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THE IRANIAN FERTILIZER INDUSTRY

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The Iranian Fertilizer Industry

Preface

This report on the fertilizer industry of Iran has been prepared mainly by a team of three UNIDO personnel.

Dr. Abu El Haj was responsible for the market research in Iran, and nearby countries and for the writing of Section 3.00, Dr. W. Mydans (Chemical Engineer) prepared Section 4.00 dealing with the technical aspects of production, and Mr. J. Goodwin (Project Evaluator) wrote Section 1.00, 2.00, 5.00 and 6.00, the latter section covering the economics of production and site location.

Mr. F. Bazargani, the Head of the Chemical Engineering Section, at the Research Centre of the Ministry of Economy, and Mr. J. Sajjadi of the same division assisted and advised in many ways, contributing to the value of the report.

Acknowledgement is made to the valuable information provided by the Soil Institute of Iran, whenever their help was sought.

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The Iranian Fertiliser Industry

1.00 Introduction

1.01 The development of the Iranian fertilizer industry offers a complex analytical problem, in which most of the parameters are rapidly changing.

1.02 It was necessary to estimate future regional demands, beyond the end of the 5th Development Plan, derived from an end-use analysis, and also to take a much closer look into the variation in costs deriving from site location, to obtain a clearer understanding of the development options available to the industry.

1.03 The topography of the land, the annual rain-fall, the availability of surface and ground water for irrigation, and the climate have already established a pattern of cropping, and with it a broad pattern of fertilizer application in which three main concentrations of use are seen to be in the north and north-west, the north-east and the south-east. The detailed market studies indicate that this broad pattern will continue up to the year 1361, although there will be changes in the relative proportions of the areas.

1.04 In addition to these three main areas of fertiliser application within Iran, there could be export potential for fertilizers from the south through Bandar Shahpour and possibly from the north through Bandar Pahlavi.

1.05 Although the ultimate use of fertilisers is limited mainly by the availability of water, the rate of increase in the use of fertilisers will be determined as much by advancement in farming techniques, farm management, and the economics of crop production, as by irrigation development.

1.06 The projected internal demand under the assumptions quoted in this report for nitrogen and phosphate fertilisers by the year 1361, is 1235 thousand tons per annum in total, and since planned plant expansions up to 1356 as distinct from new plants, provide only about 610 thousand tons output capacity, new fertiliser plants will eventually become necessary. According to a recent announcement by the National Petroleum Company it is also planned to build a new urea plant, of 310 thousand tons and a mono-ammonium phosphate plant, capacity 200 thousand tons by 1356.

1.07 The location of these new plants will be decided by the cost of distribution of the fertilisers, the cost of raw materials at the plant, the availability of water, capital investment charges, the possibilities of export of fertilisers and of the intermediate products, ammonia, phosphoric acid and sulphuric acid, and of course Government policy.

1.08 Although reference is made to potassium fertilisers, the current usage of which is only less than 1% of the total demand, possibly increasing to 5% by 1361, this report mainly relates to nitrogen and phosphate fertilisers.

2.00 Summary, Conclusions and Recommendations

2.01 The projections of fertilizer demand on the basis of end-use analysis in each province indicate that by the year 1361, it is possible for demand to reach 500,000 tons of urea and 735,000 tons of diammonium-phosphate (DAP).

2.02 The total fertilizer demand has been computed on the basis of producing only two products, - urea and DAP, in line with the policy of reducing the number of fertilizer products to be marketed. This policy, in the longer term, may prove to be too rigid and perhaps uneconomic, because of the need to finely balance the soil nutrient content.

2.03 The distribution of demand shows a concentration of demand in the north and northwest (35%), the northeast (12%), and the southeast (27%).

2.04 These projections take into account the planned expansion of irrigated areas, the trends in crop distribution, and the latest test applications of fertilizers made by the Soil Institute. The figures are not to be regarded as the ultimate Iranian demand but they are thought to be realistic and attainable by 1361.

2.05 Expansions to production capacity at Bandar Shahpour to be completed by 1356, will increase the production capacity of existing plants to 311,000 tons of urea and 297,000 tons of DAP.

2.06 It is also reported that it is planned to erect a new urea plant at Bandar Shahpour to produce 310,000 tons, bringing the total urea capacity to 621,000 tons. Since the projected demand for urea only reaches 500,000 tons in the year 1361, there would be a substantial margin for export.

