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World Fertilizer Market Review and Outlook

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by

E. A. Harre
Owen W. Livingston
John T. Shields

NATIONAL FERTILIZER DEVELOPMENT CENTER, MUSCLE SHOALS, ALABAMA 35660

FOREWORD

The importance of fertilizer is well documented. But perhaps at no time in history, including the "Green Revolution" period of a few years ago, has the world spotlight been focused more sharply on fertilizer than it is today.

The current world fertilizer situation is characterized by extreme tightness in supplies; some demand for nitrogen and phosphate is not being met. World prices have more than doubled since 1971. AID has been unable to obtain bids for some of its fertilizer requirements. In addition, concern over food scarcity, rising food prices, and effects of the energy crisis have compounded the problem.

In short, these developments have raised serious questions about the ability of the world fertilizer industry to supply needed fertilizers at prices farmers can afford to pay.

AID asked TVA to make this study to help answer questions about prospective world fertilizer supplies in relation to expected demand. Emphasis is on expected developments between 1974 and 1978 and the factors likely to influence world and regional fertilizer supply/demand and trade. AID financed the study.

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SUMMARY

GENERAL

A shortage in nitrogen and phosphate fertilizer has developed in international trade and in domestic supply in many countries due to several factors. The more important ones are:

- The primary sources of world trade—North America, Western Europe, and Japan—have added very little nitrogen and P_2O_5 capacity in recent years; yet, indigenous demand has increased in these areas, leaving less product available for export.
- Shortages of feedstock—interruption in natural gas supply and shortages of naphtha and other petroleum-derived feedstocks—and tight pollution standards have reduced levels of operation at many plants. Supplies of phosphate rock also have been in short supply.
- Increased use of urea and other nitrogen compounds for animal feed supplement has decreased the nitrogen fertilizer supply, especially in North America.
- Planned expansion in developing countries has not come on-stream as rapidly as planned; also, some plants are operating at lower-than-expected rates because of feedstock shortages, power outages, lack of preventive maintenance, shortages of spare parts, lack of trained manpower, etc.

WORLD MARKET TRENDS

Total world fertilizer consumption is forecast to reach 105 to 123 million metric tons[1] of nutrients by 1980. Midpoint of the range is 114 million tons (57 million tons of N, 31 million tons of P_2O_5, and 25 million tons of K_2O). This compares with 72.3 million tons in 1972.

Seventy-four percent of the total consumption by 1980 is expected to be in the developed regions.

Developed regions will increase consumption by more than 27 million tons while the developing nations will expand use by more than 10 million tons.

Average world consumption growth rate is expected to range from 4.8% to 6.9% per year between 1974 and 1980. In the developed regions the fastest growth rates will be in Eastern Europe and USSR (6.1%-7.6% annually). The average annual rate of increase in developing regions will range from 8% to 10.7%, with Latin America experiencing larger gains than either Asia or Africa. This compares with expected rates of 4% to 6% in developed regions and a 7.7% to 10.6% increase in developing Asia.

Nitrogen will experience the biggest gains, increasing from 33.7 million tons in 1972 to 57 million tons of N in 1980. Of the latter, nearly 39 million tons will be used in the developed regions, 11 million in the developing regions and 6.8 million in the other Asian countries. The largest user of nitrogen will be Eastern Europe—USSR. It will be followed by North America, Western Europe, and the developing nations of Asia, which will increase use at an annual rate exceeding 9.4% per year.

By 1980 the total world use of phosphate is expected to be between 28 million and 34 million tons of P_2O_5. The average annual growth rate indicated is forecast at about 5%/year, if the midpoint value of 31 million tons P_2O_5 is attained. Phosphate use is centered in the developed regions, which accounted for over 80% of total use in 1972. By 1980 their share will decline to 76% of the world market.

Largest consumer of phosphates is Western Europe, followed by Eastern Europe and North America; each used well over 4 million tons of P_2O_5 in 1972. The developing nations of Asia rank fourth; however, their use level is just over 1.3 million tons of P_2O_5. Phosphate use will more than double in the developing countries, but their total will remain only about a fourth that of the developed regions.

By 1980, the total use of potash in the developing regions will be about 3 million tons of K_2O while consumption in the developed regions should exceed 22 million tons. Most potash trade is between developed nations. Also, most of the major reserves and production facilities for potash are located in the developed world; thus, developing countries should expect to obtain their potash requirements through trade.

NITROGEN CAPACITY AND SUPPLY

Assessment of the world nitrogen supply-demand situation for the period 1974-78 indicates that shortages will continue and may become more severe unless some of the major difficulties can be corrected. Little expansion of production has been announced for North America, Western Europe, and Japan, but several projects are under consideration. Substantial increased capacity is planned in Eastern Europe and USSR, which may provide some nitrogen for export. However, domestic demand in these regions is also expected to increase rapidly. Continued shortages of feedstocks in many countries will limit production, especially for plants that rely on hydrocarbon imports.

In 1972 the world ammonia capacity stood at 58 million tons; it should increase to more than 77 million tons by 1978 if all announced plants come on-stream as scheduled.

[1] All tons are metric tons.

Of the 1972 capacity, 83% is located in the developed countries and 17% in the developing countries. By 1978 it is expected that more than 25% of the nitrogen capacity will be in the developing areas; developing Asia will have nearly 10 million tons of nitrogen capacity (12% of world's ammonia capacity).

Based on assumptions used in this study, the developing regions of the world will continue to be deficient in nitrogen (by 2.3 to 3.6 million tons). However, if plants were operated at 100% of capacity the developing regions could produce a surplus of 1.6 million tons.

The traditional world nitrogen traders—North America, Western Europe, and Japan—will have only about 50% of the world nitrogen capacity in 1978 compared with 60% in 1972. This shift will have a significant impact on future nitrogen trade patterns.

By 1978 urea is projected to account for more than 36% of the world nitrogen capacity and over 50% of all nitrogen products traded. Urea has a larger share of the market in Asia than in other regions. By 1978 nearly all nitrogen production capacity in Asia will be in the form of urea (for direct farm use).

PHOSPHATE CAPACITY AND SUPPLY

The future of the world phosphate industry will depend largely on developments in phosphoric acid. About 80% of all phosphate products are derived from phosphoric acid. By 1978, if plans materialize, the world's phosphoric acid capacity should exceed 27.5 million tons with one-third of this capacity in North America, 21% in Eastern Europe and USSR, and 19% in Western Europe. Trends in the industry will be influenced to a lesser extent by developments in nitric phosphates.

World production of concentrated superphosphate is expected to increase slightly by 1978, primarily in North Africa and the USSR. However, ammonium phosphates (DAP, MAP) and high-analysis complex fertilizers are fast becoming the most popular way of marketing phosphate to the farmer.

If present plans materialize, the world P_2O_5 supply-demand situation will be back in balance by 1978 and surpluses could occur. However, Latin America and Asia will still be deficit producers and must depend on trade sources for their supplies.

POTASH CAPACITY AND SUPPLY

The world's potash capacity stands at over 24.5 million tons of K_2O and should exceed 26 million by 1978. The only region planning any major expansion in potash capacity is Eastern Europe, including Russia. With this expansion, this area will become the world's leading producer of potash, with North America ranked second, and Western Europe third. Slowly but steadily, the world potash market is moving toward a balanced situation by 1978.

Africa is the only developing region producing potash. Although deposits exist in each of the developing areas none is expected to be commercially developed by 1978. Developing regions will continue to depend on world trade sources for their potash supplies. By 1978 almost 3 million tons of K_2O will be imported by the developing regions, with Asia accounting for approximately a third of the total.

PRICE DEVELOPMENTS

Most nitrogen and P_2O_5 product prices are now at all-time highs on the international market. Many experts seem to feel that fertilizer prices are approaching their peaks. Some observers feel that P_2O_5 prices may peak and level off during the coming year and trend downward by 1976 or 1977 as added capacity comes on-stream. Nitrogen prices apparently have not peaked. With added capacity slow in coming on-stream, it may be 3 to 4 years before appreciable price decreases occur.

The timing of any price adjustments both in N and P_2O_5 is dependent upon the timing of additional production capacity and demand growth rates as well as success in satisfying world food demand.

Given that world food and feed grains production will increase substantially in the rest of this decade and fertilizer productive capacity will continue to expand in areas of the world with comparative advantages, fertilizer prices should decline from their present high levels but equalize at levels substantially higher than prices in the 1969-71 period.

INVESTMENT AND PRODUCTION COSTS

Since early 1973 there has been a significant increase in the battery limits costs of all plants, including ammonia, urea, sulfuric acid, and phosphoric acid. Plant costs in this report reflect current trends in plant investment which are escalating due to the demand for new capacity, shortage of engineering personnel, higher labor costs, tight supplies and higher costs of metals, undependable equipment deliveries, environmental pressures, and greater plant complexity. Published plant investment (battery limits) may be too low even when brought up-to-date with published cost factors for reasons given above.

Key raw materials for nitrogen production—such as natural gas, naphtha, and fuel oil—are increasing in cost, which will increase the cost of such end products as urea. Interest is strong in the use of alternative feedstocks, but as

feedstock complexity increases the plant investment also increases. Capital-related items in nitrogen production account for a high portion of the cost, but as the feedstock costs climb this ratio decreases.

Phosphate rock prices from U.S. sources have doubled, while Moroccan rock prices have recently tripled. Reasons cited are increased demand, lack of capacity, capital required for mine expansion, and ecological and power source constraints.

The cost of sulfur is expected to increase but should not be so drastic as for phosphate rock. The potential for sulfur and sulfuric acid recovery processes may help keep the cost of elemental sulfur down.

A 1,000 tons/day ammonia plant using natural gas and a corresponding 1,650 tons/day urea plant will require an investment in developing countries of about $100 million in 1974; the plant includes all offsites and storage, but not the cost of land or port facilities. An ammonia plant using naphtha will cost about 11% more, heavy oil 25% more, and coal 75% more compared with a natural gas ammonia plant.

At the equivalent cost/MM Btu for feedstock for ammonia production, the cost of producing ammonia is lowest using natural gas—followed by naphtha, heavy oil, and coal, because of the higher investment cost.

The cost of producing either ammonia or urea increases significantly when plants are operated at less than design capacity, especially at 60% or less. Inefficient operation at these levels can overshadow the higher cost of raw materials. In some LDC's there is a compound effect of low on-stream time and higher feedstock costs.

Raw materials for phosphate production account for a large portion of the cost; therefore, products such as DAP (18-46-0) and TSP (0-46-0) are very sensitive to changes in raw materials cost.

The plant investment per ton of phosphate product is less than that for nitrogen; therefore, costs of production are less sensitive to changes in plant investment costs.

Where available locally, natural gas is the lowest cost hydrocarbon feedstock for ammonia production. But only a fraction of the total world use of natural gas is for ammonia production. In the United States, in 1972 about 456 billion cubic feet of gas was used for ammonia out of a total production of 22 trillion cubic feet (about 2% of the total). Present estimated world reserves of gas are 2,033,372 billion cubic feet.

Rather than a shortage of natural gas, it appears that the present world nitrogen shortage is more a result of unavailability of naphtha, lags in completion of plants, plants operating at less than capacity, and a shortage of fuel for transportation—with all these factors occurring during a period of high demand.

For phosphates, shortages are attributed primarily to the unexpectedly high demand, shortages of raw material and higher costs, and lack of new capacity having been added during the lean-year period.

INTRODUCTION

It appears that the world fertilizer industry will not be able to supply sufficient materials to satisfy the total demand for plant nutrients in 1974. Tightness in supplies has caused fertilizer prices to rise sharply in recent months. Even so, additional material has been slow coming into the market. This has led to talk in some quarters of long-term shortages of both fertilizers and foods. This, however, ignores or greatly discounts the cyclical nature of agriculture and the fertilizer industry; overlooking this factor could return the industry to the depressed conditions that prevailed in the late 1960's and early 1970's.

The world fertilizer market was relatively stable during the 1960-65 period. However, drought caused food shortages in certain areas of the world, which stimulated food exports by other producing areas and was interpreted by some to be the beginning of a world food crisis. In addition, new fertilizer production technology had been developed and idle capital was quickly pumped into what looked like an opportunity for sustained large-scale returns. Many production units were built, first in the developed regions and later in many of the developing countries. The result was an oversupply of fertilizers—with low prices, distress selling, and poor returns on investment. This lasted into the 1970's when demand again caught up with supplies.

These profitless years led to caution throughout the industry; lack of new investment; closing of old, inefficient plants; and delays or abandonment of new projects. As a result, when demand surged in 1972 and 1973, there was no additional capacity readily available to supply the market. Nations that traditionally had sold internationally reduced export shipments in order to meet the domestic demand; importing countries, accustomed to a buyer's market, found that they could not go out on the spur of the moment and obtain whatever quantity or type of material they wanted. Currently, the world fertilizer market is a seller's market; however, past performance suggests that these situations do not last long and that changes can be expected.

The purpose of this report is to indicate the current and future supply situation; give some indication of the long-term market situation, assuming unrestricted world trade; and to discuss some of the factors that will dictate the timing of a return to a world supply-demand balance and some market stability. Although the overall world market is tabulated, major problems are best indicated on a regional level; minor adjustments within a regional market often will be enough to stabilize the supply level in that area.

FERTILIZER DEMANDS

The first part of any market study must be to estimate the effective demand. By definition, the effective demand is an estimate of the actual level of use that will take place in any given year, based on what the farmer will apply to the land. It is not the amount of plant food that is recommended for efficient production or that is required to achieve a stated level of food production based on the calorie and protein needs of the estimated future population. A more detailed discussion of the forecasting procedures that are used will be found in Appendix A.

TVA published its fourth edition of a world report on the fertilizer situation in August 1972. At that time, world demand for plant nutrients in 1980 was estimated to be 105.7 million tons. With revisions and an additional year's data available, some changes in the long-term growth rate for fertilizers are indicated. Several regions significantly exceeded the rate of increase projected in 1972 and the data have been adjusted accordingly.

Table 1 shows the total demand for 1972 and the revised forecast for 1980 by regions. Average high and low growth rates for the period 1972-1980 are also indicated. From this table, it is possible to see the areas where demand levels are changing and also that some regions are continuing to follow relatively stable growth patterns.

Demand estimates for the next 8 years should not be designated by a single value. Fertilizer markets fluctuate and are subject to cycles within the overall growth trend. With the use of trend lines, the scatter around the average line gives some indication of the reliability of the forecast and also helps to point out the magnitude of the market swings that should be expected. It is possible that normal swings in the market can be misjudged to be major changes in the growth pattern. While this is more likely for an individual country—Brazil is a recent example—where new methods or technology was introduced, it is not as likely to occur on a regional or worldwide scale. In addition, examination of the range values reduces the chance of misreading a large inventory buildup as actual demand, which would indicate an accelerated growth rate. Countries that are large net importers often make purchases in excess

Table 1. Total plant nutrient consumption forecast

Region	Actual consumption 1972	Consumption forecast–1980 Midpoint	Range Low	Range High	Range variation	Average annual growth rate 1972-1980 Low	High
	(million tons N, P_2O_5, K_2O)				%	(%/year)	
Developed							
North America	16.5	24.3	22.5	26.2	±7.6	4.1	6.0
Western Europe	17.5	22.6	21.7	23.5	±4.0	2.7	3.8
Other[a]	4.3	5.5	4.2	6.8	±23.6	–	6.2
Total	(38.3)	(52.5)	(48.5)	(56.5)	(±7.6)	(3.0)	(5.0)
Developing							
Latin America	3.2	7.2	6.6	7.8	±8.3	9.5	11.8
Africa[b]	1.3	2.2	1.9	2.4	±11.4	5.9	9.0
Asia[c]	5.4	10.8	9.6	11.9	±10.7	7.7	10.6
Total	(9.9)	(20.2)	(18.2)	(22.2)	(±9.9)	(8.0)	(10.7)
Total	**(48.2)**	**(72.7)**	**(66.6)**	**(78.7)**	**(±8.3)**	**(4.2)**	**(6.3)**
Eastern Europe-USSR	18.9	32.0	30.1	33.9	±5.9	6.1	7.6
Other Asia	4.9	9.1	8.1	10.1	±11.0	6.6	9.6
World	72.3	113.7	104.8	122.6	±7.8	4.8	6.9

[a]Includes Japan, Israel, Republic of South Africa, and Oceania.
[b]Excludes Republic of South Africa.
[c]Excludes Japan and Israel.

of the annual demand and then require several years to work off these inventories. Thus, the appearance of a large range value gives some indication of buying patterns.

Table 1 also presents the calculated ranges for the regional demand estimates for 1980 that were developed for this study. The variation around the midpoint is expressed as a percentage for comparison purposes.

While the developing regions will continue to lead the world in terms of relative rates of growth, the developed regions will account for the large increase in actual tons of fertilizer used. By 1980, they will increase plant nutrient use by more than 27 million tons, whereas the developing nations will expand use a little over 10 million tons.

Of the developed regions, the highest level of growth will continue to be in Eastern Europe and the U.S.S.R.–an estimated 6% to 7.6% annual gain compared to an average of between 4% and 6% for the developed regions as a whole. In the developing regions, it appears that Latin America will experience greater market gains than either Asia or Africa. The average rate of increase for the developing regions will be between 8% and 10.7%/year compared to a 4% to 6% gain in developed regions and a 7% to 10% increase in the other Asian countries.

For the world as a whole, it appears that the average growth rate will continue to fall within a range of from 4.8% to 6.9%/year. With this level of increase, the current use of 72.3 million tons of plant nutrients will be expanded to between 104.8 to 122.6 million tons, with a midpoint of 113.7 million tons.

The range variation indicated in table 1 shows that less confidence is placed in the forecasts for the developing regions–a 10% variation around the midpoint–than in the developed regions which show only a 7% variation.

The relative importance of the communist nations continues to increase in the world fertilizer market. Currently, one-third of all fertilizer is used in this area and the share will continue to increase through 1980. As will be discussed in detail later, this change in the distribution of fertilizer will have a significant effect on world production and trade patterns in the years ahead.

While table 1 gives an indication of the overall fertilizer market, there are very significant differences between the individual plant nutrients. Nitrogen will continue to gain in importance in relation to phosphates and potash, and regions will have varying requirements for each of the primary nutrients.

NITROGEN DEMAND

In 1972, total world use of nitrogen was 33.7 million tons–nearly three times the slightly more than 11.8 million tons used in 1962. This represents an average increase of more than 11%/year. By 1980 it is estimated that total nitrogen use will be between 53 and 61 million tons, the midpoint being 57 million. Achieving this level will require an average annual gain in excess of 6.7%, much below the performance of the past decade. Background data and the

high and low ranges forecast for the nitrogen market are shown in table A-1. More detail on individual regions is included in the section of the report which discusses supply-demand relationships.

Of the almost 57 million tons of nitrogen that will be used in 1980, 38.6 million will be consumed in the developed regions, 11.4 million in the developing regions, and 6.8 million in other Asia countries. By far the largest single user of nitrogen will be Eastern Europe–U.S.S.R. This region is followed by North America and Western Europe. Next will be the developing nations of Asia, whose use will increase by more than 9.4%/year. These countries will also account for better than 62% of the total use of nitrogen in the developing world, excluding the other Asian nations.

The demand forecasts in table A-1 indicate that market gains will be slower in the future than in the recent past. The last decade was one of very rapid growth based in part on widespread educational programs, new varieties, and low fertilizer prices relative to agricultural output. In many areas, nitrogen was used for the first time. In other areas, especially in developed regions, farmers operated very close to the optimum level of use. Under these conditions, nitrogen use should continue to increase but probably will not achieve the high rate of increase of previous years.

One factor that should be considered in the nitrogen market is the increased demand for meat throughout the world. Much more fertilizer is required to produce a given amount of protein as beef than as grain. As meat production increases more grain is fed to livestock. This means that nitrogen requirements will increase faster than if diets remained the same. In addition, livestock expansion means more intensive use of pasture and forage crops and greater use of nitrogen fertilizer on them. These two factors should help to maintain the market for nitrogen in the years ahead. On the other hand, the forecast expanded acreage of soybeans may dampen the growth in demand for nitrogen; the soybean requires relatively little nitrogen fertilizer since it fixes atmospheric nitrogen.

PHOSPHATE DEMAND

Phosphate use ranks second to nitrogen in importance. World consumption in 1972 exceeded 21 million tons of P_2O_5, or about 30% of the total plant nutrient demand. For many years, phosphate ranked as the leading plant nutrient applied; however, it has been replaced by nitrogen, which achieved a much faster rate of increase in the last decade. The slower growth rate of phosphate is due partly to the fact that it accumulates in the soil when applied in excess of plant needs, whereas, nitrogen and, to some degree, potash must be replenished each year because of leaching. Phosphate is vital to plant growth and must be available in sufficient quantities if maximum yields are to be attained, but it is not required in large quantities by many of the world's major crops. Table 2 gives some indication of the plant nutrient requirements of a few of the more important food and fiber crops.

By 1980 world use of phosphate should be between 28.3 million and 34.1 million tons of P_2O_5. The annual rate of growth will exceed 5% if the midpoint value of 31.2 million tons P_2O_5 is attained.

Phosphate use is centered in the developed regions of the world, which used 81% of the 1972 total. Their share will shrink only slightly–to 76% by 1980.

As indicated in table A-2, Western Europe is the major consumer of phosphates, followed by Eastern Europe and North America; each region used more than 4.5 million tons of P_2O_5 in 1972. The developing nations of Asia rank fourth, with about 1.3 million tons. Phosphate use is expected to more than double in developing Asia and the other developing countries, but will remain only about one-fourth that of the developed regions. By 1980, the Eastern European nations should become the leading use area for phosphates. With its large resources for phosphate manufacture, this region can be expected to play a larger role in the development of the world's phosphate industry and a major shift in world trade patterns could take place.

POTASH DEMAND

Potash is also vital to plant growth; however, it does not receive the attention given to nitrogen and phosphate. Many soils are inherently high in potash and require little or no supplemental applications. As a result, potash ranks third among the primary plant nutrients. Although market growth has been steady, it will continue to lag behind nitrogen and phosphate. In 1972 the world used more than 17.4 million tons of K_2O with more than 15.8 million tons

Table 2. Weight of plant food nutrient elements in selected crops

Crop	Yield	Nitrogen	P_2O_5	K_2O
	tons/hectare	kg/hectare		
Maize	3.8	106	39	78
Oats	1.8	34	7	9
Wheat	2.0	56	22	34
Rice	5.3	92	19	119
Soybean	1.7	140[a]	45	67
Cotton	1.7	73	28	56
Sugar beets	58.0	145	45	195
Tomatoes	22.3	112	39	196
Hay (mixed)	5.0	85	35	90

[a]Includes nitrogen fixed from the atmosphere.

Source: *Efficient Use of Fertilizers*, FAO, United Nations, 1958.

going to the developed nations. As shown in table A-3, use of potash in these areas will total about 3 million tons of K_2O; this compares with over 22 million tons in the developed regions.

With most of the major reserves and production facilities for potash located in the developed world, potash trade is primarily between developed nations, and the developing countries should expect to continue to obtain their potash requirements through trade.

In the past few months it has appeared to many that the world demand for plant nutrients has begun to grow much faster than in the past. As previously indicated, however, the recent spurt in demand probably is a short-term response to market conditions that occur periodically. This should be expected and planned for by governments and the fertilizer industry. The rapid rise in demand for this season is in response to high grain prices which are a result of drought conditions in some areas and also a lack of planting by farmers because of poor returns in past years. The current short fertilizer supply also is the result of poor returns on investment in plants and equipment, which discouraged the building of new facilities.

The cyclical nature of agriculture and thus the fertilizer market cannot be disregarded. The response by farmers to high grain prices and anticipated high income levels should once again reverse the cycle and provide record yields and food supplies. When this occurs, commodity prices will decline, the incentive for fertilizer use will diminish, and the cycle will move in the other direction These market swings cannot be eliminated; however, dequate planning and recognition of this pattern should help to bring about a more orderly market. While some of the forecasts presented show growth rates above those of previous reports two key points should be kept in mind: (1) the cyclical nature of the fertilizer market (as dramatized by short-term market swings) and (2) that the long-term growth of the world fertilizer market has a fairly high degree of stability.

While the demand portion of the market shows some stability, the supply side follows a saw-tooth pattern of rapid overdevelopment and then little or no increase until demand catches up with supply. The supply situation is further complicated by the fact that total capacity does not always give a true indication of the actual amount of fertilizer that will be produced.

The estimates for fertilizer supply in this study are based on a very specific set of assumptions and procedures. The methods and values used for incorporating operating rates, loss factors, and nonfertilizer uses into the supply picture have been detailed in Appendix A. Since there are many possible ways in which to estimate both supply and demand for fertilizers, a careful review of the methodology presented in the appendix is recommended, especially if comparisons are to be made with other marketing studies.

FERTILIZER SUPPLY-DEMAND RELATIONSHIPS

A true market picture can only be determined by a comparison of demand levels and available supply. Without adequate lead time to build new capacity, demand can quickly catch up to the supply level, thus hampering the optimum use of plant nutrients. This section reviews expected capacity levels for each of the primary plant nutrients, estimates the potential supplies that will enter the world fertilizer market, and defines areas where market imbalances exist. Supply surplus or deficit levels are presented for each major region to indicate its trade position. These figures can only act as a general guideline; it is impossible with available statistics to incorporate inventory changes into the analysis.

Supply-demand relationships have been carried through to the 1977 fertilizer year since there is little firm new capacity announced beyond this point. Data tables and charts have been extended one additional year to show effects on supply of plants starting production in 1976 and 1977. Many changes in the supply picture could occur after 1977, depending on market conditions; lead times for new construction would easily allow plants announced during the next 3 years to be in production prior to 1980.

NITROGEN SUPPLY LEVELS

Ammonia forms the basis of almost all nitrogen fertilizers. Thus, the first step in analyzing the nitrogen fertilizer industry is to determine ammonia capacity and supply; without adequate ammonia, nitrogen fertilizer cannot be produced in sufficient quantities. The analysis also must take into account the substantial tonnages of ammonia required for nonfertilizer or industrial uses.

In 1967 world ammonia capacity stood at almost 38 million tons of nitrogen. In 1972 this capacity was over 58 million tons. It should increase to over 77 million tons by 1977 if all announced plans come into production as scheduled.

While capacity was being expanded by 20 million tons between 1967 and 1972, demand was increasing by almost 12 million tons. Forecasts indicate a further 19-million-ton

increase in capacity in the next 5 years; fertilizer demand is expected to show a 14-million-ton gain in the same period. Thus, it is apparent that the demand for fertilizer nitrogen will continue to pressure world supplies. **Plans are being formulated for additional ammonia production, most of which are not included in this study because of lack of sufficient information on capacity, year of completion, or source of feedstock. Approximately 22 million tons of additional nitrogen capacity falls in this category.**

Distribution of the capacity data used for this study is shown in table A-4. Of the 58.2 million tons of total capacity available for the 1972 fertilizer year, 83% is located in the developed countries and 17% in the developing nations. By 1977, however, it is expected that the developing regions will account for more than 20% of the total installed capacity. Also, the portion of the total accounted for by the traditional nitrogen exporting nations—North America, Western Europe, and Japan—will drop from 60% to 48% by 1977. This shift in market position already is affecting the supply situation; it will loom even larger in the future since nitrogen trade patterns must change if the traditional nitrogen producers do not maintain their position in the market.

According to present plans, by 1977 the developing nations of Asia will have almost 10 million tons of ammonia capacity installed. This will be more than 12% of the world's ammonia capacity, a significant increase over the current 8% level.

World Nitrogen Supply

On a worldwide basis supply and demand for nitrogen should increase along parallel growth lines, as shown in figure 1. This would indicate that supply should be adequate to satisfy the demand. However, the fact that the supply and demand lines are moving together suggest that any major upward shift in demand cannot be met by excess capacity and would quickly bring on a critical shortage. On the other hand, any slowdown in demand would lead to excess supplies, at least until older, marginal operations began to close because of uneconomical operation. Similarly, the construction of any substantial part of the 22 million tons of capacity still in the planning stage could generate a surplus in supplies.

It normally requires 2 or 3 years to bring an ammonia plant out of the planning stage and into production. Thus, 1974 projections of the supply-demand relationship beyond 1977 offer little guidance to the future and cannot be considered as a true indication of the market picture. Under today's market pressures, it is likely that plans not now firm will become firm and that additional capacity will be announced and brought on-stream by 1977; conversely, some currently planned plants may not come on-stream for one reason or another.

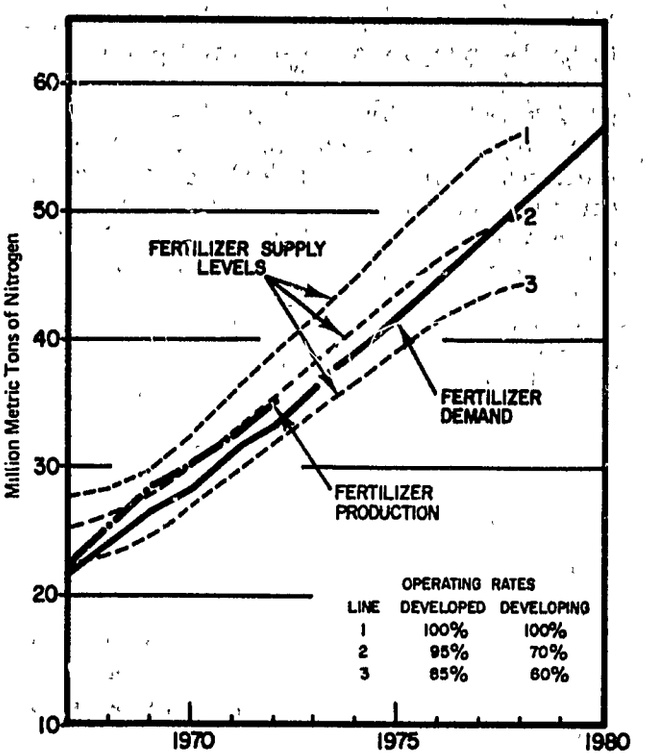


Figure 1. World nitrogen market

Figure 1 also dramatically illustrates the market situation that would exist if ammonia plants in all areas of the world were operated at maximum capacity. The supply range (lines 2 and 3) indicates the best estimate of what actual world production will be. However, it assumes that the developed world will achieve 95% of capacity and the developing world only 70% of their potential. **It is apparent that every effort should be made to bring about higher operating rates in the plants that are already in existence throughout the world.** If this is not possible, then these units should be rated at the true capacity level and plans made accordingly. In addition, it appears economically unsound to build new plants and expect them to operate at 60% or 70% of capacity. Under these circumstances, the plant is an uneconomic unit and efforts to cover costs can result in protectionistic policy and higher fertilizer costs to the farmer. This potential exists regardless of whether ownership is private or public. Only through a coordinated effort of the producers and the operators of support facilities can maximum operation levels be obtained. This also includes the transportation, distribution, and marketing system, which is responsible for accurate estimates of market potential and providing the equipment and marketing facilities to deliver the fertilizer to the farmer.

As shown in figure 1, if plants had operated at full capacity, an additional 5 million tons of nitrogen—16% above actual use—would have been available to farmers in

1973. As it was, supplies were tight and in some areas farmers did not get the amount of fertilizer desired.

Operation of this excess capacity will not mean that prices can be forced down to the levels of several years ago. Production costs have been rising steadily and only recently have producers returned to profitable operations. Production costs probably will continue to increase. Further economies of scale comparable to those realized with the development of the 1,000 ton/day ammonia plant in the 1960's are not expected under today's technology.

Ammonia feedstocks will be a worldwide problem. While ammonia accounts for only about 2% of the use of natural gas in the U.S., the competition of alternative uses which offer greater returns has resulted in short supplies for fertilizer production and greatly escalated price levels. Ammonia producers can expect to pay higher rates for natural gas or other feedstocks used to supply hydrogen.

The feedstock situation will play a large role in changing world trade patterns for fertilizer materials. Areas with plentiful reserves of natural gas will be leading world producers and traders of nitrogen. If countries without natural resources are to receive their fertilizer requirements, they must look to both the old and the new or emerging trading nations for supplies.

Developed World Nitrogen Supply

Capacity additions recently have been slower in North America, Western Europe, and Japan than in the communist world and in the developing regions. The ability of traditional producing areas to provide material for trade is steadily decreasing. In recent months, the inability to provide extra material to the world market has brought about the short supply situation in many of the developing countries. As shown in figure 2, little increase in capacity has been scheduled between now and 1977; thus, the situation could worsen as nitrogen demand increases.

Figure 3 indicates the net trade pattern evolving in developed areas under present announced plans. Note that the curves move steadily downward over the next 5 years from the 1972 high.

Developing World Nitrogen Supply

In 1972 the developing regions produced more than 3.1 million tons of nitrogen; however, they also imported almost as much—more than 2.8 million tons. Nitrogen capacity stood at 7.3 million tons of nitrogen, indicating that the high ratio of imports to actual production may not have been necessary. If the plants had been operated at maximum capacity, it is estimated that more than 4.7 million tons of nitrogen would have been produced, leaving an import requirement of about 1 million tons.

