.0	20
	K	1.0	1.0	1.0	0.5	0.5	1.0	5

Marketing and Distribution

There are 20 firms in the business of importing and selling fertilizer materials in Bolivia. This is a reduction from 1974 when there were approximately 26 firms involved in the sale and handling of fertilizers. The largest company, W. R. Grace & Co., was recently sold to Alke & Co., a local distributor. Each of the two large companies, Alke and Servicio Agricola Comercial (SAC), had between 20 and 35 retail outlets in 1969-73. This has now been reduced to approximately half that number.

Major use of chemical fertilizers began in Bolivia in 1960 when approximately 1,350 mt was sold. Even though there has been an increase in subsequent years, the marketing effort and technical service offered by the fertilizer companies have not developed to a great degree. This is due in part to the nature and attitude of the commercial companies involved in importing fertilizers. In all companies, fertilizers are a sideline along with other agricultural inputs such as pesticides, small machinery, hand tools, and veterinary medicines. For the most part, the distributors are commercial companies set up as manufacturers' local representatives. This representation includes everything from toothpaste to refrigerators and various other items that make up the commercial activity in a developing country. Fertilizers must compete with other imported products within the local company on a comparative margin. If the returns for fertilizers are low in comparison, the companies quickly lose interest and do not import or store any type of fertilizer. The importing companies with this attitude generally do not plan ahead and do not purchase at the best possible time or price; they do not anticipate the need to warehouse or stock products in advance. They simply pass on to the consumer the cost of importing the type of fertilizer brought into the marketplace. The small farmer is forced to purchase whatever products happen to be imported by the local distributors. The prices are usually not favorable to the farmer when compared with prices paid by other farmers in the world. In addition, the small farmer receives little or no technical service, credit assistance, or delivery facilities which would normally be expected from fertilizer distributors.

At the present time all fertilizers are imported and handled in bags. An undetermined number of all fertilizer sales to the small farmer are in quantities less than a bag. Most of the various markets around small villages and communities have agricultural inputs such as fertilizers and pesticides for sale in packages of 1 kilo or less. This method allows not only for adulteration of the products but also for outright misrepresentation of the material being sold. It was observed in various markets that granular TSP was being sold for granular DAP since these products have similar physical appearance.

It was noted that fertilizer is not available in the rural areas of Bolivia where it is needed most. It is found normally in the larger urban centers of the country and even this is not on a consistent basis. All types of promotional activities, normally carried on by dealers and distributors in the form of farmer meetings, demonstrations, educational brochures, films, slide shows, and personal contact, are nonexistent in the Bolivian marketplace. This lack of organized marketing operations penalizes the Bolivian small farmer. His costs are high and services from the distributor are almost nil. Also there is the likelihood of misrepresentation of the products offered in the marketplace.

It can easily be projected that the cooperative projects being developed by the SNDC in Bolivia could easily fill the marketing and distribution vacuum that has been left by the commercial companies and quickly make an impact on the availability of agricultural inputs to the small farmer. This, along with supervised credit and technical assistance to the small farmer, makes the program a definite winner. The merit of the cooperative projects has already been demonstrated in the Potosi and Cochabamba areas where 1,500 mt of fertilizer was imported by the integrated cooperative project and distributed to the small farmers (49).

Economic Returns from Fertilizer Use

The major agricultural areas in the altiplano and valley regions of Bolivia have been utilized for agriculture for many centuries. As a result, dramatic crop response increases to fertilizer applications are realized. Even with the extremely high cost of the imported fertilizer, economic returns justify the utilization of plant nutrients. Most of the subsistence crops such as potatoes, corn, and wheat have maintained their respective high market value as a result of a high continuing demand from the urban population. This is compounded by the large percentage (80%) of the rural population that relies on the production of subsistence food crops for their diet requirements. It is estimated that the consumption of potatoes by rural adults is 5 lb (2.2 kilos)/person/day. Reported research results show that on an average the percentage of increase in yield due to fertilization of potatoes is 155%; for wheat, 125%; and for corn, 192% (table 24). More recent CID results for potatoes (table 25) indicate increases of 140% on one treatment and 150% on another. There is still a margin between the hypothetical yields based on the optimum fertilization of all potatoes in cultivation and the actual consumption requirements by the urban and rural populations. Even with the use of adequate fertilizers, higher yielding varieties, earlier- and later-bearing varieties, and efficient use of pesticides, surplus production of potatoes would not occur. The annual population increases and potential for industrializing production into process and package potato products should preclude any excess; however, these processed potato foods are not now widely known or used in the Bolivian market.

Table 25 also shows that even when considering the present high cost of fertilizers and other agricultural inputs that high application rates of phosphate fertilizer can increase profit/hectare by as much as 338% when compared to local practice (this becomes over 4,000% when compared to no fertilization).

Phases for Implementation of Cost-Reducing Recommendations

Due to the excessive markups charged and the scarcity of fertilizers, exorbitant prices are being charged the farmer--$b 700 (US $35) per 50-kg bag of urea and DAP which equals $b 14,000 (US $700)/mt.

Table 24. Summary of Crop Response to Recommended Fertilizer Practice (1967) (1)

Crop	Yield Without Fertilizer (kg/ha)	Yield with Fertilizer	% Increase	Fertilizer Recommendations (kg/ha) $N-P_2O_5-K_2O$
Potato	9,000	23,000	155	80-60-0 60-120-0
Wheat	600	1,350	125	40-20-0
Corn	600	1,750	192	80-60-0 60-40-20
Sugarcane	45,000	70,000	55	80-50-0 80-50-50
Rice	1,700	2,000	17	40-20-0 40-20-20

Table 25. Revenue and Cost Comparisons for the Commercial Yield of Potatoes from 80 kg of Nitrogen and Various Levels of Phosphorus per ha in Test Plots (27)

Location	Treatment P_2O_5 (kg/ha)	Total Revenue/ha	Total Variable Costs/ha	Changes in Revenue	Changes in Cost	Gross Profit/ha	Gross Profit/ha[a] US $
		pesos ($b)					
Rakay Pampa[b]	local[c]	25,050	7,470			17,580	879
	0	11,787	4,295	(13,263)	(3,175)	7,492	375
	40	35,855	7,258	24,068	2,963	28,597	1,430
	80	39,292	7,872	3,437	614	31,420	1,571
	120	51,078	8,795	11,786	923	42,283	2,114
	160	47,152	9,130	(3,926)	335	38,022	1,901
Cruz Pata[d]	local	10,315	7,470			2,845	142
	0	5,893	4,533	(4,422)	(2,937)	1,360	68
	40	10,313	6,856	4,420	2,323	3,457	173
	80	13,261	7,611	2,948	755	5,650	282
	120	15,716	8,310	2,455	699	7,406	370
	160	18,664	9,064	2,948	754	9,600	480
	200	17,190	9,418	(1,474)	354	7,772	389
	240	18,172	9,986	982	568	8,186	409

(Continued)

Table 25. Revenue and Cost Comparisons for the Commercial Yield of Potatoes from 80 kg of Nitrogen and Various Levels of Phosphorus per ha in Test Plots (27) (Continued)

Location	Treatment P_2O_5 (kg/ha)	Total Revenue/ha	Total Variable Costs/ha	Changes in Revenue	Changes in Cost	Gross Profit/ha	Gross Profit/ha[a] US $
		pesos ($b)					
Independencia[e]	local	21,120	7,470			13,650	682
	0	4,912	4,072	(16,208)	(3,398)	840	42
	40	25,539	7,052	20,627	2,980	18,487	924
	80	32,417	7,835	6,878	783	24,582	1,229
	120	37,818	8,561	5,401	726	29,257	1,463
	160	43,222	9,287	5,404	726	33,935	1,697
	200	37,328	9,510	(5,894)	223	27,818	1,391
	240	38,310	10,031	982	521	28,279	1,414

a. $b 20.00 = US $1.
b. Conclusions: In this experiment, local practice is much more desirable than the 0 rate phosphorus treatment. However, gross profitability is superior to the local practice for all levels of phosphorus application with the most profitable level being 120 kg/ha. At the 120 rate, profitability exceeds that of the local rate by approximately 140%.
c. Local practice was assigned a base budget which was to compare returns from various fertilizer treatments. Specific fertilizer costs were assigned each treatment.
d. Conclusions: Local practice in this experiment was exceeded in profitability by all application rates. The most profitable rate is 160 kg which exceeds the local rate by 237%.
e. Conclusions: This experiment suffered inadequate weed control. However, the response to phosphorus was consistent and significant with the most profitable rate in this experiment to be 160 kg/ha which exceeds the profitability of the local rate by approximately 150%.

In order to alleviate some of the problems, a program is proposed to effect a lowering of price and an increase in availability. The program consists of a sequence of actions to allow the small farmers to reap benefits almost immediately and then to have those benefits compounded in the form of lower cost and greater availability of fertilizer as future project phases are implemented.

The IFDC recommendations for reducing fertilizer costs to the small farmer consist of six phases. Even if the initial thrust seems insignificant, the movement through the six-phase program would provide increasing benefits and incorporation and complementation of planned fertilizer projects.

A graphic representation of the fertilizer cost reduction plan is shown in figure 10. This figure depicts Phase I as serving the Bolivian market through the importation of only high-analysis bagged materials--DAP, MAP, and urea. (Potash is not considered here since tests indicate minimal response to this nutrient.) Phase II moves into the bulk handling and bagging aspect utilizing MAP or DAP; these are less subject to degradation than urea. Phase III extends bulk handling to include urea and incorporates a blending operation. During Phase IV, locally available materials such as urea from YPFB and phosphates from the RTZ project would be incorporated. Phase V is the expansion phase in which other blending plants are built in high-use areas. Finally, Phase VI would incorporate the use of locally available potash materials which, by this time, would probably be required in certain areas.

