SUPPLY AND DEMAND OF CHEMICAL FERTILIZERS

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By

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Introduction

The food problem in the next few decades threatens to be the greatest, most fundamental and almost insoluble problem that has ever faced mankind. The population of the World has been increasing since the '60's at about two percent per annum while World food production has been increasing at only 1.5 percent per year resulting in a growing food deficit.

The present population of Pakistan is about 65 millions and the rate of natural increase is about 2.5 percent per annum (Fig. I). If the present rate of growth is to continue, Pakistan's total population will double every 25 years or so. The most desirable situation would be for Pakistan to attain a 2- child family unit as early as possible. If this is achieved in 1980 the population will still continue to increase and will level out in the year 2040, when it has reached the 126 million mark. This means that there would still be continued pressure on Pakistan's agriculture. The present level of food consumption in Pakistan is not adequate. With further social and economic development, the per capita food consumption will increase at an even faster rate. As a result, total food requirements will expand more rapidly than demanded by population growth alone.

Importance of Fertilizers

The use of chemical fertilizers offers the most attractive method for stepping up agricultural production and lowering the deficit between World's food supply and demand. A statement quoted in Shahpur Chemical Company, Iran, is very appropriate "Of all the aspects of New Technology that effect the creation of powerful agricultural base, the proper use of chemical fertilizers on soils certainly represents the input that is least expensive to apply, simplest to evaluate and

control, most dramatic in effect, and quickest in realization and return." It is well established that chemical fertilizers offer the most attractive low-cost method to increase the per acre output of land, and give the farmer a high economic return for his labour and capital investment. However, it must be stressed that chemical fertilizers alone are not enough to increase land productivity and there are some additional factors which must be considered in order to make the utilization of fertilizers effective. These are :—

(*a*) Basic factors such as soil, seed, irrigation, farm management and plant protection.

(*b*) Supportive/policy factors such as Government price support, market development, agronomic research and credit facilities for the farmers.

Fertilizer Requirements

Pakistan soils are alluvial in nature with a very low content of organic matter. The process of building organic matter is extremely slow under arid/semi-arid conditions. Consequently, there is a universal requirement for additional nitrogen to support profitable crop husbandry. Large scale experiments conducted on soils in different parts of the country seem to indicate that various major crops require nitrogen in the range of 60 - 180 lbs. per acre for optimum yields.

The second major element necessary for plant growth is phosphorus. The rate of phosphorus application depends upon phosphorus levels of the soils. It has been found that 56% of the soils contain 0 to 4 ppm available phosphorus and are classified as low available phosphorus soils ; 29% contain 4 to 10 ppm available phosphorus and are classified as medium available phosphorus soils, and only 15% contain above 10 ppm available phosphorus and are termed as high available phosphorus soils. Experiments conducted on various major crops show that at least 50% of soils need additional phosphate (P_2O_5) treatment of 50 to 150 lbs. per acre for increased productivity. The application of phosphatic fertilizers should be determined by soil tests so that maximum crop productivity from the available fertilizer can be achieved.

The third major component necessary for plant fertility is potassium. Recently there have been reports of wide spread potassium

deficiency in a majority of crops. The deficiency of potassium and response to its application has particularly been noticed in case of sugarcane, maize, cotton, rice, potatoes and tobacco. Experimental evidence seems to indicate that these crops require the application of potash in quantities equivalent to that of phosphorus to give optimum yields.

Based on experiments conducted in the Punjab, the Soil Fertility Survey and Soil Testing Institute have made the following fertilizer recommendations for various crops :—

	lbs/acre		
Crop	N	P_2O_5	K_2O
Wheat	150	75	40*
Rice	120	60	60

Crop	lbs/acre		
	N	P_2O_5	K_2O
Cotton	75	40	30
Sugarcane	200	100	100
Maize	120	90	90
Potatoes	200	150	100
Tobacco	30	60	60
Berseem	30	60	60

Coarse Grain crops

Pakistan grows coarse grain crops amounting to over 8 million acres, 4.5 million acres for grain and 3.6 million acres for fodder and produces around 1.4 million tons of grain annually. Unlike wheat and rice, the production per acre of coarse grain is abysmally low and almost stagnant, except for maize. However, the genetic potential of these crops is much greater than that of wheat and rice. For instance, the yields of improved exotic varieties in demonstration plots have been as high as 110 maunds of dry shelled grain of maize, 70 maunds of jawar, and 50 maunds of bajra per acre as against 8 to 12 maunds of maize and 5—8 maunds of jawar and bajra that is produced at present. This

* The response of wheat to the application of potash has not been established as yet except in the rice area. However, the application of K at the rate of 40 lbs/acre have been found beneficial to give optimum wheat yields under almost all soil conditions.

indicates the potential of various crops, provided proper conditions of water, fertilizers and seeds are provided.

Irrigation

The total area irrigated by the network of rivers, dams and barrages in Pakistan is about 40 million acres. The optimum water requirements for major crops in Pakistan are estimated at 87 million acre feet. The Water and Power Development Authority have projected that ultimate water balance available for farm use in Indus plains in an average year is about 82 million acre feet of water. This leaves a deficit of about 5 million acre of water.

