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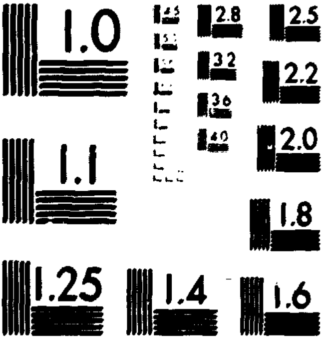

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Development of Fertiliser Industry in Pakistan

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A CASE STUDY OF ITS MINI FERTILIZER PLANTS

by

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September, 1982.

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NTRODUCTION

Pakistan lies between latitudes 23.30° and 36.45° North and longitudes 61° and 75.31° East, stretching over 1,600 kilometers north to south and about 885 kilometers east to west. It covers a total area of 796,095 square kilometers and its geography is marked by three distinct features viz., a north to north-western mountain belt, an arid plateau to its west, and the fertile plain of Indus River Basin from north-east to south-west. Rainfall in the largely barren mountain belt and the sand-strewn, stony plateau is negligible and agricultural activity in these arid regions is limited to scattered subsistence farming and cattle grazing. The vast alluvial plain is served by an irrigation system comprising a network of canals and tubewells. The plain is thickly populated, extensively farmed and produces the main food and cash crops, viz., wheat, rice, cotton, sugarcane, maize and tobacco.

Pakistan's population is estimated at 85.65 million, 71.7% of which lives in rural areas. About 90% of the farms are less than 10.1 hectares each.

AGRICULTURAL PRODUCTION AND FERTILIZER CONSUMPTION IN PAKISTAN

With these characteristics, it is but natural that agriculture should play a vital role in the economy of Pakistan. Although significant structural changes have taken place in the country's economy in recent years, agriculture still remains its foremost and the largest single commodity producing sector, making up as much as 30.1% of the gross domestic product (national production minus inputs from outside). More than 70% of this contribution comes from crop production, statistics of which (Principal Crops) are given in Table 1. The total production has no doubt witnessed substantial growth during the last 30 years (Figure 1) but the annual and periodical growth rates have been subject to considerable variations, depending on weather conditions and government policies. The growth of agriculture during the 1960s averaged about 6% per year, mainly due to the introduction of high - yielding varieties of rice and wheat and increased use of fertilizers. In the earlier years of the following decade, a number of adverse factors like bad weather, inadequate price incentives and inefficient support services were responsible for a slow-down and agricultural growth failed to keep pace with population growth. During the last five years, however, production performance has shown an annual growth rate of about 5%.

A study of the figures published in the latest FAO year books on Production and Fertilizers discloses some interesting features of the position of Pakistan among all developing countries. Its land area and arable area constitute 1% and 2.8% respectively of total land and arable areas of these countries but its irrigated area constitutes 9.5% of their total irrigated area. Whereas only 9.3% of the land area of the developing countries is arable, 25.5% of Pakistan's land area is arable of which 72.6% is irrigated against the overall average of 21.5% for all the developing countries. With a 36% growth in Agricultural Production and a 38% growth in Food Production during 1971-1980, Pakistan had somewhat better results than those achieved collectively by all developing countries i.e., 33% (Agricultural Production) and 35% (Food Production). Out of the 110 or so developing countries whose production indices have been compiled by FAO, only about 30 countries had equal or better growth rates than Pakistan during this decade.' However, when a reference is made to the indices of per caput production, a quite different picture emerges. Whereas Pakistan's index of Agricultural Production per caput has been stagnating around 99 for a number of recent years, the corresponding index for all developing countries rose to 107 in 1980. Similar indices for Food Production per caput were 101 (Pakistan) and 108 (all developing countries). 47 developing countries had equal or better growth rates of food and agricultural production per caput during the decade. Table-2 shows that except in the case of Tobacco leaves, the yields (kg/ha) of the principal crops (wheat, rice-paddy, barley, etc.) in Pakistan were lower than those achieved in all developing countries during 1980.

One of the major challenges faced by those associated directly or indirectly with agricultural production in Pakistan, therefore, is that related to the problem of growth of productivity. A number of fundamental factors continue to limit agricultural productivity at levels well below the potentials implied by existing land and water resources and by technologies already available.

In this context, the importance of the role of fertilizer use cannot be over-emphasised. While it is perhaps true that, in general, the developing countries have only a small proportion of their total food output attributable to fertilizer use, its much higher contribution to subsequent increases in output has now been fully established. The potential for increased agricultural and food output through increased and efficient use of fertilizers has got to be exploited if developing countries like Pakistan are to attain self sufficiency in food. Table 3 and Figure 2 show how great has been the growth of fertilizer consumption in Pakistan over a period of twenty five years; it increased from a meagre start of 1,000 nutrient tons in 1952-53 to more than a million nutrient tons in 1981-82 with an N : P_2O_5 ratio of 3.7:1.

Fertilizer consumption per hectare of arable land (and permanent crops) has grown from 16.8 kg during 1969-71 to 51.9 kg in 1979. This compares favourably with the growth from 18.0 kg to 43.9 kg registered during the same period in all developing countries (Table-4). The growth of fertilizer consumption per caput in Pakistan was also steeper (from 5.3 kg to 13.1 kg vs. 5.1 kg to 10.8 kg). The total fertilizer consumption per hectare and per caput was thus significantly higher (18.2% and 21.3% respectively) than the average in all developing countries, and yet the agricultural production was only 2.25% higher.

Tables 5 to 8 show figures of area, production and yield per hectare in the case of wheat, rice, cotton and sugarcane in Pakistan in recent years. Analysts believe that the output in these key crops is mainly due to good overall weather conditions and that increases in yields per hectare were made possible through the distribution of improved varieties of seeds. Figure 3 shows the growth rates of fertilizer offtake and agricultural production (principal crops and food crops) during 1971-81. Admittedly, the growth of production is not entirely or directly dependent upon the growth in the use of any single input like fertilizer offtake, but the fact remains that such a wide disparity in the growth rates as displayed by Figure 3 does call for a deep analysis of the various factors involved. Ways and means have to be found for improving the efficiency of fertilizer application and response (correct type of fertilizers applied at the right time and in proper balance, etc.) if full benefits are to be derived of the investment and effort involved in importing, manufacturing and distributing ever-increasing quantities of fertilizers in the country. Consideration needs to be given to improving the fertilizer distribution system in the country so that the right type of fertilizer can be supplied to the farmer in sufficient quantities as and when required by him. In order to achieve this objective and thus improve the overall returns from investment in fertilizer industry, the policy of setting up small plants right in the consumption areas instead of large plants away from these areas offers some obvious advantages.

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Keeping in view the importance of agricultural production, Government of Pakistan has always been on the lookout for methods of improving its efficiency and productivity. As far back as 1951, an Agricultural Enquiry Committee was set up under the chairmanship of Lord Boyd Orr to consider possibilities and recommend measures to increase yields and to reduce costs by introducing modern methods of agriculture, including use of fertilizers. In its report (October, 1952), the Committee pointed out that whereas nitrogenous fertilizer could increase crop yields by 20-40%, only negligible quantities of fertilizers were being used in Pakistan. One of the reasons for this was that despite a 50% subsidy on the fertilizer (Ammonium Sulphate), the farmers still found its cost to be high. The Committee came to the conclusion that the high cost of fertilizers was a definite impediment to its use on ordinary farm crops like wheat, cotton and rice. It was of the view that it might be possible to reduce the cost if the fertilizer was manufactured in the country because the quantity of Ammonium Sulphate available for import was very restricted and costly. The Committee, therefore, recommended the erection of one or more plants for the manufacture of Ammonium Sulphate. Another recommendation was that the Government should continue to subsidize the sale of fertilizers till the agriculturists have realised the advantages and begun to use them regularly when the subsidy might be reduced gradually and ultimately withdrawn.

Pakistan Industrial Development Corporation (PIDC) played a pioneering role in the setting up of fertilizer industry in the country and within a short span of time after its inception in 1950 it had installed two fertilizer factories. It also arranged the training and supply of professional managers and technicians for the operation and maintenance of these factories.

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The first plant was located in the Punjab at Daudkhel (Iskandarabad), where large deposits of coal and good quality gypsum were available. It was admittedly a backward area but it was connected with the rest of the country by road and railway. The fertilizer plant, as an important component of an industrial complex which also included a cement plant and a factory for manufacturing pharmaceuticals, was to be instrumental in the socio-economic development of the area around Daudkhel. It was rightly felt that the transportation of the manufactured fertilizers to the agricultural areas of the Punjab and the North Western Frontier Province (NWFP) would not present any problems. Keeping in view the anticipated growth of fertilizer demand in the foreseeable future, it was decided that a 40 tons/day of ammonia plant for manufacture of 150 tons/day of Ammonium Sulphate (50,000 tons per annum) would be the most suitable size for the proposed factory. Civil works for the project were started in 1953 and erection work was taken in hand in 1955. Trial production of the Pak-American Fertilizers (PAFL) plant was achieved in 1958 and commercial production in February, 1959. Foreign exchange assistance had been provided by the United States Government and the total outlay on the project was Rs. 91 million with a foreign exchange component of Rs. 43.7 million. The investment per nutrient ton of annual capacity came to US $ 1821 at the then prevailing rate of exchange (1 US $ = Rs.4.76).

The plant consisted of equipment for gasification and primary purification (coal gasifiers, oxygen compressors, tar washing and removal plant and oil distillation plant), equipment for pre-washing for removal of hydrogen sulphide, equipment for removal of carbon dioxide and conversion of carbon monoxide, gas fractionating plant (heat exchangers and nitrogen compressors), air fractionating plant (heat exchangers, liquifiers, air compressors, soda washing unit) and equipment for synthesis of ammonia (convertor, waste heat boiler, hyper-compressors and ammonia condensor). Hydrogen for use in the synthesis of Ammonia was produced by pressure gasification of local coal which was expected to have no more than 12% ash content after crushing and screening. About 130 to 150 tons of coal were used daily and the gases produced were processed to remove tar, oil, carbon dioxide and hydrogen sulphide. The latter was utilised in the production of sulphuric acid needed for reaction in the ammonium sulphate plant. "Off gases" were removed in the gas fractionating plant and utilised in the boilers of the power station. The plant achieved its rated capacity within 4 years of commissioning but subsequently its overall production levels fell below the rated capacity (Table-9) because of problems with the hydrogen sulphide removal system and the gas fractionating plant. In view of the increase . . the demand for fertilizers in the country it was decided to find ways and means of increasing the capacity of the plant in an economic manner. It was felt that instead of burning the "off" or "rest" gases realised from the gas fractionating plant, these rich gases could be better utilised so as to yield an additional production of about 34 tons of Ammonia daily. In this manner the total production of Ammonium Sulphate could be raised to 90,000 tons annually. This would also have the effect of reducing the costs of production. Accordingly, a steam reforming (Kopper) plant was added alongwith Sulphinol washing for carbon dioxide removal in 1968-69. During the subsequent 3 or 4 years the production did rise beyond 50,000 tons annually but it did not reach the rated capacity of 90,000 tons until the plant was converted from use of coal to natural gas. The main reason for abandoning coal gasification was that instead of 12% ash content assumed in the design of the plant the coal supplied to the plant had a much higher ash content, going as high as 35% at times. It also had high moisture content which affected production of gas and Ammonium Sulphate. The costs of maintenance of the gasifier and the power station also showed an increasing trend and there were frequent breakdowns and problems, particularly in the maintenance of I.D. fan in the boiler. Boiler tubes got burst every now and then because of problems with ash and continuity or reliability in the power house and the steam system could not be depended upon. At the time these problems were being faced natural gas became available in the Meyal and Dhullian oil fields and arrangements were made to lay a pipeline for this gas which was used for power station boilers, auto thermal and steam reforming units. Subsequent to completion of this conversion the plant gave more than 90,000 tons production annually.

The plant now utilizes steam reforming and auto-thermal catalytic reforming processes for syngas production, shift conversion process for converting carbon monoxide to carbon dioxide, sulphinol process for carbon dioxide removal, final purification by liquification and ammonia production by Casale process. Ammonium Sulphate is produced by double decomposition of ammonium carbonate and gypsum.

The plant has manufactured 1.6 million tons of Ammonium Sulphate since its commissioning and its overall capacity utilization has been more than 93% (Table 9). It has also been suppling Ammonia and Argon for refrigeration and industrial purposes. It has been a success and can be regarded as having achieved its direct objectives i.e., economic production of Ammonium Sulphate, as well as yielding many indirect benefits like introduction of and familiarization with a new (fertilizer) technology in the country, creation of a reserve of a large number of trained operators, supervisors, engineers and managers who subsequently contributed enormously to establishment and development of fertilizer industry in the country, development of a backward area in the country, providing employment to nearly 1000 workers in the area etc.etc. The product of the plant, though low in nutrient value, is still a preferred fertilizer in many parts of the country.

Most of the equipment of the plant has been in operation now for more than 20 years and some of it needs replacement and rehabilitation. A project to undertake this in phases is presently in hand.

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At about the time planning for the ammonium sulphate plant was in hand, PIDC also examined the desirability of setting up a phosphatic fertilizer plant. The demand for phosphatic fertilizers was slow to develop and it would have been premature at that time to think in terms of a large capacity plant. Yet the need could not be denied of making a start towards introducing phosphatic fertilizer technology in the country by indigenous manufacture of a simple product. Pakistan is deficient in sulphur and rock phosphate resources and the proposed plant had of necessity to be based on imported raw materials. Because of this, perhaps the best location would have been near a port but PIDC learnt that a private sector enterpreneur was in the process of putting up a 20 tons-a-day sulphuric acid plant at Lyallpur (now Faisalabad) in the Punjab but could not complete it because of shortage of funds. There were also perhaps some second thoughts about the growth of demand for sulphric acid in the area. An agreement was entered into with this party to purchase controlling shares of the company and to make use of its equipment for manufacturing not only sulphuric acid but 20 tons (later raised to 60 tons) daily of Single Super Phosphate (18% P_2O_5) also. Rock phosphate was to be imported from Jordan and no problem was anticipated on this account because Faisalabad is connected by railway. The plant was completed at a cost of Rs.3.35 million and it started production in August, 1957.

The plant employs straightforward processes and has simple equipment for the manufacture of sulphuric acid (Contact Process) and Single Super Phosphate (continuous Den Process). Solid sulphur is melted and then burnt with dry air to produce sulphur dioxide, which is converted to sulphur trioxide in the presence of a catalyst (vanadium pentoxide). This gas is passed to an absorption tower to produce 98.5% sulphuric acid, which is mixed with finely ground rock phosphate in a mixer. The reaction yields a slurry which is discharged into a slowly rotating den where the product attains a solid form. The output from the den is cured for 10-15 days to permit the acidulation reaction to be completed.

The plant faced a number of problems of maintenance of grinders and den gears. In the early years, the demand for Single Superphosphate (SSP) was slow to pick up with the result that production of the fertilizer was restricted to what could be sold and a sizable proportion of sulphuric acid was sold away instead of being used in the manufacture of SSP. In the days when the demand for sulphuric acid was less than its rated capacity, the plant had to be shut down very frequently. This not only affected the economics of production but also the life of equipment.