The following is a detailed discussion of the six-phase program with an explanation of the phases.

Phase I

This phase is merely an extension of the present fertilizer supply procedure, that is, the importation of bagged materials. However, only DAP or nongranular MAP and urea will be considered (obtaining materials of the highest analysis possible to reduce transportation cost per ton of nutrient). This plan is suggested instead of importing in bulk and bagging at the port. In Bolivia's case the dockside bagging procedure would result in a loss of control since the port is in a separate country. Even with the treaties between Bolivia and Chile and Bolivia and Peru, there would not be sufficient control to ensure the success of such an undertaking.

In order to secure lower priced fertilizers in the short term, several actions can be taken even with the present situation of importing in bags: basically, the requirement is to incorporate better business practices in every phase of purchasing and delivery of the fertilizer. One major step would be to tender for the fertilizer purchases to secure contract prices as opposed to "spot" purchases. Business practices which can be undertaken to effect an immediate price decrease are as follows:

1. As mentioned, contract versus "spot" purchasing;

2. Shipment in volume to get the benefit of lower per-ton freight costs;

3. Negotiations with carriers to take advantage of space available on ships destined for Chile or Peru;

IFDC RECOMMENDATIONS

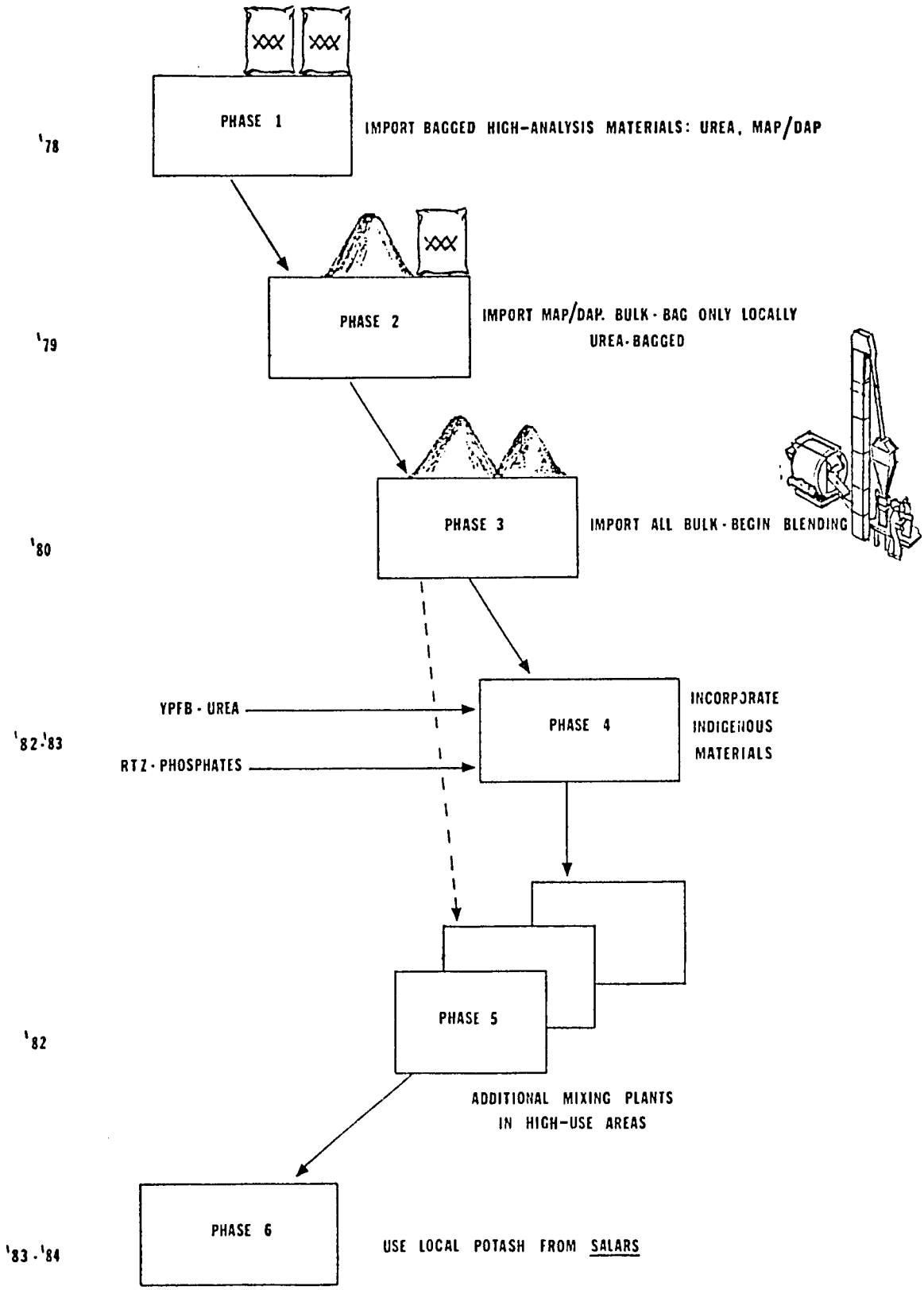


Figure 10. Chronological Relationship of Suggested Phases

4. Agreements with Chile or Peru to make joint fertilizer purchases to increase volume;

5. Handling of the fertilizer imports through the integrated cooperatives which should result in a low markup;

6. Use of direct inland transport from the port, bypassing interim storage, resulting in immediate savings as well as a decrease in handling losses;

7. Ensuring that fully loaded railcars of amounts greater than 28.5 mt are shipped (this results in the lowest rate per metric ton); and

8. Monitoring world fertilizer market conditions to determine the best time for releasing tenders.

Most of these recommendations are made to improve on current practice. There are, at present, only a few dealers who regularly handle fertilizers, and they appear to have no incentive to improve service or lower price. There are even rumors that these dealers may hold fertilizer off the market to create artificial shortages and maintain higher prices. The dealers engage in almost no marketing activity. There is no pre- or post-purchase support rendered, no extension services by dealers; little instruction to improve fertilizer use; almost no advertising; no formal distribution system outside 5 or 6 major cities; and little activity to improve the situation or increase availability.

It was as a result of such actions and lack of service by the dealers that the integrated cooperatives began to import their own fertilizers. During 1978, two cooperatives in Cochabamba and Potosi brought in 1,500 mt of fertilizer as a direct purchase. This purchase was handled through SNDC/Nathan Associates. SNDC requested bids for the shipment and accepted the bid of Agricultural and Industrial Chemicals, Inc., of New York.

This importation plan resulted in a documented, delivered cost to Cochabamba for DAP and urea of $308 and $297, respectively.[2] Even these prices were substantially below those which were being charged by the established dealers ($400 and $380, see table 17). This is not merely interesting but quite astounding. Even with a very small shipment, exorbitant ocean freight charges, at least a 10% premium f.o.b. price, and practically no experience in this type of business, the cooperatives were actually able to supply fertilizer more cheaply than established suppliers who presumably were using the best bargaining and transport methods. The fact that excellent results were achieved on the first attempt further supports the assumption that additional improvements in the form of decreased costs can be achieved through experience gained in the continuation of this procedure.

Nongranular MAP is recommended for the following reasons:

1. This material provides a price advantage/kilogram of nutrient over DAP, the preferred fertilizer in Bolivian agriculture. This price advantage is effective only when comparing straight MAP and DAP. Due to the high cost of urea per kilogram of nutrient, the cost advantage of MAP is negated by the added value of urea supplied to increase nitrogen levels. Greater quantities of urea are required with MAP than DAP to yield a specific NP mixture (see table 26).

2. From integrated cooperative waybills.

Table 26. Production Possibilities in Bulk-Blend Facility

Ratio	Raw Material, kg/mt	Grade	Annual Production[a]	Raw Materials, mt Required
1-1-0	DAP - 622	28.6-28.6-0		4,976
	Urea - 378		8,000	3,024
1-1.5-0	DAP - 784	24-36-0		9,408
	Urea - 216		12,000	2,592
1-1-0	MAP - 535	26.8-26.8-0		4,280
	Urea - 465		8,000	3,720
1-1.5-0	MAP - 663	22-33-0		7,956
	Urea - 337		12,000	4,044

a. Based on 20,000-mt/yr production.

2. Most of the fertilizers now used in Bolivia are used on phosphate-deficient soils.

3. The present application methods (mostly by hand) do not warrant granular fertilizers which are suitable for use in mechanical applicators.

The final costs involved in supplying a 1-1-0 ratio or a 1-1.5-0 ratio using MAP and urea or DAP and urea are practically equal (table 27) on a cost/kilogram of nutrient basis (assuming equal value for both N and P_2O_5). Therefore, there exists no price advantage in the use of either product during the initial phases. When arriving at Phase III, however, there is a distinct advantage to recommending nongranular MAP. This advantage will be discussed at greater length at that point.

Phase II

In this phase the cooperatives will begin to import DAP or nongranular MAP in bulk; for the bagging operation, the bulk material will then move to Cochabamba. Urea will still be imported in bags; this will represent only about one-fourth of the total fertilizer being imported. The bagging operation will require a limited investment and a small amount of equipment (table 28 and figure 11): one bagging machine with spare parts, a front-end loader and a storage building. The bagging machine should be of the simplest design possible and adaptable for packing both 25- and 50-kg bags (see equipment specifications, annex 2). Both 25- and 50-kg bags have been specified in an attempt to reduce product adulteration which is prevalent when large bags are opened and smaller quantities sold. This would also enable the farmer to achieve more easily the recommended application rates without buying partial bags. Guarantee tags should be placed on the bags to assure the purchaser of the nutrient content and weight for unopened bags.