2.07 A new plant to produce 200,000 tons of mono-ammonium-phosphate (MAP) is reported to be planned for erection by 1356 at Bandar Shahpour, bringing the total of DAP and MAP to 500,000 tons, or about 520,000 tons of equivalent DAP based on P_2O_5 content. No further DAP plants are envisaged whereas the projected demand by 1361 is estimated to be 735,000 tons of DAP.

2.08 The limited demand for mixed fertilisers has been taken into account separately, but it is noted that if mixed fertilisers were freely available, the increase in demand could become a major share of the total fertiliser demand.

2.09 Potassium fertilisers, estimated to be 5% of the total by 1361, will continue to be imported, unless a suitable mineral deposit is found in Iran.

2.10 The development of the industry, is considered as being spread over three phases.

(i) Completion of extensions to existing plants at Bandar Shahpour, to provide total outputs of 310,000 tons of urea and 297,000 tons of DAP.

(ii) The erection of a new fertiliser complex in the northwest.

(iii) The erection of a further fertilizer complex in the northeast.

The time scale of the second and third phase is not considered to be in any way rigid, but it is probable that Phase II would come into production about the year 1357/8 and Phase III at around 1360/2. Actual timing would depend upon the observed trend of increased demands, in comparison with the projections provided in this report.

2.11 The existing plans limit the production of fertilizers to Bandar Shahpour, and this fails to make provision for export of fertilisers to the USSR, because it would not be economic to transport fertilisers from the south for export through Bandar Pahlavi.

2.12 The centre of distribution of the north-western area has been shown to be to the east of Rasht, and Rasht with the adjacent port of Bandar Pahlavi is therefore a possible location to be considered. Further it is on the route of the 42" northern pipeline. An alternative location for consideration is at Ghazvin, because it is at the termination of the railway system, and Ghazvin too is on the route of the 42" pipeline.

2.13 In the case of DAP production in the northwest, the cost of transporting sulphur, and phosphoric acid or phosphate rock from Bandar Shahpour is shown to be prohibitive. On the other hand, if phosphate rock of suitable quality could be imported from the USSR through Bandar Pahlavi, at prices no higher than the rock imported from Florida, USA, through Bandar Shahpour, then DAP production in the north-west becomes a possibility. Preliminary inquiries indicate that a suitable phosphate rock may be available from the USSR.

2.14 Unfortunately the only known deposit of phosphate rock in Iran at Shemshak, is reported to be of low grade and uneconomic for the production of phosphatic acid.

The possible import of phosphate rock from south Russia through Caspian ports, should not be lightly past over, when a world shortage of phosphate rock is probable. Furthermore, phosphate rock from the USSR may have a lower CIF cost than rock imported from more distant sources through Bandar Shahpour.

2.15 Further provided Iran's excess sulphur production can be exported through Bandar Shahpour, a further reduction in production cost of DAP in the northwest would ensue from importing the sulphur requirements from the USSR, but this has not been taken into account in estimating the costs.

2.16 Urea production in the north-west would be economic, provided the capacity of the supporting ammonia plant was at least 700 tons per day. If the whole of this ammonia production were to be converted into urea, then a urea capacity of 400,000 tons per annum would be required. This quantity, together with the expanded production in the south, would total approximately 700,000 tons, as compared with the projected demand of 500,000 tons, leaving 200,000 tons for export either from Bandar Shahpour or Bandar Pahlavi.

2.17 This dependency on exports would be reduced if a DAP plant, using phosphate rock from the USSR were to be constructed, in the north-west, having a capacity of 250,000 tons per annum. The expanded capacity at Bandar Shahpour of 297,000 tons is short of the estimated demand for DAP by 438,000 tons per annum. A DAP plant of 250,000 tons capacity requires 58,000 tons of ammonia, equivalent to 100,000 tons of urea, and in this case the urea plant could be designed for 300,000 tons, leaving a reduced national balance of 100,000 tons for export.

2.18 From this it emerges that it would be desirable to have a plant in the Ghazvin or Rasht areas to produce 300,000 tons of urea using gas from the 42" pipeline together with a DAP plant of 250,000 tons capacity using phosphate rock from the USSR. Because Ghazvin is connected to the railway system it is probably a more suitable location for a urea/DAP complex than Rasht, provided the requisite water supply is available. but should a rail link be made between Ghazvin and Rasht, then Rasht would probably be more advantageous.