With the increase in the demand of phosphatic fertilizers and in view of its projected growth it was decided to instal another unit for manufacturing SSP about 30 kilometers away in the same area (Jaranwala). The new unit was to have a capacity of producing 72,000 metric tons per annum and was to be completed in two phases. The first was completed in February, 1968 and the unit had one sulphuric acid plant of 50 tons-a-day capacity which could be used to manufacture 36,000 tons of SSP annually. The second phase was undertaken with the addition of another sulphuric acid plant in 1976. The total cost was Rs.15.65 million. 318 persons are employed at this plant and 156 in the Faisalabad plant, many of whom are provided with residential accomodation near the plants.

Table 10 shows how the production at these plants has grown. Apart from the difficulties and considerations mentioned above, problems of cash flow were also faced by the plants because of delays in release of funds from certain government agencies. This severely restricted their capability to finance the import of sulphur and rock phosphate in a steady and regular manner. The result was that up to about 1974-75 the SSP plants were not able to achieve reasonable figures of capacity utilization. With the growth of demand for phosphatic fertilizers, the popularity of SSP was established, particularly in view of its beneficial effects on lands affected by salinity. It was decided to increase the production of the fertilizer at the plants and a restriction was placed on the sale of sulphuric acid. Problems of cash flow and interruptions in imports were tackled, proper maintenance of equipment was organised and some equipment added for balancing purposes and for improvement in operations. As a result of these efforts, the plants have been operating at more than 100% capacity for a number of years now. More than 850,000 tons of SSP has been manufactured in these plants; nearly 64% of this quantity was produced during the last 6 years, when the overall capacity utilization was 101%.

Being located in the heartland of the fertilizer consumption area, the two SSP plants have not had any problems in distributing their product. While the comparative economics of manufacturing low nutrient SSP by importing basic raw materials have suffered due to widely fluctuating prices of such products as DAP and NP in the international market alongwith the rising trend in the prices of sulphur and rock phosphate, particularly after the oil crisis of the 1970s, it cannot be denied that these small plants have played a very significant and positive role in demonstrating the usefulness of and popularising the application of phosphatic fertilizers in the country, especially among farmers with low purchasing power.

The price fixed by Government for the sale of Single Superphosphate to the farmers is much lower than the current cost of manufacture in these plants. The main reason is their dependence on imported sulphur and rock phosphate. In recent years the prices of these raw materials have registered steep increases with the result that these plants have had to depend on an arrangement with the Government under which a fixed return on equity is assured provided the production does not fall below the rated capacity of the plants. The plant management has consequently been under more-than-normal pressure to keep the costs of manufacture at the lowest levels side by side with attaining high rates of capacity utilization. Research and development work has been undertaken, particularly with a view to finding the best method of using local rock phosphate, small reserves of which were discovered in the Hazara district of NWFP some time ago. As a result of this work, the Faisalabad unit calcines this local rock which is quite hard and rather low in P_2O_5 content and mixes it with the imported rock to the extent of 20%. Plans are in hand to use a similar mix at the Jaranwala plant also. This should help in bringing down the cost of manufacture of SSP.

Another development has been the setting up of a small (600 tons a year) zinc sulphate plant at Faisalabad. The equipment for this plant was designed, fabricated and installed by local expertise. It is presently meeting the entire demand of this micro-nutrient in the country and can be expanded to meet future growth in requirements.

The operation and maintenance of these small plants has helped to develop a corps of operators and supervisors who have learnt to rely on local resources for their requirements.

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The discovery of a large reserve of high grade natural gas at Sui in 1952 proved to be a great boon and as soon as plans were finalized for the exploitation and distribution of this gas in the country, consideration was given to using it as a good quality raw material (94% methane in purified gas) for the manufacture of fertilizers, the demand for which had started picking up. PIDC had been considering the establishment of a large industrial complex near Multan, a centrally located and well-connected large city in Pakistan. The pipeline from the gas field was to pass close by and the city had enough facilities to provide an economical infrastructure to the proposed complex, which was to consist of a steel mill, a large thermal power station and a (natural gas) fertilizer factory. The steel mill project was deferred and later on abandoned in favour of another site but the projects for the power house and the fertilizer factory were undertaken and duly completed.

PIDC's project proposal for the Natural Gas Fertilizer Factory (NGFF) at Multan was approved by Government in November, 1957. It was estimated to cost Rs.168.9 million with a foreign exchange component of Rs.112.0 million. It was to be designed to produce 204 tons of Ammonia daily (in two lines), which was to be converted into 180 tons of Urea (46% N) and to 180 tons of Nitric acid, for use in the manufacture of 300 tons of Ammonium Nitrate (26% N) daily. The selection of these capacities was dictated primarily by the availability of proven technology in this range. It was expected that the plant would be completed by April, 1961.

Six firms competed for the scheme and the turn-key quotation of Messrs. ENSA of France was accepted in January, 1958 because it was the only one which offered deferred payment terms. The contract had provisions for firm F.O.B. foreign prices, including normal spares, erection and civil engineering costs (foreign exchange part) and for estimated rupee costs which were subject to escalation clauses. The price of additional equipment which might become necessary later was also not firm. Capital costs began escalating soon after the construction started and a revised project proposal(involving a total expenditure of Rs.243 million i.e., an escalation of nearly 44%) had to be prepared by PIDC in 1960 and submitted to Government for approval and provision of funds.

The contractors were to complete and hand over the plant after guarantee tests by October, 1960, but serious damage to certain important equipment during handling at the Karachi port and while unloading at site by the Railway necessitated replacements from abroad. Delays, therefore, occured in the completion of the project and the contractors were granted time extensions on two occasions and the project completion date had to be moved to October, 1961. The construction and erection work could not, however, be completed before December, 1961. Furthermore, when trial runs were undertaken, leakages developed in the production line and the factory had to be closed down. Under the terms of the contract, Messrs. ENSA were to deliver the factory to PIDC after it had produced at least 75% of the guaranteed capacity over a 24 hours period. Equipment damaged in the trial run was replaced by the contractor and there was some improvement in the production results but the contracted capacity levels were not attained.

In view of these teething troubles, further modifications were contemplated. This led to the appointment of a third party, a chemical engineering firm of repute, to carry out a general inspection of the plant and to give its views regarding the engineering soundness of design and equipment and on the commercial soundness of completed plant. This firm noted the problem about catalyst consumption in the ammonia plant, which was the main cause of its inadequate capacity and was of the view that this consumption had exceeded the normal limits only due to the difficulties during the very first start-up and to some wrong operations. It was felt that catalysts used were in general of correct quality and specifications. The firm's findings on the leakages in the production line and on other shortcomings in the ammonia plant were optimistic and it recommended that the plant was commercially sound and could be taken over by PIDC.

On receipt of these recommendations, detailed discussions were held with the contractor and agreement signed for the implementation of certain modifications and supply of additional equipment, free of cost. Messrs. ENSA carried out guarantee tests and implemented the modifications, and PIDC finally tookover the factory in April, 1963. The total capital cost was recorded at Rs.229.2 million. The plants at that time were supposed to have daily capacities of 203 tons of Ammonia (two lines, Grande Paroisse design), 180 tons of Nitric acid (C&I Girdler technology), 295 tons of Ammonium Nitrate (design by Saint Gobain, France) and 170 tons of Urea (Inventa technology). During initial operations, it was found that while the ammonium nitrate and urea plants had somewhat greater capacities than these guaranteed rates, the ammonia plant could not give more than 75-80% of its guaranteed rate. The main culprit was the short life of the catalysts, which did not last more than 3 months and the plant had to be shut down frequently for replacement of catalysts. Another problem was in the maintenance of hyper compressors where vibration limits had to be carefully monitored. Efforts were made to improve the productivity of the plant by finding more suitable catalysts which could last longer and by careful maintenance and operations of the equipment, particularly the compressors. The performance and output improved somewhat but as the figures in Table 11 show, full capacity utilization of the urea and ammonium nitrate plants was never achieved due to the problems in the ammonia plant, which had to be overhauled during 1967-68 and one of the lines of which had to be shut down for many months during 1971-72 due to failure of one of the compressors.

It was soon obvious that PIDC had got an unbalanced and inefficient plant with high operating costs. In order to balance the production of Ammonia and hopefully to utilize the excess capacities of the fertilizer plants, it was decided to instal a package type (Ammopac: C&I Girdler technology) ammonia plant with a daily capacity of 60 tons at a cost of Rs.27.3 million. This unit was commissioned during 1968-69. Unfortunately, even this investment did not yield the expected results because the new unit could not be operated satisfactorily mainly due to problems with gas engine driven multi-service compressors. Even extensive modifications and the provision of a stand-by compressor by the suppliers did not help in getting full production and achieving better capacity utilization rates.

The plant manufactured 1.13 million tons of Ammonium Nitrate and 0.53 million tons of Urea upto 1977-78. With this troubled history, it was not surprising that the under-utilization of capacity of the fertilizer plants due to production bottlenecks in the ammonia plants was responsible for high costs of manufacture of Ammonium Nitrate and Urea. These were found to be 40% higher than the imported (C&F Karachi) prices, but it was claimed in 1969 that if the costs of prod"ction at NGFF and costs of imports were to be "sh. priced",it could be established that from the point o w of overall national economy, it would be beneficial to continue to manufacture the two fertilizers at Multan than to import these.

The capital cost (including the expenditure on the Ammopac unit) aggregated to Rs.256.5 million or Rs.4,741 (US $996) per nutrient ton of annual rated capacity. In actual experience the investment came to nearly Rs.7,624 (US $ 1602) per nutrient ton of average annual capacity actually achieved.

The selection of Ammonium Nitrate and Urea for manufacture at NGFF, Multan had been made in view of the greater agronomic efficiency expected of these products as compared to Ammonium Sulphate, and the need to start manufacture of high analysis fertilizer in the form of Urea, which could yield economies in cost of production as well as in transportation per nutrient ton. While the technology selected for the factory was certainly an improvement over that employed at the Daudkhel plant, the problem faced by PIDC at Multan was that it became out-dated soon after the commissioning of the factory which never operated on satisfactory lines. Subsequent technological developments in the manufacture of Ammonia drastically reduced production costs and plants based on these were found to be more reliable and economical.

These were adopted in the fertilizer plants which were set up in the country after the NGFF plant and the latter suffered in comparison.. A project for modernisation and expansion of NGFF based on latest technology was also undertaken and the old ammonia plants alongwith the ammonium nitrate plant were shut down permanently in 1978.

Another factor which emerged from the use of outdated technology was the comparatively high number of employees required for the maintenance and operation of the plants at Multan. The labour productivity measured in terms of overall nutrient tons produced per man-year, gradually came down from 26 in 1964 to 15 in 1975. Although it was still higher than that achieved at PAFL (8 nutrient tons per man-year), its decline over the years at NGFF created difficulties for the factory management. From the point of view of providing employment in a labour surplus economy, this could perhaps be regarded as a welcome feature in certain quarters but it did pose many problems to the plant management when modernisation and expansion were undertaken and it was found that despite the increase in the scope of operations and the capacities of the new plants, the number of staff required, particularly in the unskilled and semi-skilled categories, was lower than that already employed in the old plants. On the other hand, valuable experience was gained by the operators, supervisors, engineers and managers at NGFF during all types of adverse operating conditions of bottlenecks, frequent shut downs and heavy routines of maintenance and upkeep. On the basis of this experience many of them were able to find lucrative jobs with the private sector in the country as well as in the middle east.

This exodus, though a cause of considerable inconvenience to the public sector fertilizer industry, did have direct and indirect benefits for the national economy. The experience at NGFF also provided enough confidence to its top management to undertake an ambitious scheme of modernisation and expansion during the 1970s on a "cost reimbursable" basis.

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Five years after the discovery of the Sui gas field, another fairly large gas field was discovered at Mari in 1957 with an estimated recoverable reserves of 3.94 trillion cft. This gas had 73.2% of methane, 19.9% of nitrogen and 6.8% of carbon dioxide. Its chemical composition, particularly in the matter of nitrogen, and heating value were quite different from those of Sui gas. It was perhaps for this reason that no effort was made to link it with the main gas distribution network and it was regarded as more suitable for use in "well head" fertilizer plants. Messrs ESSO (now EXXON Chemicals) decided to set up such an ammonia/urea plant at Daharki, a village in district Sukkur of Sind, 11 kilometers away from the gas field. It is situated on the national highway and is connected with the rest of the country by railway also. The fertilizer plant was designed and engineered by EXXON itself, for a production capacity of 300 tons/day of Ammonia to be converted into 510 tons/day of Urea; the process licensor being Mitsui Toatsuo of Japan. The plant was commissioned in December, 1968 at a total investment of the order of Rs. 425 million or Rs. 5367 (US $542) per nutrient ton of installed capacity. It has been operating very smoothly right from its start-up and was expanded in 1974 by modifications, mainly in the reformer area. It is now capable of producing at considerably higher levels than the original rated capacity and in its 14 years' life, it has manufactured more than 2.7 million tons of Urea (Table 12). Though strictly not in the mini fertilizer plant category, it is yet a small and compact plant as compared to other plants subsequently installed in Pakistan, utilizing latest developments in ammonia technology. In such matters as productivity, capacity utilization, efficiency and economy in operations, ex-factory prices, etc., the plant enjoys a position of prestige in the fertilizer industry in Pakistan and is frequently quoted as a model for other plants.

WOOD HERCULES EMICALS LTD, IKHUPURA AHORE)

The second fertilizer plant in the private sector was established by Dawood Hercules Chemicals Limited (DH) in 1971 with a daily production capacity of 625 tons of Ammonia, all to be converted into 1100 tons of Urea. It is a joint venture of Messrs. Hercules of USA and Dawood Corporation of Pakistan. The plant is located at Chichokimallian (Sheikhupura), 25 kilometers from Lahore, right in the fertilizer consumption area of the Punjab and draws its feed-stock from the national network of natural (Sui) gas pipeline. The ammonia plant employs Kellog process and had the distinction of being the first to use the new centrifugal compressor technology in Pakistan. The Urea process is that of Mitsui-Toatsu (total recycle). The engineering was done by Flour Corporation of USA. The total cost was of the order of Rs. 833 million or Rs.5,249(US $ 530) per nutrient ton of annual capacity. The performance of the plant has been outstanding and in the ten years since its commissioning it has manufactured 3.8 million tons of Urea and maintained more than 100% of capacity utilization (Table 13).

The selection of processes and product in these two private sector plants depended largely upon the trends of Urea demand in Pakistan and the breakthrough achieved in the nitrogenous fertilizer production technology during the sixties and seventies. Both of them are located at places which are very well connected by rail and road so that problems of distribution of products are minimized. The EXXON plant, however, is located away from the main consumption areas and has, therefore, to move its product over longer distances; investment has had also to be made on the development and maintenance of infrastructure in the form of a self contained housing colony and ancillary facilities. The DH plant, on the other hand, is located in the consumption area and near a large city and has not had to worry too much about these.