The recommended site for the bagging operation and later the blending plant, is Cochabamba. There are several reasons for this choice: (a) the valley regions, of which Cochabamba is near the center, account for the greatest use of fertilizers in Bolivia (see table 20), (b) the cooperatives have experience in importation from 1978, and (c) Cochabamba has good transport links to other areas.

Phase III

The third phase of the project consists of establishing bulk-blending facilities at Cochabamba to complement the bagging system installed in Phase II. The existing storage facility and the storage area for bagged material would be used. By this time use rates should have increased such that both the urea and MAP could be imported in bulk. The additional equipment required for blending is listed in table 29, annex 2, and shown in figure 12. The total complex is visualized in figures 13 and 14. The only difference between the plant suggested here and those in use in the United States is the addition of a crusher for the urea. Crushing the urea will render it compatible (sizewise) with nongranular MAP. This also reduces the quality control requirements for the urea.

Table 27. Raw Material Cost Used in Blends

Ratio (Grade)	Raw Materials/ Product	Estimated Cost of Raw Materials, c.i.f. Cochabamba	Cost of Raw Materials	$/kg of Nutrient
	- - - mt - - -	- - - $/mt- - - -	- - - $ - - -	
1-1-0 (28.6-28.6-0)	DAP - 0.622	228.88	142.36	
	Urea - 0.378	203.88	77.07	
			219.43	0.384
1-1-0 (26.8-26.8-0)	MAP - 0.535	213.88	114.43	
	Urea - 0.465	203.88	94.80	
			209.23	0.390
1-1.5-0 (24-36-0)	DAP - 0.784	228.88	179.44	
	Urea - 0.216	203.88	44.04	
			223.48	0.372
1-1.5-0 (22-33-0)	MAP - 0.663	213.88	141.80	
	Urea - 0.337	203.88	68.71	
			210.51	0.383
(18-46-0)	DAP - 1.0	228.88	228.88	0.358
(10-50-0)	MAP - 1.0	213.88	213.88	0.356
(46-0-0)	Urea - 1.0	203.88	203.88	0.443

Table 28. Estimate of Cost of Equipment and Installation

Equipment Required for Phase II--Bulk Unloading, Storage, Bagging	Cost Estimate		
1. Storage building with sufficient area For future installation of bulk-blend equipment Total area = 400 m^2 Storage area with/bays for 4 raw materials With capacity of 20,000 mt, total			100,000[a]
2. Elevator	10,000		
3. Bagging machine and associated equipment	20,000		
4. Front-end loader	12,000		
Total equipment costs (TEC)		42,000	
Spare parts (10% of total equipment)		4,200	
Ocean freight and export packing (25% TEC)		10,500	
Total delivered equipment cost			56,700
5. Total facility			156,700[b]

a. Price for prefabricated wooden structure. This estimate would be for a reinforced concrete structure based on U.S. construction costs which would not necessarily be needed in this instance.

b. Assuming adequate warehouse facility can be procured on rail spur for $100,000. This is a local currency expenditure.

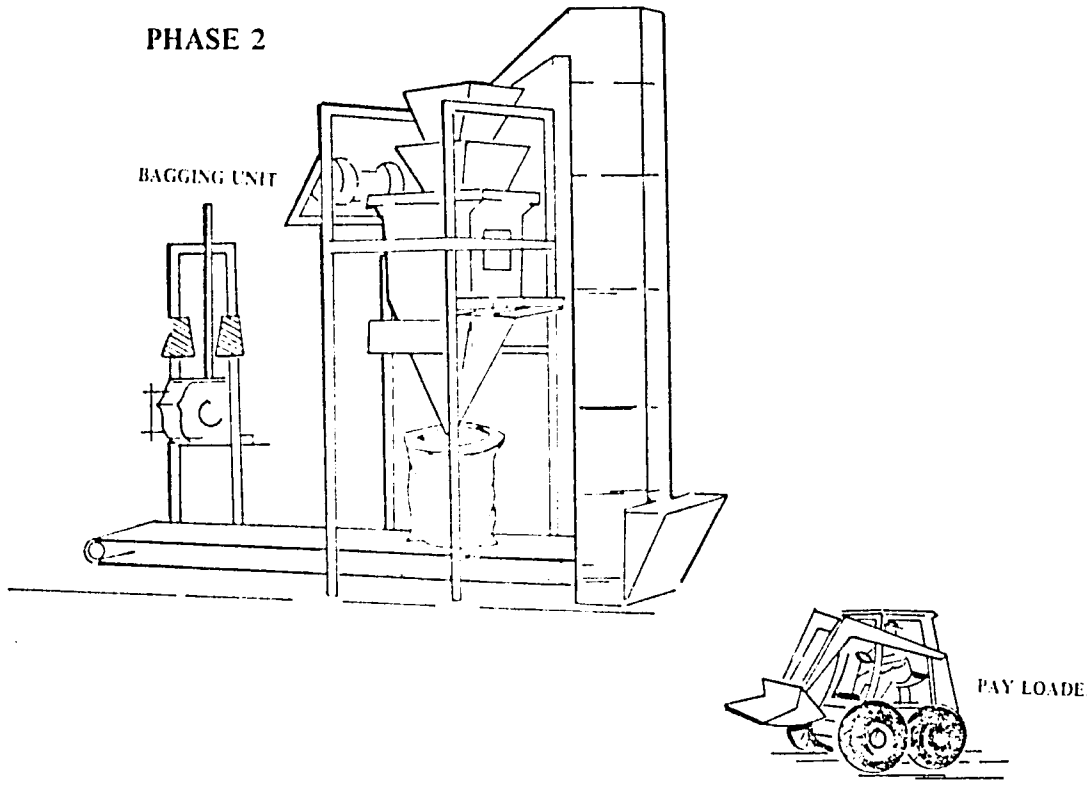


Figure 11. Apparatus for Bagging of MAP/DAP Received in Bulk

Table 29. Cost Estimates for Phase III[a]

Additional Equipment Required for Phase III	Cost Estimate	
	- - - -US $- - - -	
1. Weigh system	7,500	
2. Conveyors	4,000	
3. Batch mixer (1 mt)	7,500	
4. Mill	2,500	
5. Hoppers and ducts	2,500	
6. Electrical	2,500	
7. Front-end loader (additional)	12,000	
Total equipment cost (TEC)		38,500
8. Spare parts (10% TEC)	3,900	
9. Ocean freight and export packing (25% TEC)	9,600	
Total delivered cost blending equipment		13,500
10. Bagging equipment cost	56,700	56,700
Total delivered equipment cost (TDEC) for blending and bagging		108,700
11. Contingency (15% TDEC)		16,300
		125,000
12. Building	100,000	
13. Contingency (15% building cost)	15,000	
Total Building		115,000
Total facility estimate (TDEC and subtotal)		240,000

a. No inflation or escalation considered.