Fertilizer Consumption in Pakistan

Fertilizer consumption in Pakistan during the past twenty years is shown in Figs. 2 and 3. Fertilizer consumption was very low and remained stagnant during the period 1952-1961. Fertilizer use increased slightly during 1960 to 1966 and after 1966 the rate of growth increased very sharply. Fertilizer application increased from a figure of 6 lbs. of nitrogen per acre in 1966, to about 28 lbs. per acre in 1973 and the total fertilizer use increased from 95,000 tons nitrogen to 800,000 tons during the same period. This is equivalent to a rate of growth of 215 percent during the five years 1963-73. The main factors contributing to this remarkable growth are :

1. Introduction of high yielding crops mainly dwarf wheat and rice.
2. Concentrated efforts made by the Government agencies and by leading fertilizer companies in promoting the use of fertilizers.
3. Well co-ordinated research efforts in evaluating crop responses to fertilizers (nitrogen, phosphorus and potassium) and the economies of fertilizer use on these crops.
4. Establishment of a net work of sales depots for fertilizers in most of the agricultural areas of Pakistan.

Supportive/Policy Factors

Besides the various basic factors outlined above, the Government has taken various steps which has increased the agricultural production and also promoted the use of fertilizers. These are :—

(*i*) Introduction of co-operative farming.

(*ii*) Better utilization of water resources.

(*iii*) Improved farm mechanization.

(*iv*) Scientific approach to data collection and analysis.

(*v*) Improved research facilities.

(*vi*) Availability of fertilizers to the farmer at controlled price at credit.

Fertilizer Production Capacity of Pakistan

The demand for fertilizer today surpasses the country's manufacturing capacity.

At present there are four plants for the manufacture of nitrogenous fertilizers at Daudkhel, Multan, Daharki and Chicho-ki-Mallian and one single super-phosphate plant at Lyallpur.

Production of fertilizer began in Pakistan in 1957 with the operation of WPIDC's plants for single super-phosphate at Lyallpur and ammonium sulphate at Daudkhel. Later on WPIDC established another factory at Multan for the production of ammonium nitrate and urea which went into production in 1962. The first plant in the private sector was established by Esso at Daharki, which went into production in late 1968, and another by Dawood Hercules at Chichoki Mallian was commissioned in late 1971. Both of these plants manufacture urea from natural gas.

Figs. 2 and 3 summarise the production capacity of various manufacturing units mentioned above, which also give the projected production of the two primary nutrients (nitrogen and phosphorus) untill 1980.

Fertilizer Imports

Fertilizer demand in Pakistan increased dramatically during the last ten years. Consumption of nitrogen fertilizers increased from 37,000 tons in 1961/62 to 370,000 tons in 1972/73. The demand for phosphatic fertilizers increased at a much faster rate from about 17,000 tons of P_2O_5 in 1966/67 to 70,000 nutrient tons in 1972/73.

Fertilizer Consumption Factors

In order to project further demands, various factors which will affect fertilizer consumption in Pakistan have been considered. These are :—

(*a*) Change over from local to high yielding crops

Esso Marketing has made a survey of the irrigated areas under major crops in Pakistan. We have taken these figures for the change over from local to high yielding varieties of dwarf wheat, IRRI rice and cotton as one of the basis for furture forecasts.

(*b*) Increase in Irrigated Area

World Bank has estimated the total increase in cropped acreage up to the year 2000. These figures take into account the increase in surface and tube well water for irrigation and have been considered in calculating the additional production.

(*c*) Low Grade Food Grains

We feel that a revolution in coarse grain production will take place during the next ten years, because the present level of productivity of bajra, maize, jowar, barley, is too low and must be raised to an economic level. As a conservative estimate, we feel that these coarse grains will take up at least 10 percent of total fertilizer consumption.

(*d*) The Efforts of the Government in Providing Fertilizer.

Increase in the fertilizer demand during the last five years, will be sustained during the coming years and will contribute further to the fertilizer demand for medium, large as well as small holdings.

The forecast for the future demands for nitrogenous and phosphatic fertilizers are plotted in Figs. 4 and 5. A realistic rate of growth will depend upon such factors as the economic development of the country, efforts made by the Government in educating the farmer, providing credit facilities and change over to co-operative farming.

A realistic forecast for the nitrogenous fertilizers can be made by assuming a rate of growth of 7.5 to 10 percent per annum and this is shown in Fig. 4. This compares with the U.N. forecast for the developing countries.

The rate of growth of phosphatic fertilizers during the last ten years has been rather slow. The experience of other countries show that the growth of phosphatic fertilizers tend to follow the nitrogenous fertilizer demand although the effect is delayed by a few years in the beginning. Ultimately a ratio of 3 : 1 for nitrogenous to phosphatic fertilizer is desirable for optimum land productivity. In order to achieve

this a 20 percent increase in the rate of growth of phosphatic fertilizers would be reguired. The projection forecast for phosphatic fertilizers is shown in Fig. 5.

According to these forecasts the estimated consumption of nitrogenous fertilizers for 1979/80 is 990,000 to 1,000,000 nutrient tons and for phosphatic fertilizers 240,000 nutrient tons per annum. These forecasts seem to show fairly good agreement with the projections made by the Government of Pakistan and also indicate that there is immediate need for setting up at least three new Urea Plants and two Phosphatic Fertilizer Plants in Pakistan.

These estimates are based on internal consumption only. In addition to the local demand, there would be sizeable demand for these fertilizers in the CENTO Region.