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A mention has been made earlier of the unsatisfactory operation of the Natural Gas Fertilizer Factory at Multan which had been in operation since 1962 but had not been able to manufacture Ammonia and, therefore, Urea and Ammonium Nitrate at anywhere near full capacity. The problem had not been solved even by the addition of a small package unit for ammonia production. Being based on obsolete technology, the old plants also were proving to be energy-intensive and uneconomical to operate. Meanwhile, fertilizer demand in Pakistan was exceeding production; increasing adoption of high - yielding varieties of wheat and limited domestic production of nitrogen and phosphatic fertilizers led to a severe shortage of these inputs which was only partly offset by imports. The need for further increasing Pakistan's fertilizer production capacity was evident. A large number of international companies showed an interest in building large fertilizer plants in Pakistan and received Government approval to proceed with studies. However, after several investigations had been made, no firm commitment resulted. In this background the desirability of modernising and expanding the facilities at Multan naturally came up for serious consideration and studies were undertaken by PIDC with the help of consulting firms. These studies described various expansion alternatives i.e., to make phosphatic fertilizer from (i) imported phosphoric acid, or (ii) imported rock phosphate and sulphur to make phosphoric acid locally, or (iii) imported rock phosphate and no sulphur and to make nitrophosphate via nitric acid. The comparative evaluation showed that this last alternative was economically the most attractive.

A project proposal was, therefore, prepared by PIDC in early 1970s for the erection of a separate, large and modern 910 tons per day ammonia plant which was to replace the existing ammonia units. This new facility was to feed a new 1200 tons per day nitric acid plant (two lines) and a combined Nitrophosphate (NP) and Calcium Ammonium Nitrate (CAN) complex with daily capacities of 1015 tons of prilled NP and 1500 tons of prilled CAN. There would have been left enough Ammonia to enable the manufacture of 180 tons of prilled Urea in the old urea plant. In addition to the replacement of old ammonia plants and setting up of new nitric acid, NP and CAN plants, the project was to include installing new boilers, turbo - generators and cooling towers, as well as other offsites and storage facilities. An important consideration for making the proposed investment at Multan rather than at a new site was that it permitted closing down older ineffecent units while continuing to utilize existing infrastructure.

The decision to manufacture a "compound" fertilizer with both nitrogenous and phosphatic nutrients was a part of Government efforts to correct progressively the strong imbalance in the usage of N and P fertilizers among farmers. The balanced nutrient content of NP (23:23:0) and the presence of nitrogen nutrient in nitrate form in it were put forward as arguments for selecting this product because of convenience of application and expected agronomic advantages. It was, however, considered that in order to be successful in alkaline soils such as those in most parts of Pakistan, the NP fertilizer must have a highly water soluble (80%) phosphate content. The recent development of processes capable of producing such water soluble NP was a crucial element in the decision to set up NP/CAN plant as a part of modernization and expansion of the old facilities at Multan. It was expected that by making use of latest technology, particularly that related to large centrifugal compressors, it would be possible to achieve considerable economies of operation (e.g. energy consumption, maintenance costs) in the new plants.

PIDC's proposal for the project was approved by Government in 1973 for Rs.832 million with a foreign exchange component of Rs. 588 million, the financing of which was arranged with the World Bank, Asian Development Bank and by equity participation from Abu Dhabi National Oil Company (ADNOC). Proposals for engineering services were invited competitively from internationally experienced engineering firms and Messrs. Kellog of U.K. were selected to undertake design and procurement of the ammonia plant and offsites while Messrs. Uhde of West Germany were chosen to design and procure the nitric acid, NP and CAN plants. Messrs. Stamicarbon of Holland were appointed as the Technical Advisers.

Ownership of the existing NGFF at Multan was transferred to a newly formed company viz., Pakarab Fertilizer Limited (PFL). Government of Pakistan holds 52% of its shares through its holding company viz., the National Fertilizer Corporation (NFC) and ADNOC holds the balance.

The contracts with the engineering firms stipulated an optimistic period of 28 months from effectiveness of contracts to mechanical completion, which was expected in April, 1976. However, due to a delay in making financing arrangements, the effectiveness of the engineering contracts slipped and the completion of engineering and procurement work was delayed by 5 months. The oil embargo on industrial countries caused the need for further changes in the implementation schedule of the project. Since equipment prices escalated rapidly, many promised delivery times for orders accepted earlier were lengthened several fold; price escalation became part of most offers and some equipment suppliers quoted such long delivery times that other suppliers had to be found, which meant repeating bidding and evaluation processes. Despite active expediting, many suppliers further delayed deliveries by four to six months.

Another adverse factor faced by the project was that the increasing numbers of skilled workers leaving Pakistan for higher paid jobs in the middle east created manpower shortages in the country. Local firms interested in undertaking mechanical and electrical construction work were unable to bring in sufficient welders, electricians and other craftsmen so that the engineering contractors had to be called upon to supply expatriate craftsmen. This process caused delays and problems besides increasing the capital costs.

In 1976, wide-spread floods occured in Pakistan, causing delays in transporting equipment from Karachi to Multan. One ship carrying project equipment caught fire at sea and another lost 28 consignments meant for PFL in a marine accident. Re-ordering and delivery took many months. Further delays arose in February, 1977, caused by political disturbances which resulted in expatriate engineering and erection personnel not being assigned to Pakistan until several months later.

Despite these problems, work on the project continued, albeit at a slower pace. The power plant was brought into operation in February, 1978. The production units were successively completed during the rest of that year, with Ammonia and nitric acid being produced in September, Urea in October, CAN in December 1978 and NP in January, 1979. Mechanical completion was substantially achieved in September, 1978 i.e., 52 months from the time the engineering contracts became effective.

The delay in completion of the project was naturally accompanied by a very substantial cost overrun. The final cost is Rs.2511 million with Rs.1292 million in foreign exchange. Furthermore, a number of crucial design deficiencies in the plants became apparent after start-up. Cooling water has caused serious corrosion in several heat exchangers which have required costly replacements and the water treatment process control needs to be made more efficient. Operations of the demineralized water units of the steam plant had inadequate capacity and a third unit had to be installed. Additional equipment had to be installed to increase the capacity of the calcium carbonate precipitation/ filteration system in the CAN plant to its design rating. Similarly, additional crystallisers and allied equipment have had to be installed and other modifications carried out in the NP plant in order to improve its production performance i.e., quantity of output and the water solubility of the product. The effects of these modifications are yet to be established and tested.

As a consequence of these problems, the PFL plants at Multan have not yet achieved their rated levels of production (Table 14). The final capital cost per nutrient ton of design capacity comes to Rs.8,829 (US $ 892). The productivity per employee is much better than in NGFF days and the ex-factory prices of the fertilizers are going down as capacity utilization improves. On the basis of updated production and price projections, the economic rate of return of the project has been reestimated at 15% and is considered satisfactory even if substantially lower than the original estimate of 34%. At full production, the project is expected to result in net foreign exchange savings to Pakistan of around US $120 million annually, in 1979 prices.

A number of lessons have been learnt during the implementation of this project. Even internationally known and fully experienced engineering firms can sometimes quote on the low side(in terms of cost and/or time required) to enhance the attractiveness of their bids. They need to have more experience with projects under conditions such as prevailing at Multan. Too great a reliance should not be placed on the existing infrastructure and a detailed study should be carried out to determine and provide for, in plans and costs, the modifications required for the existing facilities to be useable in the expanded plant. These can prove to be more time-consuming and costly than expected on the basis of a superficial check up. Implementation and operation of high level technology projects require highly trained, experienced and appropriately motivated technical and managerial personnel. Project management must have sufficient autonomy in setting compensation scales to attract and keep adequate technical and management personnel. The main reason for the design errors in the case of PFL project perhaps was to be found in the failure of translating the laboratory scale data for the rock phosphate to be used at Multan to full - scale plant design. Perhaps the most important point to be kept in view in the transfer of latest technologies and processes to developing countries is that these must first be checked to have been in actual and successful operation on a full plant scale before these are adopted.

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With the object of achieving self sufficiency in the matter of nitrogenous fertilizers and to exploit Mari gas reserves for this purpose, Government of Pakistan approved in 1975 a project proposal by NFC to set up a large ammonia/urea plant at Mirpur Mathelo, about 14 kilometers away from the gas field at a cost of Rs.1912 million (Rs.1376 in foreign exchange). The plant was to be designed for a production level of 1000 tons/day of Ammonia (Topsoe technology) to be converted into 1740 tons (or 557,000 tons per annum) of Urea (Snamprogetti process). Financing for this project, known as the Pak-Saudi Fertilizers Limited (PSFL), was arranged through loans from Saudi Government, Saudi Fund for Development and from the Asian Development Bank. Work on the project was taken in hand in April,1975, and the contract for engineering was awarded to Messrs. Snamprogetti of Italy. There were some unavoidable delays in the execution of the project but these did not lead to any serious problems or heavy cost overruns. This was partly due to the experience gained by NFC in the implementation of PFL expansion project. The precommissioning activities were started in the third quarter of 1979 and Ammonia/Urea produced for the first time in April, 1980. Unfortunately, two serious setbacks delayed the start of commercial production for sometime. The refractory of the secondary reformer in the ammonia plant was found to be unsatisfactory and had to be replaced. Due to a design error in a valve, the carbon dioxide compressor in the urea plant got damaged. Time consuming repairs/replacements had to be undertaken before the plant could be restarted and brought into commercial production from Ist October, 1980. It has been performing very satisfactorily since its start up and has already achieved 90% capacity utilization during ... 1981-82 (Table 15).

The final cost of the plant is Rs.2081 million i.e., Rs.8122 (US $820) per nutrient ton of annual capacity. The productivity per employee is quite high and the ex-factory price very competitive. The plant is expected to yield substantial foreign exchange savings in the years to come.

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More or less simultaneously with the abovementioned PSFL project, construction of another ammonia/urea plant of the same capacity was undertaken at Goth Machhi, 53 kilometers from Mari gas field. This private sector plant (FFC) came into commercial production in May, 1982 and has been operating very satisfactorily since.

With the completion of FFC, there are three ammonia/urea plants which use Mari Gas. These plants are located near the gas field and although they are well connected with the rest of the country by main railway line and the national highway, they are at some distance from the main areas of fertilizer consumption. This has required a constant review of rail and road transportation requirements. It is necessary to co-ordinate arrangements for effectively meeting the demand of railway wagons and road trucks and it has become necessary to build large warehouses for the storage of of fertilizer near the consumption areas. On their completion, full train loads will move the fertilisers from the plants to the storages regularly with the twin objectives of avoiding plant shut-downs due to excessive stocks during off season and making the best utilization of railway facilities. Had it been possible to pipe the gas economically and to set up small plants in the various consumption areas, the additional investment in storage facilities and on making elaborate arrangements with the Railway could have been avoided..

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As a part of friendly economic assistance, Peoples Republic of China offered during early 1970s to set up in Pakistan an ammonia/urea plant with a capacity of 170 tons of Ammonia and 290 tons of Urea daily. A project proposal was drawn up by NFC and after discussions with Chinese experts, Haripur in the NWFP was chosen as the best site for this plant. It is connected with the rest of the country by rail and road and is within convenient distance of fertilizer consumption areas of the NWFP and upper Punjab. Other fertilizer plants are located in the central and southern parts of the country and location of a plant at Haripur is expected to provide relief to the overloaded national transportation system which has to carry large quantities of indigenously manufactured and imported fertilizers from South to North. Another reason for selecting this site was the consideration that at a later stage, a phosphoric acid plant based on local rock phosphate discovered earlier in the district, would also be set up here alongwith a plant for the manufacture of Urea Ammonium Phosphate (UAP-27:27:0). Sufficient quantities of gas for the project were expected to be available from the natural gas network in the area.

Discussions regarding preliminary design and other subjects were held in China during 1974 and 1975 and Government approval was accorded during 1976-77 to the implementation of the project at a cost of Rs.366.4 million with a foreign exchange grant for equipment and services from China estimated at Rs.175.2 million. It was hoped that mechanical completion of the plant would be achieved towards the end of 1977 and it would be commissioned in early 1978. However, this schedule could not be adhered to because the details of the equipment required and the contracts for their supply and for provision of engineering and technical personnel could not be concluded with the Chinese organisations concerned till the middle of 1978. It was then learnt that the weight and cost of equipment to be supplied from China would be considerably higher and its actual fabrication and shipment would be spread over a longer period than anticipated earlier. A revised project proposal had, therefore, to be prepared by NFC to provide for these and associated additional expenses such as higher erection charges, preliminary and pre-production expenses and interest for a longer period. Government's approval was obtained in early 1980 for Rs.641.8 million with a foreign exchange component of Rs.302.5 million. It was hoped that it would be possible to commission the plant by mid 1981. The first group of Chinese experts arrived in Pakistan in July, 1978 and the first consignment of material was shipped from Shanghai in September, 1978. Experts in all facets of project implementation (civil works, foundations, mechanical erection, insulation, electrical and instrument work etc) arrived from China to supervise the work closely. Two batches of Pakistani engineers (24 in all) were sent to China for training on the operation and maintenance of similar plants. Over the next four years, nearly 11,000 tons of material was received from China in more than 60 shipments. No major problems were encountered in the transportation, unloading and erection of the equipment. It was, however, experienced that the schedule of shipments of the equipment from China could not be co-ordinated with the requirements of installation and erection programmes at Haripur. The urea reactor originally fabricated for the plant was found to have a manufacturing defect. Fortunately, this was detected before shipment but its replacement could be made available and shipped in August, 1981 instead of by end of 1980. The completion and commissioning of the plant, therefore, suffered some delay but this was restricted to the minimum by round-the-clock work by the Chinese and Pakistani workers and by undertaking in parallel as many as possible of the activities of mechanical, electrical and instrument installation.

Production of Ammonia and Urea was achieved in March, 1982 after a very smooth start up. The plant has been operating at near 100% capacity levels and it is confidently expected to be capable of giving 5% higher production. The gas consumption for fuel is a little higher than the design value but it is expected to stabilize at a lower figure soon. Some problems have been encountered because of interruption of electric supply which is purchased from outside and a proposal to set up a power house for the fertilizer plant is under consideration.

The actual expenditure on the plant is Rs.622 million including Rs.334.7 million on supplies of equipment and services from China. Since the plant is designed to manufacture 95,700 tons (44,022 nutrient tons) of Urea annually, the investment per nutrient ton of annual capacity comes to Rs.14,145 (US $1155 at the present rate of exchange i.e. 1 US $ = Rs.12.25). The plant presently employs 325 workers and 110 officers and supervisors.

With the completion and commissioning of these plants, Pakistan has an installed capacity of 1.11 million nutrient tons of fertilizers (1.03 million nutrient tons of nitrogenous and 86,000 nutrient tons of phosphatic fertilizers). The total capacity in terms of product tons is 2.72 million tons, out of which 2.10 million tons is accounted for by the four plants located on the main railway line/national highway between Multan and Mirpur Mathelo, a distance of 382 kilometers, / production capacity of 1.29 million tons is concentrated within a distance of 60 kilometers only, between Goth Machhi and Mirpur Mathelo.

A scheme for an expansion of the capacity of the old urea plant at Multan (from 180 tons to 280 tons daily), as a part of its rehabilitation, is being taken in hand. Government has also approved proposals for the expansion of the [illegible] D.A.P. plant and for setting up of a complex of DAP [illegible] plants in the country. However, no actual progress has so far been reported on these projects.