PHASE 3

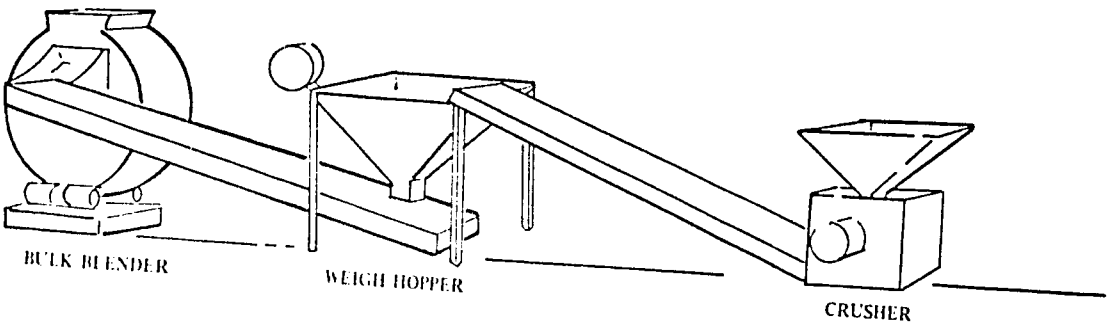


Figure 12. Blending Equipment Required

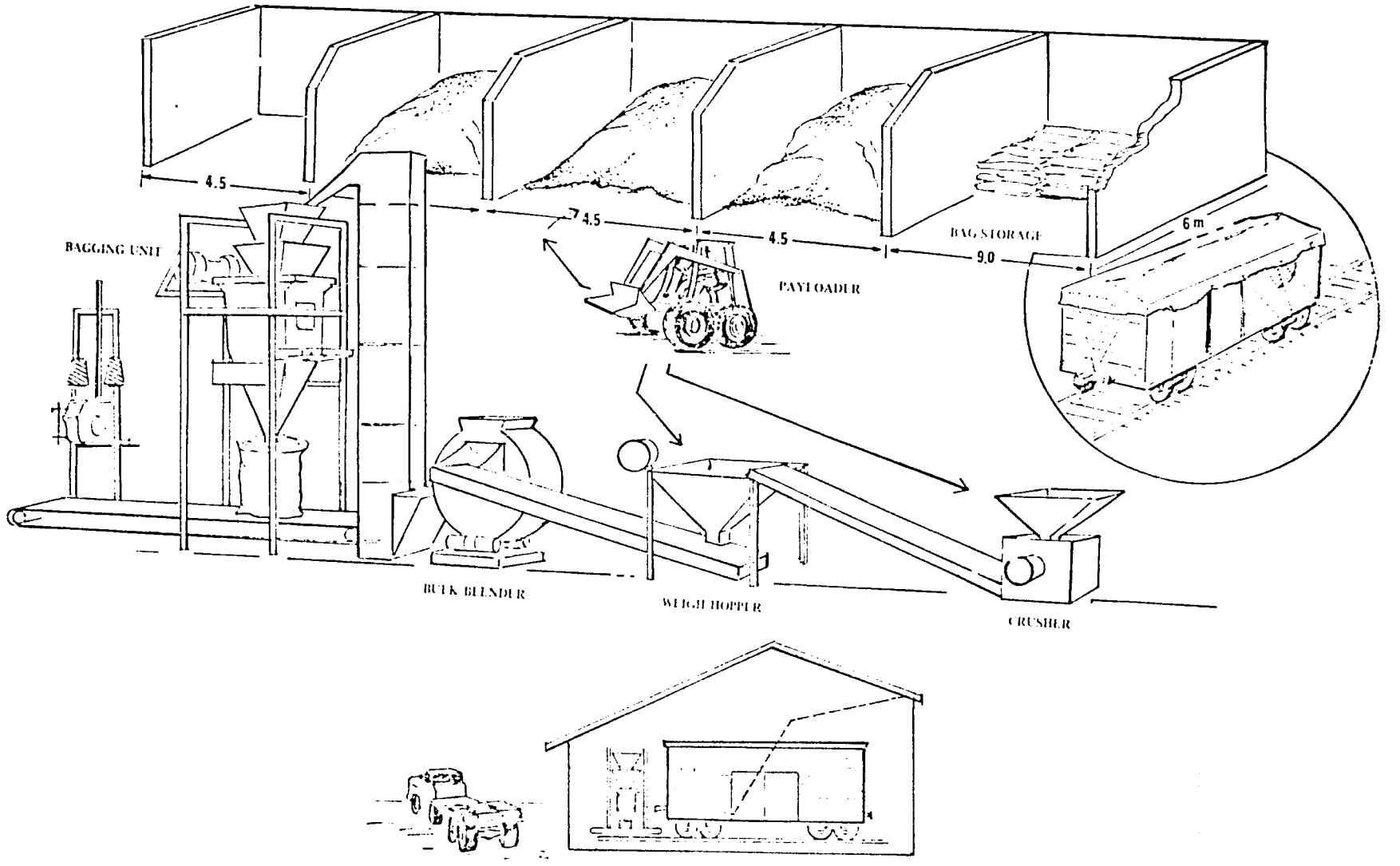


Figure 13. Bulk-Blending and Bagging Operation

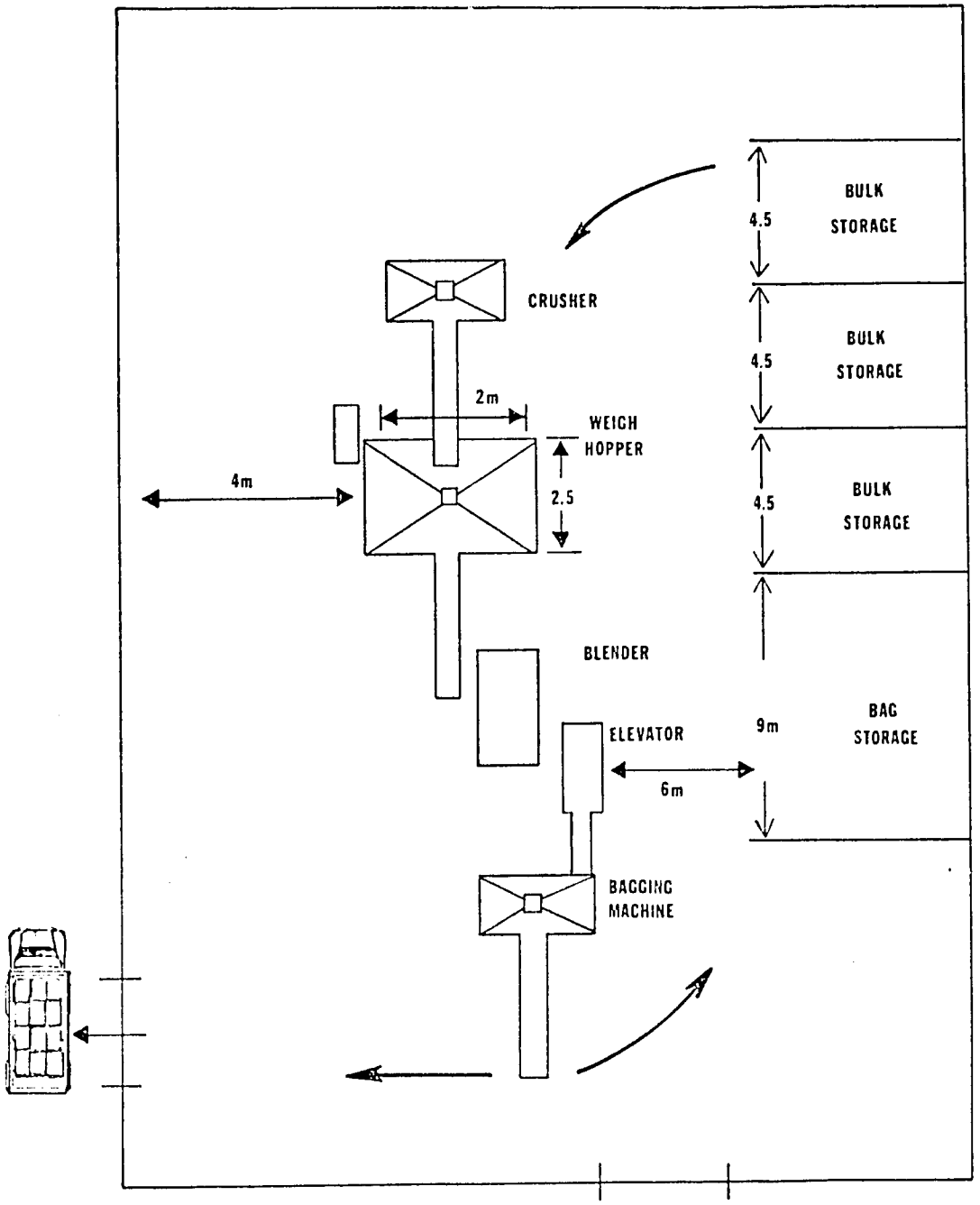


Figure 14. Plan View of Bagging Facility

The size compatibility offers the ultimate reason for suggesting nongranular MAP as the preferred phosphate material. By utilizing this crushing scheme, the urea will blend easily with the MAP. This enables the use of prilled urea (which will ultimately be available from Santa Cruz) and standard-grade potash. When blending operations use DAP as a phosphate source, the urea and potassium chloride (and other ingredients) must be in similar granular form. There are two methods of obtaining a compatible mixture: (1) purchase urea and potash in granular form or (2) purchase DAP as small granules which are compatible with available urea prills. Both of these alternatives result in higher prices due to either limited supply, as in the case of granular urea, or purchase of a specially produced material, as is the case with smaller-than-standard-sized DAP. Actually, neither DAP nor KCl are available commercially in sizes which would be compatible with prilled urea.

Phase IV

This phase would mark the incorporation of indigenously produced fertilizers into the bulk-blending arrangement. At this time the two materials under consideration would be urea from the YPFB plant and phosphates from the fertilizer facilities associated with the proposed RTZ zinc refinery.

The use of locally produced materials should offer several advantages. The raw material supply would be under Bolivian control. Even if no price advantage became evident, the foreign exchange element would decrease. There would exist clear incentives for the parties involved in supply of raw materials and those in the bulk-blend and distribution business to work closely to increase efficiency and to provide better service to the farmer.

Phase V

As the local demand for fertilizers continues to increase, the capacity of the small blending unit will become inadequate for the local market, even though the 1-ton batch-blend plant offers a great deal of flexibility. Dependent on the number of shifts utilized, this plant has the capacity of producing 80,000 mtpy. However, long before this level is reached, it will probably become apparent that other blend plants are required to serve high-use areas. At this time, alternate sites would be chosen to optimize the cost of shipment of raw materials and the distribution of bagged product.

Phase V would probably continue as the fertilizer industry expands. Plants would be added as they were needed or in anticipation of the need for greater production or more flexibility in certain areas. Logical locations for future blend plants would be at the sites of the nitrogen and phosphate plants.

The simplicity of the initial operation provides the opportunity for additions to increase production rate and handling efficiency as volume and expertise warrant. For example, under-track unloaders and raw material conveying systems or automatic batch-weighing systems could be added to the initial equipment package at a later date.

As is evident from figure 10, Phases IV and V are actually independent steps. The alternate route shown from Phase III to V would be viable if delays develop in the completion of the local plants or in the lack of development of local resources. By the same token, there is no reason why expansion to more blending units could not take place prior to the incorporation of locally produced materials. In fact, if this were to happen, it is conceivable that further market development would follow, causing the local projects to appear more feasible.

Phase VI

This phase would involve the use of locally available potash from the salars in the southwestern part of Bolivia. Potash is considered last in this plan due to the lack of response to potassium reported for most areas. Also, the value added for transportation and handling of imported potassium chloride could easily be twice the f.o.b. purchase price.

Since the KCl should be available in crystalline or granular form depending on the recovery process, this material is relatively easily transported in bulk and should lend itself well to the bulk-blend operation.

Cost Analysis of Bulk Handling and Blending[3]

When considering the costs involved in this bulk-handling and blending program, it is evident that the costs of the equipment and plant operation are relatively insignificant compared with the raw materials cost. This would tend to indicate that, barring exorbitant penalties for small volumes, bulk blending could yield benefits at almost any use volume.

IFDC estimates of current fertilizer prices used in the following cost analysis are shown in table 30. Shipping cost estimates were obtained from prices published for recent shipments to Chile. These costs are somewhat lower than those obtained from the importation effort of the integrated cooperatives. Generally, some small fluctuations can be attributable to market conditions at the time of purchase. The actual variation between the cooperative prices and IFDC estimates is less than 10% on an f.o.b. U.S. Gulf basis. The major difference is in the ocean freight involved, part of which could be attributable to use of vessels of U.S. registry and to the small size of the shipment (1,500 mt).