The demand for potassic fertilizers will also increase during the next few years and it is anticipated that the requirement of this fertilizer will follow the curve for phosphatic fertilizers. The Government of Pakistan should immediately look into the possibility of producing potassic fertilizer from local rock.

World Fertilizer Demand

Projection of fertilizer production and consumption has been made for all countries in the World for 1975/76 and 1980/81 based on the historical data from 1955/56 to 1969/70 and reported at the Second Inter-regional Fertilizer Symposium in 1971.

In spite of the above projection fertilizer market in the World is becoming short of supply in nitrogenous fertilizer and the price of fertilizers have dramatically increased during the last six months. For example, no further expansions of nitrogenous fertilizer production is expected in Japan and U.S.A.

In the case of Japan, more than half of her fertilizer production is exported to Mainland China, India, Indonesia, etc., and all of the raw material for ammonia production such as L.N.G., L.P.G. and naphtha are imported. So the manufacture of fertilizer In Japan might not be a paying business because of keen international price competition.

At present, the production capacity of nitrogenous fertilizer in Japan is under control of the Government and the construction of nitrogenous fertilizer plants may not be allowed even if the plant location is outside Japan.

In the U.S.A. natural gas is a major raw material for ammonia production, but recently there has been a shortage of natural gas supply and gas suppliers are willing to sell the gas for town gas because of the higher profitability. The U.S. is importing liquefied natural gas trom Algeria, but in spite of this there is short supply of nitrogenous fertilizers in the U.S.

The fertilizer supply and demand situation in the CENTO Region is far from satisfactory. Turkey accounts for 52 percent of regional consumption, Pakistan 29 percent and Iran 19 percent. The total regional consumption represents 1.3 percent of World consumption. Based on these rigures, it is estimated that the region will be short of supply for nitrogen nutrient by about 0.7 million tons of nitrogen equivalent in 1975/76 and by 1.4 million in 1979/80 assuming that no further expansion in production capacity occurs.

In terms of P_2O_5 capacity, the region will be short or supply of about 150,000 tons in 1975/76 and 250,000 in 1979/80.

In view of the very tight World supply and demand situation for nitrogenous and phosphatic fertilizers, it is necessary that the production capacity in the region is improved by installing new facilities for the manufacture of these fertilizers.

Regional Production Capabilities

The modern development in fertilizer technology is towards increasingly large single train plants. The production of chemical fertilizers require that the product conforms to the international specifications and that the plant is able to produce at design capacity and yield. Fertilizer production also requires a high proportion of inputs that are not easily available in the developing countries. These are :—

(*a*) Cheap raw material.
(*b*) Highly sophisticated technology.
(*c*) Large capital investment.
(*d*) Technically trained personnel.

Previous experience in the operation of large scale chemical plants has shown that in order to financially justify large scale projects the plant must be able to produce specification material at design capacity and yield. These plants usually break even at 80 percent production capacity. Experience also indicates that full capacity is difficult to attain in

developing countries. In addition the total time required for mechanical completion of a plant in the developing countries is about 36 months compared with 18 to 24 months in the industrialized countries.

Further delays also occur during commissioning and due to start up problems. All these factors tend to increase the capital investment which is usually 25 to 30 percent higher in the developing countries compared with the cost of a similar plant in a developed country. The capital investment is further increased due to the high cost of imported labour and technical personnel.

In view of the various factors mentioned above, it has often been argued whether there is any economic advantage for the developing countries to install large scale chemical plants for the production of fertilizers.

Because of their direct and indirect effects on the investment decision, it is worthwhile to indicate the nature of the technological changes that have been taking place in chemical fertilizer production.

In the case of nitrogenous fertilizers, the most important developments have been achieved in the production of ammonia, urea and nitric acid. The advances in the production of ammonia have occurred due to the following reasons :—

(*a*) Availability of cheap raw material *e.g.*, natural gas and naphtha.

(*b*) Developments in the materials of construction for high temperature and high pressure equipment.

(*c*) Advancements in the chemical and mechanical engineering which have made possible the design, fabrication and construction of large scale plants.

The new ammonia technology has greatly reduced the capital investment and also the running costs of the plant. Production cost of ammonia has, therefore, dropped by about 50 percent.

The implication of the factors mentioned above is that in developing countries sufficient consideration should be given to technological forecasting because there is generally a danger of embarking on to an expensive project which looks very attractive on the surface, but may not go very far in giving good long term economic returns to the investor. As a result, the economic development of the country will suffer a serious setback due to the poor utilization of money at the critical time of its development. In developing countries, therefore,

extreme care has to be taken in analysing each and every project from the standpoint of financial return on capital investment, its economic viability and efficiency of performance over the life of the project.

In order to determine the potential of CENTO countries for large scale production of fertilizers to meet their growing demands, we shall examine the important factors which make the operation of large plant financially attractive.

1. **Raw Materials**

The principal materials for the manufacture of chemical fertilizers are natural gas (or naptha), phosphate rock, potash minerals and sulphur. With the exception of mainland China and Peru, no developing country possesses all four raw materials. Most developing countries do not possess easily tapped natural gas. Amongst the CENTO countries Iran and Pakistan have sizeable reserves of natural gas. The total reserves of Iran are estimated at 2700 billion cubic feet.

Phosphate rock and sulphur are the major raw materials for the manufacture of phosphatic fertilizers. Pakistan has recently discovered phosphate deposits and its extent is estimated at 17 million tons. The rock contains varying amount of P_2O_5 and it can be easily beneficiated to raise its P_2O_5 content to 30-32 percent. The rock is suitable for conversion into single super phosphate (SSP).