Table 16 shows statistics of actuals production of fertilizers in Pakistan since the 1950s.

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Comparatively small capacity fertilizer plants were set up in Pakistan not as an alternative to large plants but in view of the market requirements and the technology available at the time of their installation. The first plant to be set up was at Daudkhel with an ammonia plant of only 40 metric tons-a-day capacity. Its location was decided upon primarily on considerations of its proximity to the raw materials, gypsum and coal, and by the need to develop a backward area. The sizes of the ammonia, urea and CAN plants set up at NGFF, Multan were determined by the technology then available. Admittedly, these plants were located in an area in the neighbourhood of which the demand for fertilizers was expected to grow but the main consideration for selecting this site was the ease with which the infrastructure for a large industrial complex comprising a power house and a fertilizer factory could be developed at Multan. In the matter of location of the original Single Super Phosphate plant it was more the location of a sulphuric acid plant than considerations of easy logistics. The SSP plants as now located require the transportation from Karachi to Faisalabad and Jaranwala of rockphosphate containing 32% of P_2O_5, a significant proportion of which after acidulation has to be moved back to southern Punjab and [illegible] even Sind in the form of fertilizer with 18% P_2O_5.

It is only in the case of the [illegible]onia/urea plant at [illegible] that it [illegible] ll pl[illegible] was deliberately chosen to serve an immediate neighbourhood of consumption area. Another factor, of course, was the size the Chinese Government had in view while offering to put up a fertilizer plant in Pakistan as a component of its economic assistance programme.

During a meeting of the Fertilizer Planning Committee of the Government of Pakistan held in September, 1979, a question was raised as to whether the country should aim at having its indigenous fertilizers manufactured in large or small plants. It was noted that the advantages and disadvantages of the alternatives had been debated in the past, without detailed economic comparison. Consequently, the experts of the National Fertilizer Development Centre (NFDC) of the Planning and Development Division, prepared a report in May, 1980 on the economic comparison of two urea plants, then under construction in Pakistan viz., the large Pak-Saudi Fertilizers Limited Plant at Mirpur Mathelo and the small Hazara Urea Fertilizer Plant at Haripur. For this comparison, the anticipated investment and production costs for each plant were converted into rupees per ton; the (estimated) investment, production cost and output volume of the large plant were used as the starting point and corresponding figures of the smaller plant were "scaled up" to the large plant level and March, 1980 price to the farmer of Urea (Rs.1860 per ton) was used in calculations of profitability with both plants being allowed incidentals and freight expense reimbursement at the same level (Rs.180 and Rs.80 per ton respectively. Economic comparison of a number of socio-economic factors was kept "open", because it was not considered "possible" and because "political considerations might be relevant in making decisions".

The findings of the above mentioned report were almost totally in favour of the large plant and no redeeming feature was detected in the small plant.

It was concluded that a small fertilizer plant was an "exceedingly costly path", from the view point of "investment, production cost and for creating employment opportunities; large plants utilize scarce investment and raw materials much more efficiently." The investment per (product) ton of capacity was found to be double that of the large plant (Rs.6,714 vs.3,310) and it was pointed out that with the per ton investment cost of the small plant applied to the tonnage of the large plant, the resources would be adequate to erect two large plants and still leave a balance (Rs 57 million) for investment in conveyance facilities. The production cost per ton in the small plant was also found to be more than double that in the large facility. The investment cost per employee opportunity in the small plant was calculated to be higher by Rs.1.63 million for each additional position. The report added that perhaps the economic utility of the small plant lay in its capacity to feed supplies of its product into the overall national supply at a cost below the cost of imports, thus causing a saving in foreign exchange. It put forward the view that there was little evidence that questions of management demand, transportation/erection of process equipment and conveyance of output should favour construction of small plants.

The analysis underlying the report suffered from a couple of serious drawbacks. The calculations were based on [illegible] and production costs which underwent substantial changes on completion of the plants. Another large plant of the same capacity as the Paksaudi plant was under installation while the report was being prepared and it came into operation at about the same time as the small plant at Haripur. The total investment in this plant is reckoned to be of the order of US $300 million. The actual expenditure on the smaller plant was not much different from the approved estimates of cost. As a result, the difference in investment per ton of capacity was narrowed down considerably, to about 20%, and there are hardly any grounds to assert that if the per ton investment cost of the small plant were to be applied to the tonnage of the large plant, the resources would be adequate to erect two large plants.

Another factor ignored by the NFDC report was that while the plant and equipment of the larger plant had been procured by international competitive bidding, that for the smaller plant had been obtained from a single source. It can, with some justification, be argued that if competitive bidding had been adopted for the smaller project also, some economies could have been achieved, at least due to shorter delivery periods and, consequently, in the time and costs incurred in installation, if not in the prices charged for the various pieces of equipment. This would have further reduced the margin in the investment costs per ton of the two plants.

In the matter of gas consumption, maintenance charges, labour and overall production costs, a reliable base for comparison will be available only after HUFP has been in operation for at least 12 months, but the figures so far available indicate that these are not going to be as widely different from those of the large plants as pointed out in the NFDC report.

An assumption made in the report regarding the equivalence of actual freight charges for distribution of Urea from the two plants under comparison is open to question. The experience of NFC's marketing subsidiary has been that the average freight expenditure (during 1981-82) on despatches in th case of Hazara Urea was only Rs.97 per ton, as against Rs.173 per ton for Urea despatched from the larger (PSFL) plant. It is expected that as more and more markets are developed for Urea in the remote and inaccessible Northern areas, it will be most economical to supply them from HUFP than from any other plant in Pakistan.

Based on available information regarding the actual numbers of personnel employed in the factories in operation, the investment per employment opportunity provided by the larger plant is definitely higher than that by the smaller plant. The conclusion of the NFDC report in this respect suffered from a serious conceptual flaw. While "scaling up" the production, investment and employment levels of the small plant to those of the larger plant, it was assumed that all the additional small plants (for a production equivalent to that of the single large plant) would be located at the same site. On this basis, additional investments and operating costs required for transporting the fertilizer over the same distances as required from the large plant were computed and taken into account. One of the main points about small plants is that these can be located at convenient sites from the point of view of availability of raw materials, easy access to markets, existence of adequate infrastructure etc. and by ignoring this point in the comparison, the NFDC report arrived at some misleading figures.

As the fertilizer industry has developed in Pakistan, it has been necessary to set up large plants in recent years and these have had to be located not very far from each other along the main transportation route in the country. It was found necessary to make a substantial investment in the provision of storage space outside the plants so that large quantities of fertilizers could be moved from the plants to the consuming areas as smoothly as possible. This has naturally added to the total investment and operation costs. According to conservative estimates, the operation of these ware-houses adds Rs.16-20 per ton to the cost of distribution of the products of these large plants.

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It is evident that a much more comprehensive comparison needs to be carried out objectively of the advantages and drawbacks of small and large fertilizer plants under carefully defined conditions of national economy and demand for fertilizers. This comparison must not exclude the socio-economic and distributional benefits (and also the disamenities, such as levels of pollution, problems of urban congestion etc.) associated with the alternatives. While it cannot be denied that many of these considerations are hard to quantify and harder still to place a monetary value on, but it has also to appreciated that some of these do lend themselves to a rough and ready assessment, at least for the short term and for project appraisal purposes. With restricted investment resources or limited reserves of raw materials, the choice may only be between setting up a small plant or no plant at all. Economic (and political) decision-makers cannot obviously ignore the usefulness of a small plant in such a situation.

The experience in Pakistan with small fertilizer plants cannot be regarded as anything but rich and rewarding. Not only did the (initial) small plants help in economic development by manufacturing and supplying substantial quantities of a much needed agricultural input by making use of local raw materials and labour, but they also contributed towards popularizing the use of fertilizers through ready availability of fresh products. Furthermore, they were instrumental in up-grading the skills and experience of operators, supervisors, engineers and managers in fertilizer technology and industry. Without this experience it would have been very hard indeed for Pakistan to adopt modern technologies at later stages for large scale manufacture of fertilizers. These plants have also stimulated socio-economic development of their surrounding areas. Through the need for developing their own infrastructure they helped in bringing prosperity and higher standards of living in the neighbouring areas.

There is still need for small fertilizer plants at convenient locations. Pakistan's fertilizer industry is deficient in adequate capacity for manufacture of phosphatic and potassic fertilizers. As soon as the reserves of local rock phosphate are proved as to their quality and quantity, the question will have to be considered whether the best use for this valuable raw material will not be to set up small SSP plants in the NWFP if the beneficiation costs prior to manufacture of Phosphoric Acid or NP are going to be prohibitive. One of the factors in favour of this is the cost of transportation of this rock phosphate, which is to be mined in somewhat difficult - to - reach locations. If this material could be used to supply the requirements of phosphatic fertilizers in the northern areas and NWFP, it would cut out the costs of long haul of imported fertilizers all the way from Karachi or even of locally manufactured fertilizers from Multan or Jaranwala. The ideal solution would thus appear to be to set up SSP plants in the consuming areas.

The oil and gas resources of the country are being re-assessed and it appears that for some time to come, it would be difficult to spare large quantities of gas from the existing gas fields (except perhaps Mari gas field) for fertilizer manufacture. In this situation, the alternative will either be to set up another "well head" fertilizer plant in the Mari gas field area and face problems of further overloading the rail and road transport systems or to make use of small quantities of gas available elsewhere and to set up small plants at convenient locations, perhaps in central Punjab, where they can conveniently meet the growth in demand for fertilizers in the area. Even if 7% annual growth in demand of Nitrogenous fertilizers is conservatively assumed for the years to come in Pakistan, it could justify setting up a 200 tons-a-day Ammonia (350 tons Urea) plant every year instead of waiting for 4 to 5 years to justify a large plant. The savings in foreign exchange required for imports during the intervening period could perhaps off-set the higher per ton investment costs of the mini fertilizer plants. A study is being undertaken in Pakistan to examine all aspects of the fertilizer manufacturing sector of the national economy. It will hopefully help in devising a suitable strategy for the next decade.

The lines on which the old plant at Daudkhel should profitably be rehabilitated or replaced depend to a large extent on the volume of natural gas which can be earmarked for it in the years to come. If this cannot be more than the present levels, consideration may have to be given to convert the boilers to oil burning and to use the gas mainly as feed stock in an economic sized small plant (200 tons-a-day Ammonia for conversion into Urea and/or Ammonium Sulphate).

Large quantities of sulphuric acid are likely to become available in Baluchistan/Sind area on the installation of the proposed Copper recovery plant. This acid can be used in the manufacture of Phosphoric acid, DAP, TSP or SSP in Sind or Baluchistan in small-to-medium sized plants to meet local requirements or even for export purposes if the cost of manufacture can be kept competitive.

It would obviously be futile to hold that small or mini fertilizer plants will always be capable of meeting the requirements of a country where the level of demand is such that only a large scale plant will deliver the goods in terms of immediate economics of investment and operations. Countries which propose to set up fertilizer plants not to meet their own requirements in the immediate future but primarily for export purposes so as to earn maximum profits on the value added to their abundant and cheap raw materials, will obviously opt for large modern plants in order to remain competitive in the international market. At the same time, it must be recognised that small plants can be gainfully employed either to start a fertilizer industry in a developing country with limited resources and/or to provide a useful network at convenient locations to supplement the production of large plants, if any, and thus reduce the burden on the country's transport system. These can also be employed for the manufacture of specialized or preferred fertilizers in quantities just enough to meet the demand for them. An important factor to be kept in view by such developing countries as are embarking upon the setting up of a fertilizer industry is that they would be well advised to select only those processes and equipment which have a record of trouble-free and satisfactory operation. The new industry should not place an undue strain on the usually limited resources of competent and experienced management and operators. It should be possible to handle and transport the heavy reactors, vessels and other equipment from the port to the site of the plant and then to erect these without very costly gear and arrangements. The desirability of incorporating rugged and easy-to-maintain control and instrumentation systems instead of rather sophisticated (electronic) system should also be carefully considered. It will usually be found that small and mini fertilizer plants can meet these requirements adequately.

If the drawbacks of higher investment cost per ton of capacity and of higher production costs are within such a range that these can be offset by the comparatively lower risks involved in small or mini plants in the matter of cost over-runs, delays in installation or design defects, then obviously the choice would be in favour of such a small plant. It may be mentioned here that in a recent technical conference on ammonia fertilizer technology held in Beijing, China, it was claimed that by deliberate consideration in design of waste heat utilization, the energy consumption of a 200-300 tons-a-day natural gas or refinery off gas based ammonia plant could be brought close to that of large-scale ones. If this can indeed be achieved and maintained the attractiveness of the alternative of beginning with a small fertilizer plant can certainly be enhanced.

Another important consideration to be kept in view is the ease and speed with which facilities for the gradual manufacture or repair of spare parts and equipment of the plant can be developed locally and reliance stopped on costly imports. This objective is easier to attain with small plants based on simple and well tried technology than with large plants based on modern and sophisticated equipment and processes.

There will always be situations in the developing world where the total demand (or the increments in demand) for fertilizers in a country is not sufficient to justify investment in large fertilizer plants. Countries with pockets of raw material resources or with difficult geographical features may find it uneconomical to invest huge amounts in a large plant which cannot be assured of the requisite amounts of raw materials over its economic life or from which it is difficult to transport and distribute the products all over the country because of inadequate transportation facilities and high costs. In such situations the obvious choice is to set up small plants located near the consuming centres or markets. Apart from the direct advantages of easy transportation, early exploitation of the country's dispersed resources, etc., there are benefits to be gained from this approach by a sure-footed progress in training of a large number of technicians, engineers and managers, socio-economic development of areas in which these plants are located and providing greater employment opportunities. There is every reason to believe that with a growth in the demand for small and mini fertilizer plants, investment costs per ton of capacity will register a favourable trend and if technological advances continue, even the operating costs can be expected to come down. All these factors coupled with the comparative ease and speed with which adequate quantities of fertilizers can be marketed and supplied to farmers from a network of strategically located small plants can be of significant help in improving the yields to be expected from fertilizer use and thus achieving better growth rates in agricultural production in a developing country.