Present fertilizer prices in Bolivia are shown in table 17: $400 and $380 for DAP and urea, respectively, c.i.f. Cochabamba. Since no ROI calculations are included in the analysis for the blend plant and since the actual markups included on the DAP and urea prices are unknown, comparison will be made using f.o.b. U.S. Gulf prices and adding the appropriate freight and handling charges.

3. All costs in this section are reported as U.S. dollars unless noted otherwise.

Table 30. Cost Comparisons of Fertilizer Materials Delivered to the Ports Serving the Bolivian Market[a]

Material	Fertilizer Cost, $b (US $)		Freight Costs to Various Ports[c]					
			Antofagasta and Arica		Buenos Aires and Santos		Matarani	
	Bulk[b]	Bagged[b]	Bulk[d]	Bagged	Bulk	Bagged	Bulk	Bagged
DAP	3,100	3,740	315	375	300	360	310	370
	(155)	(187)	(15.75)	(18.75)	(15.00)	(18.00)	(15.50)	(18.50)
Urea (prills)	2,600	3,240	315	375	300	360	310	370
	(130)	(162)	(15.75)	(18.75)	(15.00)	(18.00)	(15.50)	(18.50)
Urea (granules)	2,640	3,280	315	375	300	360	310	370
	(132)	(164)	(15.75)	(18.75)	(15.00)	(18.00)	(15.50)	(18.50)
MAP (nongranular)	2,800	3,440	315	375	300	360	310	370
	(140)	(172)	(15.75)	(18.75)	(15.00)	(18.00)	(15.50)	(18.50)
KCl (standard)	1,120	1,660	315	375	300	360	310	370
	(56)	(83)	(15.75)	(18.75)	(15.00)	(18.00)	(15.50)	(18.50)
KCl (granular)	1,360	1,900	315	375	300	360	310	370
	(68)	(95)	(15.75)	(18.75)	(15.00)	(18.00)	(15.50)	(18.50)

a. Based on IFDC data, materials for delivery July 1978.
b. F.o.b. U.S. Gulf coast.
c. Freight rate estimates are for 15,000- to 20,000-mt shipments; for 5,000- to 10,000-mt shipments charge would be N $4.00 more.
d. July shipment from U.S. Gulf to Chile "Green Markets," July 24, 1978. A $1.50 increase has been added to reflect firming of the market.

The equipment costs for the blend plant are shown in tables 28 and 29. The equipment has an estimated value of about $125,000 while the building is estimated at $115,000.[4] The total estimated cost of $240,000 shown in table 29 does not include the cost of land or inflation effects.

Table 31 shows the labor involved in the operation of the plant. The assumption is made that the bulk-blend equipment is operated one shift/day during a 5-day week. The total production capacity is assumed to be 10 mtph or 80 mtpd. Salaried labor personnel depicted in table 31 are assumed to have salaries of just under $10,000 per year. The assumption is also made that hourly labor is available as production warrants. The labor rate for hourly workers has been assumed to be $3/day.

Estimated production costs, not including raw materials, are presented in tables 32 and 33. Costs are estimated on an annual basis and also on a per-ton basis. Some differences exist in these numbers due to rounding. Based on volume the variation of costs on a per-metric ton basis ranges from $20.08/mt at the 5,000 mtpy level to $10.58/mt at the 30,000 mtpy level. This nearly 50% cost decrease with volume proves insignificant when raw material costs are considered.

Raw materials considered in this analysis are shown in table 34. The estimated costs per mt of DAP, MAP, and urea delivered to Cochabamba are $228.88, $213.88, and $203.88, respectively. The value added to urea for delivery costs is almost 60% of the f.o.b. price estimate. Therefore, the importance of shipping and handling costs and the control of these become evident.

The raw materials required for blending of various fertilizer ratios have been calculated. Two ratios (1-1-0 and 1-1.5-0) are chosen based on the IBTA recommended fertilization rates (kg/ha) for the altiplano, 80-80-0, and the valley regions, 80-120-0 (tables 26 and 27). For discussion purposes the assumption is made that 60% of the production is supplied as 1-1.5-0 with the remaining 40% as 1-1-0. In reality several grades would be produced to meet differing fertilization requirements; these should be determined by soil testing.

Cost comparisons of a typically available 1-1-0 ratio bagged fertilizer, 20-20-0, and the highest grade of 1-1-0 ratio which could be supplied by blending, 28.6-28.6-0, and comparably blended 20-20-0 using filler reveal several interesting points (table 35). The overall cost per ton is marginally lower using the bulk blend. However, when considering the cost per kilogram of nutrient we see that, due to the possibility of more concentrated formulation, the advantage of the blend is a two-thirds reduction in cost. When directly comparing chemically granulated, bagged 20-20-0 with the same analysis material produced by bulk blending, the advantage is even more apparent--$170 versus $240. The assumption is made here that a suitable filler material is available locally at a cost of no more than $10/mt.

To take a cursory look at the profitability factors affecting this plant, it is evident from tables 36 and 37 that, assuming production of 20,000 mtpy, a substantially lower cost/metric ton results than when considering bagged imported materials. Working capital is assumed to be a 6-month supply of raw

4. Includes 15% contingency cost.

Table 31. Labor Cost for Bulk-Blend Facility

Basis: 1-ton rotary blender capable of production at a rate of 10 mt/hr and operation for 1 shift/day. Normal production = 80 mt/day

Labor Requirements		US $
1. Annual		
Plant Manager,	$400/mo x 12 mo	4,800
Operators		
Front-end loader,	150/mo x 12 mo	1,800
Mixing	100/mo x 12 mo	1,200
Bagging	80/mo x 12 mo	960
Mechanic	100/mo x 12 mo	1,200
TOTAL ANNUAL		9,960
2. Hourly labor (varies with production rate)		
4 baggers		
3 storage and loading		
1 raw materials unloading and general		
8 @ $3/day = $24/shift labor cost		

Table 32. Labor Costs Required for Various Production Rates

Rate	5,000	10,000	15,000	20,000	25,000	30,000
Days required	63	125	188	250[a]	313	365[b]
Total hourly labor costs	1,512	3,000	4,512	6,000	7,512	9,000
Annual labor costs	9,960	9,960	9,960	9,960	9,960	9,960
Total labor costs	11,472	12,960	14,472	15,960	17,472	18,960
Cost/mt	2.29	1.30	0.96	0.80	0.70	0.63

a. Begin additional shift.
b. At least 10 days of 2-shift operation required.

Table 33. Estimated Operating Cost of Bulk Blending not Including Raw Materials

Production, mt/yr	5,000		10,000		15,000		20,000		25,000		30,000	
Days of operation at 10 mt/hr maximum rate[a]	63		125		188		250		313		365[b]	
Bulk-storage throughput production/capacity[c]	0.25		0.5		0.75		1.0		1.25		1.50	
Bag-storage throughput[d]	0.67		1.33		2.0		2.67		3.33		4.0	
Plant investment												
Equipment	125,000		125,000		125,000		125,000		125,000		125,000	
Buildings, bulk and bag storage	115,000		115,000		115,000		115,000		115,000		115,000	
TOTAL	240,000		240,000		240,000		240,000		240,000		240,000	
	$/mt	Annual	$/mt	Annual	$/mt	Annual	$/mt	Annual	$/mt	Annual	$/mt	Annual
Operating labor[e]	2.29	11,472	1.30	12,960	0.96	14,472	0.80	15,960	0.70	17,472	0.63	18,960
Electricity	0.05	250	0.05	500	0.05	750	0.05	1,000	0.05	1,250	0.05	1,500
Maintenance (2% of equipment cost)	0.54	2,700	0.27	2,700	0.18	2,700	0.14	2,700	0.11	2,700	0.09	2,700
Building maintenance (1% of cost)	0.23	1,150	0.12	1,150	0.08	1,150	0.06	1,150	0.05	1,150	0.04	1,150
Equipment depreciation (15 years)	1.80	9,000	0.90	9,000	0.60	9,000	0.45	9,000	0.36	9,000	0.30	9,000
Building depreciation (25 years)	0.92	4,600	0.46	4,600	0.31	4,600	0.23	4,600	0.18	4,600	0.15	4,600
Taxes and insurance (2% of total)	0.96	4,800	0.48	4,800	0.32	4,800	0.24	4,800	0.19	4,800	0.16	4,800
Average interest on investment (10% of 1/2 total)	2.40	12,000	1.20	12,000	0.80	12,000	0.60	12,000	0.48	12,000	0.40	12,000
Gasoline, tires, etc.	0.40	2,000	0.22	2,200	0.16	2,400	0.13	2,600	0.11	2,800	0.10	3,000
Bags (woven polypropylene + polyethylene liner @ 0.40 each)[f]	8.00	40,000	8.00	80,000	8.00	120,000	8.00	160,000	8.00	200,000	8.00	240,000
Miscellaneous administrative expenses	0.20	1,000	0.10	1,000	0.07	1,000	0.05	1,000	0.04	1,000	0.03	1,000
Contingency and overhead (100% of labor)	2.29	11,472	1.30	12,960	0.96	14,472	0.80	15,960	0.70	17,472	0.63	18,960
Total operating cost (blending and bagging)[g]	20.08	100,444	14.40	143,870	12.49	187,344	11.55	230,770	10.97	274,244	10.58	317,670

a. Assumes only 8-hour workday (1 shift only).
b. 10 days would require 2 shifts; total maximum production at 3 shifts per day would be 87,600 mt/yr.
c. Bulk storage = 20,000 mt.
d. Bag storage = 7,500 mt.
e. From table 32 labor rate.
f. Assumed based on 50-kg bags, price will be higher for 25-kg size, bag priced on import from United States or another source, bag costs in Bolivia for 50-kg size in $b 14 = US $0.70/bag: Local bag manufacturer, INBOLSA, S.A., La Paz, October 6, 1978.
g. Some cost/mt and annual costs differ due to rounding.