2.19 If after a full investigation into the possibility of obtaining phosphate rock from the USSR, the proposal has to be discarded, then a 400,000 ton urea plant located in the Ghazvin area is an economic unit, provided a sustained export to Russia of 150,000 tons per annum of urea is possible, and 50,000 tons through Bandar Shahpour.

2.20 The centre of distribution of the north eastern area has been shown to be west of Mashad in the Esferain locality, but the projected quantity of fertilizers required, as compared with the north-western area, is considerably less.

At a date probably around 1361, as a third stage after the construction of a fertilizer plant in the north-west, when demand may well exceed the projected demand in 1361, the north-eastern area has some distinct advantages as a venue for a fertilizer plant, even though the factory production cost may be unavoidably higher with a smaller plant.

2.21 A 16" pipeline, 125 km. in length, from the gas field east of Mashad to Mashad, is nearing complstion, and compared with Bandar Shahpour, the relatively small additional cost of gas transport is more than off-set by the considerable reduction in the cost of fertilizer distribution. The factory production cost of urea at Mashad could be up to $8.00 a ton more than at Bandar Shahpour and still be an economic proposition.

The projected demand for urea in 1361 in Khorassan, Masandaran, Gorgan and Semnan is 140,000 tons, while the DAP demand is projected at 190,000 tons.

2.22 DAP production using phosphate rock imported from the USSR through Bandar Shah, employing a specially constructed jetty and improved roads to Mashad, is an economic possibility. Assuming the same landed cost for phosphate rock at Bandar Shah as at Bandar Shahpour, and the same cost of natural gas, the production and distribution cost of DAP at Mashad, is a little more expensive than Bandar Shahpour but still ranks as a possibility. It is further assumed that the gas analysis is such that the sulphur required to make sulphuric acid will be available from the gas field.

2.23 There are more unknown factors in the north-eastern area, for example the availability of water in the required quantities at Mashad or to the west of Mashad, but in view of the indicated economies of distribution, and the Government policy of regional development, a detailed feasibility study covering optimum plant size, distribution costs and the possibility of phosphate rock imports from the USSR may well result in the eventual construction of a fertiliser plant in this area.

2.24 Although the costs in the report are estimated, emphasis is placed on cost differences rather than absolute costs, from which it is possible to draw broad conclusions.

The estimated costs indicate that it is marginally economic to produce urea alone at Ghasvin, Rasht and possibly Mashad, but only if at least 150,000 tons a year are exported to USSR, would it be possible to take advantage of economies of scale.

It is not economic to produce DAP at Rasht, Ghasvin or Mashad based on phosphate rock imported through Bandar Shahpour, but with phosphate rock from Russia it may become possible to produce DAP at all three locations at marginally economic rates.

2.25 Of paramount importance is the need to operate all fertiliser plants at maximum capacity, because of the high proportion of capital charges included in the cost per ton, and both the availability of Russian phosphate rock, and the export of urea to Russia would need to be based on long term contracts.

2.26 This report has indicated possible options on plant locations, source of phosphate rock and sulphur and urea exports. The export of DAP to Russia is less likely to be economic but is worthy of investigation.

2.27 The possibilities of Russian trade in phosphate rock imports and urea/DAP exports could be a profitable source of inquiry, following which a more accurate study of the feasibility of plants in the north-west and north-east would become possible.

3.00 Projected Fertilizer Demand

3.01 The chemical fertilizer requirements in 1361 have been estimated by the end-use method at about 780,000 tons of plant nutrients ($N:P_2O_5:K_2O$). This compares with 162,000 tons in 1350 and a 5th Plan target of 415,000 tons by 1356.

3.02 Consumption per hectare of irrigated land area has risen from 7 kg/hectare in 1342[1] to 45 kg. in 1350. This compares to a projected 5th Plan target of 100 kg. and a projected 175 kg. by 1361. Roughly comparable figures for Lebanon and Israel (1350) are respectively 400 kg./hectare and 340 kg./hectare[2].

3.03 Estimates of the 1361 requirements were based on a projected crop area under irrigation (see Appendix II) and using assumed rates of fertiliser application per hectare for major crops (Appendix VIII). Allowance was made for non-coverage of crop area and for future increase in the use of potassium fertilisers, in the amounts 10% and 5% of the total respectively. Additional allowance was made - 90,000 tons of plant nutriente for use on 1.5 million hectares of wheat grown on dryfarming.