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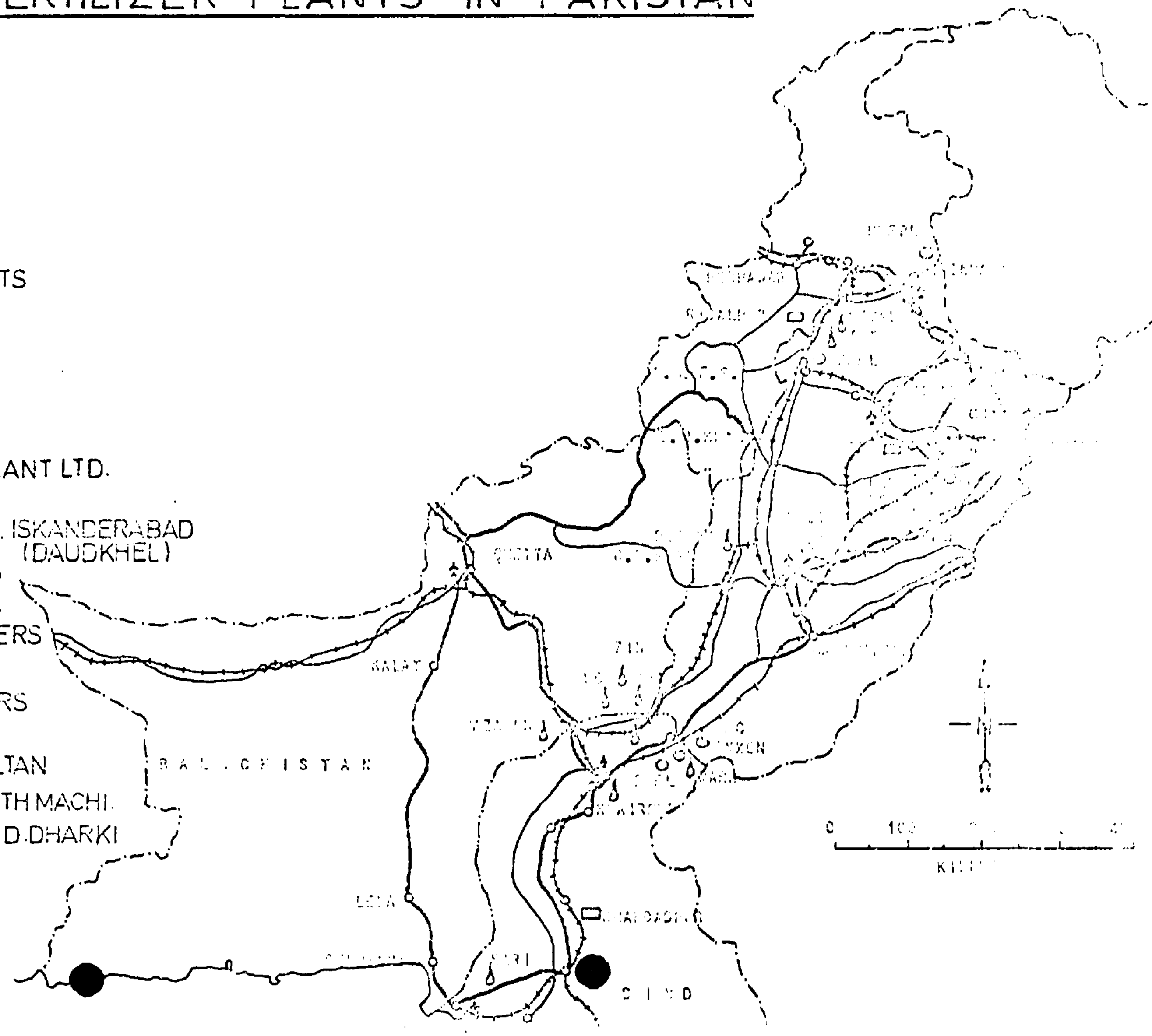
TABLES AND FIGURES

LOCATION OF FERTILIZER PLANTS IN PAKISTAN

- CITIES AND TOWNS
- NATIONAL ROADS
- PRIMARY AND SECONDARY ROADS
- RAILWAYS
- AIRPORTS
- NFC FERTILIZER PLANTS
- PRIVATE SECTOR FERTILIZER PLANTS
- FERTILIZER STORAGES
- NATURAL GAS FIELDS

HUFPL: HAZARA UREA FERTILIZER PLANT LTD. HARIPUR.
PAFL: PAK-AMERICAN FERTILIZERS LTD. ISKANDERABAD (DAUDKHEL)
D.H. DAWOOD HERCULES CHEMICALS LTD. CHICHOKIMALIAN LAHORE.
LCFL(F) LYALLPUR CHEMICALS & FERTILIZERS LTD. FAISALABAD
LCFL(J) LYALLPUR CHEMICALS & FERTILIZERS LTD. JARANWALA.
PFL PAKARAB FERTILIZERS LTD MULTAN
FFC FAUJI FERTILIZER COMPANY. GOTH MACHI.
EXXON EXXON CHEMICAL (PAKISTAN) LTD. DHARKI
PSFL PAKSAUDI FERTILIZERS LTD MIRPUR MATHELO.



PRODUCTION OF PRINCIPAL CROPS IN PAKISTAN

(000 Tonnes)

Year	Food Crops									Cash Crops						Total Principal Crops
	Wheat	Rice	Bajra	Jowar	Maize	Barley	Total Food-grains	Gram	Total Food Crops	Sugar-cane	Rape-Seed & Mustard	Sesamum	Cotton	Tobacco	Total Cash Crops	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1947-48	3,354	693	301	205	359	113	5,025	472	5,497	5,529	175	9	197	14	5,924	11,421
1948-49	4,033	748	345	247	379	178	5,935	766	6,701	6,947	188	6	172	18	7,331	14,032
1949-50	3.924	805	376	271	407	148	5,931	609	6,540	7,849	145	6	220	26	8,246	14,786
1950-51	3,893	865	392	248	387	131	6,016	756	6,772	5,506	199	8	250	30	5,993	12,765
1951-52	3,010	730	269	208	383	101	4,701	429	5,130	5,399	200	7	249	36	5,891	11,021
1952-53	2,405	832	271	224	352	93	4,177	321	4,498	7,266	127	6	317	26	7,742	12,240
1953-54	[illegible]	921	468	232	408	129	5,803	571	6,374	8,956	166	6	254	38	9,420	15,794
1954-55	3,186	838	355	225	433	106	5,143	604	5,747	8,836	219	6	281	74	9,416	15,163
1955-56	3.370	841	346	253	457	128	5,395	699	6,094	8,200	221	6	299	49	8,775	14,869
1956-57	3,638	844	369	259	469	116	5,695	692	6,387	8,947	226	6	304	46	9,529	15,916
1957-58	3,564	876	278	186	447	127	5,478	663	6,141	11,294	233	6	304	56	11,893	18,034
1958-59	[illegible]	992	314	215	489	129	6,046	577	6,623	12,489	266	6	283	58	13,102	19,725
1959-60	[illegible]	995	329	233	495	139	6,100	608	6,708	10,662	239	8	292	61	11,262	17,970
1960-61	[illegible]	1,030	306	220	439	120	5,929	610	6,539	11,641	214	7	301	60	12,223	18,762
1961-62	[illegible]	1,227	370	248	488	116	6,475	623	7,098	14,357	205	11	324	70	14,967	22,065
1962-63	4,170	1,095	422	251	489	113	6,540	678	7,218	18,439	257	8	367	71	19,142	26,360
1963-64	4,162	1,192	361	238	526	111	6,590	610	7,200	16,140	211	8	419	75	16,853	24,053
1964-65	[illegible]	1,350	446	293	528	118	7,326	672	7,998	18,668	214	9	378	82	19,351	27,349
1965-66	[illegible]	1,317	370	274	540	83	6,500	539	7,039	22,309	182	7	414	110	23,022	30,061
1966-67	[illegible]	1,365	371	277	587	88	7,023	635	7,658	21,982	203	7	463	140	22,795	30,453
1967-68	6,418	1,499	413	291	791	108	9,520	481	10,001	18,660	275	9	518	130	19,592	29,593
1968-69	[illegible]	2,032	330	262	626	97	9,965	528	10,493	21,971	229	8	528	125	22,861	33,354
1969-70	[illegible]	2,401	302	284	667	104	11,052	506	11,558	26,370	255	8	535	117	27,285	38,843
1970-71	6.476	2,200	355	329	717	91	10,168	494	10,662	23,167	269	10	542	113	24,101	34,763
1971-72	[illegible]	2,262	360	312	705	103	10,632	510	11,142	19,963	301	14	708	87	21,073	32,215
1972-73	7,442	2,330	304	302	706	109	11,193	553	11,746	19,947	287	10	702	63	21,009	32,755
1973-74	7,629	2,455	351	378	767	139	11,719	610	12,329	23,911	292	12	659	66	24,940	37,269
1974-75	7,673	2,314	266	266	747	137	11,403	550	11,953	21,242	248	8	634	77	22,209	34,162
1975-76	[illegible]	2,618	308	281	802	130	12,830	601	13,431	25,547	267	11	514	58	26,397	39,828
1976-77	9,144	2,737	311	261	764	124	13,341	649	13,990	29,523	296	12	435	73	30,339	44,329
1977-78	8,367	2,950	318	284	821	121	12,861	614	13,475	30,077	236	13	575	74	30,975	44,450
1978-79	[illegible]	3,272	317	252	799	129	14,719	538	15,257	27,326	248	19	473	68	28,134	43,391
1979-80	[illegible]	3,216	277	249	875	118	15,540	313	15,853	27,498	247	19	728	78	28,570	44,423
1980-81	11,475	3,120	214	234	946	199(P)	16,188	343(P)	16,531	32,359	258	18	715	67	33,417	49,949
1981-82 (P)	[illegible]	3,429	[illegible]	245	932	[illegible]	16,054	[illegible]	16,316	[illegible]	424	18	749	71	37,825	[illegible]

(P) Provisional.

Source: Ministry of Food, Agriculture & Co-operatives

(11)

TABLE-2

YIELD (KG/HA) OF PRINCIPAL CROPS IN PAKISTAN, ASIA AND ALL DEVELOPING COUNTRIES (1980)

	Pakistan	Asia	All Developing Countries
Wheat ..	1563	1631	1568
Ricepaddy ..	2400	2800	2674
Barley ..	741	1266	1133
Maize ..	1365	2242	1826
Millet ..	515	712	664
Chickpeas ..	278	486	507
Total Cereals ..	1587	2038	1803
Sugarcane ..	38189	48850	54105
Seed Cotton ..	1002	1004	1014
Tobacco leaves .	1559	1052	1050

Source : 1980 FAO Production Year Book Vol.34.

TABLE 3

ANNUAL FERTILIZER OFFTAKE IN PAKISTAN FROM 1952-53 ONWARDS (NUTRIENT TONS)

Year	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	Total
1952-53	1 000	-	-	1 000
1953-54	14 800	-	-	14 800
1954-55	14 100	-	-	14 100
1955-56	6 600	-	-	6 600
1956-57	9 000	-	-	9 000
1957-58	16 400	-	-	16 400
1958-59	18 000	-	-	18 000
1959-60	19 300	100	-	19 400
1960-61	31 000	400	-	31 400
1961-62	37 000	500	-	37 500
1962-63	40 000	200	-	40 200
1963-64	68 000	700	-	68 700
1964-65	85 000	2 200	-	87 200
1965-66	69 830	1 220	-	71 050
1966-67	112 760	3 890	120	116 770
1967-68	176 170	12 160	250	188 580
1968-69	205 210	39 470	2 230	246 910
1969-70	273 950	36 640	1 340	311 930
1970-71	251 520	30 450	1 240	283 210
1971-72	343 973	37 231	744	381 948
1972-73	386 385	48 730	1 380	436 495
1973-74	341 929	58 081	2 673	402 683
1974-75	362 831	60 571	2 086	425 488
1975-76	445 276	102 517	2 843	550 635
1976-77	510 992	117 935	2 356	631 283
1977-78	549 934	156 332	5 977	712 245
1978-79	684 215	187 719	7 578	879 512
1979-80	805 990	228 460	9 604	1 044 054
1980-81	842 930	226 900	9 630	1 079 460
1981-82	833 000	226 000	22 000	1 080 000

TABLE-4

GROWTH OF CONSUMPTION OF FERTILIZERS PER HECTARE OF ARABLE LAND AND PERMANENT CROPS IN PAKISTAN, ASIA AND IN ALL DEVELOPING COUNTRIES

100 grammes N, P_2O_5, K_2O

	1969-71			1973			1976			1979		
	Pakistan	Asia	All Developing Countries	Pakistan	Asia	All Developing Countries	Pakistan	Asia	All Developing Countries	Pakistan	Asia	All Developing countries
Nitrogenous Fertilizers	150	178	121	176	228	158	259	277	195	400	430	290
Phosphate Fertilizers	18	54	40	30	76	59	60	86	73	114	132	105
Potash Fertilizers	1	29	18	1	40	30	1	39	32	5	53	45
Total Fertilizers	168	260	180	208	344	247	319	402	300	519	615	439

Source: 1980 FAO Fertilizer Year Book (Vol.30)

TABLE 5

AREA, PRODUCTION AND YIELD PER HECTARE OF WHEAT IN PAKISTAN

Year	Area (000 Hectares)	Production (000 Tonnes)	Yield per Hectare (Kgs)
1976-77	6,390	9,144	1,431
1977-78	6,360	8,367	1,316
1978-79	6,687	9,950	1,488
1979-80	6,912	10,805	1,563
1980-81	6,961	11,475	1,648
Average (1976-77 to 1980-81)	6,662	9,948	1,489
1981-82 (P)	6,980	11,030	1,580

(P): Provisional

Source: Ministry of Food, Agriculture and Co-operatives.

TABLE 6

AREA, PRODUCTION AND YIELD PER HECTARE OF

RICE IN PAKISTAN

Year	Area (000 Hectares)	Production (000 tonnes)	Yield per Hectare (Kgs)
1976-77	1,749	2,737	1,565
1977-78	1,899	2,950	1,553
1978-79	2,026	3,272	1,615
1979-80	2,035	3,216	1,581
1980-81	1,935	3,120	1,612
Average (1976-77 to 1980-81)	1,929	3,059	1,585
1981-82 (P)	1,972	3,429	1,739

(P) : Provisional

Source: Ministry of Food, Agriculture and Co-operatives.

TABLE-7

AREA, PRODUCTION AND YIELD PER HECTARE OF COTTON IN PAKISTAN

Year		Area (000 Hectares)	Production (000 Tonnes)	Yield per Hectare (Kgs)
1976-77	.. ..	1,865	435	233
1977-78	.. ..	1,843	575	312
1978-79	.. ..	1,891	473	250
1979-80	.. ..	2,081	728	350
1980-81	.. ..	2,108	715	339
Average	(1976-77 to 1980-81)	1,957	585	297
1981-82	(P) ..	2,167	748	346

TABLE-8

AREA, PRODUCTION AND YIELD PER HECTARE OF SUGARCANE IN PAKISTAN

Year		Area (000 Hectares)	Production (000 Tonnes)	Yield per Hectare Tonnes
1976-77	.. ..	788	29,523	37.5
1977-78	.. ..	822	30,077	36.6
1978-79	.. ..	752	27,327	36.3
1979-80	.. ..	718	27,498	38.3
1980-81	.. ..	825	32,359	39.2
Average	(1976-77 to 1980-81)	781	29,356	37.6
1981-82	.. ..	915	36,564	39.9

P : Provisional

Source : Ministry of Food, Agriculture and Cooperatives.

TABLE 9

PRODUCTION OF AMMONIUM SULPHATE (21%N) AT THE PAK-AMERICAN FERTILIZER PLANT, DAUDKHEL.