The manufacture of potassic fertilizers differs markedly from nitrogen and phosphate nutrients in that :—

(*a*) It is more of a mining than a chemical industry,

(*b*) All processing of potash salts takes place near the mining area, and

(*c*) There are no over riding economies of scale. West Pakistan has some potential deposits of potassium but the reserves have not been exploited so far. However, the World price of potassium salts are sufficiently low and its import to CENTO countries will not put undue burden on the foreign exchange.

Technical Personnel

An expensive and highly sophisticated plant requires competent and highly qualified personnel to operate it. There is a need for suitably trained staff at all levels of plant operation.

Most contracts for technical back up are limited to design, construction and start-up phase. Once the plant is commissioned the local staff must have the capability of taking over the plant operation and ensure that the plant can be run continuously without excessive breakdowns. There is also need for technical personnel who are capable of handling routine problems of day to day nature and well as long range problems so that the maximum life of the plant is ensured.

Efficient Management

Another valuable component that is most important in the operation of single train large fertilizer plants is the ability to deal and supervise well trained work force. This requires the management skills of highest order. Controls and discipline, efficient utilization of resources both human and material, early and correct decision on technical, commercial and financial matters, development and planning for the future needs of the organi ation, all require careful management review. Problems such as the timing and duration of plant turn around, calling outside help where needed, modernizing existing facilities and developments in new areas must be handled carefully.

Pakistan has demonstrated its ability to run successfully large scale plants on modern management lines. Dawood Hercules Plant at Chichoki Mallian and Esso Plant at Daharki are two examples where production above the design capacity has been attained within a period of two years after commissioning.

The e are two major advantages in increasing the production of chemical fertilizers in the CENTO region by installing large scale plants in the area. The first is the "learning process" that the training and experience gained by organising and running the domestic fertilizer industry will create valuable resources for developing other process industries, particularly the chemical and petro-chemical field.

The second advantage is that the domestic fertilizer production saves a substantial amount of foreign exchange and thus eases constraints upon output elsewhere in the economy. For example a single 1100 TPD Urea Plant will have the country $90 million per annum in foreign exchange.

It may be concluded that in view of the large reserves of gas in the CENTO region and the availability of trained and experienced technical

staff for the operation of the large fertilizer plants, there is a scope for expanding the production facilities not only for domestic requirements, but also for capturing the World markets, specially in South East Asia. Pakistan is already in the process of finalizing arrangements for the installation of three more Urea Plants which will make her self-sufficient by 1978/79.