Projected Demand/fertilizers, 1361 [3]

(1000 tons of plant Nutrients)

	N	P_2O_5	K_2O	Total
Estimated requirements for major crops	315	280	-	595
Non-coverage (10% of total)	32	28	-	60
Potassium fertilizers (5% of total)	-	-	34	34
Dry farming - wheat	45	45	-	90
Grand Total	392	353	34	779

(1) National Petrochemical Company, The Fertilisers Marketing System in Iran, February 1973.

(2) & (3) see overleaf.

Table 1 summarizes chemical fertilizer consumption in plant nutrients and by fertilizer products for the years 1350, 1356 & 1361.

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(2) Israel : - Plant Nutrients (1971/72)

	N	32,500 tons
	P_2O_5	15,850 tons
	K_2O	11,900 tons

Irrigated crop area (1971/72) = 179,000 hectares

Source : Statistical Abstract of Israel, 1972, pp 384, 342

Lebanon : Plant Nutrients (1971)

	N	21,590 tons
	P_2O_5	6,718 tons
	K_2O	4,848 tons

Irrigated land 89,000 hectares of which 60,000 hectares adequately irrigated and 20,000 hectares partly irrigated.

Source : The Litani Project Organisation, Lebanon.

(3) Appendix II.

Table 1

FERTILIZER DEMAND BY TYPE, 1355, 1358 AND 61

(In Tons)

	Fertilizer Products						Plant Nutrients											
	1355 (1)		1358		1361		1355				1358				1361			
	Tons	%	Tons	%	Tons	%	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total	N	P_2O_5	K_2O	Total
Urea (46% N)	137,200	(40.0)	345,000	(43.1)	500,000	(31.5)	63,112	-	-	63,140	158,700	-	-	158,700	230,230	-	-	229,298
Calcium Ammonium Nitrate (26%N)	31,353	(9.7)	40,000	(5.0)	45,000	(3.1)	8,151	-	-	8,404	10,400	-	-	10,400	11,700	-	-	11,700
Triple Superphosphate (45% P_2O_5)	50,447	(15.0)	-		-	-	-	23,000		23,000	-	-	-	-	-	-	-	-
Ammonium Sulphate (21%N)	11,951	(3.0)	13,430	(1.0)	20,000	(1.3)	2,520	-	-	2,740	3,150	-	-	3,100	1,200	-	-	4,200
Di-Ammonium Phosphate (18%N, 46% P_2O_5)	95,017	(28.1)	346,070	(43.4)	730,000	(50.7)	17,000	45,300		65,107	61,400	160,500		221,900	131,401	338,393	-	470,764
Potassium Sulphate (50% K_2O)	300	(0.1)	3,000	(0.4)	50,000	(3.4)	-	-	163	180	-	-	1,500	1,500	31,212	-	-	34,240
Compound Fertilizers		(1.2)																
(15 - 15 - 15)	3,070		30,000	(0.2)	100,000	(7.0)	431	461	300	1,230	7,500	7,500	5,000	20,000	15,000	15,000	10,000	40,000
(20 - 20 - 0)	800		-		-		170	170	-	306	-	-	-	-	-	-	-	-
TOTAL (%)	335,434	(100.0)	800,100	(100.0)	1,430,000	(100.0)	92,790	69,207	501	162,400	240,200	167,000	6,500	410,700	380,350	380,300	34,210	780,100

Sources:

1355 - 1358: National Petrochemical Company [illegible]

1361: [illegible]

(1) Data relating to sales by Fertilizer Distribution Company. No data available from private sector except import of 50,000 ton. of [illegible] which were added in the table.

3.10 Crop Area Under Irrigation:

3.11 Current estimates of crop area under irrigation is about 3.6 million hectares, projected to increase by an additional 400,000 hectares by the end of the Fifth Five-Year Development Plan (1356). It is assumed that by 1361 another 400,000 hectares of land will be brought under irrigation and that the necessary irrigation development will be undertaken. Areas under various types of crops were projected roughly on the basis of trends assumed between 1350 and 1356.

3.12 A necessary condition for sustained and intensive use of fertilizers is adequate irrigation. Present estimates of adequately irrigated area from both surface and underground water varies from 1.5 to 2.5 million hectares. The latter estimate is made by the Planning Bureau of the Ministry of Agriculture. However, it is a fact that the country's water resources are not presently utilized to their full potential. A considerable amount of controlled water is wasted by seepage, avoidable evaporation and by poor irrigation practices.