YEAR	PRODUCTION: METRIC TONS	CAPACITY UTILIZATION %
1958-59	36,312	72.6
1959-60	42,865	85.7
1960-61	47,360	94.7
1961-62	52,739	105.6
1962-63	52,459	105.5
1963-64	49,904	99.8
1964-65	35,411	70.8
1965-66	39,041	78.1
1966-67	42,864	85.7
1967-68	46,809	93.6
1968-69	42,568	85.1
1969-70	53,302	72.6
1970-71	55,890	62.1
1971-72	66,789	74.2
1972-73	58,177	64.5
1973-74	92,552	102.8
1974-75	95,094	105.7
1975-76	97,257	108.1
1976-77	100,405	111.6
1977-78	95,599	106.2
1978-79	97,887	108.8
1979-80	98,868	109.9
1980-81	96,642	107.4
1981-82	94,005	104.5
Total since 1958-59	1,590,799	93.4

Note: Rated Capacity: 50,000 tons per annum from 1958-59 to 1968-69, 73,400 tons per annum for 1969-70, and 90,000 tons per annum from 1970-71 onwards.

TABLE 10

PRODUCTION OF SINGLE SUPER PHOSPHATE (18% P_2O_5) LYALLPUR CHEMICALS & FERTILIZERS LIMITED PLANTS AT FAISALABAD AND JARANWALA.

Year	Faisalabad Plant Production (M.Tons)	Faisalabad Plant Capacity Utilization %	Jaranwala Plant Production (M.Tons)	Jaranwala Plant Capacity Utilization %
1957-58	1041	6.3	-	-
1958-59	2319	12.9	-	-
1959-60	861	4.8	-	-
19[illegible]-61	8985	49.9	-	-
1961-62	8038	44.7	-	-
1962-63	6054	33.6	-	-
1963-64	6695	37.2	-	-
1964-65	8167	45.4	-	-
1965-66	7985	44.4	-	-
1966-67	4024	22.4	-	-
1967-68	7314	40.6	8757	24.3
1968-69	4738	26.3	9644	26.8
1969-70	8482	47.1	14769	41.0
1970-71	7294	40.5	18121	50.3
1971-72	10778	59.9	16697	46.4
19[illegible]-73	15878	[illegible]8.2	19794	82.8
1973-74	6786	37.7	15857	44.1
1974-75	6461	35.9	25239	70.1
1975-76	15071	83.7	43950	63.7
1976-77	19040	105.8	47033	65.3
1977-78	18750	104.2	56910	79.1
1978-79	19320	107.3	79204	110.0
1979-80	19780	109.9	81418	113.1
1980-81	20191	112.2	81622	113.4
1981-82	20681	114.9	82011	113.9
Total since commissioning	254,733	56.8	601,026	76.3

Note: Rated Capacity for the Faisalabad plant : 16500 tons per annum for 1957-58 and 18,000 per annum thereafter.

Rated Cap[illegible] for [illegible] 72,000 [illegible]

TABLE-11

PRODUCTION OF UREA (46% N), AMMONIUM NITRATE (26% N) AND AMMONIA AT THE NATURAL GAS FERTILIZER FACTORY MULTAN

Year	UREA		AMMONIUM NITRATE		AMMONIA			
					Main Plant		Ammopac	
	Production M. Tons	Capacity utiliza -tion %	Production M. Tons	Capacity utiliza -tion %	Produc-tion M.Tons	Capacity utiliza-tion %	Produc-tion M.Tons	Capacity utiliza-tion %
1961-62	733	-	9332	-	N.A.**	-	-	-
1962-63	27942	47.1	64317	62.5	40324	60.2	-	-
1963-64	37811	63.7	60494	58.8	46760	69.8	-	-
1964-65	44228	74.5	75325	73.2	55858	83.4	-	-
1965-66	41426	69.8	75012	72.9	53808	80.3	-	-
196[illegible]-67	47591	80.1	79500	77.2	58888	87.9	-	-
1967-68	43522	73.3	76807	74.6	54895	81.9	-	-
1968-69	48721	82.0	73574	71.5	53660	80.1	4752	24.0
1969-70	47638	80.2	84161	81.7	53708	80.2	7261	36.7
1970-71	28990	48.8	84986	82.5	46228	69.0	3579	18.1
1971-72	27263	45.9	76855	74.7	45817	68.4	1294	6.5
1972-73	13981	23.5	64840	63.0	33773	50.4	N.A.**	-
1973-74	32947	55.5	63430	61.6	39170	58.5	7230	36.5
1974-75	20326	34.2	59093	57.4	29851	44.6	6716	33.9
1975-76	24695	41.6	70750	68.7	36999	55.2	8028	40.5
1976-77	26335	44.3	64541	62.7	34818	52.0	7918	40.0
1977-78*	17658	29.7	47137	45.8	28026	41.8	5429	27.4
Total since start of production	531,807	55.9	1,130,154	68.6	712,583	66.5	52,207	29.3

Note : Rated capacity for Urea Plant .. 59,200 tons per annum

Rated capacity for Ammonium Nitrate Plant .. 103,000 tons per annum

Rated capacity for Ammonia Plants

Main .. 67,000 tons per annum

Ammopac .. 19,800 tons per annum

* The Ammonium Nitrate and Ammonia plants were shut down permanently after 1977-78.

** N.A. - Figures not readily available.

TABLE 12

PRODUCTION OF UREA (46% N) AT THE EXXON CHEMICALS LIMITED PLANT AT DHARKI

Year	Actual Production (M. Tons)	Capacity Utilization %
1968-69	63197	63.0
1969-70	159879	92.4
1970-71	175254	101.3
1971-72	163969	94.8
1972-73	191954	111.0
1973-74	197038	113.9
1974-75	205778	118.9
1975-76	210720	121.8
1976-77	208069	120.3
1977-78	211330	122.2
1978-79	235083	135.9
1979-80	213790	123.6
1980-81	237198	137.1
1981-82	245472	141.9
Total Production since start up	2,718,767	115.7

TABLE 13

PRODUCTION OF UREA (46% N) AT THE DAWOOD HERCULES CHEMICALS LIMITED PLANT AT SHEIKHUPURA NEAR LAHORE.

Year	Actual Production (M.Tons)	Capacity Utilization %
1971-72	203170	101.4
1972-73	327581	95.0
1973-74	344383	99.8
1974-75	392836	113.9
1975-76	368145	106.7
1976-77	361821	104.9
1977-78	376866	109.2
1978-79	356132	103.2
1979-80	360049	104.4
1980-81	365859	106.1
1981-82	346234	100.4
Total since start up	3,803,076	104.2

TABLE 14

PRODUCTION OF UREA (46% N) NP (23:23) AND CAN (26% N) AT THE PAKARAB FERTILIZERS LIMITED PLANT MULTAN.

Year	Urea		Nitrophosphate		Calcium Amm. Nitrate	
	Actual Production (M.Tons)	Capacity utiliza-tion %	Actual Production (M.Tons)	Capacity Utiliza-tion %	Actual Production (M.Tons)	Capacity Utiliza-tion %
1978-79	29,496	66.4	41,281	29.3	81,143	30.3
1979-80	43,702	73.6	137,230	45.1	199,000	44.2
1980-81	47,963	80.7	171,209	56.2	272,671	60.6
1981-82	49,784	83.8	210,510	69.1	321,391	71.4
Total	170,945	76.8	560,230	53.1	874,205	54.0

TABLE 15

PRODUCTION OF UREA (46% N) AT PAKSAUDI FERTILIZERS LIMITED PLANT, MIRPUR MATHELO.

Year	Actual Production (M.Tons)	Capacity Utilization %
1980-81	327924	78.5
1981-82	501908	90.1
Total	829832	85.1

TABLE- 16

TOTAL INDIGENOUS PRODUCTION OF FERTILIZERS IN PAKISTAN FROM 1952-53 ONWARDS

(Product and nutrient tonnes)

Year	N	P_2O_5	Total nutrients	Product Quantities
1952-53	-	-	-	-
1953-54	-	-	-	-
1954-55	-	-	-	-
1955-56	-	-	-	-
1956-57	-	-	-	-
1957-58	1 456	184	1 640	7 958
1958-59	7 505	411	7 916	38 020
1959-60	8 859	153	9 012	43 035
1960-61	9 788	1 592	11 380	55 457
1961-62	13 557	1 424	14 981	69 483
1962-63	39 955	1 073	41 028	148 407
1963-64	43 820	1 186	45 006	154 434
1964-65	46 620	1 447	48 067	160 563
1965-66	46 021	1 415	47 436	160 889
1966-67	50 751	713	51 464	171 239
1967-68	49 665	2 847	52 512	182 217
1968-69	78 608	2 544	81 152	239 147
1969-70	129 274	4 151	131 425	371 683
1970-71	140 133	4 512	144 645	398 569
1971-72	215 132	4 868	220 000	563 507
1972-73	274 529	8 222	282 751	702 645
1973-74	300 077	4 200	304 277	754 393
1974-75	296 326	10 620	306 946	781 929
1975-76	316 455	10 624	327 079	830 586
1976-77	309 276	11 880	321 156	820 948
1977-78	312 409	15 006	327 415	842 509
1978-79	334 007	26 961	360 968	949 949
1979-80	388 858	49 754	438 612	1 155 279
1980-81	580 872	57 695	638 567	1 621 240
1981-82	715 000	66 903	781 903	1 953 120

Figure: 1
PRODUCTION OF PRINCIPAL CROPS
IN PAKISTAN (1947-48—1981-82)

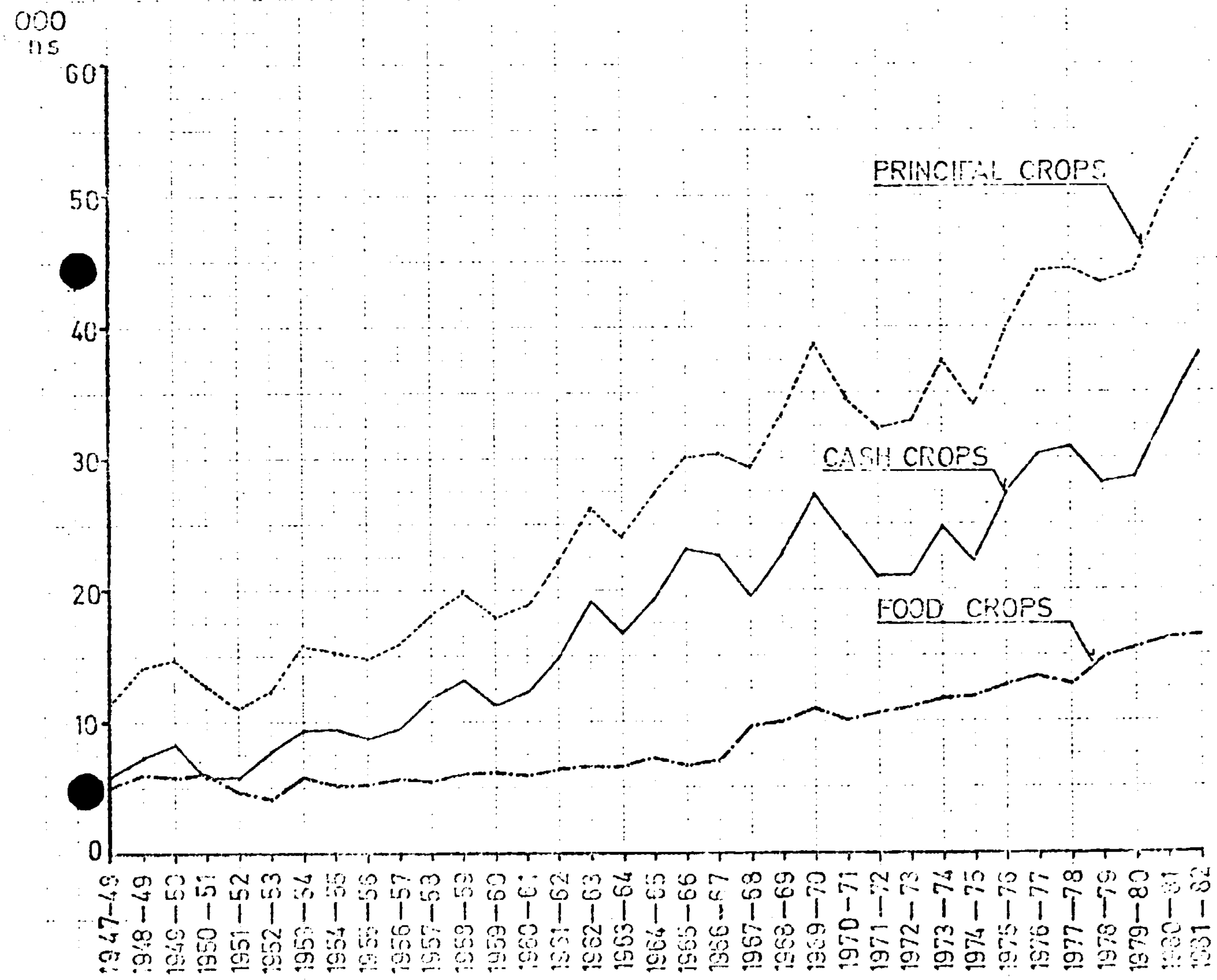


Figure: 2
TOTAL OFFTAKE OF FERTILIZER IN PAKISTAN (1961-62/1981-82)