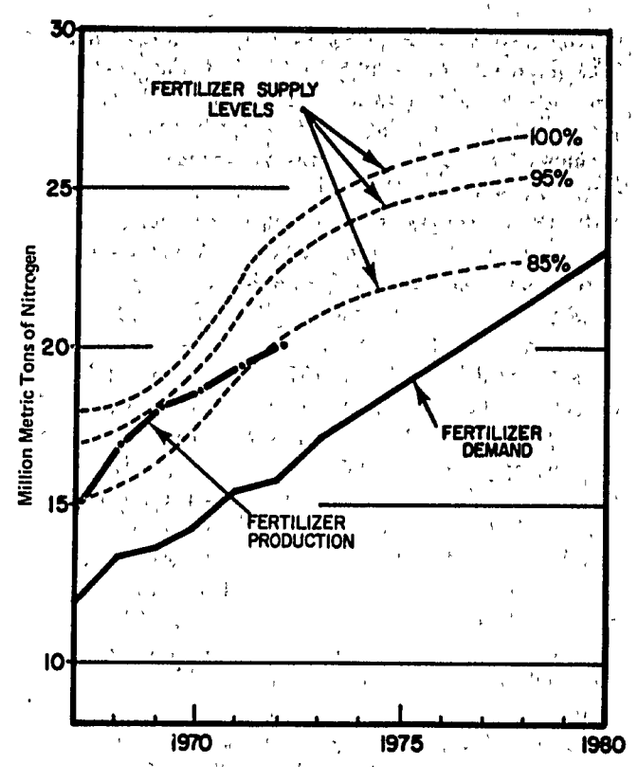


Figure 2. Developed regions nitrogen market

As shown in figure 4, the developing regions are scheduling additions to capacity that will more than double present levels by 1977. The opportunity exists for them to make significant inroads into the large trade deficit they now have. In fact, by 1975 the developing regions could become net exporters of nitrogen if all of the existing plants and those that are planned for completion in the next 5 years were to operate at anywhere near their full capability. Should they continue their relatively poor performance, however, the developing regions will remain net importers, requiring 1 to 2 million tons of nitrogen above their own output. In view of the lack of firm plans in the developed free world that would assure this amount of material, developing nations should make every effort to increase their operating efficiency and to adequately plan new facilities so that their level of operation will be as high as possible.

Developing Asia Nitrogen Supply

Over 60% of the 16 million tons of nitrogen capacity planned in the developing regions by 1977 will be in developing Asia. To the current nitrogen capacity of just under 5 million tons of nitrogen, would be added a similar amount—current plans call for this region to add more than

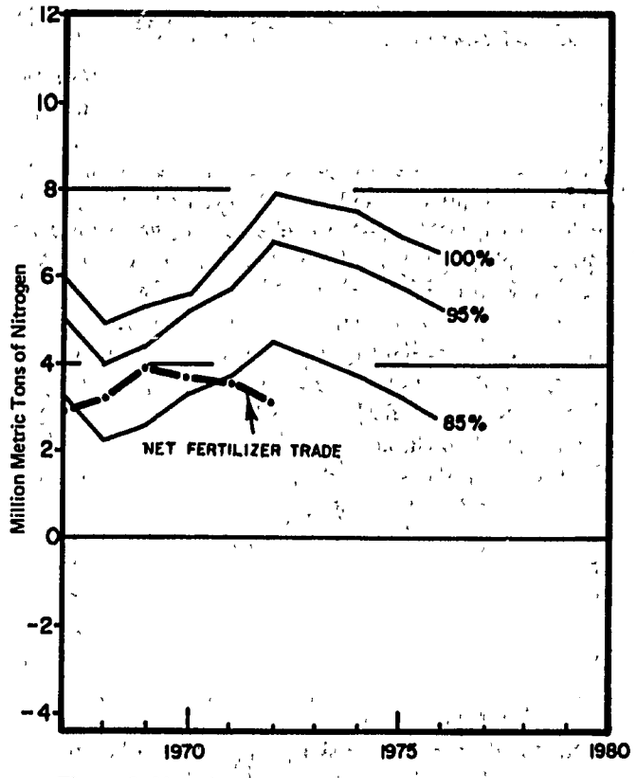


Figure 3. Net nitrogen trade balance in developed regions under varying supply levels

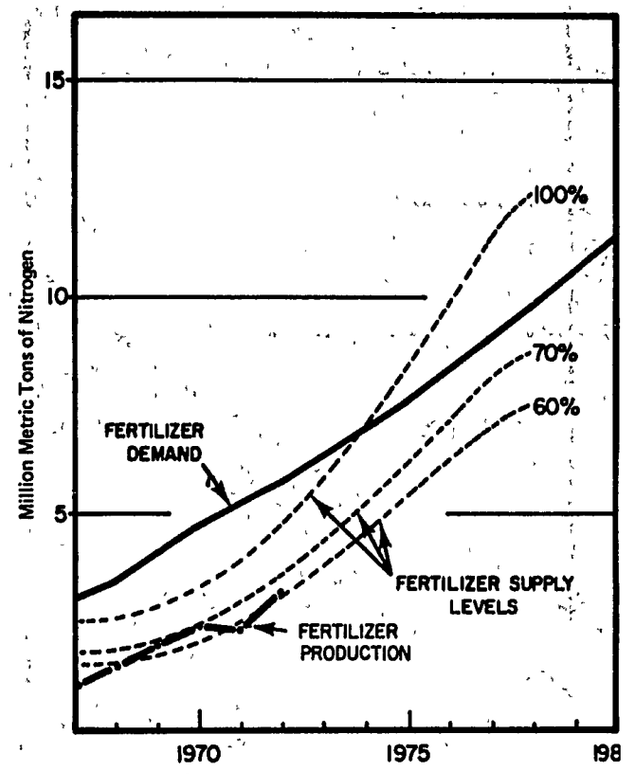


Figure 4. Nitrogen market in the developing regions

4.9 million tons—in the next 5 years. From figure 5, it is apparent that this could more than meet the expected demand, but only if a high level of performance gain is obtained in new and existing plants. Failure to improve on the poor operating rates of recent years—between 60% and 70% of capacity—will mean continued large imports.

The maximum effect of this large capacity addition will not be felt until 1977. Even then, operation at 70% of capacity would mean that about 400,000 to 500,000 tons of nitrogen would need to be imported. It appears that the short-term emphasis should be placed on getting as much production as possible out of the new and existing facilities.

Based on the known location of natural gas reserves, this area will have some countries with surplus supplies and others with deficits. This would provide opportunities for trade within the region, which might be better than depending on nations outside the region. With the region growing in importance and the critical nature of its agriculture, a more detailed study of the subregions and countries should be undertaken to determine future supply levels and possible trade patterns.

Developed Regions Nitrogen Supply

Two areas within the developed regions should receive some detailed discussion. Eastern Europe and Russia are adding nitrogen capacity far in excess of apparent needs. North America faces a critical shortage of nitrogen fertilizers and has not yet announced adequate capacity to catch up with a steady increase in growth. But many feel that the needed additional capacity will be forthcoming.

Figure 6 indicates the situation that will exist in Eastern Europe and Russia in the next few years. Even with the minimum supply level assumed, the ammonia capacity expansion being planned will be about adequate to meet future demand growth. In the past decade, the use of nitrogen has been increasing faster in this area than any other in the world when looked at in terms of consistently large increases year after year. There is reason to suspect a slowing in growth during the next few years as application rates approach the optimum level and farmers get less response to additional fertilizer. If this happens, the region would have excess capacity and its countries would enter the world market to a much greater extent than in the past. The region could emerge as the world's leading supplier of

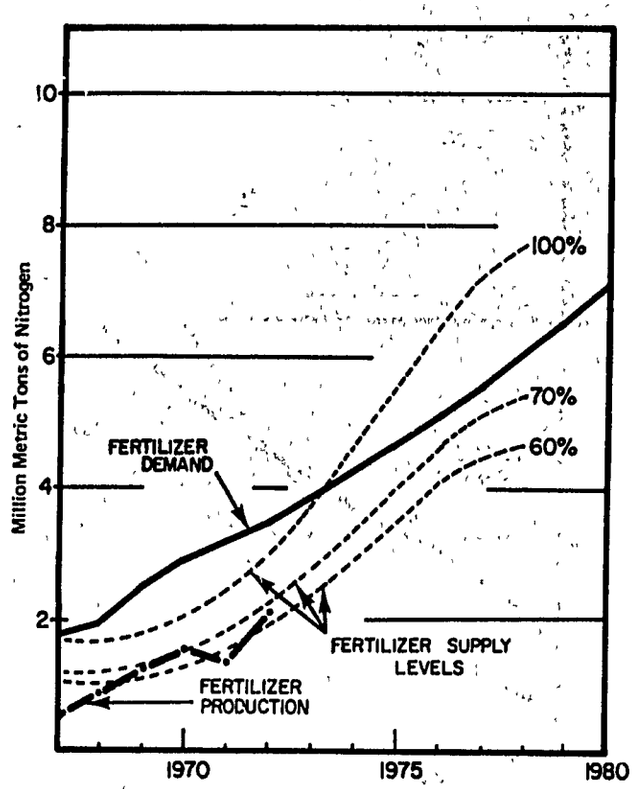


Figure 5. Nitrogen market in developing Asia

nitrogen fertilizers, for both the developed and the developing world.

The North American picture is opposite that of the Eastern European countries. In the next 2 years, only two new ammonia plants are scheduled for completion, and they will not have adequate capacity to sustain the anticipated growth in demand. If nitrogen demand continues to increase, North America will become a large net importer of nitrogen. It is doubtful, however, that this will actually happen any time soon. With the lifting of controls by the Cost of Living Council, prices of nitrogen fertilizers have increased, bringing back an attractive return on investment for prospective investors. Although natural gas supplies remain critical, the vital nature of nitrogen fertilizers and their importance to agriculture should be given a high priority on gas and ensure adequate nitrogen production in North America.

Figure 7 shows the situation as it would exist if no new production capacity is forthcoming. **It is not possible to estimate future expansion levels, but it should be safe to assume that it will be adequate to meet domestic demand growth for nitrogen.** The problem could again become that of timing new additions to avoid serious oversupply, such as existed in the late 1960's.

In the previous discussion, only the major areas of importance have been singled out. In any evaluation of the

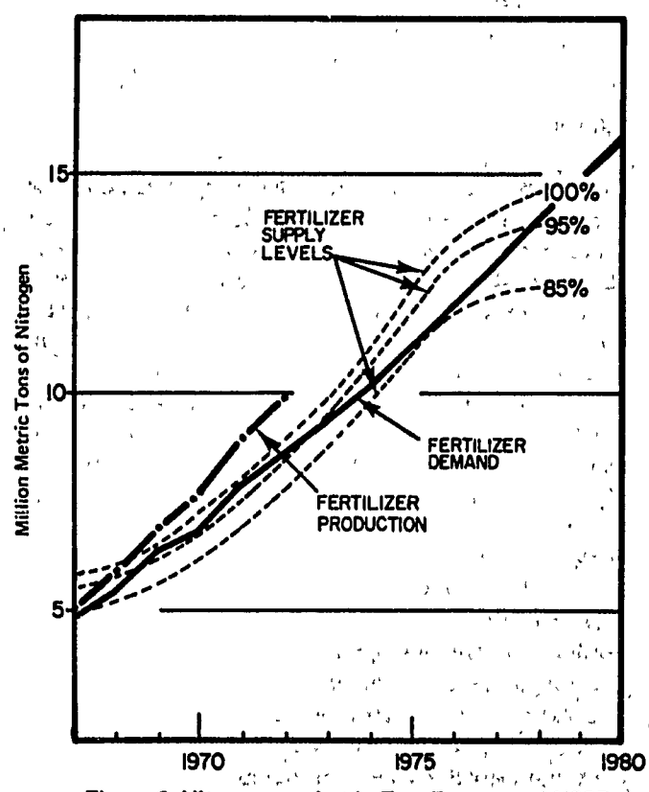


Figure 6. Nitrogen market in East Europe and USSR

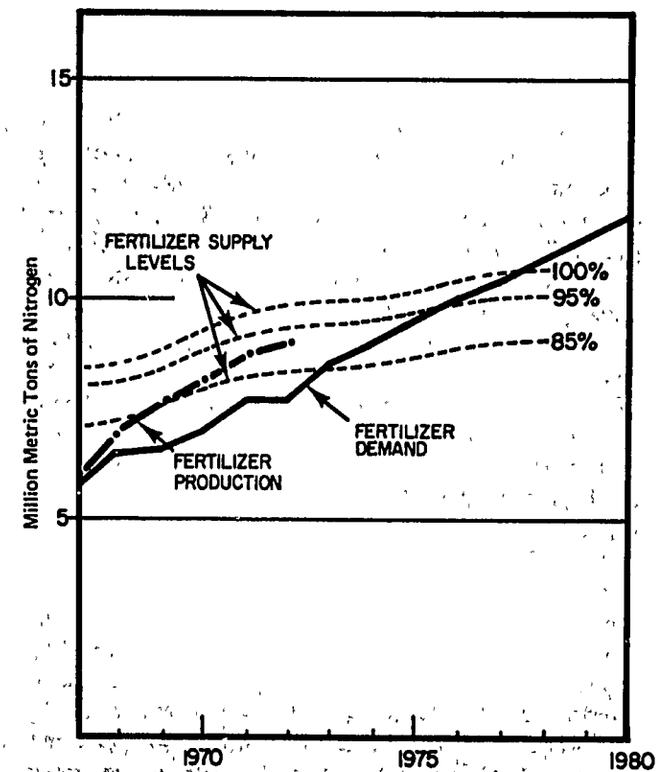


Figure 7. Nitrogen market in North America

world fertilizer market, each region should be looked at for possible changes that may be taking place. For this purpose, tables A-5, A-6, and A-7 have been included to show potential production levels. The assumed rate of 100% of capacity (table A-5) is labeled maximum; high (table A-6) refers to a rate of 95% in the developed world and 70% in the developing regions; low (table A-7) uses 85% and 60%, respectively.

Potential supply surpluses or deficits under the three assumed levels of production are shown in tables A-8, A-9, and A-10. These supply levels have been calculated for the years 1967 to 1978 so that comparisons can be made with the actual production or trade levels that have been achieved in the last 6 years. Actual tonnage figures are presented in table A-11A for the 1967 to 1972 period. Preliminary data for 1973 were not available when this report was being completed.

Urea Fertilizer

Many different fertilizer materials contain nitrogen; however, one stands out as the future market leader. Urea, with 46% nitrogen, is rapidly becoming the world's leading nitrogen fertilizer. World capacity is estimated to stand at 18.6 million tons of nitrogen. It is scheduled to increase to almost 23 million tons by 1975 and to more than 28 million by 1977 (table A-12). If this growth happens, urea would account for 36% of the total world's nitrogen capacity in terms of ammonia.

This steady increase in growth means that urea will replace some of the older, traditional nitrogen products such as ammonium sulfate and ammonium nitrate. Considering its high analysis, urea should account for an even higher percentage of nitrogen that enters world trade.

Educational programs must be continued to assure acceptance of a new fertilizer material. The benefits of its high analysis must be shown to the farmer along with proper management practices so that he will receive the highest return from his use of urea fertilizers.

Urea is relatively more important in Asia than in other regions. By 1977 almost all nitrogen fertilizer produced and distributed in this area will be in the form of urea. Compared to the traditional marketing and uses of nitrogen materials, the marketing system for urea will require more effort in showing the region's farmers how urea should be applied and showing producers its use in mixtures and, as markets mature, in nitrogen solutions and liquid mixed fertilizers.

PHOSPHATE SUPPLY LEVELS

The world phosphate situation has changed markedly in the past 2 years. By 1972, capacity additions had stopped and demand, while not increasing as fast as nitrogen, continued to grow faster than the potential supply level. Materials became short on the world market, bringing higher prices and, in recent months, enticing new investment into the industry. In the following, major regions are again singled out to show emerging trade patterns and potential market deficits or surpluses.

Phosphate Rock

Before any discussion of the phosphate market is possible, a brief look at the raw materials that go into phosphate manufacture is needed. The first of these is phosphate rock.

In 1972 world production of phosphate rock was 85 million tons of materials. Production has continued to climb, and is estimated at close to 100 million tons of rock. Production is centered in three regions—North America, Russia, and Africa. Reserves are found in many other regions, but these three regions account for 87% of the world's output.

Phosphate rock mining capacity a few years ago was far in excess of demand. This led to oversupply and a halt in capacity additions in recent years. Demand caught up with supply and inventories now have been depleted. New mines that were expected to begin operations in the last 2 years were not completed on schedule because of market conditions. Also contributing to the tightness was the interruption of shipments from Tunisia, Israel, and Jordan as a result of Mideast hostilities.

In recent months, phosphate rock prices have more than doubled. This has resulted in higher levels of operation for new mines and the announcement of capacity additions in North America. Without this new capacity, the planned phosphate fertilizer plants will not be able to produce at capacity.

In the long term, phosphate rock capacity is not expected to limit the supply of phosphate fertilizers. In the short term, however, it appears that rock supplies will be tight until the new equipment on order can be put into production and the true effect of environmental and pollution controls can be determined. As in the other segments of the industry, it takes some time for the industry to respond to the new set of market conditions that are developing.

Sulfur

Sulfur is also of primary importance to the phosphate industry. Sulfur is one of the most plentiful minerals. But the poor market conditions of recent years discouraged orderly expansion of production and supplies now are tight. As with other commodities, supply and demand are cyclical and today's higher prices should stimulate the needed

production. However, short-term shortages could develop 2 or 3 years from now when several planned large phosphate plants come on-stream in a relatively short period.

There are five major sulfur/sulfuric acid sources: (1) Frasch mining using hot water to tap sulfur domes, (2) sulfur recovery from "sour" natural gas, (3) sulfur recovery from high sulfur oil, (4) sulfuric acid production from pyrite smelter operations, and (5) mining of sulfur deposits. Looming on the horizon is sulfur recovery from coal burned in power plants or by other industries.

While the Frasch domes may be curtailing operation because of depleted reserves or a lack of fuel to heat the water, sulfur is plentiful from other sources. Fertilizer producers should not anticipate any large supply of sulfur from stack gases in the near future. The technology of recovery may be as much as 10 years away, especially if demands for complete recovery are enforced. Both the high cost of recovery equipment and the possibility of interruptions in power production due to failure of sulfur recovery equipment will cause the utility industry to weigh heavily the feasibility of turning to either low-sulfur coals or nuclear power. Some economic return must be forthcoming from recovered sulfur before this can be considered a likely supply alternative.

Phosphate Fertilizers

The phosphate market differs from the nitrogen market in that there are two basic sources of supply:

1. Products not based on phosphoric acid. Normal superphosphate, made by treating phosphate rock with sulfuric acid, is the major product. Others include basic slag (a byproduct of steel production) available for fertilizer use in some areas, and the portion of concentrated superphosphate that comes direct from phosphate rock.

2. Products based all or in part on phosphoric acid including concentrated (triple) superphosphate, nitric phosphates, ammonium phosphates, and other complex fertilizer materials.

The former group of products is declining in importance, but the current tightness and high prices of phosphates should temporarily slow the rate of decline. However, once the scheduled large expansion in phosphoric acid and nitric phosphates comes into production, the decline should accelerate.

In 1972 the nonphosphoric-acid-based portion of the phosphate market accounted for over 10 million tons of P_2O_5, or about half of the market. The expected share in 1977 drops to around 30% of the total as measured by demand levels.

Projected production levels for the major nonacid sources of P_2O_5 are shown in tables A-13, A-14, and A-15. Normal superphosphate will continue to be replaced by products that supply more plant food per pound of material. However, its life will be extended somewhat by its role in the production of low-analysis mixed fertilizers that are very popular in some areas. Also, normal superphosphate contains sulfur, which is needed in some soils. Future production will be concentrated in relatively few areas.

Little or no change is expected in the total world production of concentrated superphosphate in the next few years. The ammonium phosphates and other high-analysis complex fertilizers are fast becoming the most popular way of providing phosphate to the farmer.

Basic slag production is centered in Western Europe. Over the next few years little change in the production level is indicated. Since this product is directly related to the region's steel industry, it appears that a shift to new steel making processes or use of different ores would be necessary to bring about any change in the current production pattern.

The future of the world phosphate industry will depend on developments in phosphoric acid and, to a lesser extent, in nitric phosphates. World nitric phosphate capacity is expected to climb from the 1972 level of about 2.3 million tons to almost 3.9 million tons of P_2O_5 by 1980. Production will center in Eastern and Western Europe, which together will have 3.4 million tons of capacity by 1977. Nitric phosphates will be of minor importance in other regions of the world.

Nitric phosphates use phosphoric acid in the manufacture of complex fertilizers. The water solublity requirement and economics of the raw materials used determine the percentage of phosphoric acid used. For this study, it was assumed that half of the P_2O_5 contribution in nitric phosphates is from phosphoric acid except in the major producing areas of Europe where only a 20% contribution was assumed. This percentage likely will increase as phosphoric acid becomes more plentiful. Capacity data used in the determination of future supply levels are shown in table A-16.

The United States has been the leader in the use of phosphoric-acid-based phosphate products; about 80% of its phosphate fertilizers comes from phosphoric acid. As indicated by the future capacity levels shown in table A-17, phosphoric acid will become increasingly important in most world phosphate markets. Capacity in 1967 was only about 11 million tons, with almost half of this in North America. By 1972 the world total had grown to 17 million tons, with almost all of the increase outside of North America. If present plans are realized, world capacity should exceed 27 million tons in 1980, with only one-third of this in North America. This level of capacity is fast approaching the forecasted demand for phosphates.

While some regions are expanding faster than others, Oceania is the only region that has not scheduled an increase in capacity of phosphoric acid. Thus, the use of phosphoric acid in fertilizer production will be spread over

all regions of the world as high-analysis complex fertilizers replace the older, low-analysis grades. Since urea is compatible with these types of complex fertilizers, it appears that urea and the ammonium phosphates will be the primary carriers of both nitrogen and phosphate materials to the farm. As with urea, farmers will need to be advised of the relative merits of these new materials and new management techniques developed. Any additional investment in the production of fertilizers must include educational programs if the full benefits of fertilizer are to be realized. Increased food production in the developing areas will be achieved only through proper use of fertilizer in relation to other farm inputs along with the adoption of good farm management practices.

World Phosphate Supply

Since 1967 the world phosphate industry has been working its way out of an oversupply situation. In 1972 actual production was reported at 22.5 million tons—700,000 tons below the estimated minimum supply level indicated in table A-20. As shown in figure 8, the industry has been plagued with low operating rates; this led to the closing of many plants that were obsolete or uneconomical to operate at the low prices prevailing during 1967-70. By 1971 demand had reduced inventories to less than normal levels; in fact, producers were not in a position to meet any market growth over and above the modest rate of increase that had been projected. This led to shortages in 1972, 1973, and 1974. It also started another round of planned expansions in the industry and current prospects are that future phosphate capacity levels should be more than adequate to meet the demand. Note that the supply lines in figure 8 begin to move upward at a faster rate than the forecasted demand after the 1974 season.

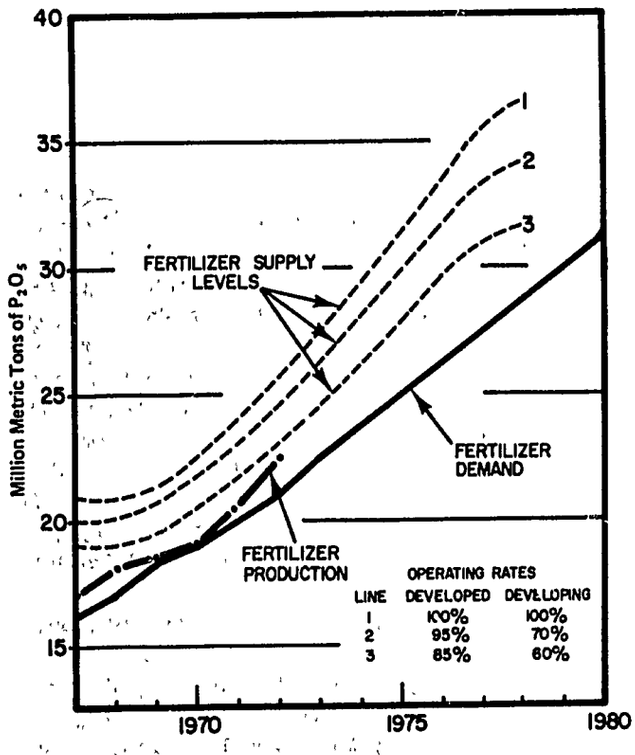


Figure 8. World phosphate market

Using the low estimates of supply as a guide, in 1972 the world's supply capability for phosphate stood at over 23 million tons of P_2O_5. This is expected to increase 33% in the next 5 years—to over 31 million tons. Demand is expected to increase 29% in the same period. The possibilities of higher operating rates and keeping on-stream any plants scheduled to be phased out provide a large supply cushion. However, an excess of phosphoric-acid-based products could speed the closing of older plants and help maintain a balanced market.

North America is the world's leading producer of phosphate fertilizers, followed closely by Western Europe and Eastern Europe and Russia. In terms of trade, North America supplies over 1 million tons of P_2O_5 to the world market. Western Europe and Africa are the only other regions with net export balances. Trade patterns likely will change in the next few years, however. Western Europe could become a net importer, whereas Eastern Europe and Russia will emerge as exporters, although not at a comparable level with North America. Africa will supply more phosphate fertilizers for world trade. Other regions will either maintain supply-demand balances within their regions or require higher levels of imports.

Developing World Phosphate Supply

Developing nations produced only about 9% of the 23-million-ton supply of P_2O_5 in 1972. Their share is expected to increase to about 12% by 1977, but increases in demand likely will preclude any improvement in overall supply position. At the minimum production rate shown in figure 9, capability will increase from 2.1 million tons to over 3.6 million tons. Higher operating rates will be required if developing regions are to progress toward self-sufficiency in phosphates.

Economics dictate that phosphate fertilizer production be centered at the phosphate rock mine site as long as analysis of the final product exceeds analysis of the raw material. Since Africa is the only developing region with large reserves of phosphate rock that can be mined economically, both Latin America and Asia have had little economic justification to establish large-scale phosphate production units. The exception has been Mexico, which has large sulfur reserves. However, its industry will not satisfy the Latin American market; like Africa, Mexico's production is aimed at the developed nations market.

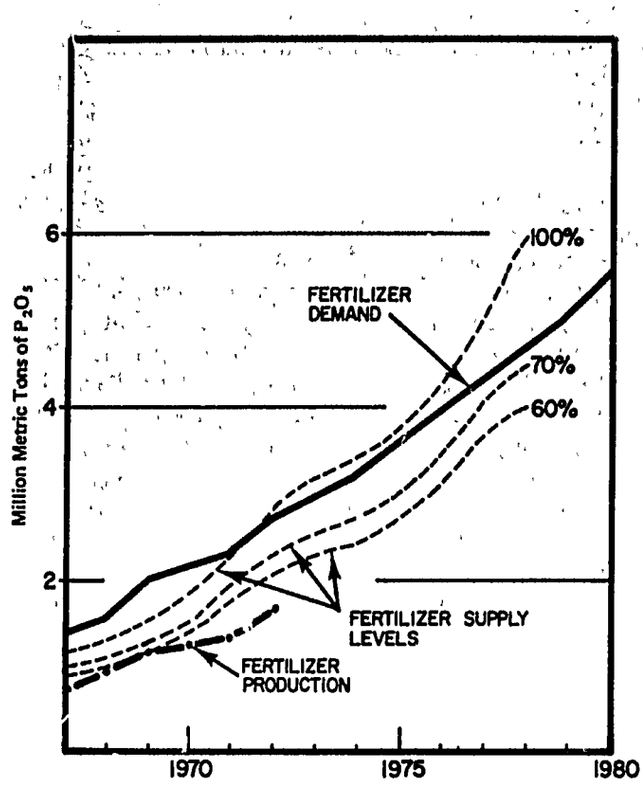


Figure 9. Developing regions phosphate market

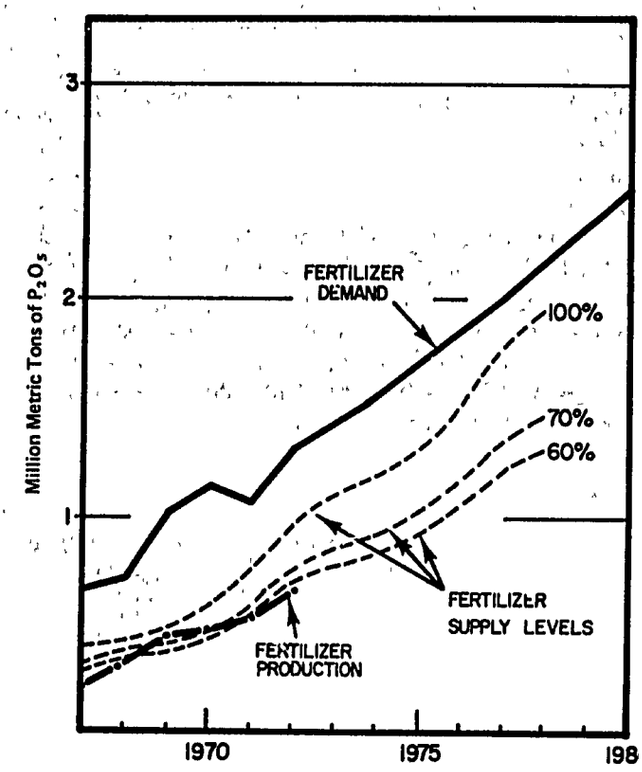


Figure 10. Developing Asia phosphate market

It also should be noted that some nations likely will decide to produce phosphates in spite of unfavorable economics; assurance of supplies may override poor economics.

Developing Asia Phosphate Supply

Demand is expected to increase faster than production capacity currently being planned in this area. As shown in figure 10, these countries will continue to face a trade deficit even if the existing and new plants were operated at the highest possible rate. Since deposits of phosphate rock in sufficient quantities or quality to sustain high production levels are not widely found in this region, the economic justification of large plant construction does not seem favorable. The Asian nations should carefully evaluate their individual market positions and determine if world trade should be their primary source of phosphate fertilizers. Their relative level of development and the types of fertilizers used, along with total demand requirements, should be considered in the decision to either produce phosphate fertilizers from imported raw materials, produce finished products from imported intermediate materials such as phosphoric acid, import finished materials which can be blended or manufactured into the desired grades, or to import the finished complex fertilizers ready for farm distribution. The final outcome likely will be a combination of these alternatives.

North American Phosphate Supply

The expected phosphate market in North America is shown in figure 11. After a long period of excessive inventories, relatively poor growth in demand, and depressed prices from the oversupply situation, American producers are unable to meet both domestic and export demand. However, a large number of new plants and expansions were announced during the past 6 months for completion between 1974 and 1976. These will increase North America's capability for export from the 1.1-million-ton level in 1972 to almost 2 million tons by 1977. Should demand warrant, export capability could be increased to as much as 2.5 to 3.0 million tons of P_2O_5 by raising production above the 85% level that has been assumed.

Phosphate mining also is scheduled to increase to meet the needs of new and expanded plants. In the short term, integrated phosphate producers probably will reduce rock exports to meet domestic requirements for production.

The three supply estimates and supply surpluses and deficits are found in tables A-18 through A-23. Actual

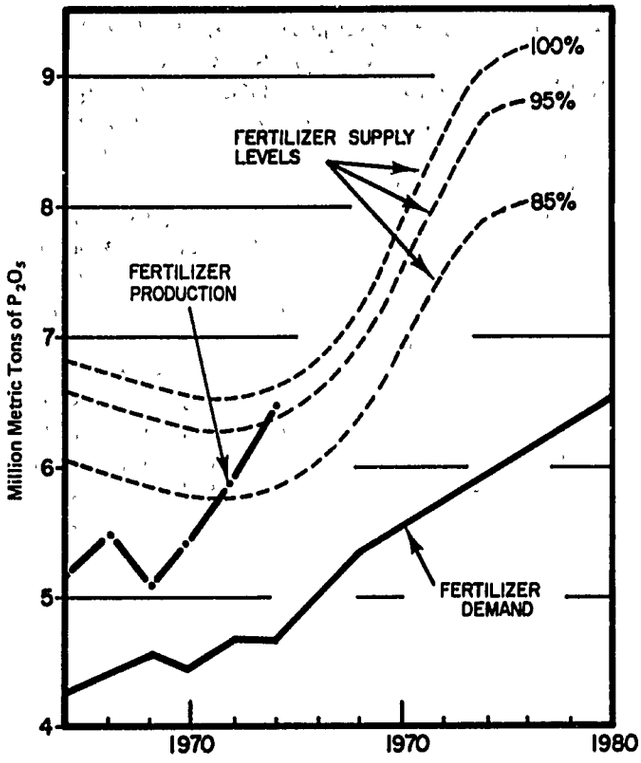


Figure 11. North American phosphate market

production and trade data for the 1967-72 period for comparison with the calculated estimates is found in table A-24. Net trade data for the past 6 years has been included to show the true level of trade achieved by each of the major regions. Total world net trade does not necessarily balance out since shipments may be in progress, losses occur in transit, or statistical reporting procedures differ between exporting and importing nations.