FIG. I

POPULATION GROWTH IN WEST PAKISTAN
AFTER ACHIEVEMENT OF A 2-CHILD FAMILY AVERAGE

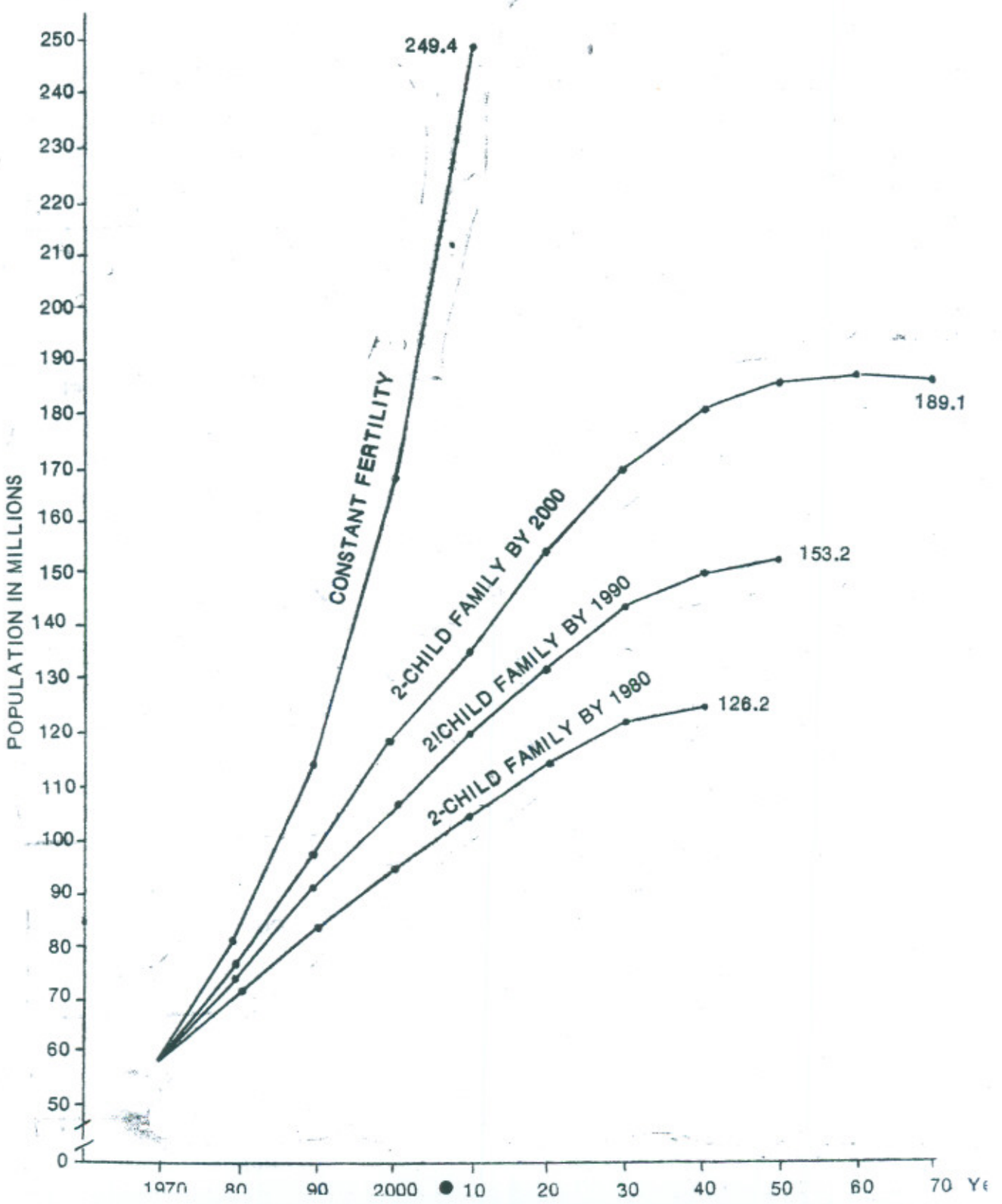


FIG. 2