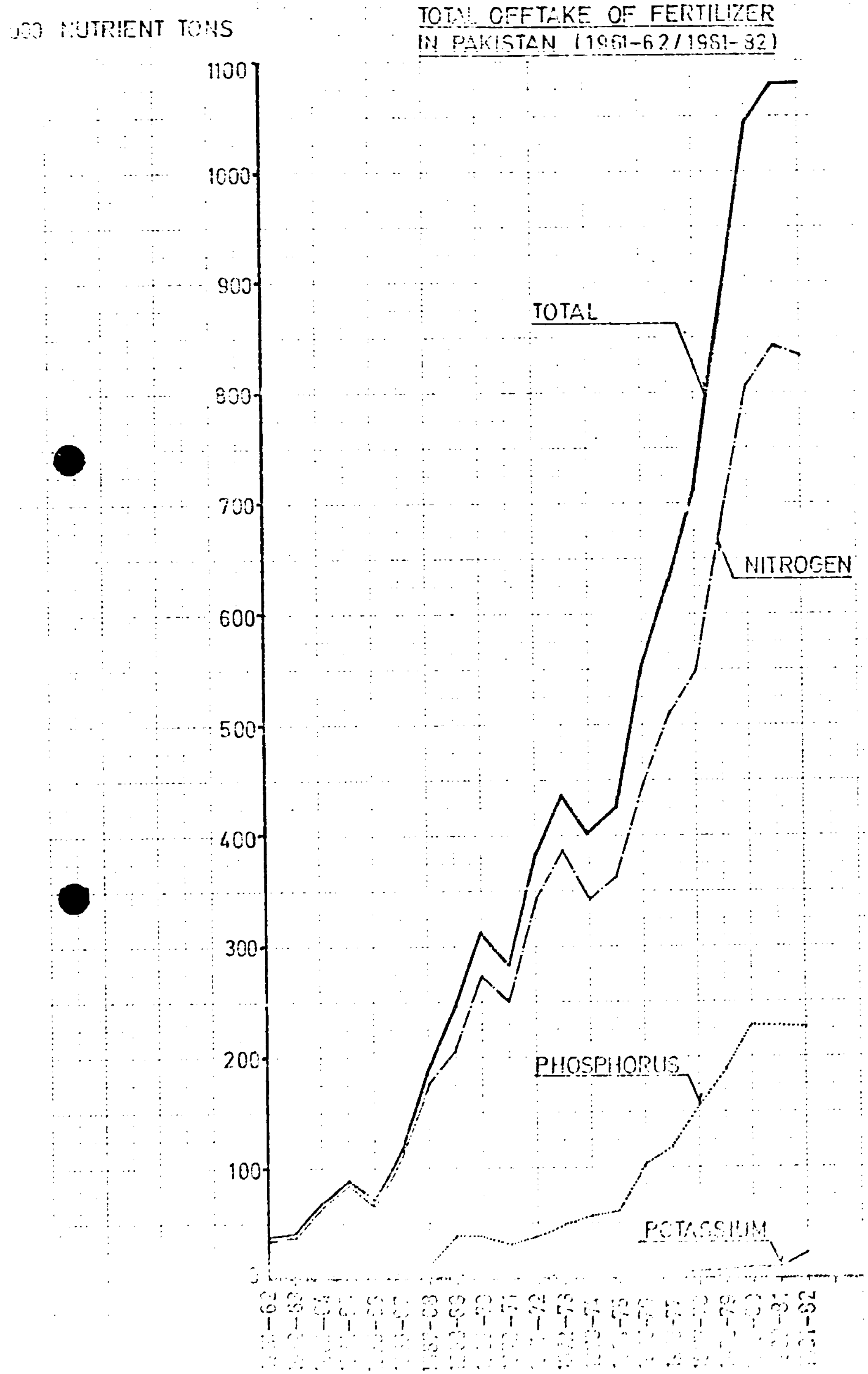
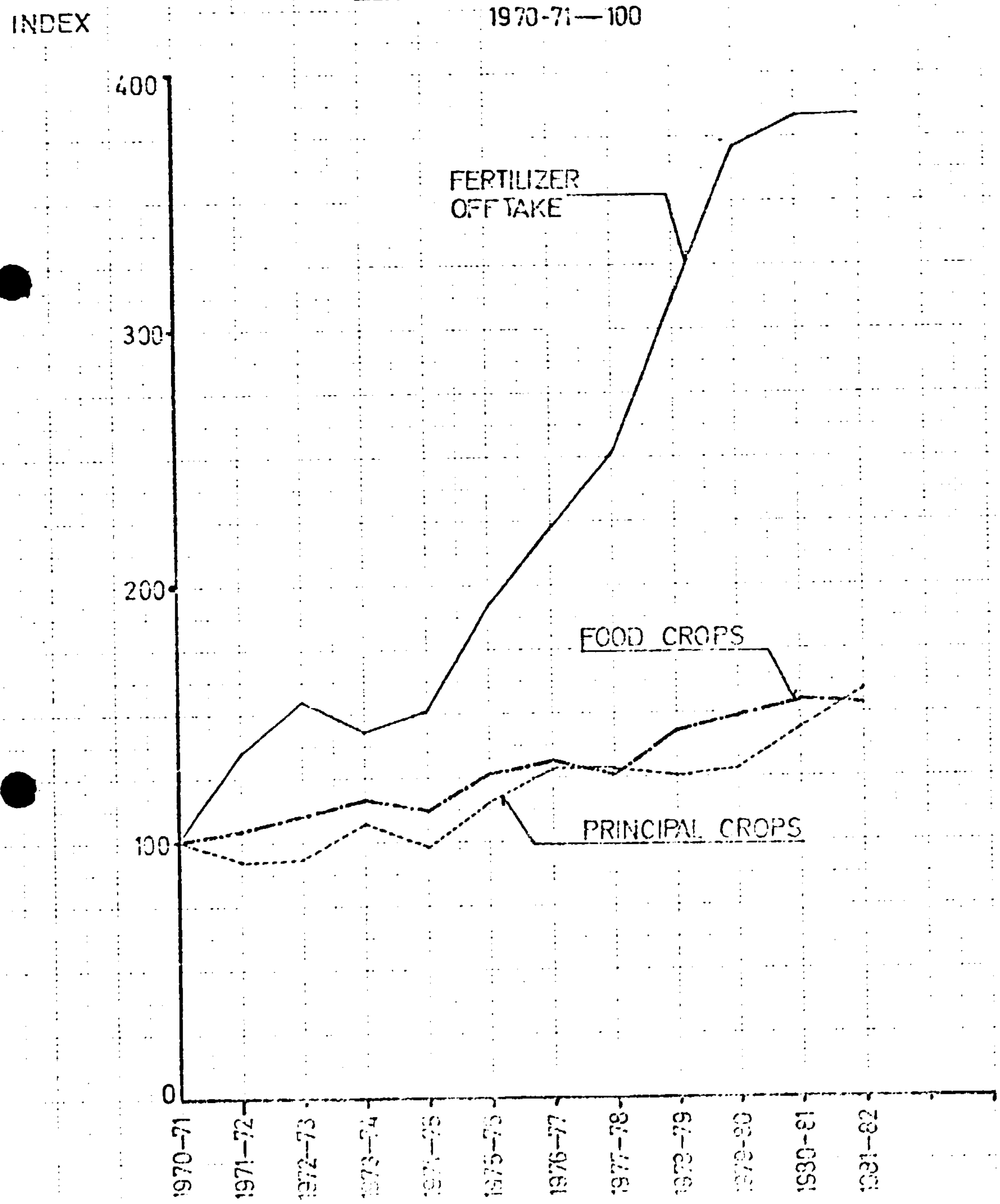


Figure: 3

GROWTH OF FERTILIZER OFFTAKE AND AGRICULTURAL PRODUCTION IN PAKISTAN (1970-71 — 1981-82)

1970-71 — 100



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Development of Fertilizer Industry in Pakistan

and

A CASE STUDY OF ITS MINI FERTILIZER PLANTS

(Abstract)

Riyaz H. Bokhari

1982

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Pakistan, with a population of 85.65 million and an area of 796,095 square kilometers, depends on agriculture as the mainstay of its economy. It is endowed with large tracts of arable land of which a substantial proportion is irrigated. With 36% increase in agricultural production during the period 1971-80, Pakistan has done better in this respect than other developing countries. While the production of its principal crops has risen considerably (Table 1), its index of Agricultural Production per caput has been stagnating. A number of factors continue to limit agricultural productivity at levels well below the potentials implied by existing land and water resources and technologies already available.

Fertilizer consumption in Pakistan has registered a phenomenal growth - from 1,000 nutrient tons in 1952-53 to more than a million nutrient tons in 1981-82 (Table 2). Consumption per hectare of arable land has grown from 16.8 kg. during 1969-71 to 51.9 kg. in 1979 and it was 18% higher than the average in all developing countries, yet the Agricultural Production was only 2.25% higher. One of the major challenges facing Pakistan is, therefore, that related to the problem of growth of productivity. Ways and means have to be found for improving the efficiency of fertilizer application and response if full benefits are to be derived of the investment and effort involved in importing, manufacturing and distributing ever-increasing quantities of fertilizers. In order to achieve the objective of a streamlined system of fertilizer distribution so that the right type of

fertilizers can be easily supplied to the farmer in sufficient quantities as and when required by him, the policy of setting up small plants right in the consumption areas instead of large plants away from these areas offers some obvious advantages.

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Soon after independence it was noted that whereas the use of nitrogenous fertilizers could increase crop yields by as much as 20-40%, only negligible quantities were being used in Pakistan. Despite a 50% subsidy on Ammonium Sulphate, the farmers found its cost to be high, and since its quantities available for import were restricted and costly, indigenous manufacture of fertilizers had to be considered in order to reduce costs and to popularise their use with the ultimate objective of increasing agricultural productivity.

The first fertilizer plant to be set up in Pakistan started production of Ammonium Sulphate during 1958-59 with an annual capacity of 50,000 tons (10,500 nutrient tons). There are now eight large and small plants in the country with a combined annual capacity of 1.11 million nutrient tons (Annexure). In terms of product tons, they can manufacture more than 2.72 million tons. The locations of these plants were decided upon on considerations specific to each proposal. For instance, availability of raw materials in the neighbourhood, proximity to consumption areas and the need to encourage socio-economic development of a backward region were the main considerations in one case and the previous selection of the site for an acid plant in another. In yet another case the fertilizer factory was to be a part of a large industrial complex at a central location. The ammonia/urea factories (one small and two large) have been set up as "well-head" plants near the Mari gas field. The choice of products was dictated by such factors as simplicity of manufacturing process and their expected agronomic advantages. The capacities were determined on considerations of expected demand for products as well as the technologies and capacities of equipment then available.

Because of a combination of reasons the early fertilizer plants at Daudkhel (Ammonium Sulphate), Faisalabad and Jaranwala (Single Super Phosphate) and Multan (Urea and Ammonium Nitrate) could not be operated at their full capacities for a number of years. In the case of the project at Multan (200 tons of Ammonia, 180 tons of Nitric Acid, 295 tons of Ammonium Nitrate and 170 tons of Urea daily), a number of problems were encountered during installation and guarantee tests with the result that there were delays and cost over-runs, and unsatisfactory and uneconomic operations after start up. The inadequacy in the capacity of the ammonia plant because of problems with catalyst life and maintenance of compressors, could not be rectified even by the installation of a small (60 tons of Ammonia/day) package unit because this unit itself could not be operated to its rated capacity due to problems with gas engine driven compressors.

It has to be admitted, however, that these early plants were instrumental in popularising the use of fertilizers, introduction of and familiarization with a new technology in the country, creation of a reserve of trained operators, supervisors, engineers and managers and development of backward areas.

The next phase of the development of fertilizer industry in Pakistan started with the setting up of a 300 tons ammonia/510 tons urea plant by Esso (EXXON) at Daharki, near a gas field (Mari), in 1968. It has been operating very smoothly and efficiently ever since. It is quoted as a model in such matters as productivity, capacity utilization (substantially higher than 100%), efficiency and economy in operations. The second plant in the private sector was established by Messrs. Dawood Hercules (DH) 1971 at Sheikhupura near Lahore with a daily capacity of 625 tons of Ammonia and 1100 tons of Urea. The performance of this plant, too, has been outstanding and it has consistently maintained more than 100% levels of capacity utilization.

With the increase in the demand for fertilizers following the introduction of high-yielding varieties of wheat the need for further increasing the capacity for indigenous manufacture of fertilizers was felt. For phosphatic fertilizers, studies indicated that the best alternative would be to manufacture Nitrophosphate via nitric acid. It was, therefore, decided to modernise and expand the old NGFF plants at Multan by setting up a modern ammonia plant capable of producing 910 tons/day alongwith a 1200 tons/day nitric acid plant, a 1015 tons/day nitrophosphate (NP) plant and a 1500 tons/day calcium ammonium nitrate (CAN) plant. A project was accordingly undertaken for this purpose and the plants and assets of NGFF were transferred to a new company viz., The Pakarab Fertilizer Limited (PFL). Unfortunately, the progress on the project suffered many setbacks, considerable delays and cost over-runs e.g., long delivery periods in the wake of oil embargo on industrial countries, exodus of skilled manpower from Pakistan, floods and accidents which interrupted transportation of equipment to the site. The mechanical completion took 52 months against the original (optimistic) estimate of 28 months and the cost escalated from Rs.832 million to Rs.2,511 million. It was not before January, 1979 that the NP plant could be brought into operation, and then a number of crucial design deficiencies became apparent. Considerable time and effort has had to be spent on modifications. As a consequence of these problems, the PFL plants at Multan have not yet achieved their rated levels of production.

A number of lessons have been learnt from the PFL project. Even internationally known firms can sometimes quote on the low side and they need to have more experience of undertaking projects in such conditions as have to be faced in places like Multan. Too great a reliance should not be placed on the existing infrastructure and the modifications required for the existing facilities to be usable in the expanded plant must be carefully assessed and provided for in cost and time estimates. Implementation and operation of high level technology projects require highly trained, experienced and motivated operators and managerial personnel; project management must have sufficient resources to be able to engage and retain such employees. The most important point to be kept in view in the transfer of latest technologies and processes is that these must first be checked to have been in actual and successful operation on a full plant scale.

In 1975, Government of Pakistan approved a project proposal by NFC to set up a large 1000 tons ammonia 1740/tons urea plant at Mirpur Mathelo, about 14 kilometers from the Mari gas field. There were some unavoidable delays but these did not lead to any serious problems or heavy cost over-runs. The plant was brought in commercial production in October, 1980 and has been performing satisfactorily. Another large ammonia/urea plant, Fauji Fertilizer Company - FFC, of similar capacities was set up a short distance away and it was brought into commercial production in May, 1982. It, too, has been operating very satisfactorily.

With the completion of FFC, there are three plants which are located near the gas field but away from the main consumption areas. This has necessitated a constant review of rail and road transportations arrangements. In order to avoid a closure of factories due to shortage of storage space and to make use of the transportation facilities available during the "peak" and "off" seasons of demand, it has become necessary to build large ware-houses for storage of fertilizers near the consumption areas. Full train-loads will move the fertilizers from the plants to the storages regularly and further distribution will be made by road.

A small 170 tons/day ammonia 290 tons/day urea plant (Hazara Urea Fertilizer Plant - HUFP) was completed earlier this year and brought into operation by NFC in April, 1982 with technical and financial assistance from the Peoples Republic of China. It is located at Haripur near the consumption areas of NWFP and Punjab. Another reason for selecting this site was the proposal to set up, at a later stage, a phosphoric acid plant based on local rock phosphate discovered earlier in the district. The acid would be used to manufacture Urea Ammonium Sulphate (UAP) at Haripur.

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Small fertilizer plants were set up in Pakistan not as an alternative to large plants but in view of the market requirement and the technology available at the time of installation. The National Fertilizer Development Centre (NFDC) of Government of Pakistan prepared a report in 1980 on the economic comparison of two urea plants then under construction viz., the large Pak-Saudi plant at Mirpur Mathelo and the small Chinese plant at Haripur. For this comparison, the anticipated investment and production costs for each plant were converted into rupees per ton; the investment, production cost and output volume of the large plant were used as the starting point and corresponding figures of the other plant were "scaled up". Economic comparison of a number of socio-economic factors was, however, kept "open" because it was not considered possible. The findings of the report were almost totally in favour of the large plant and no redeeming feature was detected in the small plant.

The analysis underlying the report suffered from a couple of serious drawbacks. The calculations were based on estimates of investment and production costs, which under-went substantial changes by the time the plants were completed. Another large plant (FFC) was under installation and at about the same time as the small plant at Haripur but at a much higher cost than adopted in the report for the large plant for comparison. As a result, the difference in investment per ton of capacity was narrowed down considerably. Another factor ignored by the NFDC report was that the plant and equipment of the larger plant had been procured by international competitive bidding while that of the small plant had been obtained from a single source. An assumption was made in the report that the average freight charges for distribution of Urea from the two plants would be equal. This has been belied by actual experience. In the comparison of relative economies, it was also assumed that all the small plants needed to give a production equal to that of a single large plant would be located at the same place. One of the main points about small plants is that these can be located at convenient sites from the point of view of availability of raw materials, easy access to markets, existence of adequate infrastructure etc. and by ignoring this point the NFDC report arrived at some misleading figures.