POTASH SUPPLY LEVELS

Since the development of the potash mines in Canada began in the mid-1960's, production capability has been more than adequate to meet world demand. If mines had operated at maximum rated capacity, supplies would have exceeded demand by 4 to 5 million tons of K_2O. As a result of this excess capacity, the Canadian producers were placed on a quota system in 1970. Production initially was held to about 50% of the total capacity. This led to a steady improvement in the potash market and prices have risen as a result of the establishment of a floor price that has held firm throughout the world market.

The Canadian quota has been raised several times in recent months, as demand increased in North America and greater exports were achieved. Present production is at about 70% of rated capacity, with constant review of the market needed to avoid the possibility of not having adequate supplies for the coming spring season.

However, the supply of potash is short in many North American areas, not as a result of inadequate production but because of the lack of transportation to get material from the mines to the markets. This is a short-term situation that will be resolved as rail cars are released from moving grains to ports for export. Producers also face a short-term problem of exceeding a 70% rate because of equipment and other limitations that developed during the period of surpluses.

World potash capacity level is shown in table A-25. Total capacity stands at more than 24.5 million tons of K_2O and should increase to nearly 28 million by 1977. The only region planning any major expansion in potash capacity is Eastern European, including Russia. With completion of this expansion, this region will become the world's leading producer of potash, with North America ranked second and Western Europe third.

The world potash market is moving slowly but steadily toward a balanced situation; however, this likely will not occur before 1977. Figure 12 indicates the converging supply and demand trend lines that will characterize the potash market in the next 5 years. World trade patterns should change very little during this period. No conclusion

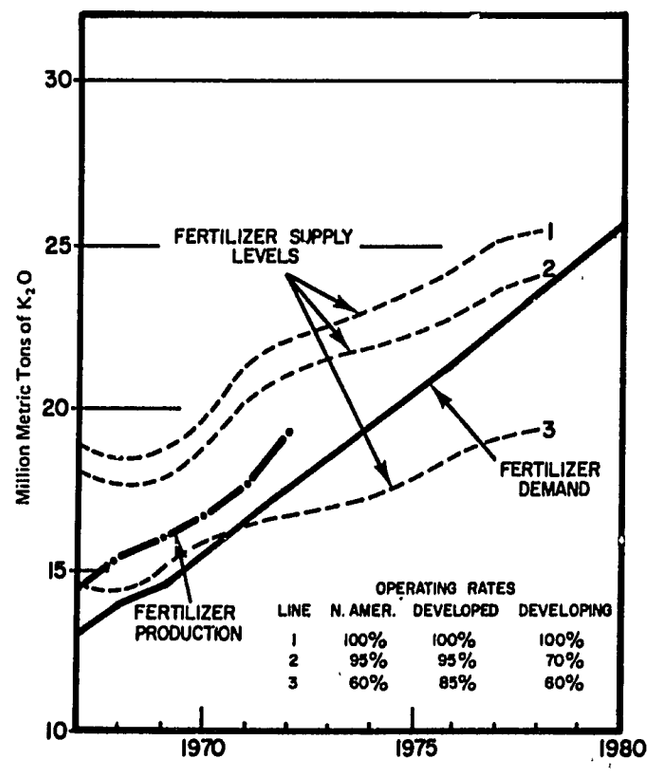


Figure 12. World potash market

can be drawn at this time on the return of Canadian potash producers to a completely free market.

Of the developing regions, only Africa produces potash. The developing regions should continue to depend on world trade sources for their potash. By 1977 they should be importing over 2 million tons of K_2O per year, with Asia accounting for about a third of this. The potential supply using the 95% operating rate in developed regions and the calculated supply balance have been shown in tables A-26 and A-27. While not depicting the supply under the Canadian quota system, these two tables can be used to indicate the long-run potash market. Actual production and trade have been included as table A-28 in order to compare actual and calculated values.

It is hard to draw general conclusions about the world fertilizer market because of the diverse nature of the regions and the distribution pattern of raw materials. At the same time, it is apparent that producers are responding to the demand for more fertilizer to spur food production. With current shortages and higher prices, it is easy to visualize large profits in the fertilizer industry. But such periods have been rather short lived in the past and the current market likely will be no exception. Rapid expansion of capacity is being planned in all areas; upon completion, new facilities will bring supply back into balance with demand and possibly result in oversupplies again. Anyone entering the industry should recognize these cycles and plan accordingly. Overreaction to short supply situations in the past has led to chaotic markets, and there is no reason to expect that it will not happen again. While difficult to achieve, because the industry is worldwide in scope, increased market awareness through rapid statistical reporting with a high degree of accuracy benefits both the buyer and seller of fertilizer; and it can help to lessen the wild market swings that have characterized this industry in the past.

FERTILIZER PRICES

World fertilizer prices bottomed out in 1969 and 1970 at abnormally low levels. Many nitrogen and phosphate products actually sold for less than the cost of their production. Prices began to recover in the early 1970's. In recent months, this recovery has been accelerated, reflecting a new set of conditions in the marketplace.

This current upswing raises several important questions. Is the world fertilizer market embarking on a new level of prices or is the current rise merely reflecting a short-term tightness in supplies? And, if we assume that market adjustments are likely, what are the new equalization prices likely to be in the short run?

It is extremely difficult to establish reliable long-term trends in fertilizer prices, especially in the developing countries. Fertilizer is relatively new to many parts of the world with many countries dependent on imported supplies. Production and consumption and trade patterns are expected to undergo considerable change in the next 10 years in many developing nations. As these countries build more indigenous capacity, fertilizer supplies will be closer to market areas (both domestic and export) and prices should stabilize.

A large part of the productive capacity has been in North America; therefore, the United States has been a major source for fertilizers exported to developing countries and has had a considerable impact on world fertilizer prices. The net import-export position for nitrogen and phosphate for the United States is shown in figure 13. AID's large-scale entry into financing fertilizer began about 1964-65 and peaked in 1966-70. Although AID is financing

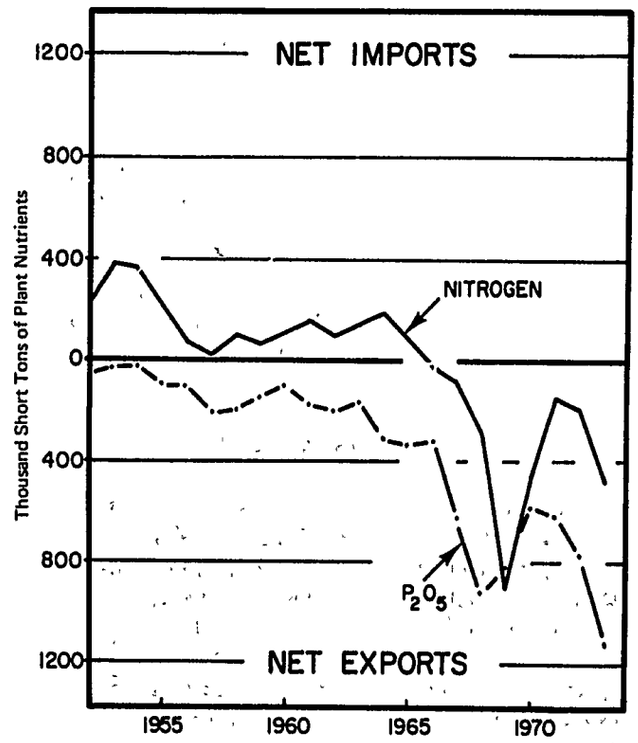


Figure 13. U.S. fertilizer net trade

considerably less fertilizer today than in 1969, U.S. exports of nitrogen and P_2O_5 are at all-time highs. On the other

hand, imports have also increased substantially, especially for nitrogen. The United States is once again approaching a net import position in nitrogen.

Figures 14 and 15 illustrate what has happened to prices of nitrogen and phosphate fertilizers since 1966. Although the AID price levels are not true world prices, they are indicative of open tender price developments. International nitrogen and P_2O_5 products prices are now at all-time highs. Many observers think that fertilizer prices are approaching their peaks. Some feel that P_2O_5 may level off during 1974-75 and that a downward trend will occur by 1976 or 1977 as added capacity comes on-stream. Nitrogen prices apparently have not peaked. New capacity is slow in coming on-stream and it may be 3 to 4 years before appreciable price decreases occur.

The timing of any price adjustments both in nitrogen and phosphate depends upon several important factors—additional production capacity, demand growth rates, and improvement in the world food situation.

Data in this report indicate the effect of the escalation in cost of building and operating new nitrogen and phosphate capacity. Taking into consideration the higher cost for investment, raw materials, energy, transportation, labor, etc., the cost of producing ammonia and urea will increase 30% to 40% from 1973 to 1977 while the production costs for phosphate products will increase about 20% to 25%. Increases in ocean freight costs also have contributed to the high delivered cost of fertilizer in the international market.

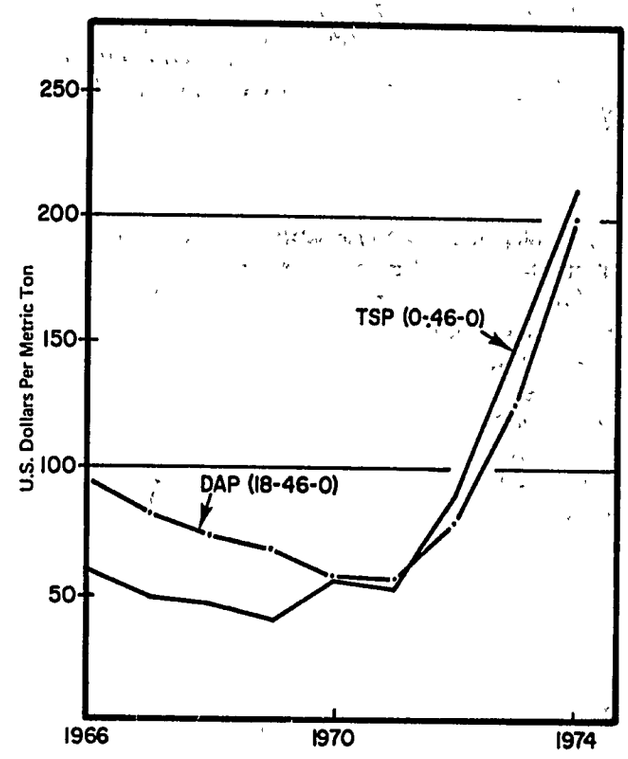


Figure 15. Phosphate product prices (AID financed-average for bulk materials for U.S. Gulf ports)

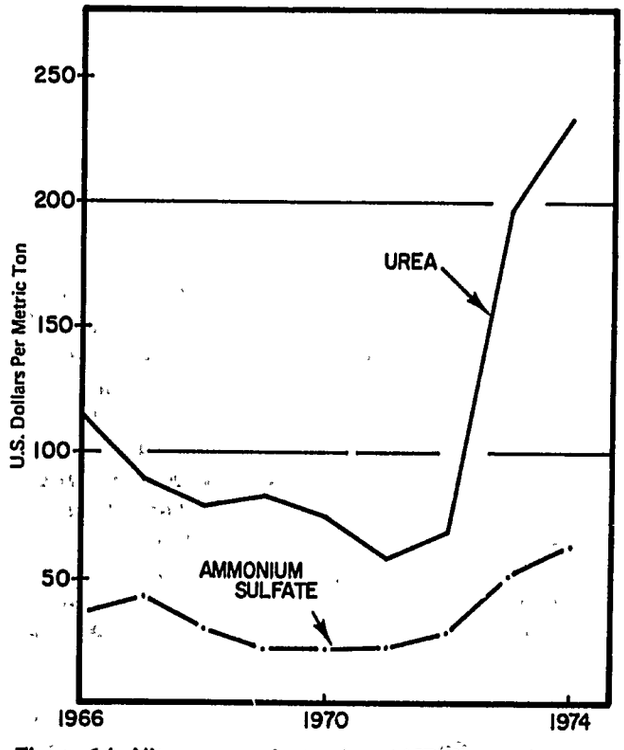
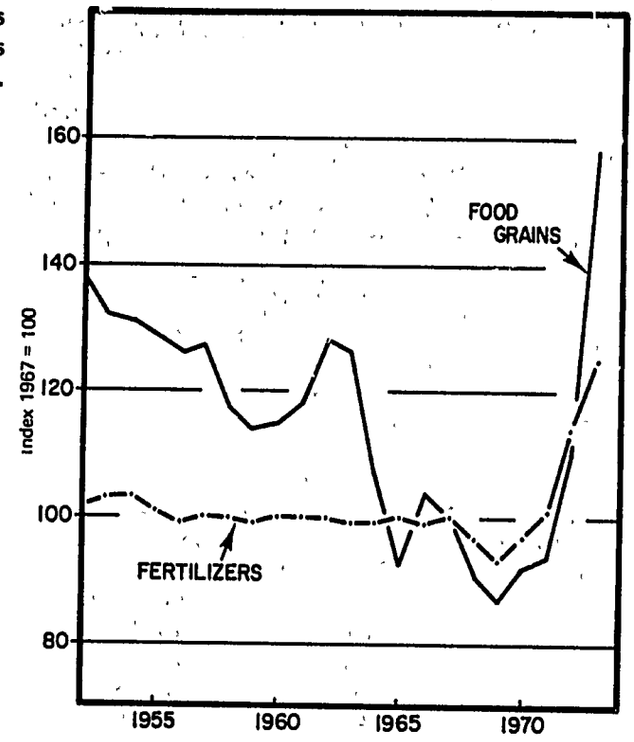


Figure 14. Nitrogen product prices (AID financed-average for bulk materials for U.S. Gulf ports)

Future developments in the world food situation, especially in production of food and feed grains, are expected to have a considerable impact on world fertilizer prices during the rest of the decade. Studies in the United States have quantitatively estimated that higher prices for crops will increase demand for fertilizer. It is difficult to say to what extent the same is true for developing countries. However, it is generally concluded that under competitive conditions fertilizer price elasticities in developing countries are similar to those in the United States and other free-economy nations.

The indexes of prices paid by farmers for fertilizer in the United States and prices received by farmers for food grains, 1950-73, are shown in figure 16. The exact extent of correlation between the two indexes cannot be determined; but both indexes have risen sharply in the past 12 months, reflecting the current supply situation in both food grains and fertilizer. While a change in the food grain index will not necessarily bring a corresponding change in the fertilizer price index, the two should move in the same general direction. This would be especially true if feed grains were included.

Figure 16. Prices received by farmers for food grains and prices paid for fertilizers in the U.S.



Assuming that world production of food and feed grains will increase substantially in the rest of this decade and that fertilizer production capacity will continue to expand in areas of the world with comparative advantages, fertilizer prices will probably decline from their present high levels but equalize at levels substantially higher than prices in the 1969-71 period.

It is important to note that world fertilizer market prices are not necessarily a true indicator of prices paid by farmers in many developing countries. Some countries protect their indigenous fertilizer industry by administering high tariffs on imported materials. Some countries control fertilizer prices and other nations subsidize prices. Such actions inflate the true fertilizer cost and, in many cases, discourage production efficiency in indigenous plants. Consequently, some developing nations will be unable to take advantage of competitive buying on the open market.

ECONOMICS OF PRODUCING NITROGEN AND PHOSPHATE FERTILIZERS

It is inevitable that the current high level of demand will create interest in construction of new plant capacity and will motivate potential investors to investigate the economics of production. The developing world will be faced with determining the technical and economical feasibility of utilizing some indigenous raw materials to serve its needs. Alternate sources of feedstocks will need to be examined along with the relative complexity involved in using other raw materials. This section should be helpful in estimating costs in a general way, comparing alternate methods of nitrogen and phosphate production. It also examines how products from new capacity in developing countries will compete in the marketplace. It should be emphasized that a specific project must be examined in more detail prior to any investment decision.

PLANT INVESTMENT AND PRODUCTION COSTS

Plant investment in this study includes the U.S. battery limits (1974) with cost factors for plant completion in 1977. A factor of 1.25 is used to cost the plant for developing countries. To this is added the cost of auxiliary facilities (25% of foreign battery limits) and supporting facilities (25% of foreign battery limits and 25% of auxiliary facilities). Storage facilities for bulk and bag and liquids are added where applicable. Therefore, the figures reflect a complex in developing countries, excluding the cost of land or facilities, such as port equipment, which may be required.

Production costs were calculated by standard TVA procedures and only indicate the cost of raw materials and operating costs. For comparison, a 20% return on investment for the complex, before taxes, is added to the production cost to reflect a gate sales price. The gate sales price does not include sales and administrative expenses; income taxes; and transportation, handling, and storage costs from the plant gate to the farm. In many countries certain other duties may be added on, such as import duty and other associated custom charges. The production cost does include interest on working capital (8% of half of the working capital) where working capital equals the value of a 1-month supply of raw materials plus 3-month value of product. All solid products—such as urea (46% N) and diammonium phosphate (DAP, 18-46-0)—are assumed to be bagged and charges are included.

Costs are estimated for a nitrogen complex where ammonia is produced and used to make urea. Feedstock to the ammonia plant would be natural gas, naphtha, heavy

fuel oil, or coal; plant capacities considered are 200, 600, and 1,000 tons/day of ammonia.

The phosphate complex consists of plants for making sulfuric acid, phosphoric acid, and DAP. Basis of production is 200, 400, or 600 tons/day of P_2O_5 as 54% phosphoric acid. It is assumed that only DAP will be sold. For comparison, a complex is considered where triple superphosphate (TSP, 0-46-0) is the product to be sold.

Where possible, the effects of varying raw materials cost and certain plant operating characteristics were investigated to determine the effect on economics.

Several examples of plant investment and plant production costs are given in Appendix B.

CURRENT TRENDS

Firm quotes on plant investment and raw materials cost are needed to make an accurate cost estimate. But it is difficult to get precise information.

The strong demand for fertilizer is tending to increase plant investment and raw materials cost faster than previously anticipated. There is a shortage of trained personnel necessary to make engineering studies, such as plant specifications, drawings, and layout. This has been brought about, especially in the United States, because much of this manpower is allocated to pollution related activities and energy problems. Some companies formerly engaged in fertilizer activities have shifted to pollution abatement problems. Labor costs per man hour have continued to rise.

Another problem is in getting specific items of equipment fabricated, such as heavy wall vessels and rotating equipment, compressors, and pumps. Delivery schedules often are indefinite. Metals are increasing in cost and supplies are tight.

Plants are being made more complex in order to have capability for using a wider range of raw materials. Equipment is being added to handle byproducts resulting from use of lower grade raw materials. For example, a lower grade phosphate rock tends to form sludge which must be removed for production of certain products. On the other hand, more stringent controls for pollution abatement are forcing companies to update existing plants or incorporate the extra equipment in new construction. This has not yet become so important in developing countries, but the trend is beginning.

These and other factors are expected to continue to increase plant costs and production costs. It should be kept in mind, however, that this is only an estimate and that specific cases may deviate somewhat from the examples.

AMMONIA

The technical aspects of ammonia production are rather complicated and no attempt is made here to develop engineering details. Numerous publications are available dealing with production from a wide variety of raw materials, including natural gas, naphtha, fuel oil, coal of various grades, and electrolytic processes. In all of these schemes, the ultimate goal is to obtain hydrogen for synthesis with nitrogen at elevated temperature and pressure to form ammonia.

Table 3 shows plant investment in developing countries for different types of ammonia plants with capacities of 200, 600, and 1,000 tons/day. Natural gas is the most economical feedstock, which accounts for its predominance in ammonia production, especially in the developed world. Investment is higher with other feedstocks because more complex facilities are required. For example, in a coal plant, in addition to oxygen, coal grinding equipment is required and gas purification is more complicated. The investment costs for the various complexes incorporate significant increases in battery limits plant cost which have occurred over the past 18 months.

Effect of Raw Material Cost

Figure 17 shows the relative cost of ammonia with natural gas, naphtha, heavy fuel oil, and coal. The energy costs are based on equivalent energy contents; i.e., $1.00/1,000 standard cubic feet (MSCUFT) natural gas is equivalent to about $46.00/ton naphtha, $42.50/ton heavy oil ($6.53/bbl), and $26.00/ton coal. The energy content for each material is noted on the chart. With $1/MSCUFT gas, the ammonia production cost is about $72 in a 1,000 ton/day plant; about $78 using naphtha; about $82 with heavy oil; and with coal about $120/ton.

The data can be interpreted in other ways, such as on an equal ammonia production cost basis. If it is desired to produce ammonia at $60.00/ton in a 1,000 tons/day plant, the natural gas can be $0.70/MSCUFT; naphtha $27.00/ton; heavy oil $20.00/ton ($3.10/bbl); and coal about $2.00/ton. These production costs do not include a return on investment; if this is added, the divergence of costs for the various raw materials is even more pronounced. Table 4 summarizes production costs and gate sales price for a 600 and 1,000 tons/day plant versus raw material costs. Gate sales price indicates a 20% return on total investment (plant investment plus working capital), but with nothing included for sales and administrative expense, transportation, storage, and handling charges.

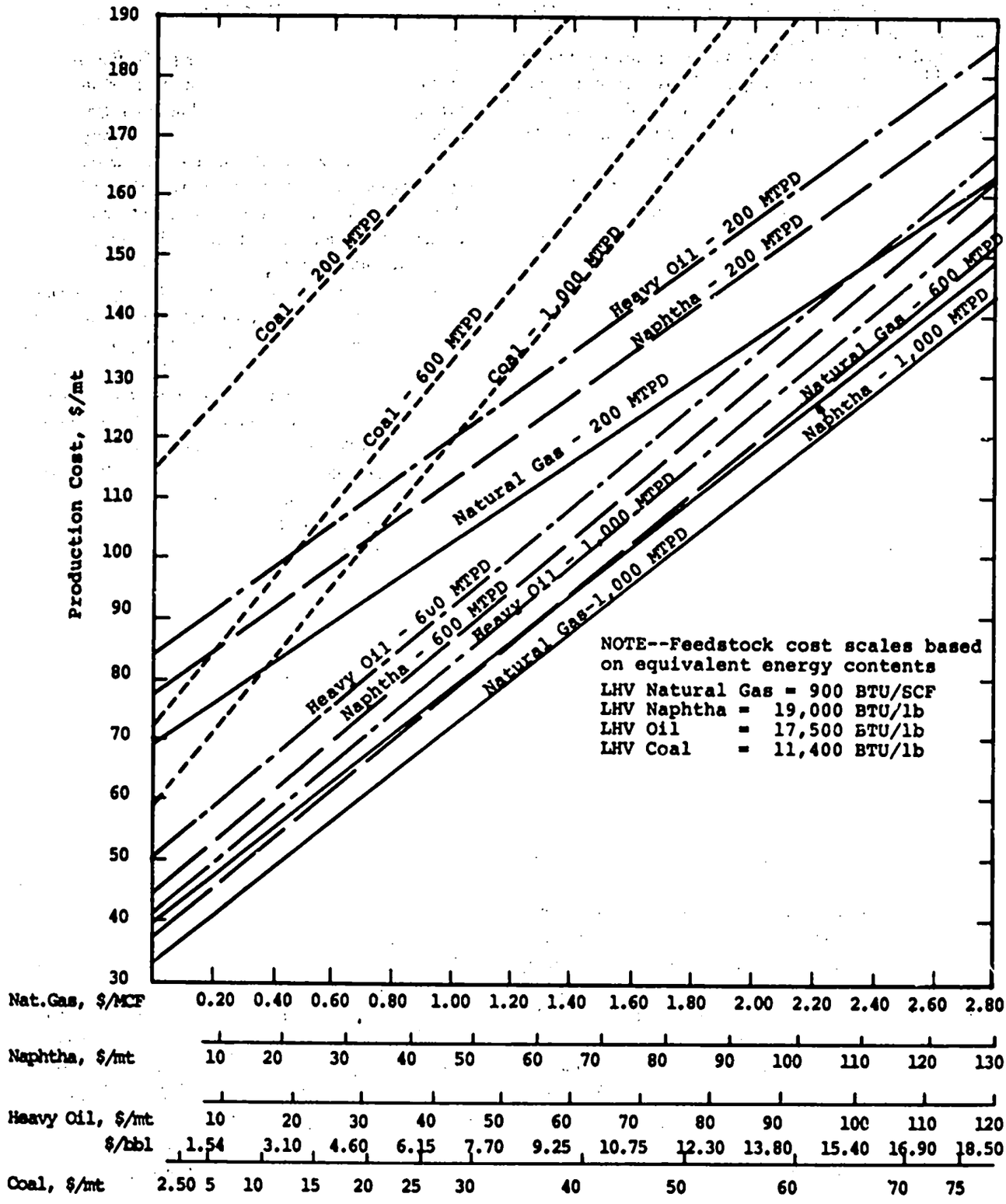


Figure 17. Ammonia production costs versus feedstock costs (100% capacity)

Table 3. Estimated plant investment for ammonia based on various raw materials

Capacity			
Tons/day	200[c]	600[d]	1,000[d]
Tons/year[a]	66,000	198,000	330,000
Plant investment, $[b]			
Natural gas	20,700,000	39,500,000	54,500,000
$/daily ton NH_3	103,500	65,833	54,500
Ratio based on natural gas	1.0	1.0	1.0
Naphtha reforming	23,100,000	44,100,000	60,750,000
$/daily ton NH_3	115,500	73,500	60,750
Ratio based on natural gas	1.12	1.12	1.11
Heavy fuel or crude oil, partial odixation[e]	25,600,000	51,000,000	69,300,000
$/daily ton NH_3	128,000	85,000	69,300
Ratio based on natural gas	1.24	1.29	1.27
Coal or lignite, partial oxidation[e]	35,700,000	72,200,000	97,600,000
$/daily ton NH_3	178,500	120,333	97,600
Ratio based on natural gas	1.72	1.83	1.79

[a]Assumed 330 days/year operating time.
[b]Investment for complex and offsites, including storage; not including land; plants in developing countries.
[c]Reciprocating compressors, electric driven.
[d]Centrifugal compressors, steam, or gas driven.
[e]Including air liquefaction unit.

Table 4. Summary of ammonia costs for various feedstocks

Costs of feedstocks at equivalent energy values		Production cost $/ton (no ROI)		Gate sales price $/ton (20% ROI)	
Material	Cost	600 tons/day	1,000 tons/day	600 tons/day	1,000 tons/day
Natural gas	$1/MSCUFT	78	72	124	109
Naphtha	$46/ton	86	78	136	120
Heavy oil	$43/ton ($6.61/bbl)	91	82	149	130
Coal	$28/ton	134	120	214	186

Raw Materials Portion of Total Cost

Often it is of interest to examine the cost of the raw materials in relation to the total cost of production and to sales price. Table 5 makes such a comparison for a 1,000 tons/day ammonia plant using various feedstocks (the costs for each feedstock are equivalent on the basis of energy content). Notice that the raw material cost can become a large part of the cost. For example, gas at $0.20/MSCUFT is equal to 19.3% of the production cost and 10.1% of the gate sales price; with gas at $1.00, the share is 53.5% and 35.3%, respectively. Similar data could be developed for other plant capacities.

Effect of Operating Level, Ammonia

Another factor which can contribute to higher production cost is a plant operating at less than design capacity. This is especially significant in developing countries. Reasons for poor operation are many—power failures, equipment failure and lack of spare parts, improper maintenance and inadequate preventative maintenance, inadequate supplies of raw materials or improper raw materials for a specific plant, problems with scheduling and planning for delivery, and management techniques.

Figures B-1, B-2, and B-3 in Appendix B show how production cost is affected by operation at less than design capacity using natural gas in a 200, 600, or 1,000 tons/day plant. Using $0.20/MSCUFT as an example, operation of a 200 tons/day plant at 100% of capacity gives a production cost of about $79.00/ton; at 80% of capacity, the cost is about $92.00, and at 60%, about $115.00. Thus, falling from 100% to 60% of capacity increased the production cost by $36/ton or 45%. With the same gas in a 600 tons/day plant, at 100% the cost is $49, and at 60% it is $71. For 1,000 tons/day the cost increases from about $42 to $60 as operating level decreases from 100% to 60%. This can, in some cases, overshadow the higher cost of raw materials. Of course, when operating problems are combined with higher raw materials cost the problem can

Table 5. Raw materials cost portion for ammonia production

Raw material (feedstock)		Production cost (1,000 tons/day)			Gate sales price[a] (1,000 tons/day)		
Amount required per ton ammonia	Cost of feedstock per unit (equivalent energy)	Raw material cost/ton NH_3 $/ton	Production cost/ton NH_3 $/ton	Raw material cost % of total	Raw material cost/ton NH_3 $/ton	Gate sales price/ton NH_3 $/ton	Raw material cost % of total
Natural gas							
38,500 MSCUFT	0.20/MSCUFT	7.70	40.00	19.3	7.70	76.00	10.1
	0.40/MSCUFT	15.40	48.00	32.1	15.40	84.00	18.3
	0.80/MSCUFT	30.80	64.00	48.1	30.80	101.00	30.5
	1.00/MSCUFT	38.50	72.00	53.5	38.50	109.00	35.3
	1.50/MSCUFT	57.75	91.00	63.5	57.75	130.00	44.4
Naphtha							
0.88 ton	8.50/ton	7.48	45.00	16.6	7.48	84.00	8.9
	18.50/ton	16.28	54.00	30.1	16.28	93.00	17.5
	37.00/ton	32.56	69.50	46.8	32.56	110.00	29.6
	46.25/ton	40.70	78.00	52.2	40.70	120.00	33.9
	69.25/ton	60.94	98.00	62.2	60.94	142.00	42.9
Heavy oil							
0.965 ton	8.00/ton (1.23/bbl)	7.72	49.00	15.8	7.72	95.00	8.1
	17.00/ton (2.62/bbl)	16.41	57.50	28.5	16.41	104.00	15.8
	34.00/ton (5.24/bbl)	32.81	75.00	43.7	32.81	121.00	27.1
	42.50/ton (6.55/bbl)	41.01	83.00	49.4	41.01	130.00	31.5
	63.50/ton (9.78/bbl)	61.28	103.00	59.5	61.28	152.00	40.3
Coal							
2.2 ton	5.75/ton	12.65	70.00	18.1	12.65	134.00	9.4
	11.00/ton	24.20	84.00	28.8	24.20	146.00	16.6
	22.25/ton	48.95	107.50	45.5	48.95	172.00	28.5
	28.10/ton	61.82	120.00	51.5	61.82	186.00	33.2
	42.00/ton	92.40	150.00	61.6	92.40	220.00	42.0

[a]With 20% return on investment, before taxes.

be extremely serious. Since other feedstocks require a higher plant investment, the effect of operation at less than design capacity is even more than that for a natural gas reforming plant.

Similar data showing the effect of operating level for the other feedstocks at 600 and 1,000 tons/day are shown in Appendix B, figures B-4, B-5, and B-6.

UREA

For the nitrogen complex in this study, it is assumed that all the ammonia can be converted to urea containing 46% nitrogen. The production of a ton of urea requires 0.6 ton of ammonia and 0.77 ton of carbon dioxide, a byproduct of ammonia production. Usually, it is necessary to have the ammonia plant adjacent to the urea plant to utilize the carbon dioxide. The plant investment given represents a total recycle urea plant in which the raw materials are used for urea and no ammonia off-gas from urea synthesis is fed to other processes. This is the highest cost plant but represents most of the plants that are being built today.

Table 6 shows the plant investment for the nitrogen complex, ammonia and urea, with the various feedstocks. The urea plant has storage for bulk and bags; all of the urea is assumed to be marketed in bagged form. The investment includes offsite facilities but no land. Total investment is the combined investment for the ammonia and urea plant with the various feedstocks and at different plant capacities; the urea unit is matched to receive the total output of ammonia for urea production. The plant investment does not include the working capital. For a 1,000 tons/day ammonia plant and corresponding 1,667 tons/day urea plant, the plant investment is about $104 million. The urea plant has offsite and auxiliary facilities which if built in conjunction with an ammonia plant as part of a nitrogen complex might be reduced or eliminated and thus reduce investment costs. In reality many complexes are built where a part of the ammonia is used in other processes such as

Table 6. Plant investment for nitrogen complex, ammonia and urea

Feedstock for ammonia	Natural gas			Naphtha			Heavy oil			Coal		
Ammonia												
Capacity, tons/day	200[c]	600[c]	1,000[c]	200	600	1,000	200	600	1,000	200	600	1,000
Plant investment,[a] million $	20.7	39.5	54.5	23.1	44.1	60.75	25.6	51.0	69.3	35.7	72.2	97.6
Urea												
Capacity, tons/day	333[d]	1,000[d]	1,667[d]	333	1,000	1,667	333	1,000	1,667	333	1,000	1,667
Plant investment,[a] million $	18.8	36.4	49.8	18.8	36.4	49.8	18.8	36.4	49.8	18.8	36.4	49.8
Total plant investment,[b] million $	39.5	75.9	104.3	41.9	80.5	110.55	44.4	87.4	119.1	54.5	108.6	147.4

[a]Indicates plant in developing country, with plant completion early 1977; has storage and all offsites, but not land.
[b]Total of ammonia and urea plant investments; urea offsites might be lower depending on location.
[c]200, 600, and 1,000 tons/day equal 66,000, 198,000, and 330,000 tons/year, respectively.
[d]333, 1,000, and 1,667 tons/day equal 109,890, 330,000, and 550,110 tons/year, respectively.