PRODUCTION AND
CONSUMPTION OF NITROGENEOUS
FERTILIZER IN PAKISTAN.

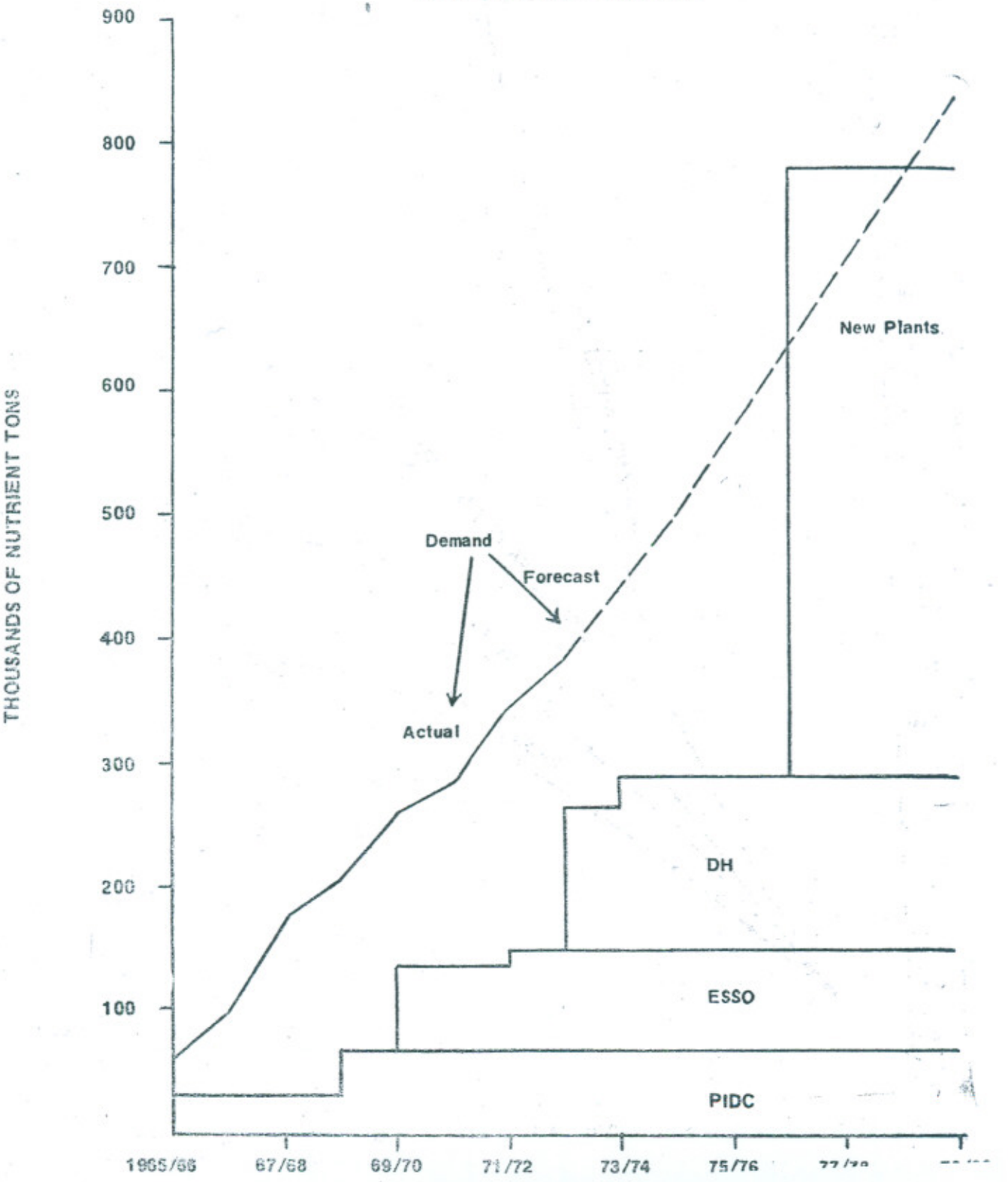
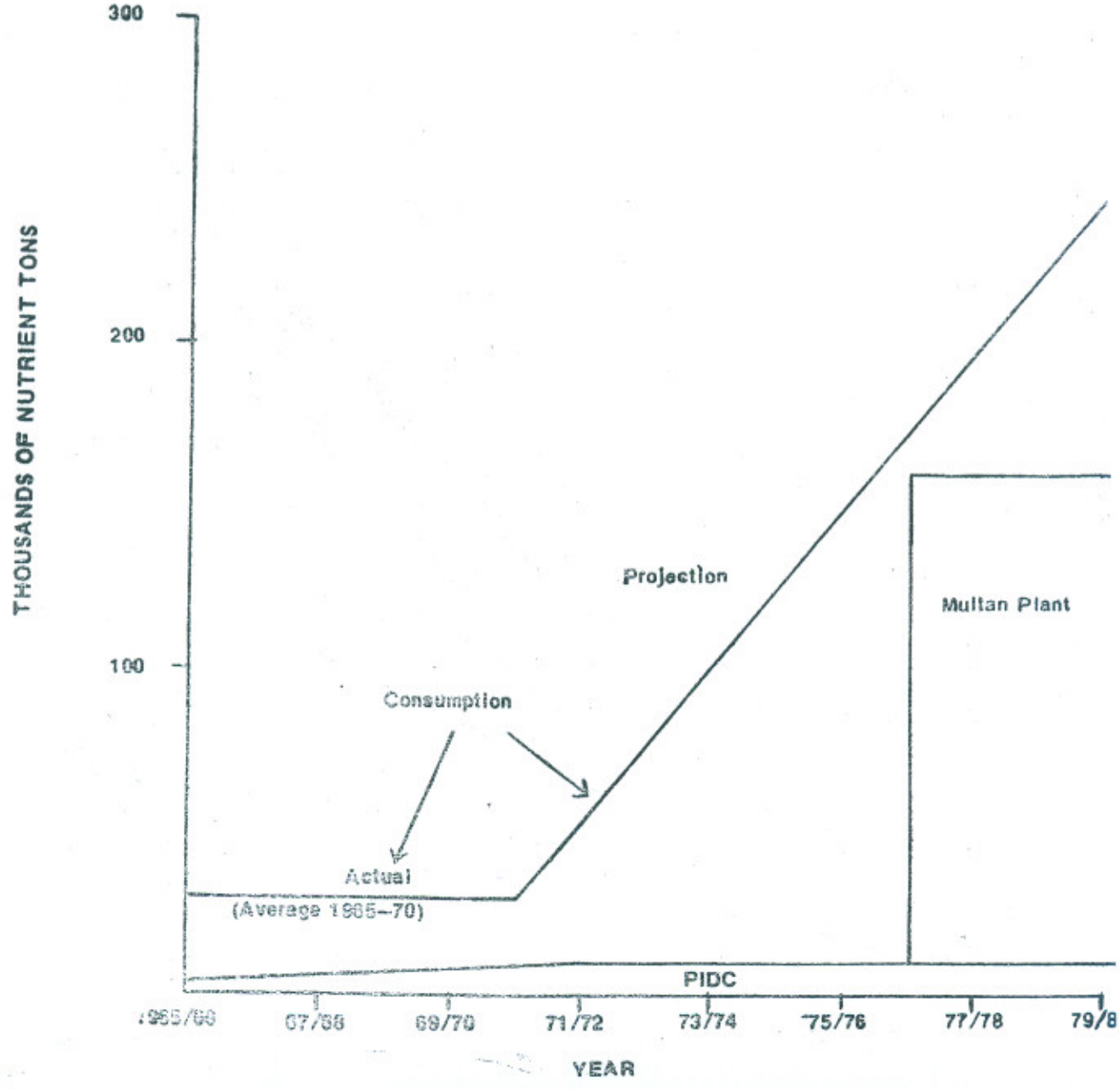