Table 34. Import Cost for Bulk Materials for Blending

	Materials, US $/mt		
	DAP	MAP	Urea
1. Fertilizer cost, f.o.b. Gulf	155.00	140.00	130.00
2. Ocean freight and insurance	15.00	15.00	15.00
3. Port charges[a]			
a. Unloading 2.85			
b. Other charges 3.50	7.21	7.21	7.21
c. Loading 0.86			
4. Duties and tariffs			
a. Port			
b. Bolivia	7.10	7.10	7.10
5. Freight = ntofagasta-Ollague	9.02	9.02	9.02
6. Freight = llague-Cochabamba	33.05	33.05	33.05
7. Incidental costs	2.50	2.50	2.50
Total delivered raw materials cost	228.88	213.88	203.88

a. Assume direct shipping (table 12).

Table 35. Cost of Importing 1-1-0 Ratio Fertilizers

		Finished Fertilizer Bagged, 20-20-0		Bulk Blend[a] 28.6-28.6-0		Bulk Blend[b] 20-20-0	
		Total $/mt	Cost per kg Nutrient	Total $/mt	Cost per kg Nutrient	Total $/mt	Cost per kg Nutrient
1. Fertilizer cost, f.o.b.		147.00	0.368	145.55	0.254	101.88[c]	0.254
2. Ocean freight and insurance		22.00	0.055	15.00	0.026	10.50[d]	0.026
3. Port charges							
a. Unloading	4.95		2.85				
b. Other charges	7.00	13.66	0.034 3.50	7.21	0.013	5.05[d]	0.013
c. Reloading	1.71		0.86				
4. Duties and tariffs							
a. Port		7.10	0.018	7.10	0.012	5.00[d]	0.012
b. Bolivia (2%)							
5. Freight Antofagasta-Ollague		9.02	0.023	9.02	0.016	6.30[d]	0.016
6. Freight Ollague-Cochabamba		40.27	0.101	33.05[e]	0.058	23.14[d]	0.058
7. Incidental cost unloading, etc.		2.50	0.006	2.50	0.004	2.50	0.006
8. Bulk-blend cost (see table 33)		-	-	12.50[f]	0.022	12.50[f]	0.031
TOTALS		241.55	0.605	231.93	0.405	166.87	0.416

a. Cost calculated as mixture of DAP and urea even though shipment is received separately and blending occurs at Cochabamba.
b. Blend produced for direct comparison.
c. Includes only 0.7 mt of materials, assumes filler is available at blending site.
d. All shipping, etc., for 0.7 mt of material.
e. Assumes large fully loaded cars, however, is not a specified bulk rate.
f. Based on 15,000-mt total production. No adjustment for bag breakage, damage, reclaiming, etc.

Table 36. Calculation of Working Capital

For 20,000-mt/yr production, the assumptions for working capital will be a 6-month supply of raw materials (10,000 mt) + a 2-month supply of bagged product.

Annual Requirement	Price
DAP[a], 14,384 x (0.5) = 7,192 x 228.88 =	$1,646,105
Urea[a], 5,616 x (0.5) = 2,808 x 203.88 =	572,495
6-month supply of raw materials	$2,218,600
2-month production = 3,333 mt of bagged product	
1-1-0 (0.4)(3,333) = 1,333 x 219.43 =	$ 292,500
1-1.5-0 (0.6)(3,333) = 2,000 x 223.48 =	446,960
2-month production	$ 739,460
Total Working Capital	$2,958,060
Interest on Working Capital (10%)[b]	$ 147,900
$/mt	$7.39

a. Table 26.
b. Calculated on average working capital (1/2 of total).

Table 37. Profitability Factors (Sensitivity Analysis of Selling Price)

Plant Investment: $240,000 Working Capital: $2,958,060 Total: $3,198,060
Annual Depreciation: $13,600

Total Annual Operating Cost, $/yr:

Operating	20,000 x 11.55 =	231,000
Int. on W.C.	20,000 x 7.39 =	147,900
Admin. Exp.	20,000 x 2.00 =	40,000
Total Operating Cost		418,900
Total Raw Material Cost[a]		4,437,200
Total Annual Cost		4,856,100

Annual Production, mt	Sales Price, $/mt	Net Sales Revenue	Total Annual Cost	Gross Income	Income After Taxes[b]	Cash Flow N.I. + Dep.	Payout Period
20,000	230	4,600,000	4,856,100	(256,100)	(256,100)	(242,500)	-
20,000	240	4,800,000	4,856,100	(56,100)	(56,100)	(42,500)	-
20,000	250	5,000,000	4,856,100	143,900	143,900	157,500	1.5
20,000	260	5,200,000	4,856,100	343,900	343,900	357,500	0.7
20,000	270	5,400,000	4,856,100	543,900	543,900	557,500	0.4
20,000	280	5,600,000	4,856,100	743,900	743,900	757,500	0.3

a. Includes shipping and handling charges to Cochabamba.
b. Assume tax concession for first 5 years of operation.

materials and a 2-month supply of bagged product. The total annual raw material cost is about $4.4 million. This results in an annual cost of $4,856,000 with a break-even cost of about $243/mt. If a markup of 25% on this cost is assumed, a selling price of about $304 results, almost $100/mt lower than the existing market quotes. Even if the assumptions used in arriving at these figures are in error as much as $50/ton, the blend price is still competitive with imported bagged goods.

To emphasize the importance of f.o.b. purchase price and freight rates, table 38 and figure 15 show that the fixed cost (using bagging cost as an estimate) is only $8.34/mt with variable operating costs increasing this very little at high production rates. Hence, the most important considerations are securing purchase contracts at the minimum levels and doing the utmost to obtain reasonable freight rates.

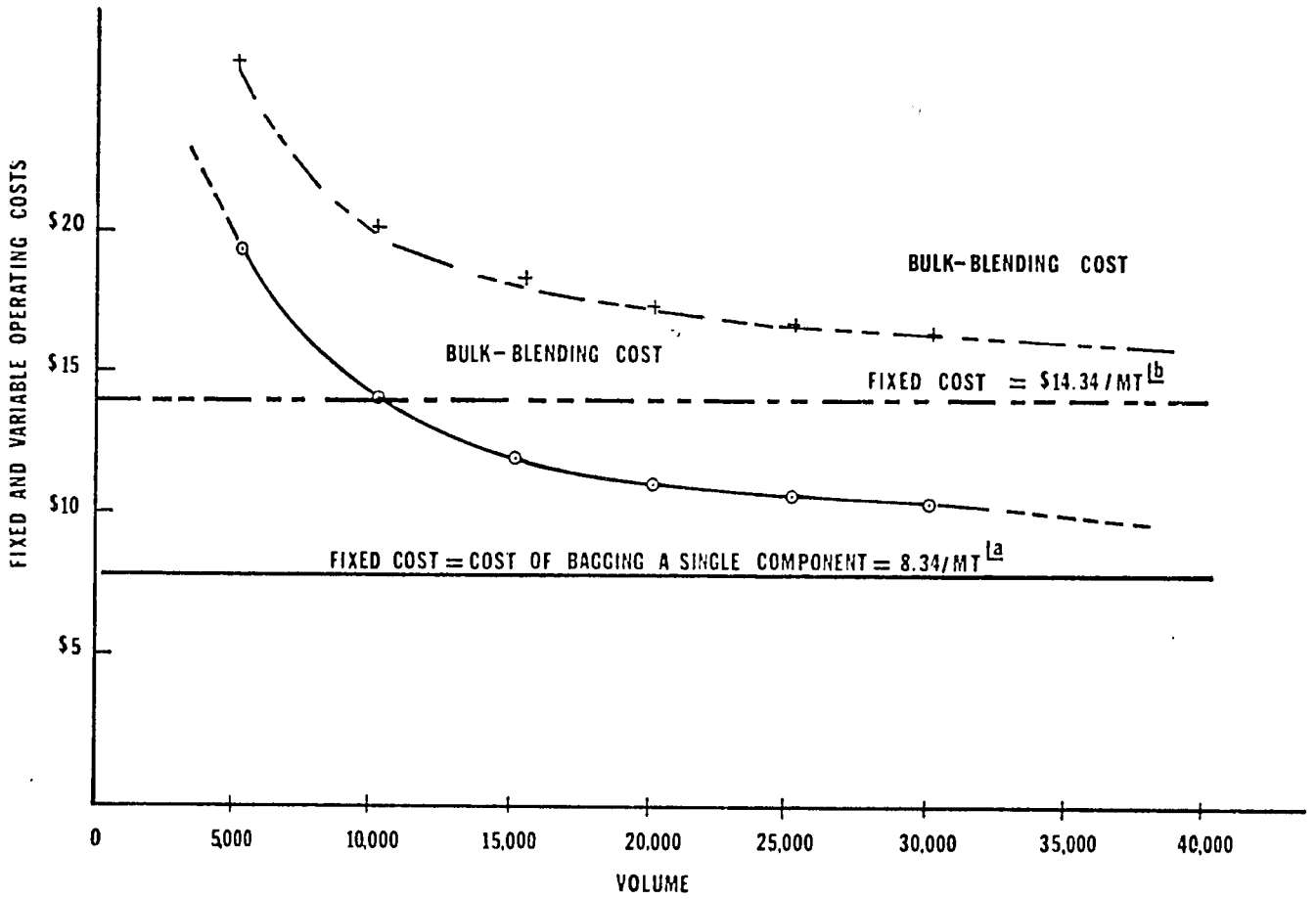
Table 38. Cost of Bagging Only in Blend Plant

Labor
Hourly labor
4 bagging
3 truck loading or storage
1 charging system
8 men @ $3.00/day = $24.00/day

mt bagged per day = 80 mt

Bagging cost/mt	=	$0.30/mt
Electrical	=	0.02/mt
Payloader fuel	=	0.02/mt
Bags (20 @ $.40/bag)[a]	=	8.00/mt
TOTAL		$8.34/mt

a. Imported bag cost, local bags at $.70 each which increase the per-mt cost to $14.34/mt.



a. Using imported bags.
b. Using local bags.