Table 7. Estimated production cost and gate sales price of bagged urea[a]

Gas cost $/MSCUFT	Ammonia[c] Tons day	Prod. cost[b] $/ton	P.I. million $	W.C. million $	C.I. million $	Urea[c] Tons day	P.I. million $	W.C. million $	C.I. million $	Total complex C.I. million $	Production cost[d] $/ton (no ROI)	Gate sales price[e] (20% ROI) $/ton
0.20	200	75.00	20.7	1.27	21.97	333	18.81	2.91	21.72	43.69	91.50	171.02
0.40	200	83.50	20.7	1.54	22.24	333	18.81	3.09	21.90	44.14	96.67	177.02
1.00	200	102.50	20.7	2.01	22.71	333	18.81	3.52	22.33	45.04	108.22	190.18
0.20	600	48.00	39.5	2.44	41.94	1,000	36.41	3.28	39.69	81.63	60.34	109.81
0.40	600	55.00	39.5	3.22	42.72	1,000	36.41	6.24	42.65	85.37	64.90	116.64
1.00	600	79.00	39.5	4.78	44.28	1,000	36.41	7.83	44.24	88.52	79.49	133.13
0.20	1,000	40.00	54.5	3.51	58.01	1,667	49.81	8.16	57.97	115.98	51.38	93.55
0.40	1,000	49.00	54.5	4.75	59.25	1,667	49.81	9.15	58.96	118.21	56.86	99.83
1.00	1,000	72.00	54.5	7.52	62.02	1,667	49.81	11.68	61.49	123.51	70.84	115.74

[a]Plants operating at full capacity; plant in developing country completed early 1977.
[b]Actual production cost, no storage, handling charges and no return on investment included.
[c]P.I. = plant investment; W.C. = working capital; and C.I. = capital investment.
[d]Carbon dioxide charged at $2/ton; ammonia at indicated cost; $6 included for bags for urea.
[e]A 20% return on investment of ammonia-urea complex; no sales and administrative expenses, transportation costs, etc., included.

ammonium nitrate, ammonium sulfate, NP, or NPK granulation, diammonium phosphate, etc. Consequently, the urea unit would be smaller than indicated in this study if this type of complex is built.

For simplicity, it is assumed that ammonia for urea production would only be produced from natural gas and data are given to show the production cost and gate sales price of bagged urea. Ammonia is charged to the urea unit at the production cost (no ROI included in transfer cost) and return on investment for the total complex is added to the urea. Data are provided in the appendix to allow calculation of production cost at various levels of raw material cost and plant capacity.

Table 7 gives the production cost and gate sales price of bagged urea at three levels of natural gas cost and plant capacity. With a typical size installation that might be considered—1,000 tons/day ammonia and 1,677 tons/day urea—the urea production cost is $56.86 with gas at $0.40/MSCUFT and $70.84 with gas at $1.00/MSCUFT; the gate sales price is $99.83 and $115.74, respectively. As the plant capacity decreases the production cost and gate sales price increase. With the smallest plant considered, urea would sell for about $170 to $190/ton. In reality, this is not the true selling price even at the plant gate because there must still be a charge added for sales and administrative expenses. This could add an extra $10 to $15 per ton at the gate. However, this will vary considerably and no attempt is made to estimate this value in this case.

Effect of Raw Material Cost

Data are given in Appendix B, figures B-7 and B-8, to allow the calculation of urea production cost over a wide range of raw material and operating costs. An example calculation is shown in Appendix B.

Raw Material Portion of Urea Cost

As indicated previously, the raw materials for the production of urea are ammonia and carbon dioxide. In this study, carbon dioxide was charged in at $2/ton, although in many cases it is assumed to be zero. Therefore, the main cost for raw material is for the cost of ammonia. Table 8 gives a summary of the raw material portion (ammonia only) of the urea cost expressed as a percentage of the total for production and gate sales price. Also, given is the cost of gas related to the cost of urea; of course, gas cannot be converted directly to urea. With a 1,000 tons/day ammonia plant and 1,667 tons/day urea plant, gas at $0.20/MSCUFT is only 9.0% of the urea production cost or 4.9% of the gate sales price; with $1.00 gas the cost is about one-third of production cost and one-fifth of sales price. In converting the gas to ammonia, this percentage increases sharply, accounting for over half of the cost of production or one-fourth or more of gate sales price.

Effect of Operating Level, Urea

Figures B-9 and B-10 in Appendix B indicate the effect of operating three sizes of urea plants at less than full capacity on the production cost and gate sales price for urea. Since a urea plant is highly capital intensive, i.e., a large investment per ton of product, the production cost increases sharply as operating level drops below 80% of capacity. Two levels of ammonia cost corresponding to gas at $0.40/MSCUFT and $1.00/MSCUFT were used in calculating the data. The sales price includes the return on investment for the ammonia-urea complex.

Effect of Plant Investment on Urea Cost

As noted previously, there is a rather dramatic upward trend in plant investment costs for specific plants, including ammonia-urea. If raw materials (feedstock) costs remain constant, the higher investment costs would increase the production cost for both ammonia and urea and the gate sales price. Table 9 illustrates the effect higher plant investment alone can have on urea cost. Previous estimates have produced results where urea could be produced for about $44/ton, but with higher investment of about 1.6 times, the production cost is about $57 ($13 increase). When return on investment is included, the difference (increase) is about $29/ton higher.

These plant investments represent current trends, but potential investors should shop around in the world market for specific quotes. Investors may be able to negotiate downward somewhat from the higher indicated cost. This indicates problems facing the potential investor today—higher plant investment cost, escalating raw material costs, and inadequate supplies. Any investor should have a firm commitment on the plant as well as a sound contract for raw materials; it is understood that both are difficult to obtain.

Table 8. Raw material cost portion for urea production

	Gas		Ammonia		Urea		Gas cost		Ammonia cost	
$/MSCUFT	Cost/ton NH_3 $/ton	Cost/ton urea $/ton	Cost/ton $/ton	Cost/ton urea $/ton	Prod. cost $/ton (no ROI)	Gate sales price $/ton (20% ROI)	% of urea prod. cost	% of urea gate sales price	% of urea prod. cost	% of urea gate sales price
200 tons/day (33,000 MSCUFT/ton ammonia equivalent to 19,800 MSCUFT/ton urea)[a]										
0.20	6.60	3.96	75.00	45.00	91.50	171.02	4.3	2.3	49.2	26.3
0.40	13.20	7.92	83.50	50.10	96.67	177.02	8.2	4.5	51.8	28.3
1.00	33.00	19.80	102.50	61.50	108.22	190.18	18.3	10.4	56.8	32.3
600 tons/day (38,500 MSCUFT/ton ammonia equivalent to 23,100 MSCUFT/ton urea)[b]										
0.20	7.70	4.62	48.00	28.80	60.34	109.81	7.7	4.2	47.7	26.2
0.40	15.40	9.24	55.00	33.00	64.90	116.64	14.2	7.9	50.8	28.3
1.00	38.50	23.10	79.00	47.40	79.49	133.13	29.1	17.4	59.6	35.6
1,000 tons/day (38,500 MSCUFT/ton ammonia equivalent to 23,100 MSCUFT/ton urea)[b]										
0.20	7.70	4.62	40.00	24.00	51.38	93.55	9.0	4.9	46.7	25.7
0.40	15.40	9.24	49.00	29.40	56.86	99.83	16.3	9.3	51.7	29.5
1.00	38.50	23.10	72.00	43.20	70.84	115.74	32.6	20.0	61.0	37.3

[a]Part of the energy input is in the form of electricity for compressor drives.
[b]Centrifugal compressors.

Table 9. Effect of plant investment on urea cost

	Previous[b]	Current[c]
Plant investment, $ (developing country)		
Ammonia, 1,000 tons/day; 330,000 tons/year	34,313,000	54,500,000
Factor increase	1.0	1.59
Working capital, $	3,472,000	4,750,000
Total capital investment, $	37,785,000	59,250,000
Ammonia production cost,[a] $/ton (no ROI)	37.37	49.00
Difference (increase), $/ton		(±11.63)
Urea, 1,667 tons/day; 550,110 tons/year	30,672,000	49,808,000
Factor increase	1.0	1.62
Working capital, $	7,049,000	9.146,000
Total capital investment, $	37,721,000	58,954,000
Urea production cost, $/ton (no ROI)	43.77	56.86
Difference (increase), $/ton		(±13.09)
Total capital investment, $	**75,506,000**	**118,204,000**
Return on total capital investment, $/ton (20% ROI, before taxes)	27.45	42.97
Gate sales price, $/ton	71.22	99.83
Difference (increase), $/ton		(±28.61)

[a]Gas cost of $0.40/MSCUFT.
[b]Indicative of plants built in 1973 and early 1974; natural gas reforming.
[c]Indicative of plant contracted in 1974 with completion early 1977; natural gas reforming.

PHOSPHATE COMPLEX—DAP (18-46-0)

Similar procedures were used to make some economic comparisons of a phosphate complex for the production of diammonium phosphate from a rock containing 30.2% P_2O_5 and 46.5% CaO (66 BPL). It is assumed that all P_2O_5 produced will be sold as DAP and that all DAP will be bagged. The raw materials needed to produce DAP are phosphate rock, sulfur, and ammonia—with intermediate production of sulfuric acid and phosphoric acid. Three levels of P_2O_5 production were chosen, 200, 400, and 600 tons/day produced as 54% phosphoric acid. Other plants were sized accordingly.

Table 10 gives the plant investment for the complex according to plant capacity. As in the nitrogen complex, some offsites might be eliminated and reduce investment costs. The table also shows the relationship of each material needed based on the indicated quantity of P_2O_5, although the quantities will vary somewhat depending on the rock analyses. In order to estimate the production cost of DAP, it is necessary to "cost-out" the intermediates sulfuric acid and phosphoric acid. For total sensitivity analyses, it is necessary to vary the cost of rock, sulfur, and ammonia. However, in order to simplify the estimates, only rock cost was varied; sulfur was held at $44.50/ton. Actually, sulfuric acid varies slightly because the production cost decreases somewhat as plant capacity increases.

Sulfuric Acid

Figure B-11 in Appendix B shows the production cost of sulfuric acid (and gate sales price) with sulfur at $44.50/ton in three levels of plant capacity. The cost is as follows:

Capacity of sulfuric acid tons/day	Cost for sulfur[a] $/ton 100% H_2SO_4	% of prod. cost	Production cost $/ton 100% H_2SO_4
550	15.31	62.7	24.42
1,100	15.31	68.8	22.25
1,650	15.31	71.8	21.33

[a]Sulfur at $44.50/ton.

Sulfur accounts for a large percentage of the total production cost of sulfuric acid, 62% to 72%. As indicated, there is little economy to scale in sulfuric acid production. The costs of sulfuric acid were charged to the phosphoric acid plant at corresponding capacity.

Phosphoric Acid (54%)

Table 11 shows how rock cost increases the production cost of phosphoric acid with rock from $14 to $44/ton. For every $10 increase in rock cost, phosphoric acid

Table 10. Plant investment for phosphate complex—DAP

P_2O_5 production, tons/day	200	400	600
Tons/year	66,000	132,000	198,000
Sulfuric acid (100%)			
Capacity, tons/day	549.8	1,101	1,651
Tons/year	181,434	363,363	544,797
Plant investment,[a] $	7,813,000[b]	12,149,000[b]	16,017,000[b]
Phosphoric acid (54%)			
Capacity, tons/day (54%)	370	741	1,111
Tons/year (54%)	122,100	244,530	366,630
Plant investment,[a] $	13,178,000[c]	17,760,000[c]	21,938,000[c]
Diammonium phosphate (DAP, 18-46-0)			
Capacity, tons/day	425.5	851	1,276.6
Tons/year	140,415	280,863	421,277
Plant investment,[a] $	6,112,000	7,783,000	9,443,000
Total complex investment, $	**27,103,000**	**37,782,000**	**47,398,000**

[a]Plant in developing country completed in early 1977; includes storage and offsites, but not the cost of land.
[b]Plant capable of 99% sulfur recovery.
[c]Plant to handle 66-68 BPL phosphate rock, includes rock grinding equipment.

Table 11. Effect of rock cost on phosphoric acid cost

Rock cost $/ton	Phosphoric acid production cost, $/ton of 54% acid: 200 tons P_2O_5/day[a]	400 tons P_2O_5/day[b]	600 tons P_2O_5/day[c]
14.00	85.19	74.67	70.64
24.00	103.30	92.79	88.75
34.00	121.41	110.90	106.87
44.00	139.60	129.01	124.98

[a]Sulfuric acid at $24.42/ton.
[b]Sulfuric acid at $22.25/ton.
[c]Sulfuric acid at $21.33/ton.

production cost increases by about $18.11. This increased cost will ultimately be reflected in higher DAP costs.

Figure B-12 in Appendix B also shows the effect of rock cost on phosphoric acid cost and gate sales price.

Figure B-13 in Appendix B shows how operation at less than design capacity affects the cost of phosphoric acid. Except in the smallest plant, the effect is not so great as in the case of ammonia-urea. This is true because much of the production cost of phosphoric acid is attributed to raw materials.

This indicates the significance of current rock quotes, which can lead to extremely high costs for phosphoric acid.

Diammonium Phosphate

One ton of DAP requires 0.23 ton of ammonia and 0.87 ton of phosphoric acid. Figures B-14 and B-15 in Appendix B can be used to estimate the production cost of DAP over a wide range of raw material costs and plant operating costs.

Table 12 gives a summary of DAP cost in the three levels of capacity as a function of rock cost and phosphoric acid cost. This shows that not much economy to scale can be expected in a phosphate complex such as DAP; i.e., production cost does not decrease much with larger capacity. The raw material costs account for the major cost of production.

The results indicate that if the current trend in raw material prices continues, prices of phosphate products will be increased significantly. For example, with rock at $34.00/ton (which could be the cost of imported rock) in a 400 tons/day P_2O_5 facility, the cost of DAP production is $121.71, for which the gate sales price is $164.29. This represents a very significant increase over the cost where rock may be available at say $10/ton. The data in this table may also be interpreted to show at a given cost of phosphoric acid what the rock cost may be in a given facility. As an example, in the 400 tons/day P_2O_5 complex, to produce acid for $80.00/ton requires rock at $17.50/ton.

Figure B-16 in Appendix B shows how rock cost from $0/ton to about $40.00/ton affects the production cost of DAP in three levels of capacity, using sulfur at $44.50/ton and ammonia at $49.00/ton. With rock at $5 available to produce phosphoric acid, DAP could be produced for $74/ton, at the same sulfur and ammonia cost.

Table 12. Production cost of diammonium phosphate (18-46-0) versus phosphoric acid cost

Sulfuric acid[a]			Phosphoric acid (54%)				Diammonium phosphate			Cost	
Production cost			Production cost								
Tons/day	$/ton (no ROI)	Total C.I.[b] $	Tons/day (P_2O_5)	$/ton (no ROI)	Total C.I. $	Rock cost[c] $/ton	Prod. tons/day (tons/yr)	Total C.I. $	Complex C.I.[d] $	Prod. $/ton[e] (no ROI)	Gate sales price 20% ROI $/ton
550	24.42	9,139,000	200	80.00	16,178,000	11.25	425	10,456,000	35,773,000	98.04	148.99
				100.00	16,978,000	22.50	(140,415)	11,271,000	37,388,000	115.67	168.92
				120.00	17,768,000	33.00		12,085,000	38,992,000	133.30	188.84
				121.41	17,830,000	34.00		12,143,000	39,112,000	134.55	190.26
1,101	22.25	14,609,000	400	80.00	23,960,000	17.50	850	16,315,000	54,884,000	94.47	133.55
				100.00	25,460,000	28.00	(280,863)	17,944,000	58,013,000	112.10	153.41
				110.90	26,362,000	34.00		18,831,000	59,802,000	121.71	164.29
				120.00	27,060,000	39.00		19,573,000	61,242,000	129.74	173.35
1,651	21.33	19,582,000	600	80.00	31,238,000	19.50	1,276	21,980,000	72,800,000	93.27	127.83
				100.00	33,638,000	30.50	(421,277)	24,423,000	77,643,000	110.90	147.76
				106.87	34,434,000	34.00		25,263,000	79,279,000	116.96	154.60
				120.00	36,038,000	41.50		26,867,000	82,487,000	128.53	167.69

[a]Sulfur charged in at $44.50/ton.
[b]Capital investment (C.I.) is plant investment plus working capital.
[c]Rock cost to produce 54% acid at the indicated cost, in the indicated plant capacity.
[d]Plant investment and working capital for the total complex, excluding ammonia.
[e]Ammonia at $49/ton.

Table 13. Raw material portion of DAP cost[a] (400 tons/day P_2O_5)

54% phosphoric acid $/ton	Ammonia $/ton	Cost of raw materials $/ton DAP			DAP		Raw material cost	
		Acid	Ammonia	Total	Production cost, $/ton	Gate sales price, $/ton	% of production	% of Gate sales price
80.00	49.00	69.60	11.27	80.87	94.47	133.55	85.6	60.6
100.00	49.00	87.00	11.27	98.27	112.10	153.41	87.7	64.1
110.90	49.00	96.48	11.27	107.75	121.71	164.29	88.5	65.6
120.00	49.00	104.40	11.27	115.67	129.74	173.35	89.2	66.7

[a]For 1 ton of DAP, the sulfur requirement is 0.444 tons/ton DAP; 1.555 tons rock/ton DAP; and 0.23 tons ammonia/ton DAP. The 54% phosphoric acid requirement is 0.87 tons/ton DAP; these quantities vary with each rock.

Raw Material Portion of DAP Cost

Table 13 shows that the major cost of production of DAP is due to the cost of raw materials; about 85% to 90% of the cost is for phosphoric acid and ammonia. Up to two-thirds of the gate sales price is for raw materials. Although sulfur and rock cannot be used directly in making DAP, it may be of interest to look at equivalent values as changes in these materials indirectly affect the cost of DAP; to produce 1 ton of DAP requires 0.44 ton of sulfur, 1.56 ton of rock, and 0.23 ton of ammonia.

PHOSPHATE COMPLEX—TSP (0-46-0)

For comparison some data were developed to show the relative cost of triple superphosphate (TSP, 0-46-0). The raw materials for TSP are phosphoric acid and ground rock; therefore, a portion of the P_2O_5 is derived from the less expensive source. Based on a given capacity of P_2O_5 as phosphoric acid, then the equivalent capacity for TSP is higher compared with DAP. This is shown in the tabulation:

P_2O_5 capacity as 54% phosphoric acid	TSP capacity		DAP capacity	
tons P_2O_5/day	Tons/day	Tons/yr	Tons/day	Tons/yr
200	572	188,628	425	140,415
400	1,143	377,223	850	280,863
600	1,715	565,844	1,276	421,277

For every 0.648 ton of 54% phosphoric acid, 0.448 ton of rock can be reacted to make 1 ton of TSP, whereas

Table 14. Plant investment for phosphate complex—TSP[a]

P_2O_5 production, tons/day	200	400	600
Tons/year	66,000	132,000	198,000
Sulfuric acid (100%)			
Capacity, tons/day	549.8	1,101	1,651
Tons/year	181,434	363,363	544,797
Plant investment, $	7,813,000[b]	12,149,000[b]	16,017,000[b]
Phosphoric acid (54%)			
Capacity, tons/day (54%)	370	741	1,111
Tons/year (54%)	122,100	244,530	366,630
Plant investment, $	13,178,000[c]	17,760,000[c]	21,938,000[c]
Triple superphosphate (TSP, 0-46-0)			
Capacity, tons/day	572	1,143	1,714.7
Tons/year	188,628	377,223	565,844
Plant investment, $	3,347,000[d]	5,782,000[d]	7,799,000[d]
Total complex investment, $	**24,338,000**	**35,691,000**	**45,754,000**

[a]Plant in developing country completed in early 1977; includes storage and offsites but not land.
[b]Plant capable of 99% sulfur recovery.
[c]Plant to handle 66-68 BPL phosphate rock; includes rock grinding equipment.
[d]Granular TSP.

Table 15. Production cost of triple superphosphate (0-46-0) versus phosphoric acid cost

Sulfuric acid[a]			Phosphoric acid (54%)				Triple superphosphate			Cost	
Production cost			Production cost								
Tons/day	$/ton (no ROI)	Total C.I.[b] $	Tons/day (P_2O_5)	$/ton (no ROI)	Total C.I. $	Rock cost[c] $/ton	Prod. tons/day (tons/year)	Total C.I. $	Complex C.I.[d] $	Prod. $/ton (no ROI)	Gate[e] sales price 20% ROI $/ton
550	24.42	9,139,000	200	80.00	16,178,000	11.25	572	7,490,000	32,807,000	69.78	104.56
				100.00	16,978,000	22.50	(188,628)	8,622,000	34,739,000	88.02	124.85
				120.00	17,768,000	33.00		9,732,000	36,639,000	105.91	144.76
				121.41	17,830,000	34.00		9,818,000	36,787,000	107.29	146.29
1,101	22.25	14,609,000	400	80.00	23,960,000	17.50	1,143	14,275,000	52,844,000	71.06	99.08
				100.00	25,460,000	28.00	(377,223)	16,495,000	56,564,000	88.96	118.95
				110.90	26,362,000	34.00		17,721,000	58,692,000	98.84	129.96
				120.00	27,060,000	39.00		18,745,000	60,414,000	107.08	139.11
1,651	21.33	19,582,000	600	80.00	31,238,000	19.50	1,715	20,613,000	71,433,000	71.30	96.55
				100.00	33,638,000	30.50	(565,844)	23,985,000	77,205,000	89.41	116.70
				106.87	34,434,000	34.00		25,121,000	79,137,000	95.51	123.48
				120.00	36,038,000	41.50		27,360,000	82,980,000	107.54	136.87

[a]Sulfur charged at $44.50/ton.
[b]Capital investment (C.I.) is plant investment plus working capital.
[c]Rock cost to produce phosphoric acid in the indicated plant; rock charged to TSP plant at corresponding cost.
[d]Plant investment and working capital for total complex, excluding ammonia.
[e]Gate sales price (20% return on total complex investment, before taxes) not including sales and administrative expense, transportation, etc.

1 ton of DAP requires 0.877 ton of 54% phosphoric acid.

Table 14 gives the plant investment for the TSP complex, including the corresponding sulfuric and phosphoric acid plants. The TSP complex costs slightly less than the DAP complex.

Table 15 shows production cost and gate sales price for granular TSP with rock and acid costs on the same basis as used for DAP; the two products can be compared directly at each level of production capacity. The production cost of TSP per ton is less than that for DAP and also the gate sales price. Therefore, TSP would appear to be a favored product. However, this is not necessarily true for a number of reasons. Granular TSP cannot be blended with urea as the mixture tends to become moist and sticky. When fixed

and variable charges are added, the TSP may be more expensive when compared on a cost per ton of nutrient basis. This is shown in table 16.

Even in this study when the gate sales prices per ton of nutrients are compared for TSP versus DAP, the DAP is lower except in the case where $11.25 rock would be used. After addition of other charges such as sales and administrative expenses, freight and handling charges, the DAP would be in an even more favorable position. This, of course, explains why DAP is becoming so popular in world trade.

Raw Material Portion of TSP Cost

As in the case of DAP, the cost of raw materials accounts for the main cost of production. Table 17 shows the relationship for TSP. Here again, sulfur is used indirectly and is equivalent to 0.331 ton sulfur/ton TSP and 1.608 ton rock/ton TSP. Varying costs in these raw materials will indirectly affect the cost of TSP.

Figures B-17 and B-18 in Appendix B may be used to estimate the production cost of TSP at various levels of raw material cost and plant capacity.

Effect of Phosphate Plant Investment Cost

The investments for either the DAP or TSP complex reflect the latest technology and higher costs than were usually used prior to 1974 and are somewhat higher than would be predicted by cost factors. The increase in plant investment increases the cost of production and gate sales price for DAP or TSP but is not so serious as in the nitrogen complex. The investment cost per ton of product is lower for phosphate compared with nitrogen and thus capital-related items are not so significant. It is not to say that plant investment is not important, but for phosphates raw materials cost somewhat overshadows the increase in plant investment.

Sulfur

It was assumed that sulfur would be imported and delivered to the sulfuric plant at $44.50/ton. But it is possible that in certain areas of the world byproduct sulfuric acid such as from smelting operations or from other recovery operations might be available and at a lower price than estimated. Or, a local sulfur ore might be available. In such cases either byproduct sulfur or sulfuric acid could be utilized. This will have some effect on the production cost of phosphoric acid and either DAP or TSP.

Sulfuric acid production cost versus sulfur cost is shown in the tabulation:

Sulfur cost, $/ton	Sulfuric acid capacity (100%) Tons/day	Tons/yr	Production cost, (no ROI) $/ton
10.00	549.8	181,434	12.39
20.00	549.8	181,434	15.88
44.50	549.8	181,434	24.42
10.00	1,101.0	363,363	10.22
20.00	1,101.0	363,363	13.71
44.50	1,101.0	363,363	22.25
10.00	1,650.9	544,797	9.30
20.00	1,650.9	544,797	12.79
44.50	1,650.9	544,797	21.33

Table 16. Comparison of gate sales prices of DAP and TSP per ton and per ton of plant nutrients

Gate sales price of DAP (18-46-0) 64% plant food $/ton	$/ton nutrients	Gate sales price of TSP (0-46-0) 46% plant food $/ton	$/ton nutrients
148.99	232.80	104.56	227.30
168.92	263.94	124.85	271.41
188.84	295.07	144.76	314.70
190.26	297.28	146.29	318.02
133.55	208.67	99.08	215.39
153.41	239.70	118.95	258.59
164.29	256.70	129.96	282.52
173.35	270.86	139.11	302.41
127.83	199.73	96.55	209.89
147.76	230.88	116.70	253.70
154.60	241.56	123.48	268.43
167.69	262.02	136.87	297.54

Table17. Raw material portion of TSP cost[a] (400 tons/day P_2O_5)

Raw material cost: 54% phosphoric acid $/ton	Rock $/ton	Cost of raw materials $/ton TSP: Acid	Rock	Total	TSP: Production cost $/ton	Gate sales price $/ton	Raw material cost: % of production	% of gate sales price
80.00	17.50	51.84	7.84	59.68	71.06	99.08	84.0	60.2
100.00	28.00	64.80	12.54	77.34	88.96	118.95	86.9	65.0
110.90	34.00	71.86	15.23	87.09	98.84	129.96	88.1	67.0
120.00	39.00	77.76	17.47	95.23	107.08	139.11	88.9	68.5

[a]To produce 1 ton of TSP requires 0.448 tons rock and 0.648 tons of 54% phosphoric acid; this is equivalent to 0.331 tons sulfur/ton TSP; 1.608 tons of rock/ton of TSP (part of the rock used for acid production and the remainder for reaction with the acid); quantities vary with each rock.

To produce 1 ton of P_2O_5 as 54% acid requires 2.75 tons of 100% sulfuric acid (1.49 tons of 100% H_2SO_4/ton 54% acid) so a reduction in sulfur cost (sulfuric acid cost) can decrease the cost of phosphoric acid. For a 400 tons P_2O_5/day phosphoric acid plant, sulfuric acid cost (at a fixed rock cost of $34/ton) varied to reflect lower cost sulfur is shown in the tabulation:

Sulfur cost $/ton	Sulfuric acid $/ton	Rock cost $/ton	Production cost of phosphoric acid (no ROI) $/ton 54% acid[a]
10.00	10.22	34.00	92.80
20.00	13.71	34.00	98.04
44.50	22.25	34.00	110.90

[a]400 tons P_2O_5/day as 54% acid.

The lower cost 54% phosphoric acid from lower cost sulfur would reduce somewhat the cost of DAP and TSP, where 0.87 ton 54% acid is required per ton of DAP and 0.648 ton of 54% acid is required per ton of TSP. Therefore, a country having byproduct sulfur or sulfuric acid would be advised to consider its use.

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APPENDIX A

Concept of Forecasting Procedures

The analysis used in this report to determine the fertilizer market situation and to forecast future market trends has been divided into two parts. First, demand forecasts have been based on the extrapolation of past trends using time series data and regression analysis techniques. Second, the supply has been determined from actual announced plans for new construction or expansion. In some cases, a judgment of the probability of the announced plant reaching completion has been required but no statistical analysis has been used for the determination of the projected supply level. In view of the many forecasts that have been made recently, and will be precipitated by the current market situation, some discussion of the concepts used in this report should be helpful in order to make a fair comparison of these projections.

Any planning carried out by market researchers in the fertilizer industry must be based on an estimate of the future demand level. In the long run, expectation of market size is the primary consideration in the justification of a new plant. There are several ways that have been used to estimate future demand levels. Each has some merit but each is also subject to limitations. All are faced with the problem of data reliability, especially when considering a market study that is worldwide in scope.

Probably the most common approach to estimating demand is an extension of a trend line based upon the compounded growth rate that has been attained during some past time period. While fairly accurate for short-term forecasts, in the long term large percentage increases can become compounded into astronomical levels of use. Also, the time period used in the calculation of the growth rate can distort the true nature of the growth pattern, turning cyclical market swings into fictitious growth markets. In the analysis of fertilizer statistics, this can lead to distortions because of the use in some areas of apparent consumption data rather than actual use. In countries that are large net importers and may be buying material several years in advance of its eventual use, the accumulation of inventory can add significantly to the compounded rate of increase from which the forecast is made.

A second method used in the determination of future demand is based on recommended levels of fertilization and crop acreage. Ideally, this method should be the most accurate of the forecasting techniques; however, past performance has shown that farmers do not apply fertilizer at the recommended rate. Thus, some percent utilization must be assumed in order to arrive at the forecast. In addition, crop acreages must be projected or assumed and shifts in cropping patterns evaluated. With the vast data requirements for this type of analysis, a worldwide evaluation would be limited by time requirements and manpower.

A comparison of food requirements and fertilizer requirements is still another approach to forecasting fertilizer demand. Future population growth rates become the key to this study along with the effect of improved diet as income levels increase. Both of these variables are difficult to measure and again require a number of assumptions. In addition, the relationship between food yield per ton of plant nutrient varies from crop to crop, country to country, and even in small areas within a country. Some idea of the aggregate level of plant food needed can be gleaned from this approach but little detail on type of nutrient is forthcoming.

One of the biggest problems in forecasting fertilizer demand is to determine if the estimates are of requirements or the true effective demand. The former is the level of plant food needed to supply an adequate level of food supply for the world's population. It is not the level of fertilizer that will be used by the farmer. The effective demand is the actual amount of plant food that the farmer buys to put on his cropland and is based on this assessment of the market for this production. Not realizing the large difference that exists between these two measures of the fertilizer market helped lead the world fertilizer industry into the oversupply situation of the last decade. Planners mistakenly based their marketing decisions on theoretical requirements rather than economic demand levels.

TVA has no unique method of forecasting nor insights into the market that cannot be obtained by careful study and review of market developments of the last four decades. Attempts have been made with varying degrees of success to use all of the forecasting techniques that have been mentioned; however, none have reduced the need for judgment by the forecaster. As a result, the methods used are offered as guidelines to the possible growth pattern that the market will take. They are based on the assumption that whatever forces acted to produce the past trend will also be responsible for extending it into the future.

Market growth is looked at in three phases as described by the typical logistic curve. Phase 1 represents the rapid increases that occur in the early stages of development. Phase 2 is the transition period between early rapid development and a mature market and is characterized by a straight line. The third phase is the older mature market in which decreasing rates of increase can be recognized. The first step in the forecast is to determine which phase of the market the country or area is in. This dictates the type of

curve (linear versus curvilinear) that is used for extrapolation as determined by the percent of error that is accounted for by the trend line.

The amount of variation around the trend line also enters into the forecast as it determines the range that should be expected in future years. Wide variation from year to year also is an indicator of the level of confidence that should be assigned to the trend line.

The guidelines for demand that are used in this report are based on the background data taken from the FAO *Annual Fertilizer Review* for the period 1962-1972. While it is recognized that this 10-year period should only be used to forecast to 1977, the trends have been extended to 1980. Market data prior to 1962 was judged to be inconsistent for use in the analysis.

Potential production estimates have been based on the tabulation of production capacity data, both operating and announced, for those products that contribute directly to supplies. These include ammonia and phosphoric acid as the primary contributors to the nitrogen and phosphate market. Because capacity of normal superphosphate and concentrated superphosphate is not a good indicator of actual production levels, production estimates have been used. Production of basic slag, a byproduct of the steel industry, was also estimated as capacity utilization is unrelated to fertilizer market conditions.

Nameplate capacity has been based on plant operation of 330 days/year in all areas except the United States and Canada where 340 days have been found to better reflect actual operating conditions. Plants reporting annual capacity rather than a daily rate were not adjusted. June 30 was used as the cutoff day in determining the first year of operation. For example, a plant with an announced startup date of May 1973 would be listed as operating in 1973. A plant scheduled to begin operations in August 1973 would carry 1974 as the first year of operation. In the maintenance of records of plant capacities, the status of the unit has been divided into the following categories: operating, under construction, contracted, planned, expansion of existing units, closed and dismantled units, idle facilities, and indefinite or unknown. All announced plans are included in the study except those listed as indefinite. If no date of initial operation is known, the year 1980 has been assumed.