3.13 As for the future, two surveys have been undertaken by the Ministry of Agriculture and the Ministry of Water and Power to establish the water resources potential of the country. The Master Plan of the Ministry of Water and Power on surface water indicates that on the basis of known major dams and irrigation projects, either under construction or planned 1.4 million hectares[(1)] of land could be brought under adequate

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(1) Only 90,000 hectares at present are under a modern network of irrigation system, to be increased to between 700,000 - 800,000 hectares, by the end of the Fifth Plan.

irrigation (Appendix IV). The Master Plan of the Ministry of Agriculture, covering both surface and underground water, estimates that potentially 5.5 million hectares could be given adequate irrigation(2).

1.14 In projecting the fertilizers requirements in 1361 it is envisaged that 80% of irrigated land will receive adequate water. In comparison the reported percentage of irrigated land in 1351 lies between 45% and 70%. This objective could be attained through the success of the vigorous agricultural policy enunciated in the Fifth Plan, to be continued through the Sixth Plan period.

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(2) Potential available water is estimated at 98.6 m^3 billion. Assuming an average of 10,000 m^3/hectare for adequate irrigation and after excluding unsuitable land for cultivation, 5.5 million hectares are estimated as the potential.

3.20 <u>Applied Rates of Chemical Fertilizers:</u>

3.21 The fertilizer rates/hectare for various types of crops, used in projecting the 1361 requirement are detailed in Appendix VIII. Rates suggested by the Soil Institute of Iran (Appendix V) have been used as a guideline in adopting applicable future fertilizer rates in this study. The Soil Institute's recommended rates are by regions, while those adopted in the projections were in most cases uniform rates. By and large the higher rates recommended presently in certain regions were adopted as applicable average future rates. These rates are fairly comparable to rates relating to practices in some countries in the Middle East. (Appendix XI).

3.22 Turning to specifics, for wheat, two rates were adopted (90-90-0 and 60-60-0). The figures 90-90-0 etc. refer to the application of nutrients per hectare of irrigated land, in term of N-P_2O_5-K_2O in that order. The higher rates are good practice applicable to good land. Application of higher rates of fertilizers (180-120-0) on sugar beets is already in use in a good number of regions in the country, a result of relatively advanced agricultural practices and price support. For rice and cotton no change has been made in the fertilizer rates recommended by the Soil Institute, but more widespread application has been envisaged.

3.23 Experiments by the Soil Institute indicated positive results from the use of fertilizers in dry wheat areas. It is assumed that by 1361, 1.5 million hectares will use fertilizers (30-30-0), primarily in the North, North East and Central regions.

3.24 At present, potassium fertilizers are of limited use but in the future there will be an increase in its application as land will, in time, begin to lose potassium nutrients due to prolonged intensive cultivation. Already in certain areas positive response on certain crops has been observed. At present potassium fertilizers are used mainly on tobacco, but it is also recommended for use on fruit orchards planted on light soils, and in certain areas of the North for preventing water-logging in cereal crops, especially rice. Rough estimates were made indicating a future need for potassium fertilizers in an order of 3 - 5% of total fertilizers. Experts at the Soil Institute are of the opinion that potassium fertilizers needed by the end of the decade may reach 10% of total fertilizer demand.

3.30 <u>Fertilizer Products in Use</u>:

3.31 In terms of plant nutrients, nitrogen is the highest in use followed next by phosphate. The soil in Iran is deficient or poor in nitrogen and only in certain soils, especially land cleared of forests has there been little or no response to application of nitrogen. Next in importance is the deficiency in phosphate. The country's soil is, however, rich in potassium.

3.32 A glance at Table 2 indicates a continuous reduction, in recent years, in the types of fertilizer products used in Iran. This is primarily a result of Government restrictions on imports to encourage local production and as a measure intended to facilitate wider use of fertilizers. Urea has grown rapidly in the last decade, ranking first among all fertilizers in use in Iran. It has the highest concentration of nitrogen, and is chemically well suited to the soil in Iran in addition to being economic. The second in importance is di-ammonium phosphate, recording the fastest growth rate followed by triple super phosphate.

Di-ammonium phosphate offers the advantage of containing both nitrogen and phosphate making it a good "combined" fertilizer.