Figure 15. Fixed and Variable Blending Costs

ANNEX I

Description of Bulk Blending

The term "bulk blend" has been defined as the physical mixing of several "fertilizer materials" to yield a product with two or more major fertilizer nutrients; no chemical reaction takes place. The actual bulk-blend operation is depicted in figure 16. Evidenced in this figure are the various steps involved in bulk-blend production.

The initial step consists of receiving the fertilizer materials. These materials are usually DAP, urea, TSP, KCl, AS, and others. Due to cost considerations, it is usually best to use the highest analysis materials available (DAP, urea, and KCl). These materials are received in bulk by either rail or truck and unloaded by mechanical methods (either under-track unloaders and belts or with special dump pits if trucks are used). Manual unloading methods can be used if relatively small quantities are being handled and if manpower is plentiful.

The second step in the bulk-blend operation is storage of the raw materials. The raw materials are moved to a protected storage area using belts or front-end loaders and are usually stored in bins or bays near the blending equipment.

Step 3 consists of reclaiming the materials from storage and charging a cluster hopper feeding system or going directly to the weighing apparatus. The simplest route is to reclaim from storage by a payloader and dump directly into the weighing system. In high-volume automated plants, the weigh system can operate automatically with the operator only maintaining materials in the charging system.

Step 4 is possibly the most important in the entire bulk-blend operation, the actual weighing of the raw materials. The accuracy with which this is accomplished directly determines the accuracy with which the desired analysis can be achieved. Usually a weigh hopper suspended by a mechanical or electrical weighing device is used for this duty. For manual operations, the operator in charge of weighing would supervise the batching operation to ensure that proper weights were achieved.

In step 5, materials are placed into a mixing apparatus. This apparatus may be of the rotary blender type shown in figure 13, or it may be one of several other types. These types include: the "cement mixer" type which rotates in one direction to blend and in the opposite direction to discharge; the blend tower, a series of baffles or cones over which the charge is dropped; static mixers which use segmented compartments from which the individual components drop simultaneously; or ribbon blenders which are either open helix types or slotted augers.

Step 6, after mixing, consists of loading the fertilizer into bulk spreaders to be taken directly to the fields for custom application. For operations where custom application cannot be accomplished, the material is stored in bulk for future use, or an additional operation, bagging, is accomplished to enable movement of the fertilizer to the final user.

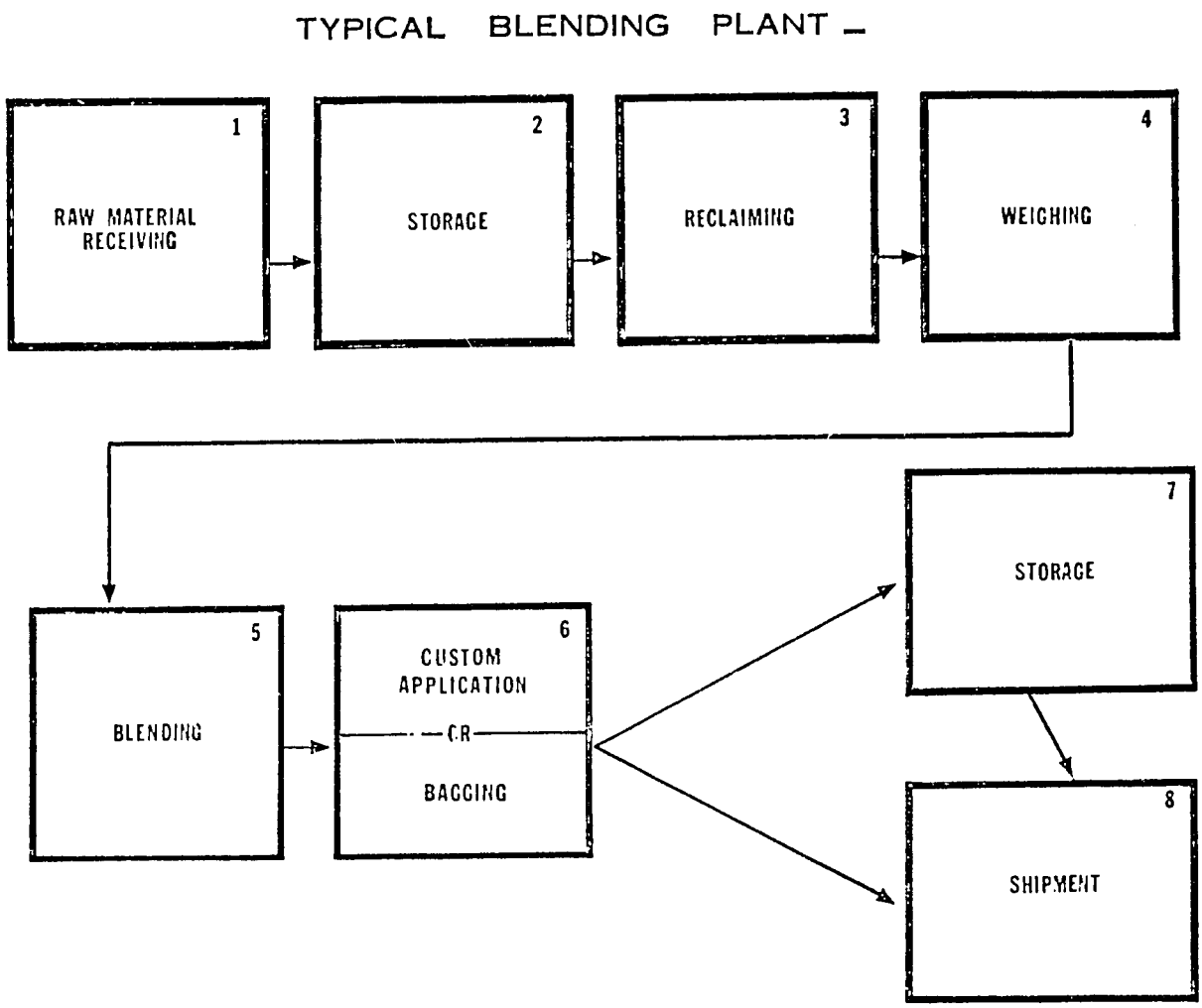


Figure 16. Bulk-Blending Block Diagram: Flowchart

This scheme appears quite simple, but in practice it is difficult to supply consistently high-quality products utilizing bulk-blend technology. One major problem is segregation or "unmixing" of the materials. This problem is caused by poor size compatibility and has essentially been eliminated in the United States due to the closely controlled sizes of granular raw materials available.

The initial blends produced in the United States and elsewhere were powdered blends. Several problems existed with these materials, mainly difficulty of application using mechanical spreaders and related dust problems during mechanical application and during production. Caking of materials in powdered form is also a greater problem than with granular materials. It was for these reasons that U.S. producers began using granular materials.

Since, in Bolivia, most fertilizer is applied by hand directly from the bag, the problems associated with mechanical spreaders are not an issue. The caking problem would still exist but could be minimized by taking care to maintain the raw materials in an area which is well protected from moisture and ensuring that proper bagging procedures are used.

Advantages of Bulk Handling and Blending

Several advantages accrue through both the handling of raw materials in bulk and the production of blends with these bulk materials. The following is a listing of some of the more important advantages:

1. Raw materials can be imported as high-analysis materials to obtain relatively low cost per nutrient ton.

2. Fertilizer grades can be easily tailored to local crop and soil requirements.

3. Cost savings are evident both in purchasing and shipping.

4. Losses are generally decreased over the handling of bags. Problems of broken or hooked bags and the resulting reclaiming and rebagging costs are eliminated by using bulk material.

5. Local labor, management, and ownership would occur with resultant savings in foreign exchange and the advantage of building a local industry.

6. The price pressure from the bulk-blend facility operated by the cooperatives could result in lowering of price and increase in services from the traditional dealers.

ANNEX II

Equipment Description and Specifications

All equipment suggested for use and mentioned under those report sections for Phase II and Phase III implementation was selected on the basis of simplicity of operation, durability, and ease of maintenance. The machinery involved in the bagging and bulk-blending schemes is by nature relatively simple in design and operation.

During Phase II, bagging operations will begin in Bolivia utilizing one central location and one bagging machine. The bagging unit will consist of a fertilizer feed hopper, a mechanical weigh and dump system, a manual tie operation for sealing the inner bag, and a sewing machine for sealing the outer bag. The bagging unit is to be adjustable to handle packing of both 25-kg and 50-kg bags.

In general, these units have the capability of packing at a rate of 40 tph but are normally operated at about 30 tph (when using 50-kg bags). The accuracy of this type of unit is usually within ±0.25% of the amount being weighed (0.125 kg in a 50-kg bag).

The following bagging machine specifications are exemplary of the type described above. There are several manufacturers who provide these types of units. The units are available both as permanently installed equipment or as portable equipment such as that used for dockside bagging operations.

Phase II--Bagging Unit Equipment Specifications

The specifications included in this section are from IFDC files. The specifications are included here as an example only, and IFDC neither supports nor rejects any claims made by manufacturers of such equipment. The prices contained in other report sections depict the best estimate of IFDC. These prices are not firm bid prices and should not be treated as such.