Maintenance of capacity records is a continuing process with totals varying from day to day. Through the use of electronic data processing techniques, it was possible to determine capacity levels based on known plants as of the month of November 1973.

After the total capacity is tabulated for each year—1967 to 1977—the first step in estimating the potential supply of fertilizer materials is to calculate the expected total production. It has been assumed that a new plant does not reach its full production level until the third year of operation, with this level being a percentage of the total capacity figure. The analysis techniques used in estimating supply allow for variation in the maximum operating rate that can be obtained. For this study, rates of 30% of capacity for the first year, 60% for the second year, and 85%, 95%, and 100% for the remaining years have been assumed for all plants in the developed regions. In the developing areas, 20% (first year), 40% (second year), and 60%, 70%, and 100% of capacity have been assumed. These rates have been allowed to vary in order to show the impact on the market when production rates are increased or allowed to decline because of raw materials supplies, lack of adequate utilities, or market conditions. The 100% level has been included to give an indication of the maximum production rate possible in both the developing and the developed nations.

Once the estimated production level has been determined, two further adjustments must be made in order to arrive at the potential supply of fertilizer. In the conversion of ammonia or phosphoric acid to products that are used by the farmer, losses will occur. While loss factors vary from plant to plant and depend on the stage at which the measurement is taken, it has been assumed that 10% of total ammonia production and 6% of the phosphoric acid produced is lost to the supply chain for one reason or another.

The last adjustment needed to calculate fertilizer supply is to estimate industrial uses of these materials. A percentage of the supply, after losses have been accounted for, is taken for industrial use because of the difficulty of making an actual determination of industrial demand. With this method, an allowance is used for industrial uses that depends on the production level rather than market conditions. Thus, a large increase in capacity automatically allows a large tonnage increase for industrial uses even though the demand may not be increasing at this rapid rate. This ensures, however, that industrial demand will be met before fertilizer demands if capacity is not adequate to meet the total requirement—reflecting pricing policy of the marketplace. For nitrogen, an industrial use of 20% has been used for developed regions and 10% for developing. No adjustment has been made in the phosphate market at this time because it has been assumed that elemental phosphorus sources of P_2O_5 entering the fertilizer market are about equal to the amount of phosphoric acid from other sources that finds its way into the industrial market. In the future as the economics of wet-process phosphoric acid become more favorable, some allowance will be needed to account for the greater use of wet process phosphoric acid in the industrial market.

After all of the above adjustments have been made, the result is the potential level of supply of fertilizer that can be expected for any given year. This is not to be confused with actual production, which is determined by market

conditions, but is a measure of the ability of the industry to supply the market under normal operating conditions. Under reporting procedures used by FAO, countries that produce fertilizer materials based on imported ammonia or phosphoric acid will be listed as producers. Under the assumptions of this study, their inclusion would result in double counting of the total available supply level.

To determine the supply-demand situation, this potential level of production is compared with the estimated level of demand with the difference assumed to be the level of net trade needed to achieve equilibrium in the market. This is the surplus or deficit that can be expected for any given year, and when compared to production or consumption within an area provides an indication of the supply-demand balance.

A worldwide supply-demand balance cannot be clearly defined as a simple equality between production and consumption. Historically, there has been an average difference of 5% between reported production and consumption. This reflects such things as (1) the normal increase in inventory levels in proportion to production levels, (2) overformulation in the manufacture of compound fertilizers, (3) transportation and distribution losses including pilferage, (4) diversion of fertilizer to other uses, and (5) inherent problems of measuring and reporting fertilizer use. This suggests that a world supply-demand ratio of 1.05 indicates a generally balanced market situation. Fluctuations around this level will indicate inventory depletion or accumulation as the case may be.

It has been the purpose of this study to review expected market developments in the fertilizer industry through the year 1977. A quick look at the range values associated with the demand estimates used, however, indicates a wide spread in the confidence limits about 5 years beyond the latest year of actual data. While the forecast of demand has been extended to 1980, the values must be considered as little more than a general indication of what the future consumption of fertilizer nutrients will be.

With the assumptions used for estimating supply levels the problem is even more acute. Since extrapolation of past production trends has not been used, additions to supply end at the time of the last scheduled plant. In this study, little in the way of new capacity has been announced from 1977 to 1980; thus, the supply lines have not been shown beyond this point. In actual practice, however, there are some plants that will enter production during this period and others that will not start producing even though they have been announced for some time. Because it takes from 2 to 4 years to complete new plants, a comparison of supply and demand probably will not accurately reflect a true market picture.

Generally, demand forecasts should be reevaluated at 2-year intervals while supply estimates need revision several times each year. Fertilizer capacity adjustment plans usually respond to current market conditions; consequently, supply will usually demonstrate greater fluctuation than demand. With large scale units currently being considered, many nations have a single production unit and its status will determine the market situation in the country. For these reasons, the TVA capacity information system is designed to evaluate and make changes as soon as they occur.

TABLE A-1: NITROGEN CONSUMPTION - MIDPOINT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1962	3156	3383	2078	695	21	54	41	459	298	913	712	9428	1670	9020	7350	11810
1963	3687	3828	2487	689	19	71	44	496	309	941	917	10825	1746	10084	8338	13488
1964	4099	4038	2661	739	22	85	64	662	359	1122	1076	11708	2143	11190	9047	14927
1965	4379	4276	3310	725	23	93	76	691	418	1187	1179	12882	2296	11868	9572	16357
1966	5050	4650	4087	775	24	99	82	730	460	1291	1594	14767	2481	13161	10680	18842
1967	5744	5025	4757	853	25	98	119	806	448	1759	2144	16621	3013	14877	11864	21778
1968	6478	5515	5437	900	28	131	146	937	470	1960	1936	18635	3367	16565	13198	23938
1969	6554	5755	6335	919	27	144	187	1117	529	2495	2556	19921	4141	17727	13586	26618
1970	7037	5992	6854	892	30	150	187	1180	589	2891	2851	21142	4660	18948	14288	28653
1971	7670	6445	7815	873	32	181	157	1360	662	3167	3358	23173	5189	20547	15358	31720
1972	7708	6824	8594	876	33	208	141	1486	773	3459	3598	24384	5718	21508	15790	33700
1973	8503	7104	9298	922	34	215	201	1651	777	3836	3935	26277	6264	23243	16979	36476
1974	8987	7444	10130	929	35	234	215	1822	838	4242	4313	27974	6902	24746	17844	39189
1975	9472	7783	10987	934	37	255	230	2004	902	4668	4703	29698	7574	26285	18711	41975
1976	9956	8123	11869	937	38	276	245	2196	968	5114	5106	31444	8278	27853	19575	44828
1977	10441	8463	12775	936	39	298	259	2399	1038	5580	5522	33211	9017	29453	20436	47750
1978	10925	8802	13707	934	41	321	274	2612	1110	6066	5950	35004	9788	31085	21297	50742
1979	11409	9142	14663	929	42	345	288	2836	1185	6572	6391	36818	10593	32748	22155	53802
1980	11894	9481	15643	921	43	369	303	3071	1263	7099	6844	38654	11433	34444	23011	56931

TABLE A-1A: NITROGEN CONSUMPTION - LOW RANGE

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1973	8024	6911	8891	852	31	197	139	1609	713	3502	3633	25045	5824	21978	16154	34502
1974	8489	7243	9681	849	33	214	151	1763	766	3871	3971	26660	6400	23379	16979	37031
1975	8952	7573	10488	843	34	232	163	1925	820	4255	4314	28285	7000	24797	17797	39599
1976	9413	7904	11313	832	35	250	175	2095	876	4654	4664	29922	7625	26234	18609	42211
1977	9873	8233	12157	818	36	269	186	2273	934	5068	5021	31571	8275	27689	19414	44867
1978	10330	8562	13019	799	37	288	197	2458	993	5497	5384	33232	8948	29161	20213	47564
1979	10787	8890	13901	777	39	308	208	2652	1054	5941	5754	34910	9647	30656	21009	50311
1980	11242	9218	14802	750	40	328	219	2853	1116	6400	6131	36599	10369	32166	21797	53099

TABLE A-1B: NITROGEN CONSUMPTION - HIGH RANGE

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1973	8982	7297	9704	993	36	233	262	1694	840	4171	4237	27507	6705	24508	17803	38449
1974	9485	7645	10579	1010	38	254	279	1882	909	4613	4655	29290	7404	26115	18711	41349
1975	9992	7993	11487	1026	39	277	297	2083	983	5080	5092	31111	8146	27770	19624	44349
1976	10499	8342	12425	1041	41	302	314	2297	1060	5573	5548	32964	8930	29469	20539	47442
1977	11009	8692	13394	1055	42	327	332	2525	1142	6092	6023	34851	9759	31216	21457	50633
1978	11520	9043	14394	1068	44	354	350	2766	1227	6635	6516	36773	10628	33007	22379	53917
1979	12032	9393	15424	1080	45	382	368	3021	1317	7204	7027	38724	11542	34842	23300	57293
1980	12545	9745	16485	1091	47	411	387	3288	1410	7797	7556	40711	12495	36721	24226	60762

TABLE A-2: PHOSPHATE CONSUMPTION - MIDPOINT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1962	2836	3680	1748	452	13	127	796	309	150	290	143	9652	749	8653	7904	10544
1963	3104	3844	1963	452	12	150	806	336	147	345	250	10331	828	9196	8368	11409
1964	3407	4120	2145	506	10	120	898	418	145	435	356	11206	998	10059	9061	12560
1965	3174	4333	2613	509	11	180	1212	454	146	455	426	12032	1055	10474	9419	13513
1966	3522	4381	2948	546	12	190	1296	467	170	456	457	12895	1093	11040	9947	14445
1967	4279	4515	3206	614	11	215	1287	533	172	666	631	14127	1371	12292	10921	16129
1968	4439	4786	3477	670	12	247	1163	656	196	712	629	14794	1564	12881	11317	16987
1969	4538	4918	3649	705	12	259	1225	757	215	1018	702	15506	1990	13647	11657	18198
1970	4429	5191	4044	702	14	261	1198	770	242	1127	832	15639	2139	13934	11795	18810
1971	4664	5487	4461	656	14	272	1065	946	279	1070	934	16639	2295	14473	12178	19868
1972	4679	5721	4795	664	16	295	1123	1043	341	1302	1111	17293	2686	15184	12498	21090
1973	5131	5810	5083	718	14	314	1286	1166	342	1411	1147	18356	2919	16192	13273	22422
1974	5333	6007	5405	729	15	330	1318	1300	377	1552	1250	19137	3229	16961	13732	23616
1975	5535	6203	5730	737	15	346	1349	1444	415	1697	1355	19915	3556	17741	14185	24826
1976	5737	6399	6056	742	15	362	1381	1597	456	1849	1462	20692	3902	18538	14636	26056
1977	5940	6595	6385	745	16	377	1412	1760	500	2006	1571	21470	4266	19351	15085	27307
1978	6142	6791	6716	745	16	392	1444	1932	546	2168	1682	22246	4646	20176	15530	28574
1979	6344	6987	7049	743	16	407	1475	2114	596	2336	1796	23021	5046	21018	15972	29863
1980	6546	7183	7385	738	17	421	1507	2305	647	2510	1912	23797	5462	21874	16412	31171

TABLE A-2A: PHOSPHATE CONSUMPTION - LOW RANGE

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1973	4559	5612	4965	649	11	287	908	1133	304	1254	1070	16991	2691	14717	12026	20752
1974	4738	5800	5270	651	11	298	924	1254	337	1373	1161	17692	2964	15386	12422	21817
1975	4914	5987	5574	648	12	309	938	1383	372	1493	1253	18382	3248	16056	12808	22883
1976	5088	6173	5877	640	12	319	951	1519	409	1616	1346	19060	3544	16727	13183	23950
1977	5261	6359	6180	629	12	328	963	1662	448	1741	1438	19732	3851	17403	13552	25021
1978	5431	6544	6482	615	12	336	973	1813	490	1868	1532	20393	4171	18082	13911	26096
1979	5600	6728	6784	596	12	344	983	1971	535	1998	1625	21047	4504	18767	14263	27176
1980	5768	6912	7085	573	12	350	991	2136	581	2130	1720	21691	4847	19453	14606	28258

TABLE A-2B: PHOSPHATE CONSUMPTION - HIGH RANGE

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1973	5703	6009	5201	787	18	342	1665	1199	379	1568	1225	19725	3146	17670	14524	24096
1974	5928	6213	5541	807	18	362	1712	1346	417	1730	1338	20581	3493	18533	15040	25412
1975	6156	6418	5886	826	19	383	1760	1505	459	1902	1456	21448	3866	19428	15562	26770
1976	6387	6624	6236	844	19	404	1810	1676	503	2082	1578	22324	4261	20349	16088	28163
1977	6619	6831	6591	860	20	426	1862	1858	551	2271	1704	23209	4680	21298	16618	29593
1978	6853	7038	6950	876	20	447	1914	2052	602	2468	1833	24098	5122	22270	17148	31053
1979	7088	7245	7315	890	21	470	1968	2257	656	2675	1966	24997	5588	23270	17682	32551
1980	7325	7453	7684	903	21	492	2022	2474	713	2890	2103	25900	6077	24293	18216	34080

TABLE A-3: POTASH CONSUMPTION - MIDPOINT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1962	2166	3479	2033	493	2	33	130	202	65	152	64	8336	419	6722	6303	8819
1963	2383	3668	2148	538	2	39	91	218	69	169	67	8869	456	7177	6721	9392
1964	2586	3783	2310	598	2	45	128	279	84	195	73	9452	558	7700	7142	10083
1965	2694	3899	2949	579	3	71	152	271	96	196	76	10347	563	7961	7398	10986
1966	3064	3932	3600	607	4	76	171	295	99	255	91	11454	649	8503	7854	12194
1967	3466	3941	3833	619	5	85	175	325	100	318	112	12124	743	9034	8291	12979
1968	3607	4234	4228	659	6	96	157	364	105	368	137	12977	837	9586	8749	13951
1969	3699	4278	4485	670	7	96	175	517	105	402	198	13410	1024	9949	8925	14632
1970	3836	4484	4787	668	9	89	194	591	124	482	177	14067	1197	10477	9280	15441
1971	4023	4798	5253	611	11	96	195	679	143	522	174	14987	1344	11078	9734	16505
1972	4108	4994	5622	583	12	108	193	698	165	610	187	15820	1473	11471	9998	17480
1973	4471	4968	6112	667	12	116	213	845	163	649	215	16561	1657	12106	10449	18433
1974	4676	5106	6512	678	13	126	221	960	176	715	231	17332	1851	12671	10820	19414
1975	4881	5245	6914	689	14	133	230	1085	188	783	247	18106	2056	13248	11192	20409
1976	5086	5384	7317	699	15	140	239	1219	201	854	264	18880	2274	13837	11563	21418
1977	5291	5523	7723	710	16	147	247	1363	215	928	280	19657	2506	14440	11934	22443
1978	5497	5661	8131	721	17	154	256	1516	230	1006	297	20437	2752	15058	12306	23486
1979	5702	5800	8540	732	18	162	265	1679	244	1086	314	21219	3009	15688	12679	24542
1980	5907	5939	8952	742	20	169	274	1852	260	1169	331	22003	3281	16332	13051	25615

TABLE A-3A: POTASH CONSUMPTION - LOW RANGE

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1973	4183	4693	5827	564	10	99	174	805	147	604	181	15550	1556	11279	9723	17267
1974	4377	4820	6183	571	11	105	181	905	157	664	192	16248	1726	11791	10065	18166
1975	4569	4947	6534	577	12	111	188	1012	167	727	202	16938	1906	12310	10404	19046
1976	4760	5072	6879	583	13	118	195	1125	177	793	212	17620	2095	12836	10741	19927
1977	4950	5196	7220	588	14	124	201	1246	188	860	221	18293	2294	13367	11073	20808
1978	5140	5320	7557	593	15	130	208	1373	198	930	229	18963	2501	13907	11406	21693
1979	5328	5442	7889	598	16	136	214	1508	209	1003	237	19623	2720	14454	11734	22580
1980	5516	5564	8217	603	17	142	221	1649	220	1077	244	20280	2946	15009	12063	23470

TABLE A-3B: POTASH CONSUMPTION - HIGH RANGE

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1973	4758	5243	6398	770	14	136	251	885	180	695	249	17572	1760	12934	11174	19581
1974	4974	5393	6841	785	15	146	262	1016	194	765	270	18416	1975	13550	11575	20661
1975	5193	5544	7294	800	17	154	272	1158	209	839	293	19274	2206	14186	11980	21773
1976	5412	5696	7755	816	18	162	283	1313	226	916	316	20142	2455	14842	12387	22913
1977	5632	5849	8226	832	19	171	294	1481	243	997	340	21023	2721	15518	12797	24084
1978	5853	6003	8705	848	20	179	305	1660	261	1081	365	21913	3002	16210	13208	25280
1979	6075	6158	9192	865	21	187	316	1851	280	1169	392	22814	3300	16922	13622	26506
1980	6298	6313	9687	882	23	196	327	2055	300	1260	419	23726	3615	17654	14039	27760

TABLE A-4: TOTAL NITROGEN CAPACITY

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
								(THOUSAND METRIC TONS OF NUTRIENT)								
1967	11642	10399	8035	2079	33	232	272	866	131	2032	2252	32692	3029	27686	24657	37973
1968	12088	11182	8677	2198	33	360	272	1056	131	2235	2252	34830	3422	29575	26153	40504
1969	13321	12012	10496	2191	33	380	372	1398	403	2464	2354	38805	4265	32574	28309	45424
1970	13584	13538	11370	3442	33	380	374	1533	597	3135	2354	42721	5265	36616	31351	50340
1971	13756	14602	11789	4082	68	380	334	1533	597	3995	2354	45011	6125	39347	33222	53490
1972	13778	15322	13693	4918	68	482	290	1722	664	4922	2336	48551	7308	42166	34858	58195
1973	13837	15556	15510	5094	68	482	262	2138	960	6403	2336	50809	9501	44800	35299	62646
1974	14242	15297	17028	5066	68	630	262	3006	960	6867	2336	52593	10833	46398	35565	65762
1975	14574	15764	20179	5066	68	782	262	3141	960	8561	2417	56695	12662	49178	36516	71774
1976	14820	15764	20283	5066	68	782	262	4577	1050	9391	2633	57045	15018	51780	36762	74696
1977	14820	16531	20283	5066	68	782	262	4577	1429	9826	3692	57812	15832	53361	37529	77336
1978	14820	16531	20283	5066	68	782	262	4577	1700	9826	3692	57812	16103	53632	37529	77607

TABLE A-5: NITROGEN FERTILIZER SUPPLY - MAXIMUM

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
								(THOUSAND METRIC TONS OF NUTRIENT)								
1967	8382	7487	5785	1497	24	167	196	701	106	1646	1824	23538	2453	20206	17753	27815
1968	8479	7656	5924	1523	24	199	196	732	106	1679	1824	24001	2517	20594	18077	28342
1969	8841	8005	6455	1578	24	231	217	818	150	1749	1841	25351	2717	21613	18896	29909
1970	9293	8739	7222	1848	24	274	239	988	226	1993	1857	27639	3207	23624	20417	32703
1971	9742	9538	8025	2256	31	274	240	1176	389	2353	1907	30106	3918	25999	22081	35931
1972	9860	10363	8779	2935	39	296	209	1272	494	2968	1892	32481	4734	28436	23702	39107
1973	9927	10875	9703	3338	49	318	189	1370	553	3776	1892	34399	5699	30395	24696	41990
1974	10033	11014	10972	3648	49	379	189	1670	634	4542	1892	36284	6846	32158	25312	45022
1975	10209	11115	12504	3648	49	444	189	2035	778	5611	1905	38158	8424	34078	25654	48487
1976	10451	11216	13544	3648	49	519	189	2711	792	6246	1953	39616	9749	35821	26072	51318
1977	10600	11516	14574	3648	49	563	189	3009	868	7274	2199	41139	11151	37716	26565	54489
1978	10670	11681	14604	3648	49	563	189	370[illegible]	1017	7748	2476	41404	12472	39272	26800	56352

TABLE A-6: NITROGEN FERTILIZER SUPPLY - HIGH

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
								(THOUSAND METRIC TONS OF NUTRIENT)								
1967	7963	7113	5496	1422	23	159	186	491	74	1152	1277	22362	1717	18583	16866	25356
1968	8059	7262	5635	1448	23	191	186	522	74	1185	1277	22824	1781	18970	17189	25882
1969	8422	7630	6166	1499	23	223	208	608	118	1255	1293	24171	1981	19986	18005	27445
1970	8858	8337	6910	1769	23	260	230	731	194	1450	1310	26387	2375	21852	19477	30072
1971	9262	9105	7647	2177	30	260	228	836	291	1754	1335	28709	2881	23943	21062	32925
1972	9371	9875	8369	2611	38	282	198	900	349	2206	1325	30944	3455	26030	22575	35724
1973	9431	10349	9279	3191	47	304	179	998	408	2605	1325	32780	4211	27712	23501	38316
1974	9537	10463	10479	3465	47	362	179	1252	472	3346	1325	34532	5070	29123	24053	40927
1975	9711	10564	11945	3465	47	426	179	1515	544	4055	1338	36337	6114	30506	24392	43789
1976	9938	10665	13031	3465	47	497	179	1981	559	4577	1386	37622	7117	31908	24791	46325
1977	10075	10948	13847	3465	47	535	179	2246	635	5193	1612	39096	8074	33323	25249	48782
1978	10137	11114	13874	3465	47	535	179	2595	762	5466	1836	39351	8823	34300	25477	50010

TABLE A-7. NITROGEN FERTILIZER SUPPLY - LOW

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
								(THOUSAND METRIC TONS OF NUTRIENT)								
1967	7125	6364	4917	1272	20	142	166	421	64	988	1094	20006	1473	16562	15089	22573
1968	7221	6533	5056	1298	20	174	166	452	64	1020	1094	20468	1536	16948	15412	23098
1969	7584	6862	5588	1341	20	206	188	538	108	1090	1111	21809	1736	17957	16221	24656
1970	7987	7532	6285	1611	20	233	210	646	183	1269	1128	23878	2098	19691	17593	27104
1971	8303	8240	6892	2020	28	233	204	723	259	1554	1144	25920	2536	21564	19028	29600
1972	8392	8900	7551	2564	35	255	177	776	301	1952	1135	27874	3029	23352	20323	32038
1973	8441	9298	8430	2897	42	277	160	874	360	2482	1135	29545	3716	24831	21115	34396
1974	8545	9362	9493	3100	42	327	160	1112	419	2947	1135	31029	4478	26014	21536	36642
1975	8715	9463	10829	3100	42	392	160	1342	467	3537	1148	32701	5346	27218	21872	39195
1976	8913	9564	11805	3100	42	451	160	1737	481	4021	1197	34035	6239	28469	22230	41471
1977	9026	9813	12394	3100	42	475	160	1992	557	4500	1416	35014	7049	29669	22620	43479
1978	9070	9979	12413	3100	42	479	160	2224	677	4705	1623	35243	7606	30436	22830	44472

TABLE A-8: NITROGEN SUPPLY BALANCE - MAXIMUM

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	2638	2462	1028	644	-1	69	77	-105	-342	-113	-320	6917	-560	5329	5889	6037
1968	2001	2141	487	623	-4	68	50	-205	-364	-281	-112	5366	-850	4029	4879	4404
1969	2287	2250	120	659	-3	87	30	-299	-379	-746	-715	5430	-1424	3886	5310	3291
1970	2256	2247	368	956	-6	124	52	-192	-363	-898	-994	5997	-1452	4176	5629	3550
1971	2072	3093	210	1383	-1	93	83	-184	-272	-814	-1451	6933	-1270	5453	6723	4212
1972	2152	3539	185	2059	6	88	68	-214	-279	-491	-1706	8097	-984	6928	7912	5407
1973	1424	3771	405	2416	15	103	-12	-281	-224	-60	-2043	8122	-565	7152	7717	5514
1974	1346	3570	842	2719	14	145	-26	-152	-204	300	-2421	8310	-56	7412	7468	5833
1975	737	3332	1517	2714	12	189	-41	31	-124	943	-2798	8460	850	7793	6943	6512
1976	495	3093	1775	2711	11	243	-56	515	-176	1132	-3153	8272	1471	7968	6497	6590
1977	159	3053	1799	2712	10	265	-70	610	-170	1694	-3323	7928	2134	8263	6129	6739
1978	-225	2679	897	2714	8	242	-85	1095	-93	1682	-3474	6430	2684	8217	5533	5640

TABLE A-9: NITROGEN SUPPLY BALANCE - HIGH

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	2219	2068	739	569	-2	61	67	-315	-374	-607	-867	5741	-1296	3706	5002	3578
1968	1581	1767	198	548	-5	60	40	-415	-396	-775	-659	4189	-1586	2405	3991	1944
1969	1868	1875	-169	580	-4	79	21	-509	-411	-1240	-1263	4250	-2160	2259	4419	827
1970	1821	2345	56	877	-7	110	43	-449	-395	-1441	-1541	5245	-2285	2904	5189	1419
1971	1592	2660	-168	1304	-2	79	71	-524	-371	-1413	-2023	5536	-2308	3396	5704	1205
1972	1663	3051	-225	1935	5	74	57	-586	-424	-1253	-2273	6560	-2263	4522	6785	2024
1973	928	3245	-19	2269	13	89	-22	-653	-369	-1031	-2610	6503	-2053	4469	6522	1840
1974	550	3019	349	2536	12	128	-36	-570	-366	-896	-2988	6558	-1832	4377	6209	1738
1975	239	2761	958	2531	10	171	-51	-489	-358	-613	-3365	6639	-1460	4221	5681	1814
1976	-18	2542	1162	2528	9	221	-66	-215	-409	-537	-3720	6378	-1161	4055	5216	1497
1977	-366	2465	1072	2529	8	237	-80	-153	-403	-387	-3910	5885	-943	3870	4813	1032
1978	-788	2312	167	2531	6	214	-95	-17	-348	-600	-4114	4347	-965	3215	4180	-732

TABLE A-10: NITROGEN SUPPLY BALANCE - LOW

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	1381	1339	160	419	-5	44	47	-385	-384	-771	-1050	3385	-1540	1685	3225	795
1968	743	1018	-381	398	-6	43	20	-485	-406	-940	-842	1833	-1831	383	2214	-840
1969	1030	1127	-747	422	-7	62	1	-579	-421	-1405	-1445	1888	-2405	230	2635	-1962
1970	950	1540	-569	719	-10	83	23	-534	-406	-1622	-1723	2736	-2562	743	3305	-1549
1971	633	1795	-923	1147	-4	52	47	-637	-403	-1613	-2214	2747	-2653	1017	3670	-2120
1972	684	2076	-1043	1688	2	47	36	-710	-472	-1507	-2463	3490	-2689	1844	4533	-1662
1973	-62	2194	-868	1975	8	62	-41	-777	-417	-1354	-2800	3268	-2548	1588	4136	-2080
1974	-442	1918	-637	2171	7	93	-55	-710	-419	-1295	-3178	3055	-2424	1268	3692	-2547
1975	-757	1660	-158	2166	5	137	-70	-662	-435	-1131	-3555	3003	-2228	933	3161	-2780
1976	-1043	1441	-64	2163	4	175	-85	-459	-487	-1093	-3909	2591	-2039	616	2655	-3357
1977	-1415	1350	-381	2164	3	181	-99	-407	-481	-1080	-4106	1803	-1968	216	2184	-4271
1978	-1855	1177	-1294	2166	1	158	-114	-388	-433	-1361	-4327	239	-2182	-649	1533	-6270

TABLE A-11A: ACTUAL NITROGEN PRODUCTION

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	6024	7033	5074	1769	25	77	44	492	163	528	1078	20066	1183	16175	14992	22327
1968	7077	7605	5945	2035	26	90	55	511	150	894	1143	22893	1555	18503	16948	25591
1969	7693	8145	6926	2099	28	145	95	636	144	1246	1272	25133	2026	20231	18205	28431
1970	8234	7841	7759	2131	30	204	160	726	163	1556	1392	26359	2445	21045	18600	30196
1971	8887	8107	9093	2105	27	200	145	768	203	1368	1631	28564	2339	21810	19471	32534
1972	9078	8366	9901	2121	32	235	170	807	235	2104	2060	29923	3146	23168	20022	35129

TABLE A-11B: ACTUAL NITROGEN EXPORT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	867	2650	237	931	1	1	0	195	1	15	24	4687	211	4661	4450	4922
1968	1151	2659	371	1052	1	6	0	202	1	69	27	5240	272	5141	4869	5539
1969	1744	3002	531	896	2	16	0	230	1	100	60	6191	331	5991	5660	6582
1970	1613	2616	640	1236	4	29	1	198	3	133	49	6139	334	5833	5499	6522
1971	1424	2698	789	1411	8	11	24	257	6	179	18	6365	442	6018	5576	6825
1972	1373	2632	1141	1274	11	15	26	243	23	197	20	6472	463	5794	5331	6955

TABLE A-11C: ACTUAL NITROGEN IMPORT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	630	827	334	0	1	22	57	533	295	1220	1118	1871	2048	3565	1537	5037
1968	630	862	362	8	2	23	101	672	383	1771	813	1988	2826	4452	1626	5627
1969	640	938	449	10	3	10	107	735	391	1661	1359	2157	2787	4495	1708	6303
1970	783	975	426	0	5	1	33	677	405	1603	1497	2223	2685	4482	1797	6405
1971	854	1125	386	0	13	2	27	848	399	1255	1745	2407	2502	4523	2021	6654
1972	794	1300	392	0	14	23	21	672	567	1390	1557	2544	2829	4981	2152	6930

TABLE A-11D: ACTUAL NET TRADE BALANCE - NITROGEN

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	237	1823	-97	931	0	-21	-57	-338	-294	-1205	-1094	2816	-1837	1076	2913	-115
1968	521	1797	9	1044	-1	-17	-101	-470	-382	-1702	-786	3252	-2554	689	3243	-88
1969	1104	2064	82	886	-1	6	-107	-505	-390	-1561	-1299	4034	-2456	1496	3952	279
1970	830	1641	214	1236	-1	28	-32	-479	-402	-1470	-1448	3916	-2351	1351	3702	117
1971	570	1573	403	1411	-5	9	-3	-591	-393	-1076	-1727	3958	-2060	1495	3555	171
1972	579	1332	749	1274	-3	-6	5	-629	-544	-1193	-1537	3928	-2366	813	3179	25

TABLE A-12: UREA PRODUCTION CAPACITY

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	1414	1526	1407	946	0	50	15	215	55	980	512	5358	1250	5201	3951	7120
1968	1508	1842	1871	1058	0	128	15	239	55	1233	549	6422	1527	6078	4551	8498
1969	1788	2536	2504	1058	0	128	15	280	120	1221	702	8029	1621	7146	5525	10352
1970	1960	2726	2915	1319	0	128	119	280	120	1759	717	9167	2159	8411	6252	12043
1971	2029	3240	3216	1842	14	128	119	510	120	2475	717	10588	3105	10477	7372	14410
1972	1984	3430	4131	1809	14	174	119	510	427	3419	717	11661	4356	11886	7530	16734
1973	1989	3542	4721	1869	14	174	104	841	427	4268	734	12403	5536	13218	7682	18673
1974	2302	3535	5151	1735	14	174	104	1023	436	4698	734	13015	6157	14021	7864	19906
1975	2529	3770	6058	1874	14	326	104	1105	436	6033	734	14675	7574	16191	8617	22983
1976	2914	3770	6150	1874	14	276	104	1447	39	7524	1788	15102	9610	18562	8952	26500
1977	2914	3905	6150	1874	14	276	104	1447	38	7747	2271	15237	9932	19019	9087	27440
1978	2914	3905	6150	1874	14	276	104	1447	976	8367	2271	15237	10790	19877	9087	28298

TABLE A-13: NORMAL SUPERPHOSPHATE PRODUCTION

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	1092	1387	2580	219	12	194	1264	94	95	154	636	6748	343	4511	4168	7727
1968	985	1215	2605	211	19	186	1241	118	91	183	660	6462	392	4249	3857	7514
1969	789	1203	2666	191	12	179	1190	161	109	140	698	6230	410	3974	3564	7338
1970	715	1112	2926	165	14	160	1134	160	111	135	796	6226	406	3706	3300	7428
1971	588	1001	2997	132	14	150	1010	183	127	145	933	5892	455	3350	2895	7280
1972	635	1079	3155	126	15	140	1010	226	200	173	1110	6160	599	3604	3005	7869
1973	580	020	3150	105	15	130	1100	250	200	180	1150	6100	630	3580	2950	7880
1974	560	1000	3150	92	15	120	1150	250	200	200	1200	6087	650	3587	2937	7937
1975	520	980	3100	86	15	110	1200	250	200	200	1250	6011	650	3561	2911	7911
1976	460	940	3000	80	15	105	1250	250	200	200	1250	5850	650	3500	2850	7750
1977	400	900	2900	80	15	100	1300	250	200	200	1250	5695	650	3445	2795	7595
1978	360	800	2800	78	15	95	1350	250	200	200	1250	5498	650	3348	2698	7398