3.33 Mixed fertilizers have so far been imported, see Appendix X. Before the Government restriction on imports in 1347, its use was rather high. Import is presently permitted for essential use. The envisaged establishment of a mixed fertilizer plant in the future is expected to increase the use of this type of fertilizer in the country.[1]

3.34 Calcium ammonium nitrate is used on a relatively limited scale and its use is envisaged to decrease in the future. Ammonium sulphate has good technical properties, has fine adaption to Iranian soil, and it is almost exclusively used in tea production.

3.35 The projected plant nutrients projected for 1361 were converted to chemical fertilizer products according to production patterns enunciated recently by the National Petrochemical Company. The main nitrogen plant nutrient will be urea. No local production of triple super-phosphate is envisaged in the future, leaving di-ammonium phosphate as the primary phosphate nutrient carrier. It is envisaged that the use of mixed fertilizers will continue to grow maintaining in 1361 a slightly higher share in total fertilizers compared to 1356. Limited growth has been envisaged in the use of calcium ammonium nitrate and ammonium sulphate. (See Table 1).

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(1) An opinion was expressed that if mixed fertilizers were available locally, the use is likely to exceed that of di-ammonium phosphate and even urea. Mr. A. Assadollah, "Use of Chemical Fertilizers in Iran" December 1968.

TABLE 3

Consumption of Fertilizers in Iran, 1342 - 1350

(Plant Nutrients in tons)

Type of Fertilizers	Apparent Consumption (1)								
	1342 (1963)	1343 (1964)	1344 (1965)	1345 (1966)	1346 (1967)	1347 (1968)	1348 (1969)	1349 (1970)	1350 (1971)
Urea (46% N)	1,667	10,668	9,984	19,038	36,417	30,886	37,037	49,700	[illegible]
Triple superphosphate (45% P_2O_5)	2,323	5,818	3,187	12,034	11,356	5,530	17,137	11,955	[illegible]
Single superphosphate (18% P_2O_5)	342	-	745	475	717	-	-	-	-
Ammonium Sulphate Nitrate (26% N)	716	-	-	-	471	-	-	-	-
Ammonium Sulphate (21% N)	647	735	1,386	1,351	3,000	1,607	[illegible]	2,543	[illegible]
Di-ammonium Phosphate (18 - 46 - 0)	5,450	7,078	6,220	14,019	21,318	29,610	[illegible]	31,787	[illegible]
Calcium Ammonium Nitrate (26% N)	2,018	3,609	2,857	3,842	3,905	4,724	[illegible]	7,062	7,0[illegible]
Potassium Sulphate (50% K_2O)	1,278	538	50	800	1,100	150	[illegible]	800	-
Compounds (15 - 15 - 10) (20 - 20 - 0)	6,854	7,700	11,230	5,386	15,331	3,943	61	2,000	-
T O T A L (N + P + K)	24,265	35,556	37,339	56,826	94,697	77,339	[illegible]	10[illegible]	[illegible]
Fertilizers Products	(58,956)	(85,850)	(91,335)	(128,462)	(193,121)	([illegible])	([illegible])	([illegible])	(277,753)
Fertilizers Consumption (2) (Tot 1)	25,793	32,531	36,402	55,794	72,196	81,012	94,614	107,725	[illegible]
N	13,369	16,000	19,897	29,069	44,606	51,857	[illegible]	69,709	[illegible]
P_2O_5	9,914	14,364	15,036	25,134	26,440	27,647	36,163	37,322	69,303
K_2O	2,610	2,167	1,469	1,591	1,250	1,518	1,701	698	589

(1) Import plus local production see Appendix IX and X

(2) After Accounting for variation in stock. Sources: National Petrochemical Co. The Fertilizer Marketing System In Iran Feb. 1975 Table 2.

3.40 Fertilizers Consumption by Provinces

3.41 Current consumption of fertilizers is highest in Mazandaran, Gorgan, Khorasan, Gilan, Esfahan and Central Ostan (see Table 3). Better irrigation practices and in certain areas of the northern region a heavy occurrence of rainfall, has made these provinces the relatively more developed agricultural areas. Further, cash crop cultivation is more predominant in these provinces.

3.42 The 1361 projections envisage a more uniform regional development in water resources utilization and introduction of modern agricultural practices. This is reflected in part, in the comparable order of magnitude of the share by provinces in consumption of fertilizers and the distribution of irrigated areas.