Bucket Elevator

Recommended is one (1) standard bucket elevator, centrifugal discharge chain type, with casing approximately 20 in by 48 in, with a capacity of 100 tph when handling material of 60-lb/ft^3 density. Discharge height of the elevator is to be 35-41 ft above grade. The headshaft speed should be ~40 rpm with a 260-fpm chain speed. The elevator should be furnished to the following specifications.

Head Section--A 16-tooth C111 solid-hub sprocket, 3-7/16-in diameter shaft, type-E pillow-block roller bearings, chain and buckets, 10-ga steel casing and head covers intermittently welded, motor mount, and drive guard. Nominal height of head is 6 ft 9 in.

Intermediate Sections--Exterior-grade plywood casing, angle reinforced, C111 chain and 16-in by 8-in steel buckets spaced every 14 in. Sections are normally 10 ft in length. To obtain height of intermediate sections, deduct 7 ft from the discharge height.

Access Door--One (1) 24-in by 32-in spring-clip access door installed in 10-ft intermediate section only.

Boot Section--12-tooth C111 solid-hub sprocket, 2-5/16-in diameter boot shaft, type SCM wide-slot take-up bearings, two clean-out doors 3/16 in thick, steel casing intermittently welded, chain, and buckets. Nominal height of boot is 5 ft 0 in.

Motor--One General Electric, Allis Chalmers, or equal, TEFC 3/60/460 service, 15-hp, 1,800-rpm motor.

Speed Reducer--One (1) Dodge shaft-mounted speed reducer, or equivalent, AGMA code #315D, complete with drive and driven sheaves with taper-lock bushings, and V-belts. One (1) backstop, for Dodge shaft-mounted speed reducer AGMA code #315D or equal, should also be used.

Motor Starter--One (1) combination, magnetic, full-voltage, across-the-line, heavy-duty General Electric, Cutler Hammer, or equal, starter and fusible disconnect switch complete with overload heater coils and reset in cover, in size 2, 15-hp Nema 4 enclosure for 460 volts, 3-phase, 60-cycle operation.

Elevator Discharge--A discharge transition piece provided as required to be compatible with the surge hopper for the bagging machine. These include:

One (1) start-stop pushbutton in standard enclosure, and

One (1) safety disconnect switch.

Bagging Equipment

One (1) bagging machine adjustable to fill both 50- and 25-kg bags should be used. The weighing system should be totally mechanical to preclude problems with electrical weigh cells. The package should consist of the following components.

One (1) net weight packer (adjustable 50- and 25-kg) with fully mechanical weighing apparatus should be used. All parts which contact fertilizer should be of stainless steel construction. Packer will have pneumatic clamps for holding jute, woven polypropylene, or multiwall paper bags during filling. Minimum acceptable capacity is to be 30 tph with material of 60-lb/ft^3 density.

Recommended is one (1) independent air supply system with 3.2-cfm air compressor and 30-gal storage tank, sealed pressure switch, and TEFC drive motor, heavy-duty Allis Chalmers, or equal, 1-hp size, 3/60/460 operation.

Recommended is one (1) combination, magnetic, full-voltage, across-the-line, heavy-duty General Electric, or equal, motor starter and fusible disconnect switch complete with overload heater coils and built-in reset in cover in size 1, 1-hp Nema 4 enclosure for 3/60/460 operation.

One (1) Nema 4 start-stop pushbutton in standard enclosure should be installed.

Recommended is one (1) heavy-duty conveyor, 12-in wide, open, stainless steel, mesh belt, by 10-ft long C to C pulleys, constructed with oil-soaked hardwood strip conveyor bed or with acceptable all stainless steel construction. One (1) Allis Chalmers, or equal, TEFC drive motor in 1-hp size, 1,800 rpm, 3/60/460 operation should be used.

Recommended is one (1) combination, magnetic, full-voltage, across-the-line, heavy-duty, General Electric, Cutler Hammer, or equal, motor starter and fusible disconnect switch complete with overload heater coils and built-in reset in cover in size 1, 1-hp Nema 4 enclosure for 3/60/460 operation.

One (1) Nema 4 start-stop pushbutton in standard enclosure should be used.

One (1) vertically adjustable, pedestal sewing machine and support for mounting to conveyor frame should be used. This machine should be adjustable 28-42 in above the conveyor top. An automatic sewing machine start-stop switch should also be included.

Sewing Machines

Two (2) Fishbein, Model 10,000, sewing-machine heads should be used with integral thread cutter (nonautomatic). These should be equipped with quick-mount sewing head adapter plates on each head.

One (1) Allis Chalmers, or equal, TEFC motor, 1-hp 3/60/460 operation is recommended.

Also recommended is one (1) combination magnetic, full-voltage, across-the-line, heavy-duty General Electric, Cutler Hammer, or equal, motor starter and fusible disconnect switch, complete with overload heater coils and built-in reset in cover in size 1, 1-hp Nema 4 enclosure for 3/60/460 operation.

Feed Hopper

One (1) 2- to 3-mt surge hopper is recommended for charging of bagging machine. The hopper should be constructed of 10-ga steel. A steel frame should be included for mounting the hopper above the bagging machine.

Specifications of Bulk-Blending Equipment

Weigh System

One (1) complete weighing system should be used for 1-ton batches. This system should include a weigh hopper with a top not more than 6 ft above floor level to enable direct charging with a front-end loader. The system should include the following items:

1. Toledo, or equal, dial scale, 1,500-kg gross capacity with pipe levers, 20-in dial, 1,250-kg by 1-kg dial, extension levers and rods;

2. One (1) 1-ton weigh hopper, 10-ga construction, complete with hole punching and reinforcing for scale-suspension rods above and inclined conveyor beneath;

3. One (1) structural steel frame punched for supporting scale suspension rods and above-mentioned weigh hopper. A shelf shall be provided for the dial scale head and brackets complete for extension lever and dash pot assembly.

Conveyor

One (1) inclined belt pan conveyor, 14-in wide belt by 12-ft long should be bolted to the 1-ton weigh hopper (less motor).

One (1) Allis Chalmers motor or equal TEFC 3/60/460 service, 5 hp, 1,800 rpm is recommended.

One (1) conveyor drive guard fabricated of 12-ga steel plate and enclosed on both sides should be installed.

Recommended is one (1) combination, magnetic, full-voltage, across-the-line, heavy-duty General Electric, Cutler Hammer, or equal, motor starter and fusible disconnect switch complete with overload heater coils and built-in reset in cover in size 1, 5-hp, Nema 4 enclosure for 3/60/460 operation.

One (1) Nema 4 start-stop pushbutton in standard enclosure should be installed.

One (1) safety disconnect switch is recommended.

Mixing System

The mixing system should consist of one (1) rotary-type mixer for bulk-blend application. The capacity is one (1) ton based on 60-lb/ft^3 material. Construction should be of 3/8-in steel plate for ends and 1/2-in thick steel plate for shell. The base should be of heavy structural steel with special rubber-tired trunnion wheels. Shafts, bearings, and preassembled takeups, including intake and discharge hoppers should be used. A manually operated interior discharge chute shall be installed. Also included will be the motor mount with drive by friction from trunnion rollers (two-wheel drive). Drive guards and wheel guards should be included.

One (1) Allis Chalmers motor or equal, TEFC 3/60/460 service, 15 hp, 1,800 rpm is recommended.

Also recommended is one (1) speed reducer, Falk FZ, or equal, horizontal concentric 1,800/100 rpm, 15 hp, class II, with integral motor bracket and flexible motor coupling.

All discharge and intake valves should be manually operated.

Four (4) mixer legs of structural steel punched to fit shall be supplied.

Recommended is one (1) combination, magnetic, full-voltage, across-the-line, heavy-duty General Electric, Cutler Hammer, or equal, motor starter and fusible disconnect switch complete with overload heater coils and built-in reset in cover in size 2, 15-hp Nema 4 enclosure for 3/60/460 operation.

One (1) Nema 4 start-stop pushbutton in standard enclosure should be installed.

One (1) safety disconnect switch should be installed.

Chain Mill

Recommended is one (1) chain mill, heavy-duty, steel-plate construction with removable top quarter panel. The interior should be fitted with baffle plate and flexible end chains to prevent buildup. The mill should be mounted on a predrilled structural steel mounting base with 27 sets of chain/bar links consisting of 2 links, 3/4-in coil chain, and solid-steel bar attachment (all case hardened). V-belt drive including driven and drive sheaves with drive guard should be included.

One (1) General Electric, Allis Chalmers, or equal, TEFC motor, 15-hp is recommended for 3/60/460 operation.

Recommended is one (1) combination magnetic, full-voltage, across-the-line, heavy-duty General Electric, Cutler Hammer, or equal, motor starter and fusible disconnect switch complete with overload heater coils and built-in reset in cover in size 2, 15-hp, Nema 4 enclosure for 3/60/460 operation.

One (1) Nema 4 start-stop pushbutton in standard enclosure should be installed.

One (1) safety disconnect switch is recommended.

A suitable charging hopper for chain mill of 10-ga steel-plate construction should be mounted above the mill for charging by the front-end loader. All structural steel supports for grade-level mounting should be included.

Conveyor

One (1) inclined belt pan conveyor, 14 in wide by 12 ft long should be bolted beneath the chain mill to be used for feeding materials to the weighing system.

One (1) Allis Chalmers motor, or equal, TEFC 3/60/460 service, 5 hp, 1,800 rpm is recommended.

One (1) conveyor drive guard fabricated of 12-ga steel plate, enclosed on both sides, should be installed.

Recommended is one (1) General Electric, Cutler Hammer, or equal, heavy-duty, combination magnetic, full-voltage, across-the-line motor starter and fusible disconnect switch complete with overload heater coils and built-in reset in cover in size 1, 5-hp Nema 4 enclosure for 3/60/460 operation.

One (1) Nema 4 start-stop pushbutton in standard enclosure should be installed.

One (1) safety disconnect switch should be used.

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