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It is obvious that a much more comprehensive comparison needs to be carried out objectively of the advantages and drawbacks of small and large plants. This comparison must not exclude the socio-economic and distributional benefits (and disamenities) associated with the alternatives. With restricted investment resources or limited resources of raw materials and other inputs, the choice may only be between setting up a small plant or no plant at all. Economic decision-makes cannot ignore the usefulness of a small plant in such a situation.

Pakistan's experience with small plants has been rich and rewarding. Not only did the (initial) small plants help in economic development by manufacturing and supplying fertilizers by using local raw materials and labour, but they also contributed towards popularising the use of fertilizers through ready availability. They were, furthermore, instrumental in upgrading the skills and experience of operators and engineers. Without this experience it would not have been easy at later stages to adopt modern technologies for large scale manufacture. These plants have also stimulated socio-economic development of their surrounding areas.

There is still need for small plants at convenient locations. Small SSP plants in the NWFP can perhaps be justified as soon as the reserves of local rock phosphate are proved. The oil and gas resources of the country are being reassessed and it appears that it might be difficult to spare large quantities of gas from the existing gas fields for fertilizer manufacture. The alternative may either be to set up another large "well head" plant in the Mari gas field area and face problems of further overloading the transport system or to make use of small quantities of gas available elsewhere and set up small plants at convenient locations.

A 7% annual growth in demand would justify setting up a 200 tons of ammonia/350 tons urea plant every year instead of waiting 4 to 5 years to justify a large plant. The savings in foreign exchange required for imports during the intervening period could off-set the higher per ton investment cost of the small plants.

It would obviously be incorrect to hold that small plants would always be capable of meeting the requirements when the level, distribution and pattern of demand are such that only a large scale plant will do. Countries which propose to export fertilizers will obviously opt for large modern plants in order to remain competitive. At the same time, it must be recognised that small plants can be gainfully used to start a fertilizer industry in a developing country with limited resources. These can also be employed for the manufacture of special or preferred fertilizers in quantities just enough to meet the demand. Developing countries which are embarking upon the setting up of a fertilizer industry would be well advised to select only those processes and equipment which have a record of trouble-free and satisfactory operation; the new industry should not place an undue strain on the limited resources of management and operators and it should be possible to handle easily the transport of heavy reactors, vessels and other equipment from the port to the site of the plant. The desirability of incorporating rugged and easy-to-maintain control and instrumentation systems should also be carefully considered. Usually small plants can meet these requirements adequately.

If the drawbacks of higher investment cost per ton of capacity and of higher production costs are within such a range that these can be off-set by the comparatively lower risks involved in small or mini plants in the matter of cost over-runs, delays in installation or design defects, then obviously the choice would be in favour of such a small plant.

Another important consideration to be kept in view is the ease and speed with which facilities for the gradual manufacture or repair of spare parts and equipment of a small plant can be developed locally and reliance stopped on costly imports. There will always be situations in the developing world where the demand for fertilizers in a country is not sufficient to justify investment in large plants. Countries with pockets of raw materials or with difficult geographical features may find it un-economical to invest in large plants. In such situations the obvious choice is to set up small plants located at convenient places. Apart from the advantages mentioned above there are benefits to be gained from this approach by a sure-footed progress in training of a large number of technicians, achieving socio-economic developments of areas in which these plants are located and providing greater employment opportunities. All these factors coupled with the comparative ease and speed with which fertilizers can be marketed and supplied to farmers from small plants can be of significant help towards improving the yields to be expected from fertilizer use and thus achieving better growth rates in agriculture production.

Annexure

FERTILIZER PLANTS IN PAKISTAN

S.No	Name of Plant	Year of Commissioning	Products	Capacity	Remarks
1.	Pak-American Fertilizers Ltd. (PAFL), Daudkhel	1958-59	Ammonium Sulphate (21%N)	40 tons/day Ammonia 150 tons/day Ammonium Sulphate	Based on local Coal and Gypsum. Total investment Rs.91 million
		1968		34 tons/day Ammonia Plant added Ammonium Sulphate capacity raised to 90,000 tons annually	Use of "off" or "rest" gases in a Steam reforming plant.
		1973			Coal gasification abandoned and use of natural gas adopted for feedstock and fuel. Total production upto 30th June, 1982 : 1.6 million tons of Ammonium Sulphate.
2.	Lyallpur Chemicals and Fertilizers Limited (a) Faisalabad	1957-58	Single Super Phosphate (SSP) (18% P_2O_5)	20 tons/day Sulphuric Acid 20 tons/day of SSP* **	Imported Sulphur and Rock Phosphate *Later raised to 60 tons/day (18,000 tons annually) **Zinc Sulphate 600 tons/year since 1981
	(b) Jaranwala	1967-68	SSP	50 tons/day of Sulphuric Acid 36,000 tons per annum of SSP	
		1976		Another Sulphuric Acid plant added (50 tons/day) SSP capacity raised to 72,000 tons per annum	Total cost Rs. 15.65 million Production upto 30th June,19[illegible] 0.85 million tons of SSP at both plants.
3.	Natural Gas Fertilizer Factory, Multan	1963	Urea (46%N) Ammonium Nitrate ([illegible])	20[illegible] tons/day Ammonia 180 tons/day Nitric Acid	Based on Natural gas (Sui) Total Capital cost Rs.229.2 million. Ammonia plant had [illegible]

S.No.	Name of Plant	Year of Commissioning	Products	Capacity	Remarks
	Natural Gas Fertilizer Factory	1968		Ammopac Unit added for additional 60 tons/day Ammonia	Total cost Rs.27.3 million. This unit also did not work satisfactorily. The Ammonium Nitrate and Ammonia plants were shut down permanently in 1978. Total production till shutdown 1.13 million tons of Ammonium Nitrate and 0.53 million tons of Urea
4.	EXXON Chemicals Ltd., Daharki	1968	Urea (46%N)	300 tons/day Ammonia 510 tons/day Urea	Based on Natural gas (Mari) Total cost Rs.425 million (Approx) Total Production upto 30th June, 1982, 2.7 million tons of Urea
5.	Dawood Hercules Chemicals Ltd., Sheikhupura Lahore	1971	Urea (46%N)	625 tons/day of Ammonia 1100 tons/day of Urea	Based on Natural gas (Sui) First plant in Pakistan to install Centrifugal Compressors Total cost: Rs.833 million (Approx) Total production upto 30th June 1932 : 3.8 million tons of Urea
6.	Pakarab Fertilizers Ltd., Multan	1979	Urea (46%N) Nitrophos-phate (23:23:0) Calcium Ammonium Nitrate (26%N)	180 tons/day Urea 910 tons/day Ammonia 1200 tons/day Nitric Acid 1015 tons/day NP 1500 tons/day CAN	Old plant (See S.No.3 above) Total cost on modernization and expansion : Rs.2511 million Design deficiencies being rectified by modifications. Full capacities not achieved. Rehabilitation of old Urea plant being undertaken. Production upto 30th June, 1982. Urea - 0.17 million tons NP - 0.56 million tons CAN - 0.87 million tons
7.	Paksaudi Fertilizers Limited, Mirpur Mathelo	1980	Urea (46%N)	1000 tons/day Ammonia 1740 tons/day Urea	Based on Natural gas (Mari) Total cost Rs. 2081 million Total production upto 30th June, 1982 : 0.83 million tons
8.	Hazara Urea Fertilizer Ltd., Haripur	1982	Urea (46%N)	170 tons/day Ammonia [illegible] tons/day Urea	Based on Natural gas. Chinese technology - Reciprocating [illegible] Total cost Rs.[illegible] million.
9.	Fauji Fertilizer Company [illegible]	1982	Urea (46%)	1000 tons/day Ammonia 1740 tons/day	Based on Natural gas (Mari) Total cost Rs.300 million (Approx)

	Food Crops									Cash Crops						
[illegible]	Wheat	Rice	Bajra	Jowar	Maize	Barley	Total Food-grains	Gram	Total Food Crops	Sugar-cane	Rape-Seed & Mustard	Sesamum	Cotton	Tobacco	Total Cash Crops	Principal Crops
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
[illegible]-48	3,[illegible]	693	301	205	359	113	5,025	472	5,497	5,529	175	9	197	14	5,924	11,421
[illegible]	4,[illegible]	748	345	247	379	178	5,935	766	6,701	6,947	188	6	172	18	7,331	14,032
[illegible]	3,[illegible]	[illegible]	376	271	407	148	5,931	609	6,540	7,849	145	6	220	26	8,246	14,726
[illegible]	[illegible]	865	392	248	387	131	6,016	756	6,772	5,906	199	8	250	30	5,993	12,765
[illegible]-52	3,[illegible]	730	269	208	393	101	4,701	429	5,130	5,399	200	7	249	36	5,891	11,021
[illegible]	[illegible]	832	271	224	352	[illegible]	4,177	321	4,498	7,266	127	6	317	26	7,742	12,2[illegible]
[illegible]	[illegible]	901	[illegible]	232	[illegible]	129	5,803	571	6,374	8,956	166	6	254	38	9,430	15,791
[illegible]	[illegible]	[illegible]	[illegible]	225	433	106	5,143	604	5,747	8,836	219	6	291	74	9,416	15,16[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	253	457	[illegible]	5,395	609	6,004	8,200	221	6	299	49	8,775	14,869
[illegible]	3,[illegible]	[illegible]	369	259	469	116	5,695	692	6,387	8,947	226	6	304	46	9,529	15,916
[illegible]	[illegible]	876	278	186	447	127	5,473	663	6,141	11,294	233	6	304	56	11,893	18,034
[illegible]	[illegible]	992	314	215	439	129	6,046	577	6,623	12,489	266	6	283	58	13,102	19,725
[illegible]	[illegible]	[illegible]	329	233	495	139	6,100	603	6,703	10,662	239	8	292	61	11,262	17,979
[illegible]	[illegible]	1,0[illegible]	306	228	[illegible]	[illegible]	5,929	610	6,539	11,681	211	7	301	60	12,223	18,762
[illegible]	[illegible]	1,227	470	[illegible]	[illegible]	116	6,475	[illegible]	7,098	14,357	205	11	324	70	14,967	22,065
[illegible]	[illegible]	1,6[illegible]	422	252	399	113	6,540	678	7,218	19,439	257	8	367	71	19,142	26,360
[illegible]	[illegible]	2,192	361	238	526	111	6,590	610	7,200	16,140	211	8	419	75	16,853	24,0[illegible]
[illegible]-65	[illegible]	1,[illegible]50	446	293	528	118	7,326	672	7,998	18,668	214	9	373	82	19,391	27,389
[illegible]	[illegible]	2,317	370	274	540	93	6,500	539	7,039	22,309	182	7	414	110	23,042	30,061
[illegible]	[illegible]	1,[illegible]	371	277	387	88	7,043	635	7,638	21,982	203	7	463	140	22,[illegible]	30,453
[illegible]	[illegible]	2,499	413	291	721	108	9,520	481	10,001	18,660	275	9	518	130	19,592	29,593
[illegible]	[illegible]	2,032	330	262	626	97	9,965	528	10,493	21,971	229	8	528	125	22,861	33,254
[illegible]	7,[illegible]	2,401	302	284	667	104	11,052	566	11,558	26,370	255	8	535	117	27,285	38,843
[illegible]-71	6,[illegible]76	2,200	355	329	717	91	10,168	494	10,662	23,167	269	10	542	113	24,101	34,763
[illegible]-72	[illegible]	2,262	360	312	705	103	10,632	510	11,142	19,963	301	14	708	87	21,073	32,215
[illegible]-73	7,[illegible]32	2,330	304	302	706	109	11,193	553	11,746	19,947	287	10	702	63	21,009	32,755
[illegible]-74	7,[illegible]29	2,455	351	378	767	139	11,719	610	12,329	23,911	292	12	659	66	24,940	37,269
[illegible]-75	7,373	2,314	266	266	747	137	11,403	550	11,953	21,242	248	8	634	77	22,209	34,162
[illegible]-76	8,691	2,618	308	281	802	130	12,830	601	13,431	25,547	267	11	514	58	26,397	39,828
[illegible]-77	9,[illegible]44	2,737	311	261	764	124	13,341	649	13,990	29,523	296	12	435	73	30,339	44,329
[illegible]-78	8,367	2,950	318	284	821	121	12,861	614	13,475	30,077	236	13	575	74	30,975	44,450
[illegible]-79	9,950	3,272	317	252	799	129	14,719	538	15,257	27,326	248	19	473	68	28,134	43,391
[illegible]-80	10,[illegible]05	3,216	277	249	875	118	15,540	313	15,853	27,498	247	19	723	78	28,570	44,[illegible]
[illegible]-81	11,[illegible]75	3,120	214	234	946	199(P)	16,188	343(P)	16,531	32,359	253	18	715	67	33,417	49,[illegible]
[illegible]-82 (P)	12,[illegible]	3,4[illegible]	269	245	932	149	16,054	262	16,316	3[illegible],564	424	18	748	71	37,825	54,141

(P) Provisional.

Source: Ministry of Food, Agriculture & Co-operatives

TABLE 2

ANNUAL FERTILIZER [illegible] IN [illegible]
1952-53 [illegible]

Year	Nitrogen (N)	Phosphorus (P_2O_5)	Potassium (K_2O)	Total
1952-53	1 000	-	-	1 [illegible]
1953-54	14 800	-	-	14 [illegible]
1954-55	14 100	-	-	14 [illegible]
1955-56	6 600	-	-	6 [illegible]
1956-57	9 000	-	-	9 [illegible]
1957-58	16 400	-	-	16 [illegible]
1958-59	18 000	-	-	18 [illegible]
1959-60	19 300	100	-	19 [illegible]
1960-61	31 000	400	-	31 [illegible]
1961-62	37 000	500	-	37 [illegible]
1962-63	40 000	200	-	40 [illegible]
1963-64	68 000	700	-	68 [illegible]
1964-65	85 000	2 200	-	87 [illegible]
1965-66	69 830	1 220	-	71 [illegible]
1966-67	112 760	3 890	120	116 [illegible]
1967-68	176 170	[illegible] 160	250	188 [illegible]
1968-69	205 210	39 470	2 230	246 [illegible]
1969-70	273 950	36 640	1 340	311 [illegible]
1970-71	251 520	30 450	1 240	283 [illegible]
1971-72	343 973	37 231	744	381 [illegible]
1972-73	386 385	48 730	1 380	436 [illegible]
1973-74	341 929	58 081	2 673	402 [illegible]
1974-75	362 831	60 571	2 086	425 [illegible]
1975-76	445 276	102 517	2 843	550 [illegible]
1976-77	510 992	117 935	2 356	631 [illegible]
1977-78	549 934	156 332	5 977	712 [illegible]
1978-79	684 215	187 719	7 578	879 [illegible]
1979-80	805 990	228 460	9 604	1 044 [illegible]
1980-81	842 930	226 900	9 630	1 079 [illegible]
1981-82	833 000	226 000	22 000	1 08[illegible]

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