3.43 Comparing consumption distribution in 1350 and 1361 the South and South East provinces are expected to record the highest advances, with only a slight improvement in the share of the provinces of the western region. A substantial reduction in the share of the provinces of the central region, and a moderate reduction is expected for the Northern and Central Ostan provinces. Provinces in the north, north west and central ostan will still maintain the highest share of the future market.

3.44 Tables 4 and 5 contain a summary of the estimated requirements of types of fertilizer products by major regions and provinces, which in all cases are projected to increase. Estimates for urea and di-ammonium phosphate and mixed fertilizers were based on the detailed projections of nutrients (N & P_2O_5), distributed by provinces according to their respective share in irrigated land area. For calcium ammonium nitrate and ammonium sulphate, the same regional distributions prevailing in 1350 were applied for 1361.[1]

1.45 Similar pattern and trends as observed earlier for total distribution of fertilizers by regions are also observed for regional distribution by major fertilizer products. The share of North, West and Central Ostan region of urea, phosphate fertilizers, and mixed fertilizers, are still the highest despite moderate reduction in their share of total fertilizers. The fastest gains are envisaged for the South and South East regions.

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(1) For details Appendix VI.

Table [illegible]

TOTAL FERTILIZER DEMAND BY PROVINCES (1) 1350 - 1361 AND DISTRIBUTION OF IRRIGATED CROP AREAS

North, North West & Central Ostan	1350		1361		Distribution of Irrigated Crop Areas Percentage (3)	
	Tons (1)	Percentage	Tons (2)	Percentage	1350	1361
Gilan	[illegible]	17.1	71,200	5.3	5.9	5.3
Mazandaran - Gorgan	[illegible]	21.2	191,300	13.7	10.6	10.7
E. Azerbejan	16,[illegible]	5.6	34,000	6.0	6.4	7.5
W. Azerbejan	[illegible]	3.4	120,400	8.6	11.1	11.7
Zanjan	1,521	0.5	18,200	1.3	1.6	1.5
Central Ostan	24,915	8.4	151,200	10.8	10.8	10.0
Semnan	3,251	1.1	12,600	0.9	0.9	0.9
Sub - Total	152,356	51.3	652,400	46.6	47.3	48.2
North East Region						
Khorasan	12,133	14.3	168,000	12.0	13.7	13.0
Sub - Total	12,133	14.3	168,000	12.0	13.7	13.0
West Region						
Kurdestan	576	0.2	8,400	0.6	1.0	1.0
Kermanshah	7,970	2.7	43,400	3.1	2.7	2.7
Hamadan	7,222	2.4	29,400	2.1	2.1	2.1
Ilam	615	0.2	2,800	0.2	0.3	.3
Lorestan	3,965	1.3	19,600	1.4	1.9	1.9
Sub - Total	[illegible]	6.8	103,600	7.4	[illegible]	[illegible]
Central Region						
Isfahan	41,401	[illegible]	81,200	5.8	5.9	4.1
Yazd	2,304	0.8	7,000	0.5	0.3	0.3
Chahar Mahle	2,064	0.7	11,200	0.8	1.1	1.1
Sub- Total	45,969	15.4	99,400	7.1	5.3	5.3
South & South East						
Khousestan	13,853	4.7	116,[illegible]	8.3	4.0	8.2
Fars	10,659	3.7	105,000	7.5	6.[illegible]	6.6
Kerman	9,055	3.0	86,800	6.2	4.1	4.0
Kuhkulooh	1,065	0.4	1[illegible],900	0.9	1.4	1.5
Coastal-Persian Gulf	[illegible]75	0.3	1[illegible]	1.2	1.3	1.1
Seistan - Baluchistan	[illegible]6	0.1	36,400	2.6	3.[illegible]	3.6
Sub - Total	36,[illegible]	12.2	376,600	26.9	25.1	25.1
Grand Total	297,[illegible]	100.0	1,400,000	100.0	100.0	100.0

Sources: (1) Consumption 1350: Chemicals Fertilizers Distribution Company - see Appendix VI

(2) Consumption 1361: See Appendix I for details of estimating method.

Excluding potassium sulphate from total.