TABLE A-14: CONC. SUPERPHOSPHATE PRODUCTION

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	1423	385	433	28	0	54	0	0	210	28	0	2323	238	2128	1890	2561
1968	1330	458	521	31	0	76	0	0	184	32	0	2416	216	2111	1895	2632
1969	1314	625	688	42	0	100	0	40	319	73	0	2769	432	2513	2081	3201
1970	1208	634	791	33	0	100	0	44	295	69	0	2766	408	2383	1975	3174
1971	1326	669	956	29	0	100	0	55	594	79	0	3080	728	2852	2124	3808
1972	1512	686	1234	32	0	100	0	94	597	98	0	3564	789	3119	2330	4353
1973	1525	690	1300	30	0	100	0	100	600	100	0	3645	800	3145	2345	4445
1974	1560	710	1413	30	0	100	0	100	600	100	0	3813	800	3200	2400	4613
1975	1560	730	1541	30	0	100	0	100	600	100	0	3961	800	3220	2420	4761
1976	1550	750	1550	30	0	100	0	100	600	100	0	3980	800	3230	2430	4780
1977	1530	750	1550	30	0	100	0	100	600	100	0	3960	800	3210	2410	4760
1978	1500	750	1550	30	0	100	0	100	600	100	0	3930	800	3180	2380	4730

TABLE A-15: BASIC SLAG PRODUCTION

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	0	1220	116	0	0	0	0	6	5	0	0	1336	11	1231	1220	1347
1968	0	1219	108	0	0	0	0	1	7	0	0	1327	8	1227	1219	1335
1969	0	1219	102	0	0	0	0	6	7	0	0	1321	13	1232	1219	1334
1970	0	1186	101	0	0	0	0	7	9	0	0	1267	16	1202	1186	1303
1971	0	1217	106	0	0	0	0	8	5	0	0	1323	13	1230	1217	1336
1972	0	1206	90	0	0	0	0	9	5	0	0	1296	14	1220	1206	1310
1973	0	1200	80	0	0	0	0	5	5	0	0	1280	10	1210	1200	1290
1974	0	1200	75	0	0	0	0	5	5	0	0	1275	10	1210	1200	1285
1975	0	1200	70	0	0	0	0	5	5	0	0	1270	10	1210	1200	1280
1976	0	1200	65	0	0	0	0	5	5	0	0	1265	10	1210	1200	1275
1977	0	1200	60	0	0	0	0	5	5	0	0	1260	10	1210	1200	1270
1978	0	1200	60	0	0	0	0	5	5	0	0	1260	10	1210	1200	1270

TABLE A-16: NITRIC PHOSPHATE CAPACITY

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	73	1306	15	17	0	27	0	60	0	36	2	1438	96	1519	1423	1536
1968	73	1411	31	19	0	27	0	60	0	36	2	1561	96	1626	1530	1659
1969	73	1419	69	26	0	27	24	60	0	36	2	1638	96	1665	1569	1736
1970	113	1512	318	65	0	27	24	60	0	36	2	2059	96	1837	1741	2157
1971	113	1538	437	65	0	27	24	101	0	36	2	2204	137	1904	1767	2343
1972	73	1594	457	65	0	27	24	101	0	36	7	2240	137	1920	1783	2384
1973	73	1874	457	65	0	27	24	101	0	36	12	2520	137	2200	2063	2669
1974	54	1964	747	70	0	27	24	128	17	36	12	2886	181	2320	2139	3079
1975	54	1982	1107	75	0	27	24	128	17	36	12	3269	181	2343	2162	3462
1976	54	1986	1180	75	0	27	24	128	17	59	12	3346	204	2370	2166	3562
1977	54	1986	1280	75	0	27	24	128	17	155	12	3446	300	2466	2166	3758
1978	54	1986	1280	75	0	27	24	128	17	290	12	3446	435	2601	2166	3893

TABLE A-17: PHOSPHORIC ACID CAPACITY

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	5615	2697	1400	496	17	54	193	151	314	232	25	10472	697	9769	9072	11194
1968	5797	2761	1675	535	17	150	193	191	314	375	25	11128	880	10333	9453	12033
1969	5867	2885	1963	653	17	185	229	563	330	375	25	11799	1268	11104	9836	13092
1970	5958	3445	2509	842	33	185	229	680	330	644	55	13201	1654	12346	10692	14910
1971	5763	3591	2987	912	33	243	193	688	330	932	55	13722	1950	12685	10735	15727
1972	5994	3866	3259	912	33	243	193	688	645	972	55	14500	2305	13546	11241	16860
1973	6665	4045	4481	985	33	243	193	733	645	980	55	16695	2358	14572	12214	19108
1974	6961	4455	5326	883	33	243	193	803	645	1130	55	18094	2578	15346	12768	20727
1975	8399	5025	5515	883	198	243	193	900	950	1527	88	20456	3377	18318	14941	23921
1976	8988	5273	5885	883	198	268	193	1465	1575	1699	88	21688	4739	20542	15803	26515
1977	8988	5273	5885	883	223	268	193	1589	1905	1871	88	21713	5365	21193	15628	27166
1978	8988	5273	5885	883	223	268	193	1589	1905	1946	88	21713	5440	21268	15828	27241

TABLE A-18: PHOSPHATE FERTILIZER SUPPLY - MAXIMUM

(THOUSAND METRIC TONS OF NUTRIENT)

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
1967	6831	5503	4145	702	28	274	1445	270	509	397	660	18928	1176	15959	14783	20764
1968	6747	5376	4267	706	35	299	1422	297	517	454	684	18852	1268	15853	14585	20804
1969	6617	5474	4533	735	28	336	1385	434	603	451	722	19108	1488	16063	14575	21318
1970	6631	5583	5179	814	34	363	1342	550	664	576	826	19946	1790	16557	14767	22562
1971	6449	5766	5726	904	39	383	1209	814	805	693	969	20476	2312	17062	14750	23757
1972	6655	6179	6394	997	46	389	1203	941	949	940	1163	21863	2830	18299	15469	25856
1973	6809	6333	7010	1022	46	401	1293	988	1042	1120	1204	22914	3150	19054	15904	27268
1974	7150	6614	7742	962	46	391	1343	1012	1221	1192	1306	24248	3425	19931	16506	28979
1975	7851	6976	8513	958	93	381	1393	1017	1281	1299	1414	26165	3597	21249	17652	31176
1976	8462	7316	8933	953	139	383	1443	1243	1466	1493	1520	27629	4202	22898	18696	33351
1977	9112	7561	9040	954	208	385	1493	1427	1824	1793	1638	28753	5044	24757	19713	35435
1978	9284	7555	9090	952	215	390	1543	1769	2242	1964	1738	29029	5975	25914	19939	36742

TABLE A-19: PHOSPHATE FERTILIZER SUPPLY - HIGH

(THOUSAND METRIC TONS OF NUTRIENT)

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
1967	6566	5364	4079	678	27	270	1436	219	405	327	653	18420	951	15292	14341	20024
1968	6482	5237	4201	682	34	296	1413	246	413	384	677	18345	1043	15187	14144	20065
1969	6352	5335	4468	711	27	333	1376	383	500	380	715	18602	1263	15397	14134	20580
1970	6357	5440	5100	780	34	356	1333	487	533	465	819	19408	1485	15793	14308	21712
1971	6176	5617	5633	873	38	374	1199	647	660	583	961	19910	1890	16167	14277	22761
1972	6383	6003	6273	956	44	380	1193	741	804	754	1147	21232	2299	17258	14959	24678
1973	6536	6150	6866	978	44	389	1283	779	880	852	1188	22246	2511	17891	15380	25945
1974	6867	6417	7585	919	44	379	1333	804	971	913	1289	23544	2688	18647	15959	27521
1975	7536	6765	8298	915	91	369	1383	850	1031	1018	1396	25357	2899	19958	17059	29652
1976	8134	7088	8675	910	138	371	1433	998	1213	1169	1503	26749	3380	21454	18074	31632
1977	8716	7307	8770	911	199	373	1483	1155	1483	1357	1612	27759	3995	22984	18989	33366
1978	8860	7288	8802	909	206	376	1533	1338	1727	1477	1712	27974	4542	23714	19172	34228

TABLE A-20: PHOSPHATE FERTILIZER SUPPLY - LOW

(THOUSAND METRIC TONS OF NUTRIENT)

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
1967	6034	5086	3947	630	26	264	1418	202	371	303	651	17405	876	14334	13458	18932
1968	5950	4959	4069	635	33	290	1395	229	379	360	675	17331	968	14230	13262	18974
1969	5821	5056	4336	664	26	327	1358	366	465	357	713	17588	1188	14440	13252	19489
1970	5009	5154	4942	737	32	340	1315	467	489	428	816	18329	1384	14771	13387	20529
1971	5631	5320	5447	810	37	355	1180	591	612	546	959	18780	1749	15082	13333	21488
1972	5838	5651	6032	874	41	361	1174	674	756	692	1142	19971	2122	16061	13939	23235
1973	5991	5784	6577	889	41	365	1264	710	827	762	1183	20911	2299	16633	14334	24393
1974	6301	6024	7270	833	41	355	1314	734	887	820	1284	22138	2441	17309	14868	25863
1975	6907	6345	7869	829	88	345	1364	777	947	924	1391	23747	2648	18526	15878	27786
1976	7478	6634	8161	824	134	347	1414	917	1128	1061	1497	24990	3106	19935	16829	29593
1977	7924	6797	8231	824	180	349	1464	1064	1370	1212	1603	25769	3646	21184	17538	31018
1978	8013	6755	8227	822	187	350	1514	1194	1553	1314	1703	25868	4061	21702	17641	31632

TABLE A-21: PHOSPHATE SUPPLY BALANCE - MAXIMUM

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	2552	908	939	88	17	59	158	-263	337	-269	29	4801	-195	3667	3862	4635
1968	2308	590	790	36	23	52	259	-359	321	-258	55	4058	-296	2972	3268	3817
1969	2079	556	684	30	16	77	160	-323	388	-567	20	3602	-502	2416	2918	3120
1970	2202	392	1135	112	20	102	144	-220	422	-551	-6	4107	-349	2623	2972	3752
1971	1765	279	1265	248	25	111	144	-132	526	-377	35	3837	17	2589	2572	3889
1972	1976	458	1599	333	30	94	80	-102	608	-362	52	4570	144	3115	2971	4766
1973	1678	523	1927	304	32	87	7	-178	700	-291	57	4558	231	2862	2631	4846
1974	1817	607	2337	233	31	61	25	-288	844	-360	56	5111	196	2970	2774	5363
1975	2316	773	2783	221	78	35	44	-373	866	-398	59	6250	95	3562	3467	6404
1976	2725	917	2877	211	124	21	62	-354	1010	-356	58	6937	300	4360	4060	7295
1977	3172	966	2655	209	192	8	81	-333	1324	-213	67	7283	778	5406	4628	8128
1978	3142	764	2374	207	199	-2	99	-163	1703	-204	56	6783	1336	5745	4409	8175

TABLE A-22: PHOSPHATE SUPPLY BALANCE - HIGH

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	2287	489	873	64	16	55	149	-314	233	-339	22	3933	-420	2640	3060	3535
1968	2043	451	724	12	22	49	250	-410	217	-328	48	3551	-521	2306	2827	3078
1969	1814	417	619	6	15	74	151	-374	285	-638	13	3096	-727	1750	2477	2382
1970	1928	249	1056	86	20	95	135	-283	291	-662	-13	3569	-654	1859	2513	2902
1971	1492	130	1172	217	24	102	134	-299	381	-487	27	3271	-405	1694	2099	2893
1972	1704	282	1478	292	28	85	70	-302	463	-548	36	3939	-387	2074	2461	3588
1973	1405	340	1783	260	30	75	-3	-387	538	-559	41	3890	-408	1699	2107	3523
1974	1534	410	2180	190	29	49	15	-496	594	-639	39	4407	-541	1686	2227	3905
1975	2001	562	2568	178	76	23	34	-594	616	-679	41	5442	-657	2217	2874	4826
1976	2397	689	2619	168	123	9	52	-599	757	-660	41	6057	-522	2916	3438	5576
1977	2776	712	2385	166	183	-4	71	-605	983	-649	41	6289	-271	3633	3904	6059
1978	2718	497	2086	164	190	-16	89	-594	1181	-691	30	5728	-104	3538	3642	5654

TABLE A-23: PHOSPHATE SUPPLY BALANCE - LOW

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
							(THOUSAND METRIC TONS OF NUTRIENT)									
1967	1755	571	741	16	15	49	131	-331	199	-363	20	3278	-495	2042	2537	2803
1968	1511	173	592	-35	21	43	232	-427	183	-352	46	2537	-596	1349	1945	1987
1969	1283	138	487	-41	14	68	133	-391	250	-661	11	2082	-802	793	1595	1291
1970	1380	-37	898	35	18	79	117	-303	247	-699	-16	2490	-755	837	1592	1719
1971	947	-167	986	154	23	83	115	-355	333	-524	25	2141	-546	609	1155	1620
1972	1159	-70	1237	210	25	66	51	-369	415	-610	31	2678	-564	877	1441	2145
1973	860	-26	1494	171	27	51	-22	-456	485	-649	36	2555	-620	441	1061	1971
1974	968	17	1865	104	26	25	-4	-566	510	-732	34	3001	-788	348	1136	2247
1975	1572	142	2139	92	73	-1	15	-667	532	-773	36	3832	-908	785	1693	2960
1976	1741	233	2105	82	119	-15	33	-680	672	-788	35	4298	-796	1397	2193	3537
1977	1984	202	1846	79	164	-28	52	-696	870	-794	32	4299	-620	1833	2453	3711
1978	1871	-36	1511	77	171	-42	70	-738	1007	-854	21	3622	-585	1526	2111	3058

TABLE A-24A: ACTUAL PHOSPHATE PRODUCTION

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	5181	5166	3213	639	14	210	1264	213	336	227	636	15627	776	13190	12414	17039
1968	5481	5246	3433	710	21	267	1241	239	392	334	660	16399	965	13931	12966	18024
1969	5099	5685	3691	766	14	271	1190	273	446	446	698	16718	1165	14192	13027	18581
1970	5451	5670	3981	730	17	312	1134	275	430	467	796	17295	1192	14506	13314	19283
1971	5929	5967	4632	665	16	325	1016	361	442	530	933	18570	1333	15271	13938	20836
1972	6454	6209	4944	685	19	330	1103	479	500	669	1110	19744	1648	16448	14800	22502

TABLE A-24B: ACTUAL PHOSPHATE EXPORT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	833	1056	156	34	0	4	0	0	179	3	0	2083	182	2109	1927	2265
1968	1189	1196	167	31	0	4	0	0	253	5	0	2587	258	2678	2420	2845
1969	1141	1344	174	32	0	6	0	2	280	14	0	2697	296	2819	2523	2993
1970	965	1283	123	47	1	1	0	3	286	7	0	2420	296	2593	2297	2716
1971	1122	1244	176	28	1	10	0	10	259	17	0	2581	286	2691	2405	2867
1972	1329	1398	126	48	1	12	0	0	347	35	0	2914	382	3170	2788	3296

TABLE A-24C: ACTUAL PHOSPHATE IMPORT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	217	745	222	0	0	14	14	303	60	275	5	1212	638	1628	990	1855
1968	193	823	287	0	0	8	12	401	70	480	8	1323	951	1987	1036	2282
1969	187	863	296	21	0	0	11	485	86	780	5	1378	1351	2433	1082	2734
1970	265	969	237	16	0	0	25	487	103	631	4	1512	1221	2496	1275	2737
1971	274	966	257	22	0	2	19	586	130	535	4	1540	1251	2534	1283	2795
1972	320	1112	252	21	0	0	9	587	181	395	1	1714	1163	2625	1462	2878

TABLE A-24D: ACTUAL NET TRADE BALANCE - PHOSPHATE

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	616	311	-66	34	0	-10	-14	-303	119	-272	-5	871	-456	481	937	410
1968	996	373	-120	31	0	-4	-12	-401	183	-475	-8	1264	-693	691	1384	563
1969	854	481	-122	11	0	6	-11	-483	194	-766	-5	1219	-1055	286	1341	159
1970	700	314	-114	31	1	1	-25	-484	183	-624	-4	908	-925	97	1022	-21
1971	647	278	-81	6	1	8	-19	-576	129	-518	-4	1040	-965	156	1121	71
1972	1009	286	-56	27	1	12	-9	-587	166	-360	-1	1270	-781	545	1326	488

TABLE A-25: TOTAL POTASH CAPACITY

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
								(THOUSAND METRIC TONS OF NUTRIENT)								
1967	6029	5253	7550	0	1600	0	0	0	0	0	110	20432	0	12682	12882	20542
1968	5638	5343	6960	0	1600	0	0	0	0	0	110	19741	0	12781	12781	19651
1969	8861	5343	6960	0	1600	0	0	0	500	0	150	22764	500	16304	15804	23414
1970	10038	5623	6420	0	1000	0	0	0	500	0	150	23081	500	17161	16661	23731
1971	10257	5623	7320	0	1000	0	0	0	500	0	150	24200	500	17380	16880	24850
1972	9604	5823	7470	0	1000	0	0	0	500	0	150	23897	500	16927	16427	24547
1973	9604	5890	8310	0	1000	0	0	0	500	0	150	24804	500	16994	16494	25454
1974	9423	6370	8310	0	1000	0	0	0	500	0	150	25103	500	17293	16793	25753
1975	9423	6710	8656	0	750	0	0	0	500	0	150	25539	500	17383	16883	26189
1976	9423	6710	10156	0	750	0	0	0	500	0	150	27039	500	17383	16883	27689
1977	9423	6710	10156	0	750	0	0	0	500	0	150	27039	500	17383	16883	27689
1978	9423	6710	10156	0	750	0	0	0	500	0	150	27039	500	17383	16883	27689

TABLE A-26: POTASH FERTILIZER SUPPLY - HIGH

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
								(THOUSAND METRIC TONS OF NUTRIENT)								
1967	5278	4599	6609	0	1401	0	0	0	0	0	75	17887	0	11278	11278	17962
1968	5111	4623	6093	0	1401	0	0	0	0	0	75	17228	0	11135	11135	17303
1969	5946	4646	6093	0	1401	0	0	0	97	0	82	18088	97	12092	11995	18267
1970	7108	4755	5620	0	875	0	0	0	194	0	90	18358	194	12932	12738	18642
1971	8468	4832	5869	0	875	0	0	0	339	0	102	20044	339	14514	14175	20485
1972	8408	4978	6159	0	875	0	0	0	339	0	102	20420	339	14600	14261	20861
1973	8408	5062	6723	0	875	0	0	0	339	0	102	21058	339	14674	14335	21499
1974	8249	5267	7004	0	875	0	0	0	339	0	102	21395	339	14730	14391	21836
1975	8249	5516	7370	0	657	0	0	0	339	0	102	21792	339	14761	14422	22233
1976	8249	5764	7681	0	657	0	0	0	339	0	102	22551	339	15009	14670	22992
1977	8249	5874	8407	0	657	0	0	0	339	0	102	23187	339	15119	14780	23628
1978	8249	5874	8891	0	657	0	0	0	339	0	102	23671	339	15119	14780	24112

TABLE A-27: POTASH SUPPLY BALANCE - HIGH

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G REGIONS	FREE WORLD	DEV'D FR WLD	WORLD
								(THOUSAND METRIC TONS OF NUTRIENT)								
1967	1812	653	2776	-619	1396	-85	-175	-325	-100	-318	-37	5763	-743	2245	2987	4983
1968	1504	389	1865	-659	1395	-86	-157	-364	-105	-368	-62	4251	-837	1549	2386	3352
1969	2247	370	1608	-670	1394	-96	-175	-517	-8	-402	-116	4678	-927	2143	3070	3635
1970	3272	271	833	-668	866	-89	-194	-591	70	-482	-87	4291	-1003	2455	3458	3201
1971	4445	34	616	-611	864	-96	-195	-679	196	-522	-72	5057	-1005	3456	4441	3980
1972	4300	-16	337	-583	862	-108	-193	-698	174	-610	-85	4599	-1134	3128	4262	3380
1973	3937	84	611	-667	863	-118	-213	-845	176	-649	-113	4497	-1318	2568	3886	3066
1974	3573	161	492	-678	862	-126	-221	-960	163	-715	-129	4063	-1512	2059	3571	2422
1975	3368	271	456	-689	643	-133	-230	-1085	151	-783	-145	3686	-1717	1513	3230	1824
1976	3163	360	564	-699	643	-140	-239	-1219	138	-854	-167	3672	-193	1173	3108	1575
1977	2958	351	684	-710	642	-147	-247	-1363	124	-928	-17	3531	-216	680	2847	1186
1978	2752	213	760	-721	640	-154	-256	-1516	109	-1006	-195	3234	-241	61	2474	626

TABLE A-28A: ACTUAL POTASH PRODUCTION

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	4811	4705	4632	0	297	0	0	0	0	0	50	14445	0	9813	9813	14495
1968	5152	4663	5074	0	329	0	0	0	0	0	55	15218	0	10144	10144	15273
1969	5288	4761	5413	0	343	0	0	0	0	0	60	15805	0	10392	10392	15865
1970	5771	4776	5590	0	435	0	0	0	67	0	65	16572	67	11049	10982	16104
1971	5438	4929	6506	0	576	0	0	0	166	0	70	17449	166	11109	10943	17685
1972	6111	4976	7233	0	552	0	0	0	274	0	75	18872	274	11913	11639	19221

TABLE A-28B: ACTUAL POTASH EXPORT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	2433	2123	1827	0	292	0	0	0	0	0	0	6675	0	4848	4848	6675
1968	3118	2251	2108	0	249	0	0	0	0	0	0	7726	0	5618	5618	7726
1969	3091	2462	2337	0	363	0	0	0	0	0	0	8253	0	5916	5916	8253
1970	3928	2294	2354	0	440	0	0	0	0	0	0	9016	0	6662	6662	9016
1971	3479	2349	3048	0	564	0	0	0	0	0	0	9440	0	6392	6392	9440
1972	4464	2014	3369	0	531	0	0	0	0	0	0	10378	0	7009	7009	10378

TABLE A28C: ACTUAL POTASH IMPORT

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	1526	1932	1363	619	0	85	175	325	105	318	56	5700	748	5065	4337	6504
1968	2048	2119	1510	659	0	86	157	364	110	368	94	6579	842	5911	5069	7515
1969	1815	2347	1674	670	0	96	175	517	117	402	137	6777	1036	6139	5103	7950
1970	2425	2508	1796	668	0	89	194	591	120	482	112	7680	1193	7077	5884	0985
1971	2315	2514	2144	611	0	96	195	679	153	522	121	7875	1354	7085	5731	9350
1972	2854	2544	2326	583	0	108	193	698	179	610	122	8608	1487	7769	6282	10217

TABLE A-28D: ACTUAL NET TRADE BALANCE - POTASH

YEAR	NORTH AMER	WEST EUROPE	E. EUR & USSR	JAPAN	ISRAEL	SOUTH AFRICA	OCEANIA	LATIN AMER	DEV'G AFRICA	DEV'G ASIA	OTHER ASIA	DEV'D REGIONS	DEV'G	FREE WORLD	DEV'D FR WLD	WORLD
						(THOUSAND METRIC TONS OF NUTRIENT)										
1967	907	191	464	-619	292	-85	-175	-325	-105	-318	-56	975	-748	-237	511	171
1968	1070	132	598	-659	249	-86	-157	-364	-110	-368	-94	1147	-842	-293	549	211
1969	1276	115	663	-670	363	-96	-175	-517	-117	-402	-137	1476	-1036	-223	813	303
1970	1503	-214	558	-668	440	-89	-194	-591	-120	-482	-112	1336	-1193	-415	778	31
1971	1164	-165	904	-611	564	-96	-195	-679	-153	-522	-121	1565	-1354	-693	661	90
1972	1610	-530	1043	-583	531	-108	-193	-698	-179	-610	-122	1770	-1487	-760	727	161

APPENDIX B

Examples of Calculation of Plant Investment, Production Costs, and Gate Sales Prices

This section gives examples of how the plant investment, production costs, and gate sales prices were calculated. Some selected plant capacities were chosen that should be of most interest. With this data one can vary the values of raw materials, utilities, and other costs to fit a specific situation.

Table B-1 shows raw material requirements per ton of product.

Table B-2 shows the calculation of plant investment for an ammonia plant, 1,000 tons/day, using four feedstocks.

Table B-3 shows plant investment for urea plants, 1,000 and 1,667 tons/day.

Table B-4 shows plant investment for the phosphate complexes, DAP and TSP.

Tables B-5 to B-14 show examples of calculation of production cost and gate sales price.

Table B-15 shows U.S. battery limits costs for all plants used in the estimate.

The charts (figures B-1 to B-18) indicate the effect of operating level and raw material costs on the various products.

Investment Estimates

The various plants were considered to be built in developing countries where the plant investment is higher. Battery limits (United States) was used as a basis in the estimates. The U.S. battery limits costs are based on a contract signed in early 1974 with the plant to be completed in early 1977.

Assumptions for plant investments are as follows:

1. The battery limits (U.S.) cost of 1974 is escalated to 1977; these are typical quotes prevailing today.
2. The foreign battery limits cost was assumed to be 1.25 times U.S. battery limits.
3. The cost of auxiliary facilities for the complex (steam, power, water supply, etc.) was assumed to be 25% of the total battery limits costs of all the plants included in the complex.
4. The cost of supporting facilities for the complex (roads, civil works, office and administrative buildings, etc.) was assumed to be 25% of the total battery limits cost plus 25% of the auxiliaries facilities cost.
5. Liquid ammonia storage of 15,000 tons was taken as $2,000,000.
6. Solid storage for urea was as follows:

   Dehumidified bulk storage equal to one-third of annual production at $16.50/ton.

   Bag storage equal to one-twelfth annual productio a $15/ton; this includes bagging equipment.

In a world study such as this certain factors are omitte which may become important when a specific country an site have been chosen for a complex. A summary of som items which may be required to satisfy the total needs of complex is given below. Obviously, incorporation of a these factors is beyond the scope of this study.

Additional cost items for a complete complex ma include:

1. A relatively large inventory of spare parts and sho facilities.
2. Facilities for off-loading of construction and proces equipment with new roads to the plant site.
3. Emergency electric power generating facilities t supplement or back up normal electrical power supplies.
4. Housing, including medical and recreational facilitie
5. Equipment for site preparation and construction.
6. Custom charges and other forms of taxes may b significant depending on the particular country.
7. Jetties or piers and other equipment for receivin raw materials and shipment of products.

Production Cost Estimates

The following values were used in estimating th production cost per ton.

1. Depreciation—15 years.
2. Interest—8% on one half of plant investment.
3. Taxes and insurance—2% of plant investment.
4. Maintenance—5% of plant investment.
5. Labor—$3/man-hour (may be less in a developin country).
6. Analyses—20% of labor.
7. Overhead—100% of labor.
8. Bags and bagging—$6/ton.
9. Utilities

Electrical power	$0.01/kWh
Cooling water	$0.02/1,000 gallons
Boiler feed water	$0.50/1,000 gallons
Treated water	$0.10/1,000 gallons
Steam	$0.50/1,000 pounds (M lb)
Fuel	$0.15/gallon

10. Working capital—cost of 1 month's raw materials plus 3 months' in-plant value of product.
11. Interest on working capital—8% on one-half of working capital.

12. To simplify calculations, product loss usually assumed as 1%, was omitted.

13. Production costs are exit plant, not including sales and administrative expense, return on investment, or transportation charges.

14. No port facilities are included in the estimates; the cost of land is not included.

15. Operating time was 330 days/year unless noted otherwise.

Selling Prices of Products

After calculation of the production cost for each product, the gate sales price was estimated. A value equal to 20% return on investment, before taxes, was added to the estimated production cost to estimate the gate sales price. Intermediate raw materials were charged in at the production cost with the return on the total investment of the complex added to the final product, as for example urea, DAP, or TSP.

Table B-1. Raw material requirements per ton of product

	Units of raw material per ton of product					
Raw material	Ammonia[a]	Urea	Sulfuric acid (100%)[b]	Phosphoric acid (54%)[b]	DAP	TSP
Natural gas, standard cubic feet	38,500	–	–	–	–	–
Naphtha, ton	0.88	–	–	–	–	–
Heavy oil	0.965	–	–	–	–	–
Coal, ton	2.2	–	–	1.79	–	0.448
Phosphate rock, ton	–	–	–	–	–	–
Sulfur, ton	–	–	0.344	–	–	–
Carbon dioxide, ton	–	0.77	–	–	–	–
Ammonia, ton	–	0.60	–	–	0.23	–
Sulfuric acid (100%), ton	–	–	–	1.49	–	–
Phosphoric acid (54%), ton	–	–	–	–	0.87	0.648

[a]1,000 tons/day plant, centrifugal compressors.
[b]Based on rock containing 30.2% P_2O_5 and 46.5% CaO.

Table B-2. Calculation of complex investment cost–ammonia[a] (1,000 tons/day capacity)

Feedstock	Natural gas[b]	Naphtha[b]	Fuel oil[c]	Coal[c]
			$	
U.S. battery limits, 1974 basis	28,000,000	32,000,000	37,000,000	51,000,000
Foreign battery limits (1.25 x 1974 cost)	35,000,000	40,000,000	46,200,000	63,800,000
Auxiliary facilities[d] (25% of foreign battery limits)	8,750,000	10,000,000	11,500,000	15,900,000
Support facilities[e] (25% of foreign battery limits)	8,750,000	8,750,000	9,600,000	15,900,000
Subtotal	52,500,000	58,750,000	67,300,000	95,600,000
Liquid storage (15,000 tons atmospheric)	2,000,000	2,000,000	2,000,000	2,000,000
Total complex investment[f]	**54,500,000**	**60,750,000**	**69,300,000**	**97,600,000**

[a]Capacity of 330,000 tons/year.
[b]Steam reforming–centrifugal compressors.
[c]Partial oxidation–centrifugal compressors.
[d]Auxiliary facilities include such items as steam, power, water supply, and air.
[e]Support facilities include roads, civil works, office, and administrative buildings.
[f]Not including the cost of land or any dock facilities.

Table B-3. Calculation of complex investment cost—urea

Capacity, tons/day	1,000[a]	1,667[b]
U.S. battery limits, 1974 basis	17,500,000	23,600,000
Foreign battery limits (1.25 x 1974 cost)	21,875,000	29,500,000
Auxiliary facilities[c] (25% of foreign battery limits)	5,469,000	7,375,000
Support facilities[c] (25% of foreign battery limits plus 25% of auxiliary facilities)	6,836,000	9,219,000
Subtotal	34,180,000	46,094,000
Storage		
Bulk, dehumidified, 1/3 annual production at $16.50/ton	1,815,000	3,026,000
Bag, 1/12 annual production at $15/ton	413,000	688,000
Total complex investment	**36,408,000**	**49,808,000**

[a]Capacity of 330,000 tons/year.
[b]Capacity of 550,110 tons/year.
[c]Offsites may be somewhat less if urea plant adjacent to ammonia plant.

Table B-4. Calculation of complex investment for phosphate—DAP and TSP (400 tons P_2O_5/day as 54% phosphoric acid)

	Sulfuric acid (100%)	Phosphoric acid (54%)	DAP (18-46-0)	TSP (0-46-0)
Capacity, tons/day	1,101	400(P_2O_5)	851	1,143
Capacity, tons/year	363,363	132,000(P_2O_5)	280,863	377,223
U.S. battery limits, 1974 basis	6,220,000	9,095,000	2,300,000	2,011,000
Foreign battery limits (1.25 x U.S. cost)	7,775,000	11,370,000	2,875,000	2,514,000
Auxiliary facilities (25% of foreign battery limits)	1,944,000	2,840,000	719,000	628,000
Support facilities (25% of foreign battery limits + 25% of auxiliary facilities)	2,430,000	3,550,000	899,000	785,000
Subtotal	12,149,000	17,760,000	4,493,000	3,927,000
Storage				
Liquid (ammonia)			2,000,000	
Bulk (1/3 of annual)			1,029,000	1,383,000
Bag (1/12 of annual)			351,000	472,000
Total	12,149,000	17,760,000	7,873,000	5,782,000
Total for complex[a]			**37,782,000**	**35,691,000**

[a]Not including the cost of land, pier, or dock facilities as may be needed for rock, sulfur, and load out of product.