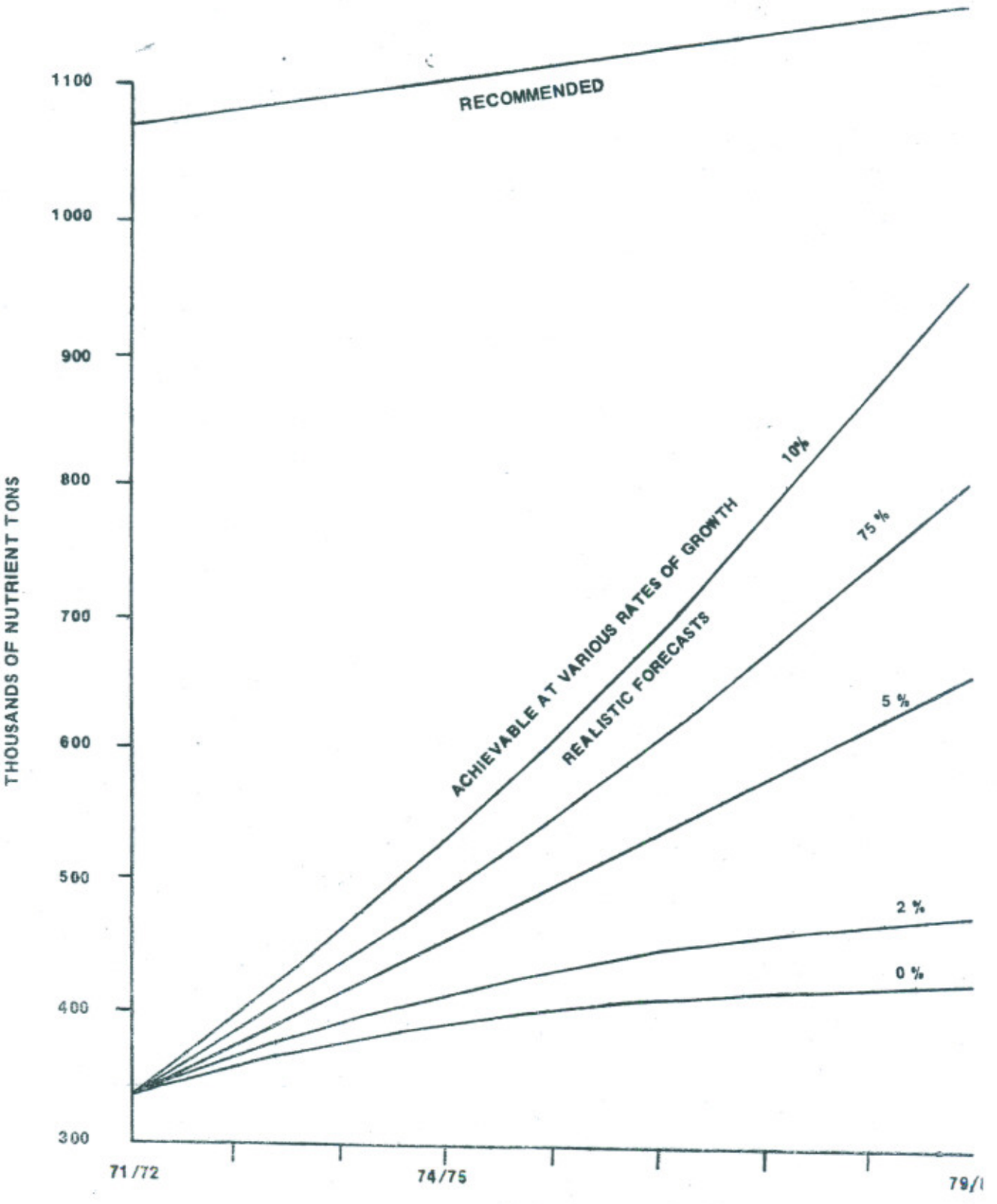
FIG. 3

PRODUCTION AND CONSUMPTION OF

PHOSPHATIC FERTILIZER IN PAKISTAN

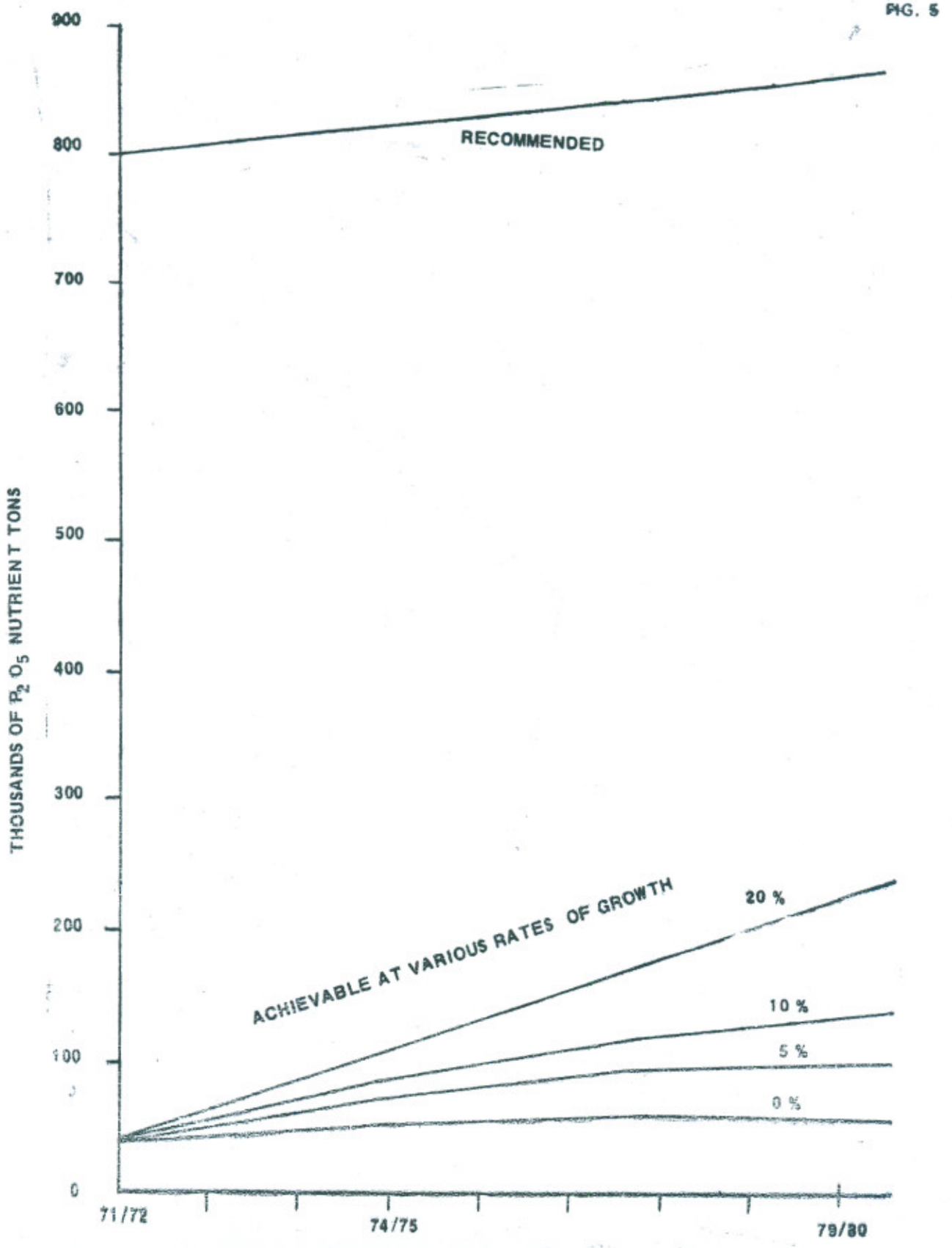


FORECASTS FOR NITROGENEOUS FERTILIZERS FIG. 4