Table B-5. Estimated production cost and gate sales price

Ammonia–natural gas feedstock
Basis–1,000 tons/day; 330,000 tons/yr
Total plant investment–$54,500,000
Working capital–$4,750,000
Total capital investment–$59,250,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Natural gas, ft^3	38,500	0.40/1,000	15.40
Subtotal			15.40
Fixed and variable costs			
Cooling water, gal	55,000	0.02/1,000	1.10
Boiler-feed water, gal	600	0.50/1,000	0.30
Electricity, kWh	33	0.01/kWh	0.33
Catalyst & chemicals			0.60
Labor, man-hr	0.12	3.00/man-hr	0.36
Maintenance (5% of P.I.)			8.25
Taxes and ins. (2% of P.I.)			3.30
Depreciation (15 yr)			11.05
Analyses (20% labor)			0.07
Interest (8% of ½ P.I.)			6.60
Overhead (100% of labor)			0.36
Subtotal			32.32
Production cost			47.72
Interest on working capital			0.58
Total			48.30
Return on capital investment (20%)			36.00
Gate sales price, $/ton			84.30

Table B-6. Estimated production cost and gate sales price

Ammonia–naphtha feedstock
Basis–1,000 tons/day; 330,000 tons/yr
Total plant investment–$60,750,000
Working capital–$6,980,000
Total capital investment–$67,730,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Naphtha, ton	0.88	35.00	30.80
Subtotal			30.80
Fixed and variable costs			
Cooling water, gal	72,000	0.02/1,000	1.44
Boiler-feed water, gal	490	0.50/1,000	0.25
Electricity, kWh	50	0.01/kWh	0.50
Catalyst & chemicals			0.80
Labor, man-hr	0.13	3.00/man-hr	0.39
Maintenance (5% of P.I.)			9.20
Taxes and ins. (2% of P.I.)			3.68
Depreciation (15 yr)			12.30
Analyses (20% labor)			0.08
Interest (8% of ½ P.I.)			7.35
Overhead (100% of labor)			0.39
Subtotal			36.38
Production cost			67.18
Interest on working capital			0.84
Total			68.02
Return on capital investment (20%)			41.00
Gate sales price, $/ton			109.02

Table B-7. Estimated production cost and gate sales price

Ammonia—heavy oil feedstock
Basis—1,000 tons/day; 330,000 tons/yr
Total plant investment—$69,300,000
Working capital—$6,510,000
Total capital investment—$75,810,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Heavy oil, ton	0.965	25.00	24.10
Subtotal			24.10
Fixed and variable costs			
Cooling water, gal	88,000	0.02/1,000	1.76
Boiler-feed water, gal	400	0.50/1,000	0.20
Steam, M lb			0.76
Electricity, kWh	50	0.01/kWh	0.50
Catalyst & chemicals			0.40
Labor, man-hr	0.16	3.00/man-hr	0.48
Maintenance (5% of P.I.)			10.50
Taxes and ins. (2% of P.I.)			4.20
Depreciation (15 yr)			14.05
Analyses (20% labor)			0.10
Interest (8% of ½ P.I.)			8.40
Overhead (100% of labor)			0.48
Subtotal			41.07
Production cost			64.41
Interest on working capital			0.79
Total			65.20
Return on capital investment (20%)			45.90
Gate sales price			111.10

Table B-8. Estimated production cost and gate sales price

Ammonia—coal feedstock
Basis—1,000 tons/day; 330,000 tons/yr
Total plant investment—$97,600,000
Working capital—$6,480,000
Total capital investment—$104,080,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Coal, ton	2.2	5.00	11.00
Subtotal			11.00
Fixed and variable costs			
Cooling water, gal	77,000	0.02/1,000	1.54
Boiler-feed water, gal	500	0.50/1,000	0.25
Electricity, kWh	150	0.01/kWh	1.50
Catalyst & chemicals			0.40
Labor, man-hr	0.2	3.00/man-hr	0.60
Maintenance (5% of P.I.)			14.80
Taxes and ins. (2% of P.I.)			5.90
Depreciation (15 yr)			19.80
Analyses (20% labor)			0.12
Interest (8% of ½ P.I.)			11.80
Overhead (100% of labor)			0.60
Subtotal			57.31
Production cost			68.31
Interest on working capital			0.79
Total			69.10
Return on capital investment (20%)			63.00
Gate sales price			132.10

Table B-9. Estimated production cost and gate sales price

Urea (46% N)
Basis—1,667 tons/day; 550,110 tons/yr
Total plant investment—$49,808,000
Working capital—$9,146,000
Total capital investment—$58,954,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Carbon dioxide, ton	0.77	2.00	1.54
Ammonia, ton	0.60	49.00	29.40
Subtotal			30.94
Fixed and variable costs			
Cooling water, gal	29,000	0.02/1,000	0.58
Steam, M lb	0.429	0.50/M lb	0.21
Electricity, kWh	155	0.01/kWh	1.55
Labor, man-hr	0.16	3.00/man-hr	0.48
Maintenance (5% of P.I.)			4.53
Taxes and ins. (2% of P.I.)			1.81
Depreciation (15 yr)			6.04
Analyses (20% labor)			0.10
Interest (8% of ½ P.I.)			3.62
Overhead (100% of labor)			0.48
Subtotal			19.40
Production cost			50.34
Bags			6.00
Subtotal (bagged)			56.34
Interest on working capital (bagged)			0.67
Total (bagged)			57.01
Return on complex investment (20%) (ammonia + urea = $118,204,000)			42.97
Gate sales price (bagged)			99.98

Table B-10. Estimated production cost and gate sales price

Urea (46% N)
Basis—1,000 tons/day; 330,000 tons/yr
Total plant investment—$36,408,000
Working capital—$6,240,000
Total capital investment—$42,650,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Carbon dioxide, ton	0.77	2.00	1.54
Ammonia, ton	0.60	55.00	33.00
Subtotal			34.54
Fixed and variable costs			
Cooling water, gal	29,000	0.02/1,000	0.58
Steam, M lb	0.429	0.50/M lb	0.21
Electricity, kWh	155	0.01/kWh	1.55
Labor, man-hr	0.264	3.00/man-hr	0.79
Maintenance (5% of P.I.)			5.52
Taxes and ins. (2% of P.I.)			2.21
Depreciation (15 yr)			7.36
Analyses (20% labor)			0.16
Interest (8% of ½ P.I.)			4.41
Overhead (100% of labor)			0.79
Subtotal			23.58
Production cost			58.12
Bags			6.00
Subtotal (bagged)			64.12
Interest on working capital (bagged)			0.76
Total (bagged)			64.88
Return on complex investment (20%) (ammonia + urea = $85,369,000)			51.74
Gate sales price (bagged)			116.62

Table B-11. Estimated production cost and gate sales price

Sulfuric acid (100%)
Basis—1,101 tons/day; 363,363 tons/yr
Total plant investment—$12,149,000
Working capital—$2,460,000
Total capital investment—$14,609,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Sulfur, ton	0.344	44.50	15.31
Subtotal			15.31
Fixed and variable costs			
Cooling water, gal	24,000	0.02/1,000	0.48
Boiler-feed water, gal	1,100	0.50/1,000	0.55
Steam, M lb	2.2	0.50/M lb	-1.10
Electricity, kWh	30	0.01/kWh	0.30
Labor, man-hr	0.08	3.00/man-hr	0.24
Maintenance (5% of P.I.)			1.67
Taxes and ins. (2% of P.I.)			0.67
Depreciation (15 yr)			2.23
Analyses (20% labor)			0.05
Interest (8% of ½ P.I.)			1.34
Overhead (100% of labor)			0.24
Subtotal			6.67
Production cost			21.98
Interest on working capital			0.27
Total			22.25

Table B-12. Estimated production and annual manufacturing costs

Wet-process phosphoric acid
Basis—400 (P_2O_5) tons/day; 132,000 tons/year (P_2O_5)
244,431 tons/year as 54% acid
Total plant investment—$17,760,000
Working capital—$8,602,000
Total capital investment—$26,362,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Unground rock, ton	3.31	34.00	112.54
Sulfuric acid, ton (100%)	2.75	22.25	61.19
Subtotal			173.73
Fixed and variable costs			
Cooling water, gal	5,500	0.02/1,000	0.11
Electricity, kWh	330	0.01/kWh	3.30
Labor, man-hr	0.28	3.00/man-hr	0.84
Maintenance (5% of P.I.)			6.73
Taxes and ins. (2% of P.I.)			2.69
Depreciation (15 yr)			8.97
Analyses (20% labor)			0.17
Interest (8% of ½ P.I.)			5.38
Overhead (100% of labor)			0.84
Subtotal			29.03
Production cost			202.76
Interest on working capital			2.61
Total		(P_2O_5 basis)	205.37
Production cost as 54% acid (0.54 x $205.37)			110.90

Table B-13. Estimated production cost and gate sales price

Diammonium phosphate (18-46-0)
Basis—851 tons/day; 280,863 tons/year
Total plant investment—$7,873,000
Working capital—$10,958,000
Total capital investment—$18,831,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Ammonia, ton	0.23	49.00	11.27
Phosphoric acid, ton (54%)	0.87	110.90	96.48
Subtotal			107.75
Fixed and variable costs			
Electricity, kWh	22	0.01/kWh	0.22
Fuel, gal	3.3	0.15/gal	0.50
Labor, man-hr	0.11	3.00/man-hr	0.33
Maintenance (5% of P.I.)			1.40
Taxes and ins. (2% of P.I.)			0.56
Depreciation (15 yr)			1.87
Analyses (20% labor)			0.07
Interest (8% of ½ P.I.)			1.12
Overhead (100% of labor)			0.33
Subtotal			6.40
Production cost			114.15
Bags			6.00
Subtotal (bagged)			120.15
Interest on working capital (bagged)			1.56
Total (bagged)			121.71
Return on complex investment (20%) (sulfuric-phosphoric acid plus DAP = $59,802,000)			42.58
Gate sales price (bagged) (DAP)			164.29

Table B-14. Estimated production cost and gate sales price

Triple superphosphate (0-46-0)
Basis—1,143 tons/day; 377,223 tons/year
Total plant investment—$5,782,000
Working capital—$11,939,000
Total capital investment—$17,721,000

	Unit/ton product	$/unit	Cost $/ton
Raw materials			
Unground rock, ton	0.448	34.00	15.23
Phosphoric acid, ton (54%)	0.648	110.90	71.86
Subtotal			87.09
Fixed and variable costs			
Electricity, kWh	8.0	0.01/kWh	0.08
Fuel, gal	3.3	0.15/gal	0.50
Labor, man-hr	0.18	3.00/man-hr	0.54
Maintenance (5% of P.I.)			0.77
Taxes and ins. (2% of P.I.)			0.31
Depreciation (15 yr)			1.02
Analyses (20% labor)			0.11
Interest (8% of ½ P.I.)			0.51
Overhead (100% of labor)			0.54
Subtotal			4.48
Production cost			91.57
Bags			6.00
Subtotal (bagged)			97.57
Interest on working capital (bagged)			1.27
Total (bagged)			98.84
Return on complex investment (20%) (sulfuric-phosphoric acid plus TSP = $58,692,000)			31.12
Gate sales price (bagged), (TSP)			129.96

Table B-15. U.S. battery limits costs of plants in study[a]

	Feedstock	Capacity, tons/day		
Nitrogen				
Ammonia		200	600	1,000
	Natural gas	$10,000,000	$20,000,000	$28,000,000
	Naphtha	11,500,000	23,000,000	32,000,000
	Heavy oil	13,000,000	27,000,000	37,000,000
	Coal	18,000,000	37,500,000	51,000,000
Urea	Ammonia	333	1,000	1,667
	Carbon dioxide	$ 9,250,000	$17,500,000	23,600,000
Phosphate				
Sulfuric acid	Sulfur	550	1,100	1,651
		$ 4,000,000	$ 6,220,000	$ 8,200,000
		200 (P_2O_5)	400 (P_2O_5)	600 (P_2O_5)
Phosphoric acid	Sulfuric acid	$ 6,740,000	$ 9,095,000	$11,240,000
	Phosphate rock			
DAP	Phosphoric acid	425	851	1,277
	Ammonia	$ 1,750,000	$ 2,300,000	$ 2,750,000
		572	1,143	1,715
TSP	Phosphoric acid	$ 1,238,000	$ 2,011,000	$ 2,568,000
	Phosphate rock			

[a]Indicates only the plant process equipment which serves as a basis for estimating developing country costs and total complex investment costs.

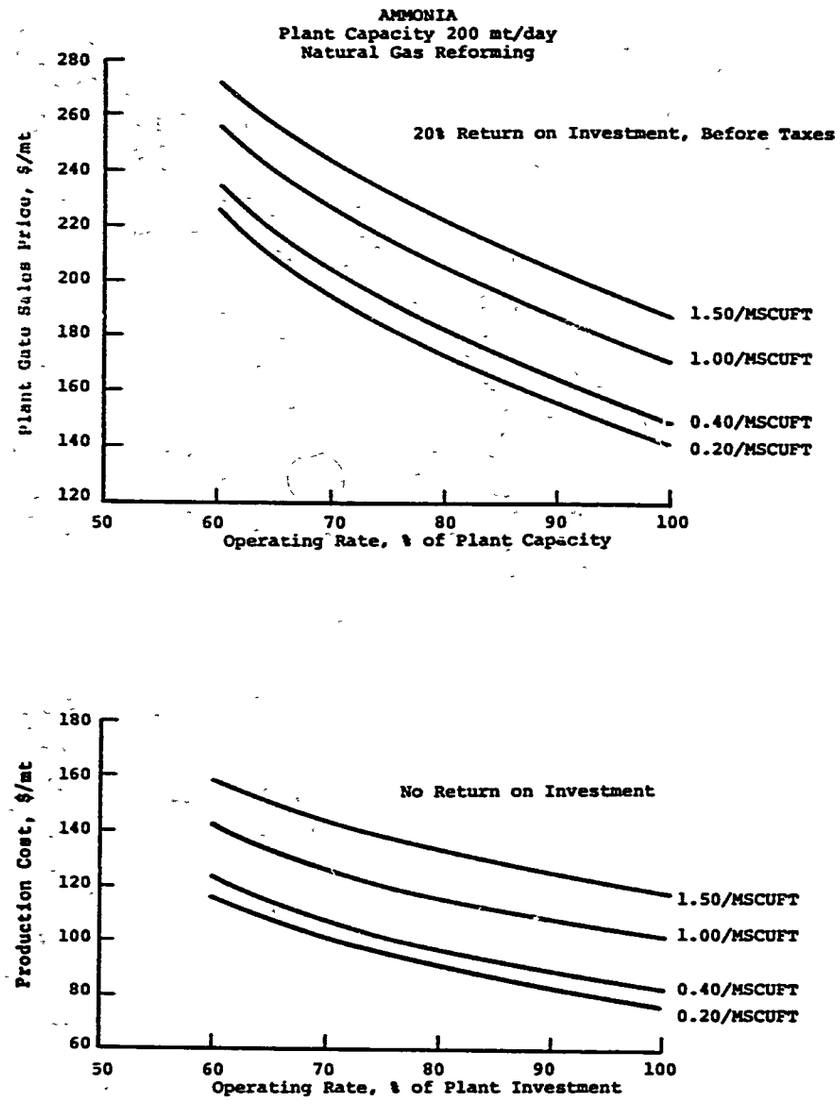

Figure B-1. Effect of plant turndown, ammonia

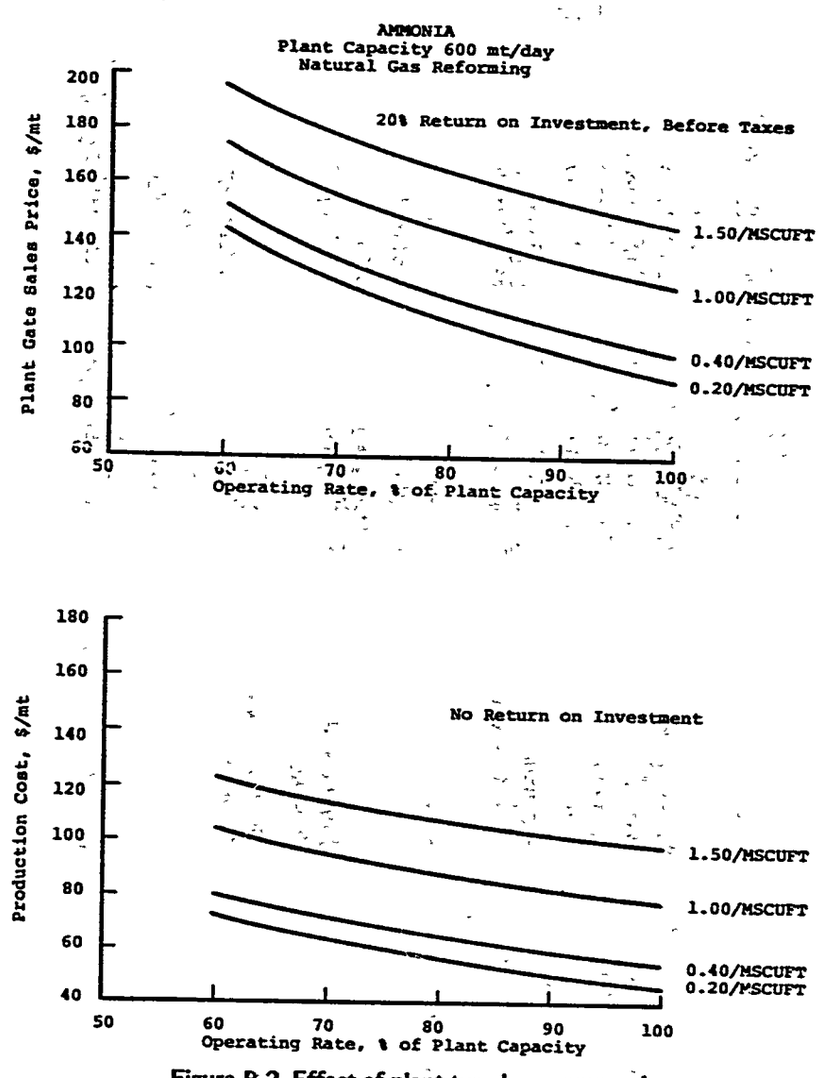

Figure B-2. Effect of plant turndown, ammonia

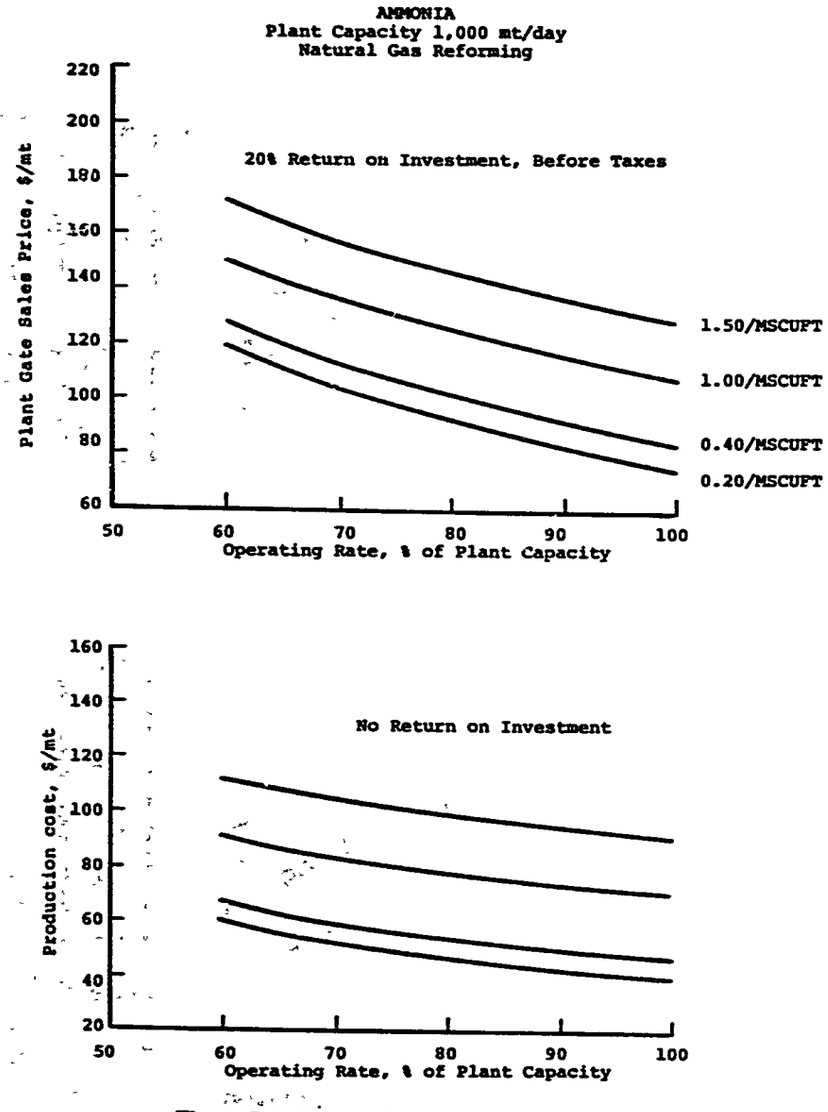

Figure B-3. Effect of plant turndown, ammonia

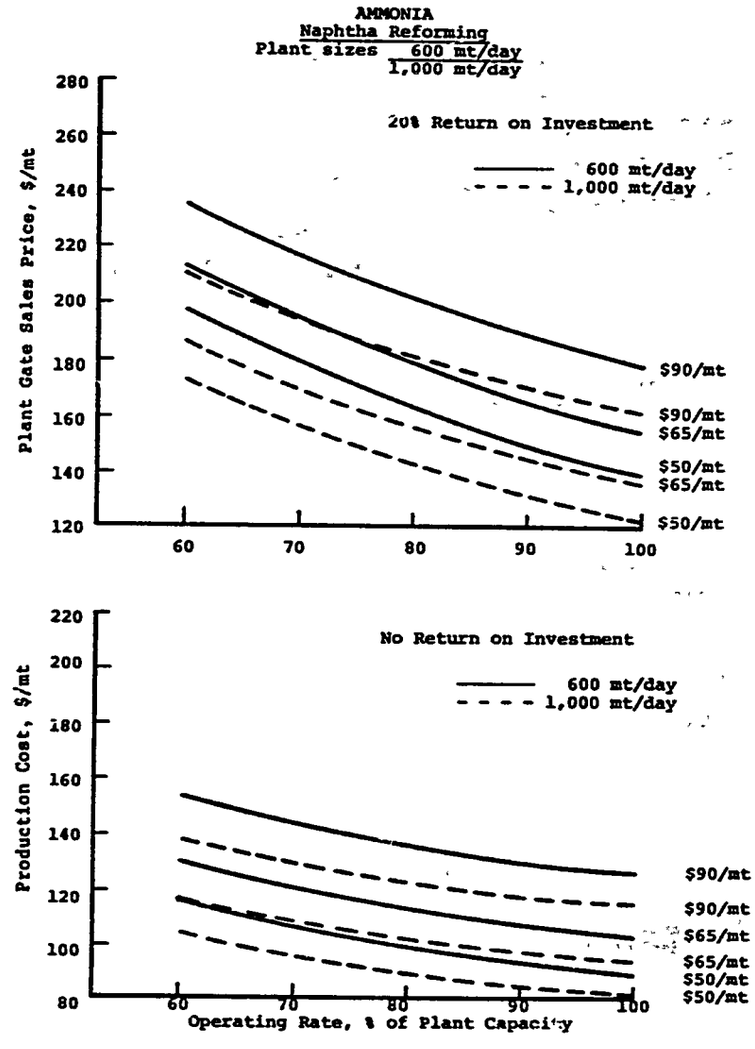

Figure B-4. Effect of plant turndown, ammonia

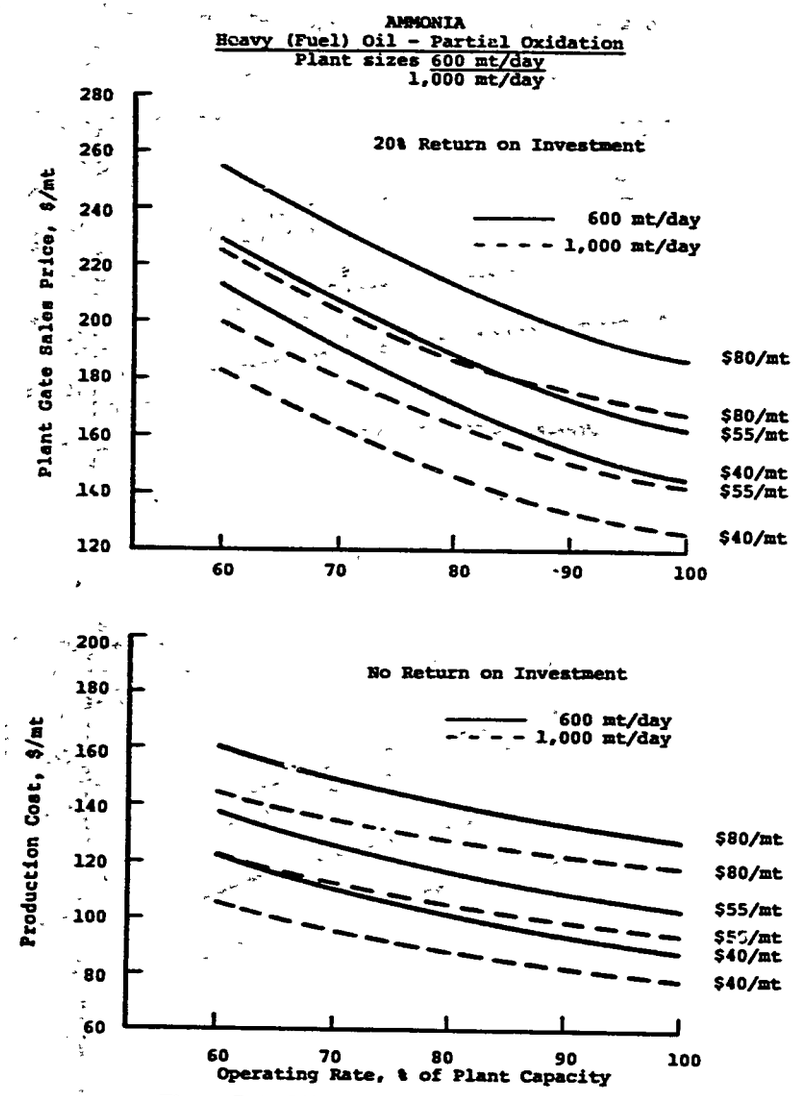

Figure B-5. Effect of plant turndown, ammonia

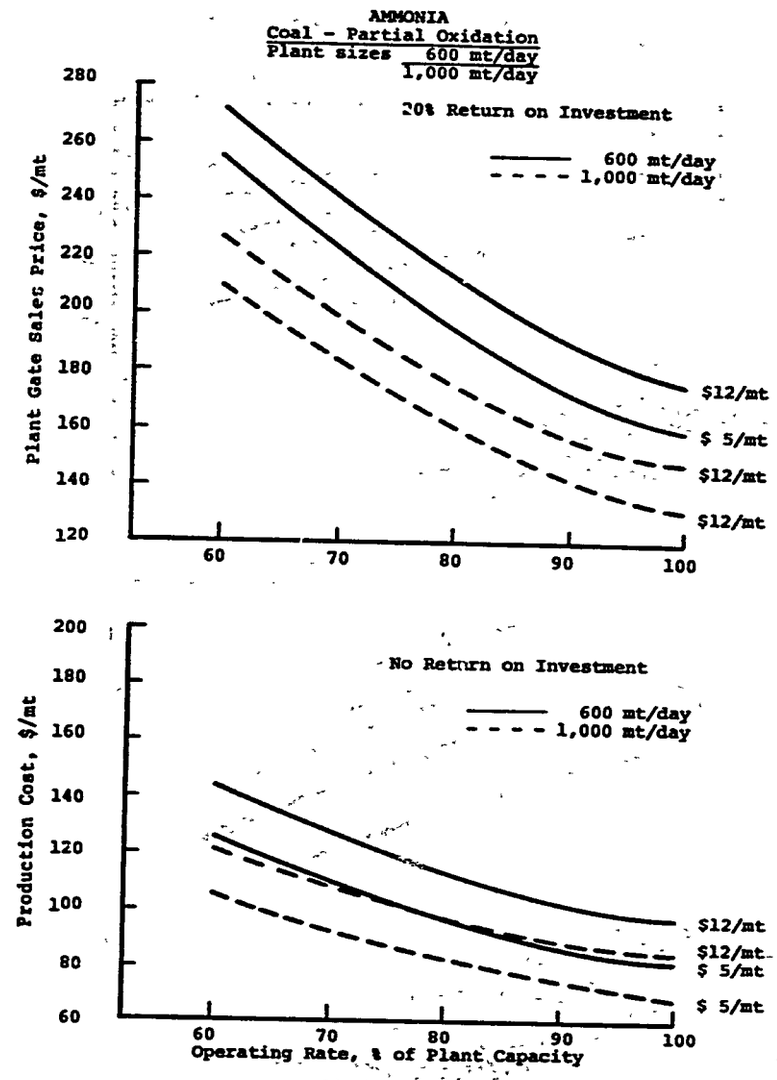

Figure B-6. Effect of plant turndown, ammonia

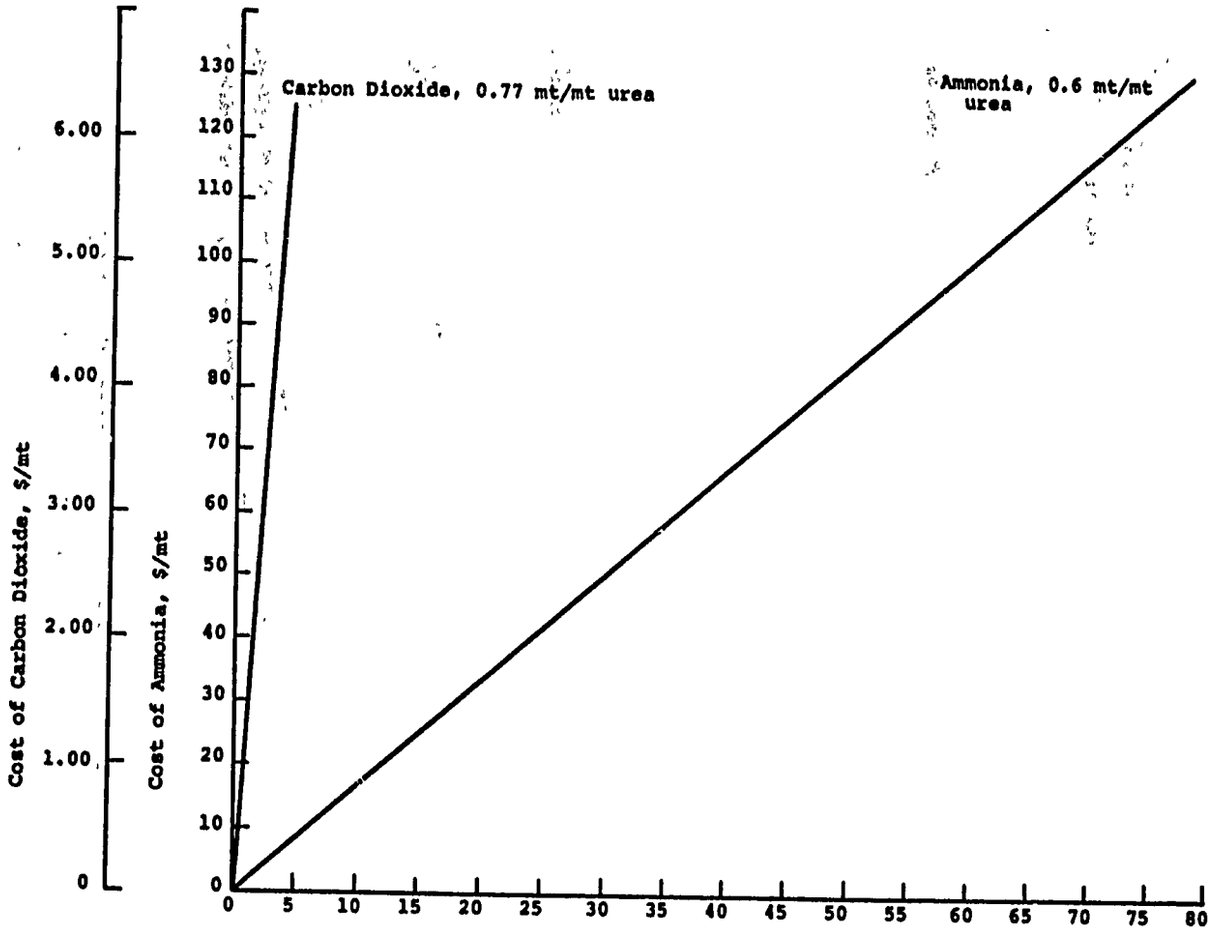

Figure B-7. Raw materials portion of urea production cost (cost/mt urea, $/mt)

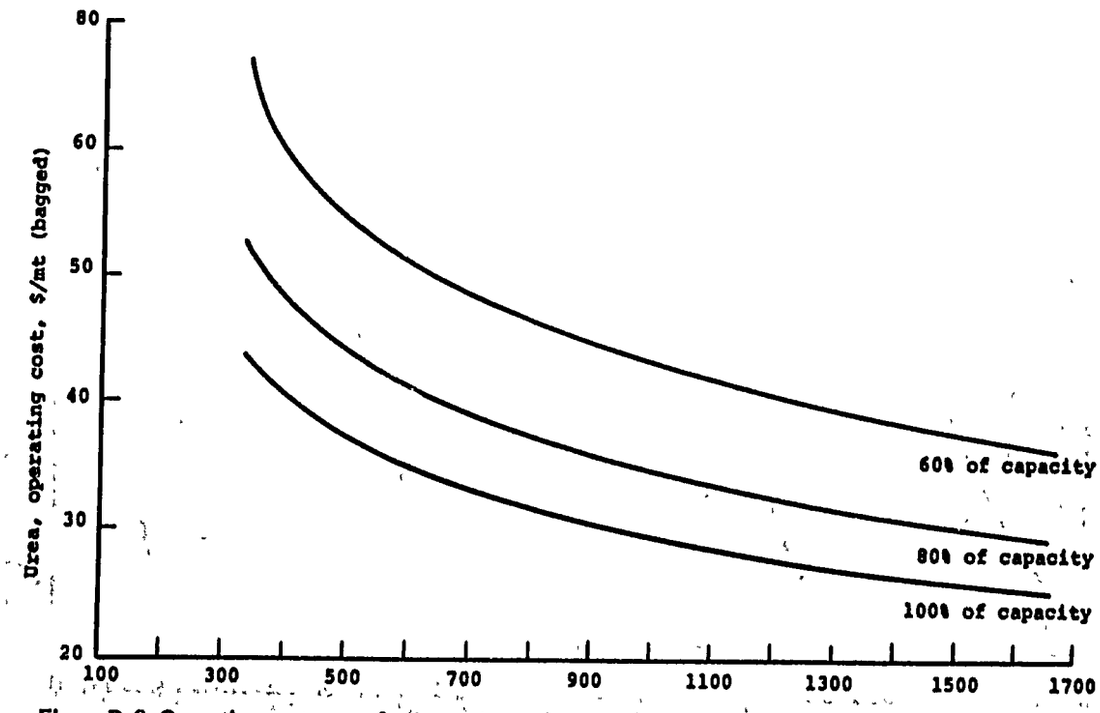

Figure B-8. Operating cost curve for bagged urea (not including raw materials) (plant capacity, mt/day)

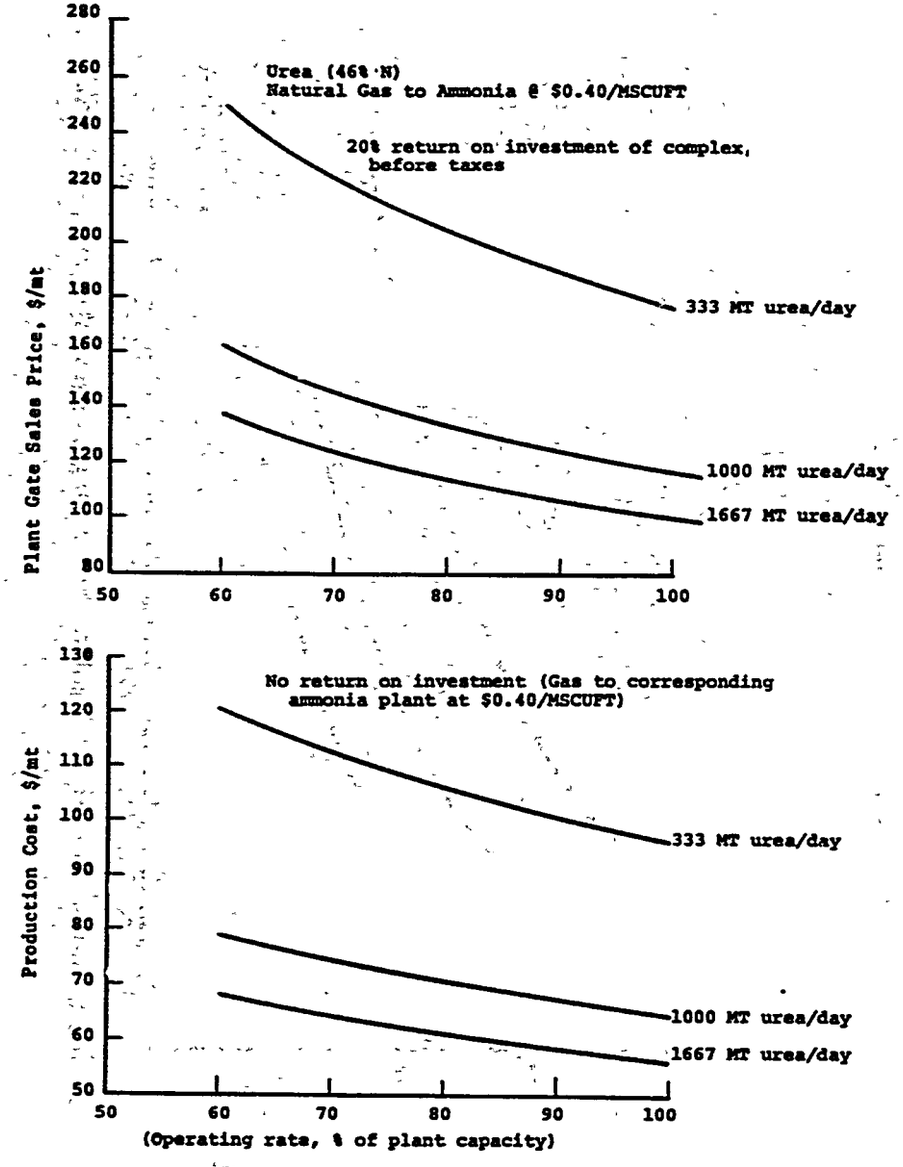

Figure B-9. Effect of plant turndown, urea

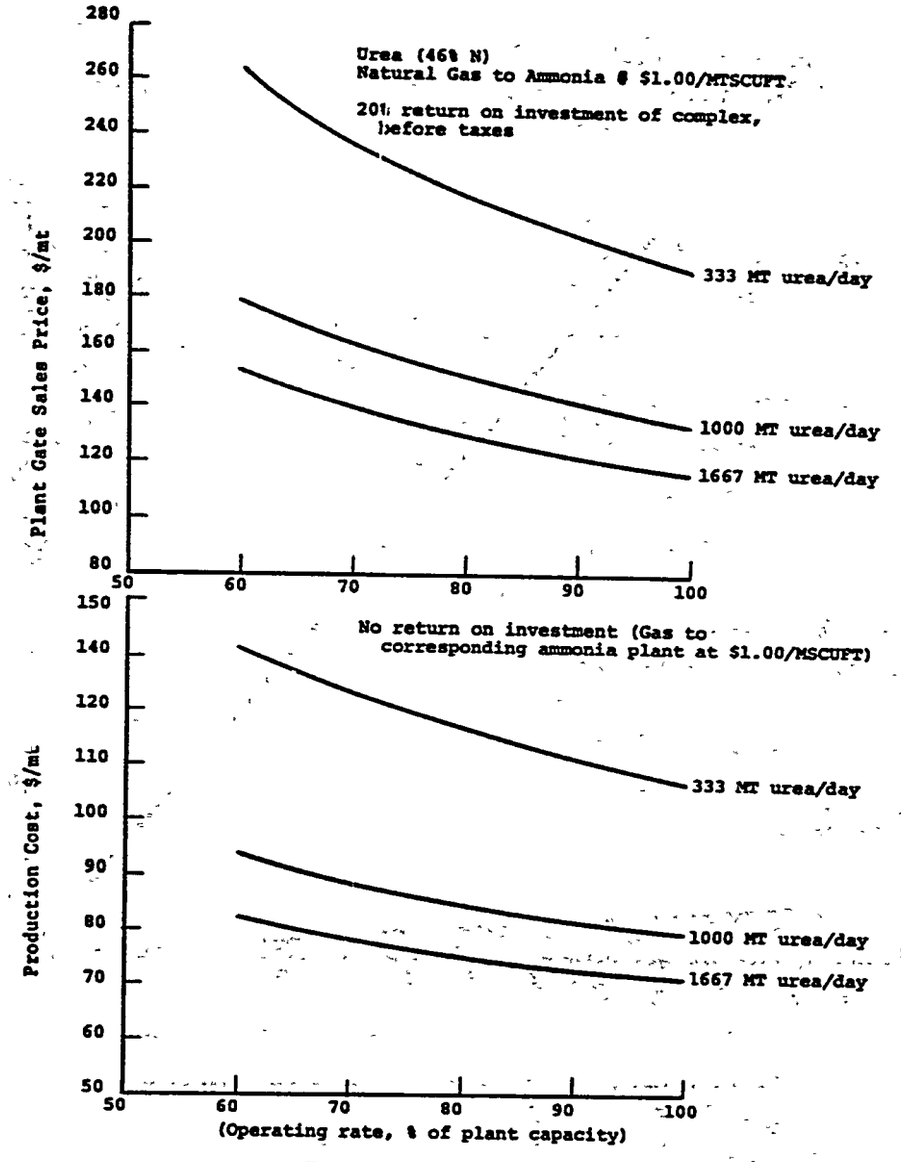

Figure B-10. Effect of plant turndown, urea

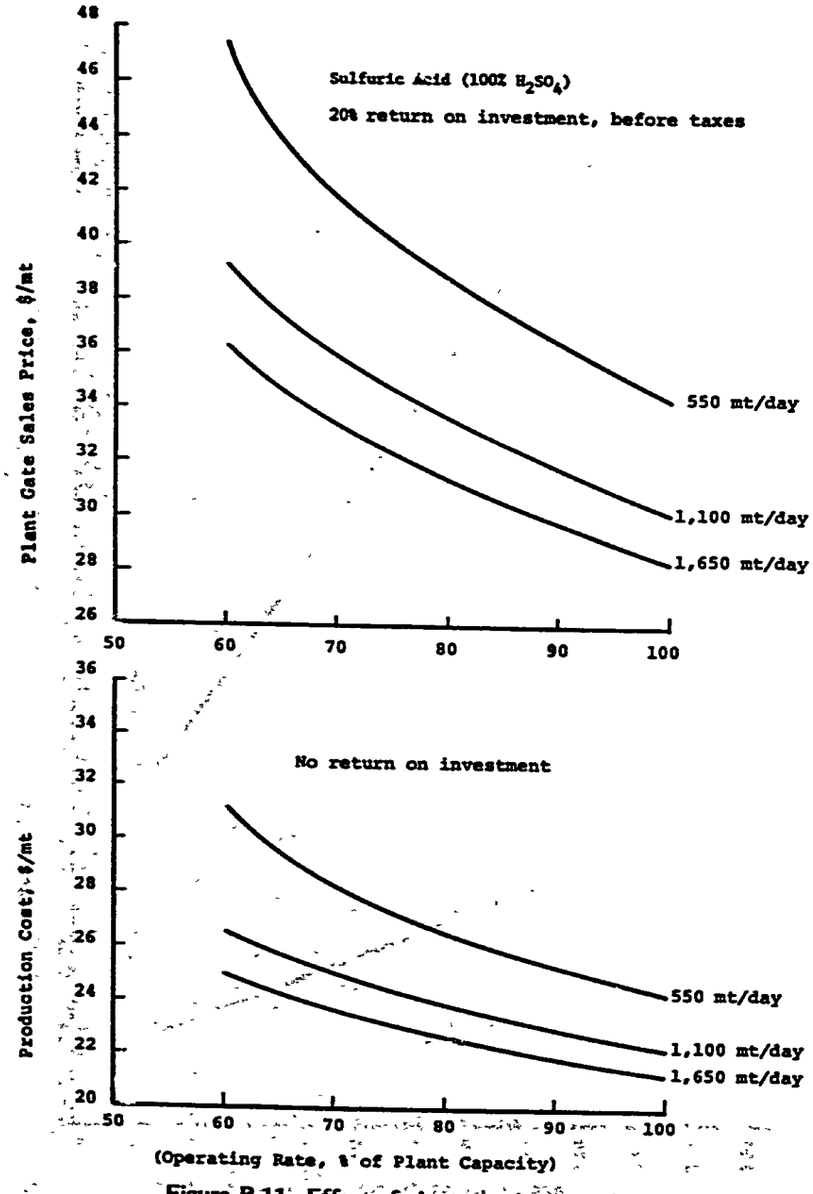

Figure B-11. Effect of plant turndown, sulfuric acid (100%)

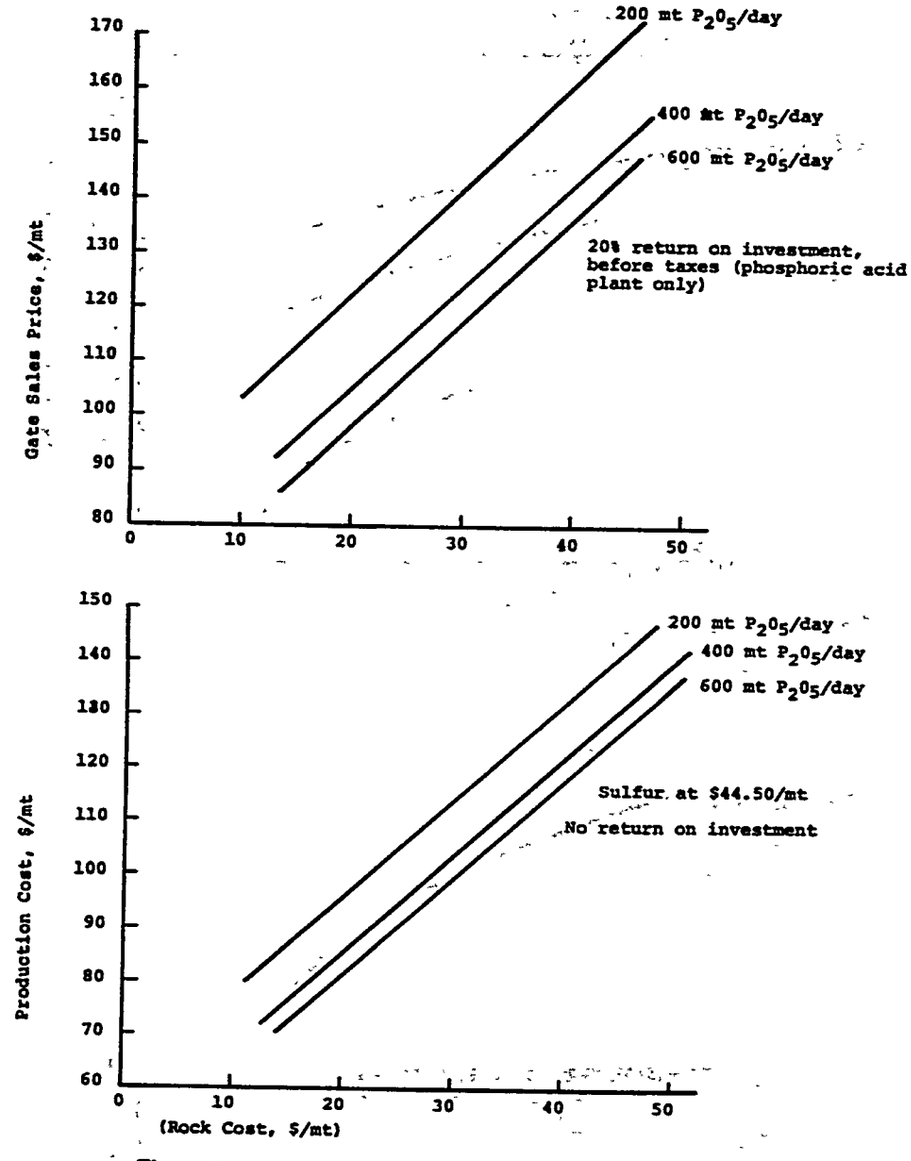

Figure B-12. Effect of rock cost on phosphoric acid cost (54%)

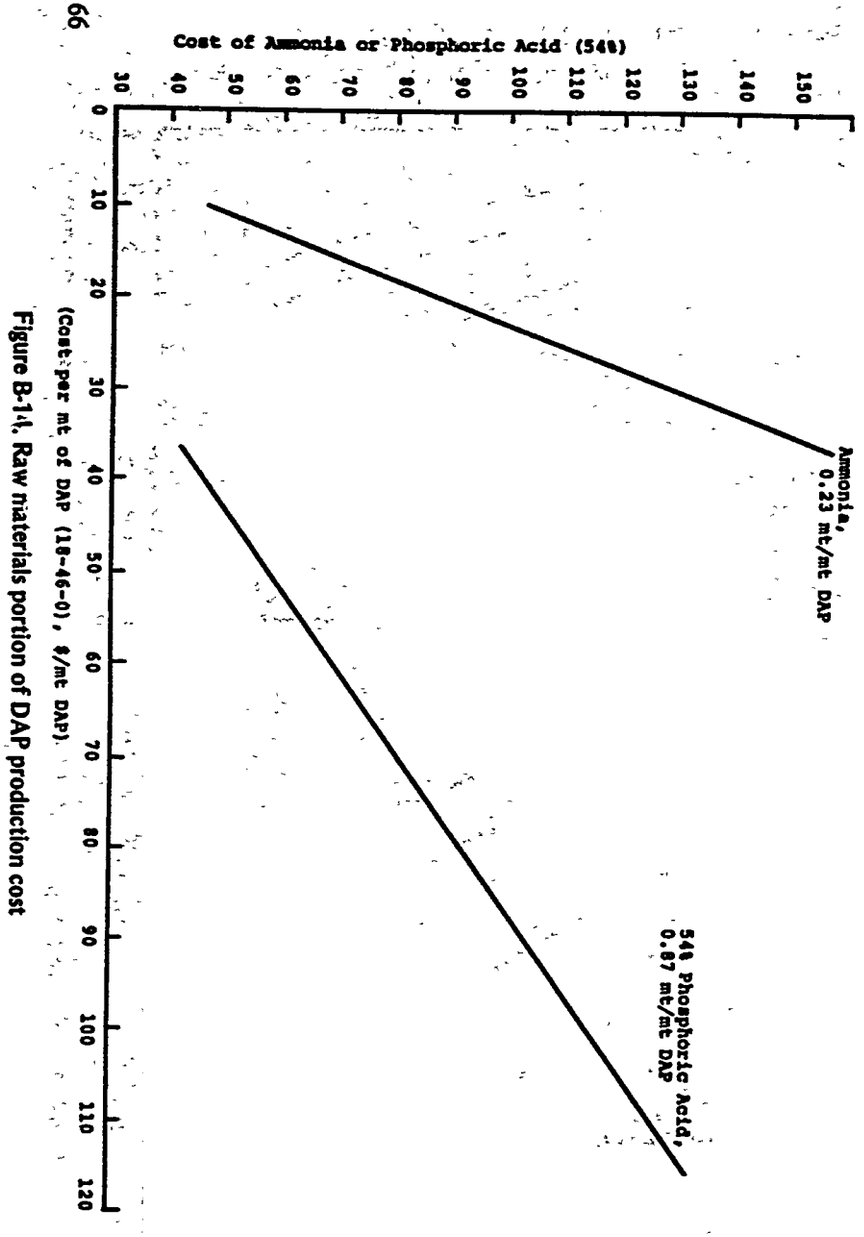

Figure B-14. Raw materials portion of DAP production cost

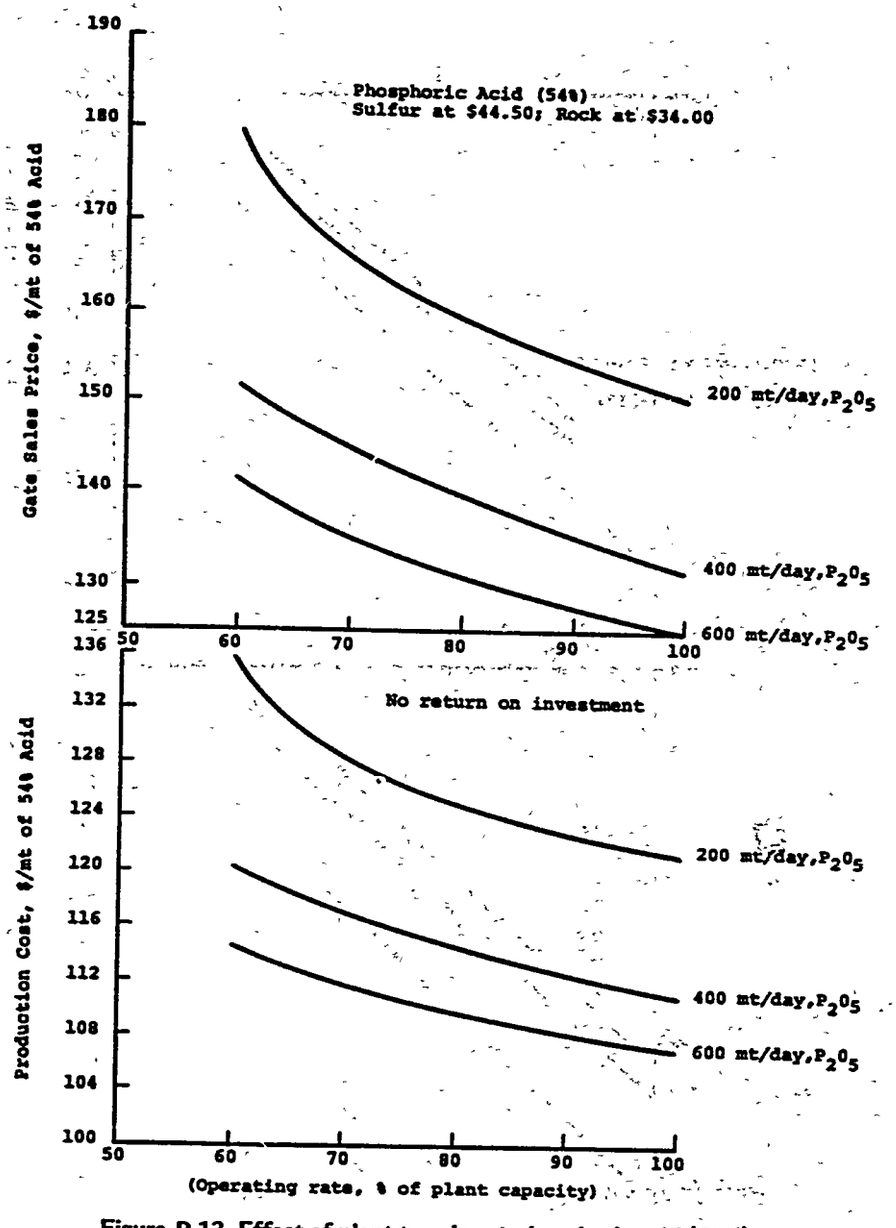

Figure B-13. Effect of plant turndown, phosphoric acid (54%)

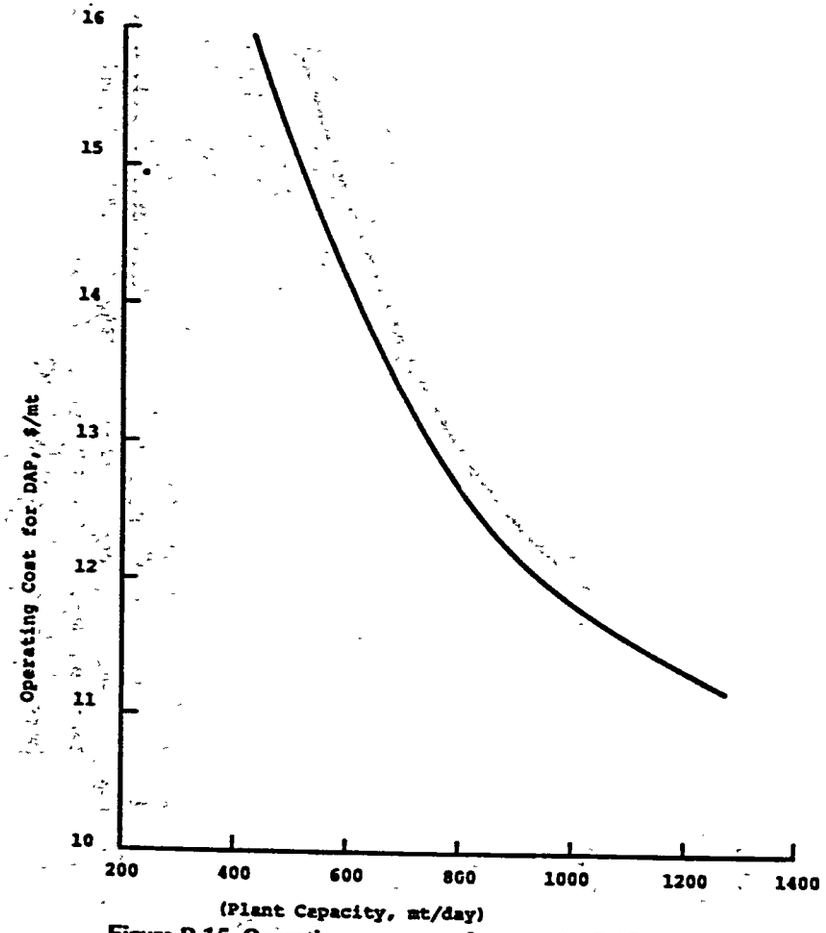

Figure B-15. Operating cost curve for granular DAP, bagged, not including raw materials

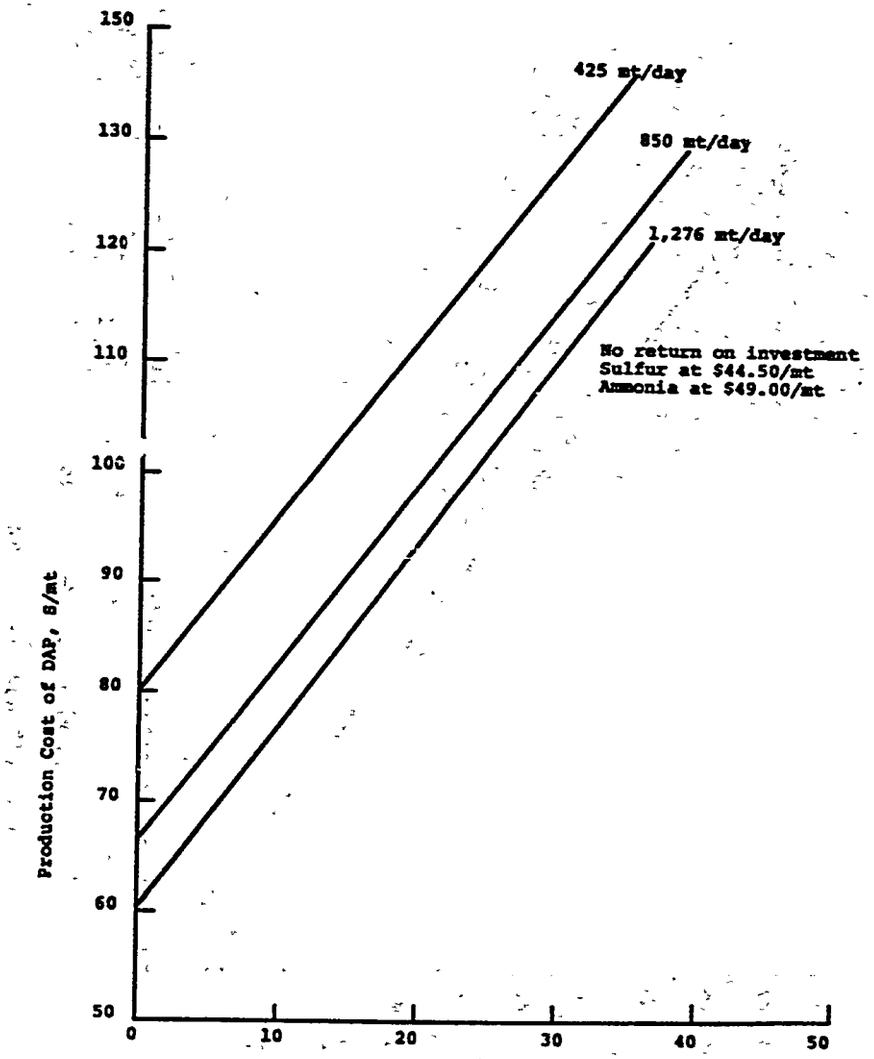

Figure B-16. Effect of rock cost on DAP production cost (rock cost, $/mt)

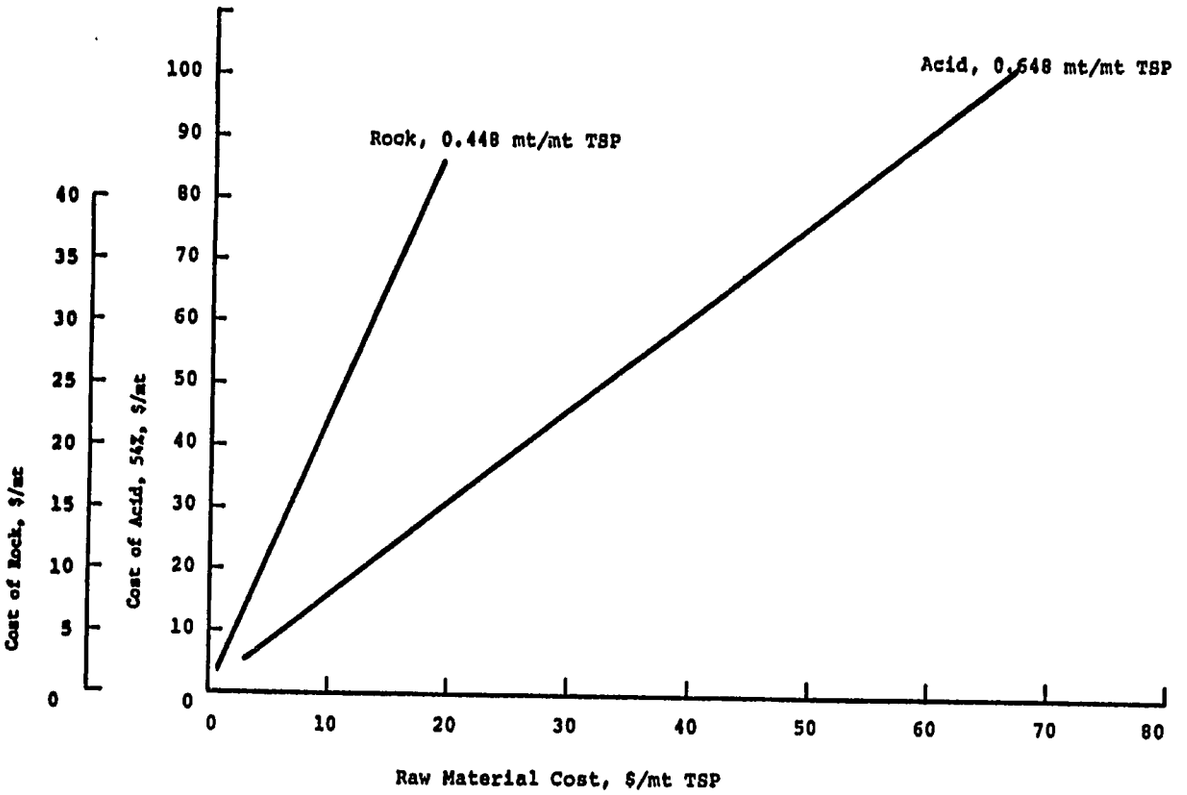

Figure B-17. Raw materials cost portion for TSP (0-46-0)

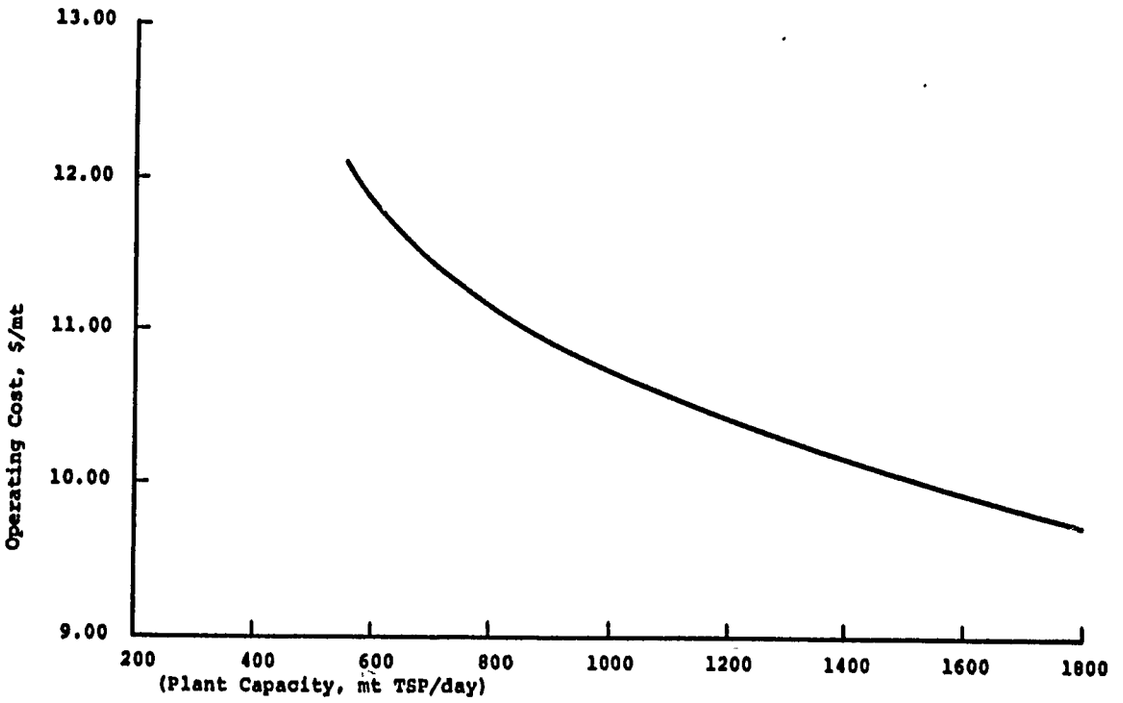

Figure B-18. Operating cost curve for granular TSP (0-46-0), bagged, not including cost of raw materials)

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