FORECAST FOR PHOSPHATE FERTILIZER

FIG. 5



WORLD PRODUCTION AND CONSUMPTION

OF NITROGEN FERTILIZER

FIG. C

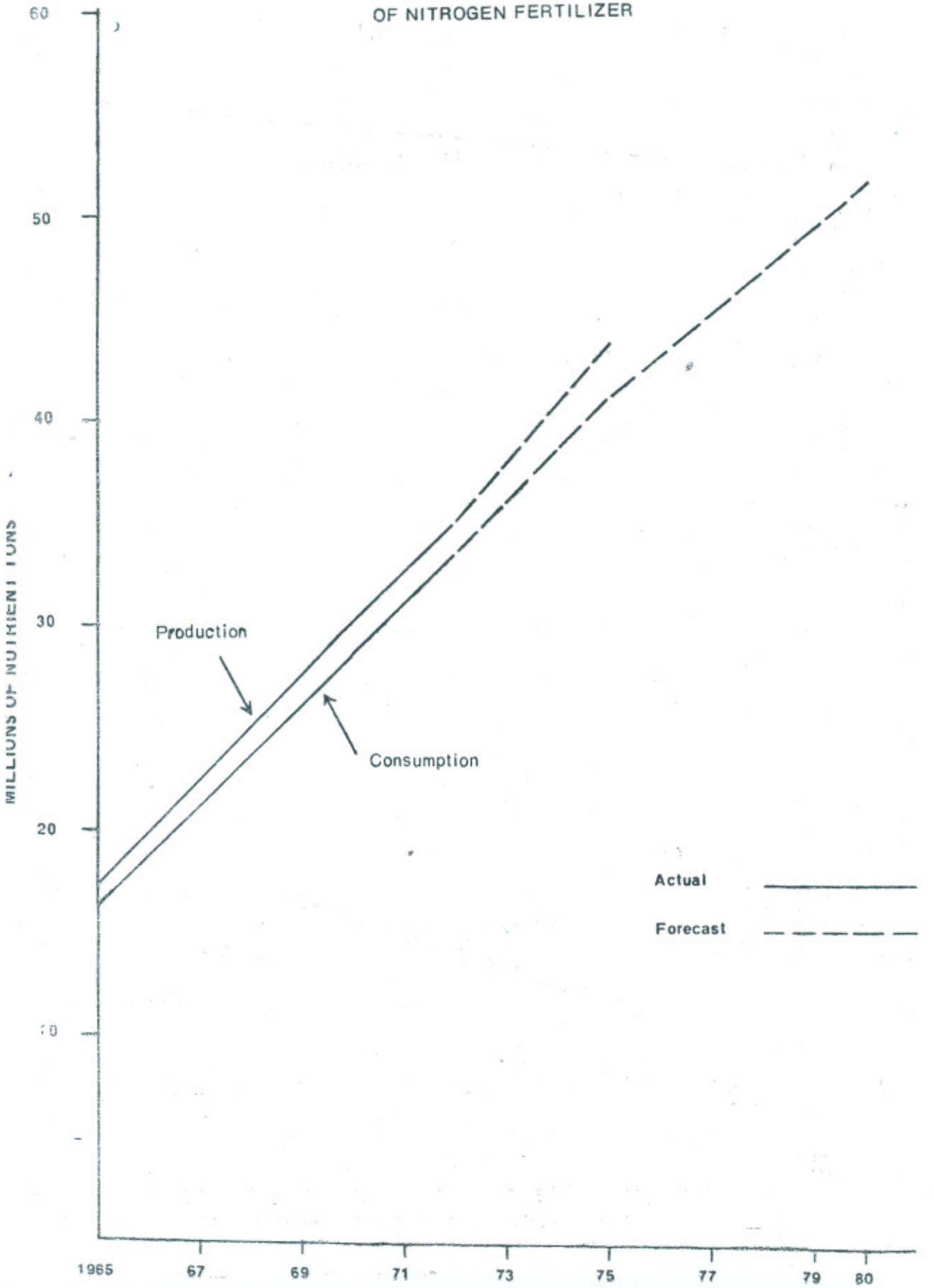


FIG. 7

WORLD PRODUCTION AND CONSUMPTION OF

PHOSPHATIC AND POTASSIC FERTILIZER