(3) Distribution of irrigated crop areas - from Appendix II

Table 4

Fertilizer Demand by Type and Major Regions 1350-1361

(Thousand Tons)

	North, N.-West and Central System	North East Region	West Region	Central Region	South & S. East Region	Grand Total
Urea						
1350 Tons	74.6	19.8	8.6	13.4	20.9	137.3
Percentage	54.3	11.4	6.3	9.8	15.2	100.0
1361 Tons	137.5	61.0	36.0	29.5	136.0	500.0
Percentage	47.5	12.2	7.2	5.9	27.2	100.0
Di-Ammonium Phosphate						
1350 - tons	10.7	6.7	7.9	17.5	8.0	59.8
Percentage	33.0	11.1	13.2	29.2	13.5	100.0
1361 - tons	338.2	88.2	57.3	44.8	209.5	738.0
Percentage	45.6	12.0	7.8	6.1	28.5	100.0
Triple Super Phosphate						
1350 - tons	34.4	10.4	1.4	0.5	3.7	50.4
Percentage	68.3	20.7	2.8	0.9	7.3	100.0
P_2O_5 Plant Nutrients						
1350 - tons	28.0	8.8	4.2	8.3	5.4	30.9
Percentage	49.1	15.7	8.3	16.3	10.6	100.0
1361 - tons	154.2	40.8	26.4	20.6	96.4	338.2
Percentage	45.6	12.0	7.8	6.1	28.5	100.0
Mixed Fertilizer						
1350 - tons	1.8	0.2	0.1	0.3	0.6	3.0
Percentage	57.5	6.8	3.7	11.0	21.0	100.0
1361 - tons	46.9	12.1	7.4	6.0	27.6	100.0
Percentage	46.8	12.1	7.4	6.0	27.6	100.0
Calcium Ammonium Nitrate						
1350 - tons	8.6	5.2	2.1	14.0	2.7	32.6
Percentage	26.5	16.0	6.4	42.9	8.2	100.0
1361 - tons	11.8	7.2	2.9	19.3	3.7	45.0
Percentage	26.5	16.0	6.4	42.9	8.1	100.0
Ammonium Sulphate						
1350 - tons	12.323	0.052	0.232	0.172	0.172	12.951
Percentage	95.2	0.4	1.0	1.3	1.3	
1361 - tons	19.040	0.080	0.360	0.260	0.230	20.000
Percentage	95.2	0.4	1.8	1.3	1.3	100.0

(1) Consumption 1350 : Chemicals Fertilizers Distribution ® (See Appendix VI)
Consumption 1361 : Estimated For detailed methods See Appendix I and VIII

Table [illegible]

UREA AND DI-AMMONIUM PHOSPHATE DEMAND BY PROVINCES (1) - 1361

	Urea		Di-Ammonium Phosphate	
	1,000 Tons	%	1,000 Tons	%
North, North West & Central Ostan				
Gilan	27.0	5.4	26.5	3.6
Mazandaran - Gorgan	7[illegible].5	15.3	[illegible]7.0	15.[illegible]
West Azerbejan	[illegible]	5.8	47.[illegible]	6.[illegible]
East Azerbejan	[illegible]	[illegible].4	6[illegible].[illegible]	[illegible].0
Zanjan	6.0	1.2	1[illegible].3	1.[illegible]
Central Ostan	[illegible]3.0	1[illegible].6	81.5	11.1
Semnan	1.[illegible]	0.[illegible]	5.9	0.[illegible]
Sub - Total	[illegible]37.5	47.5	33[illegible].2	45.6
North East Region				
Khorasan	61.0	12.2	[illegible].2	1[illegible].0
Sub - Total	61.0	1[illegible].2	[illegible]	1[illegible].0
West Region				
Kurdestan	3.0	0.6	5.1	0.7
Kermanshah	16.0	3.2	24.2	3.3
Hamadan	8.5	1.7	16.2	[illegible].2
Ilam	1.0	0.2	1.[illegible]	0.2
Lorestan	7.5	1.[illegible]	10.5	1.4
Sub - Total	36.0	7.2	57.3	7.8
Central Region				
Esfahan	24.0	4.8	36.0	4.9
Yazd	1.5	0.3	2.9	0.4
Chahar Mahl	4.0	0.8	5.9	0.8
Sub - Total	2[illegible].5	5.9	44.8	6.1
South & South East				
Khosestan	41.0	8.2	66.[illegible]	9.0
Fars	4[illegible].0	[illegible].0	56.6	7.7
Kerman	30.5	6.1	48.5	6.6
Kohkeloeh	5.0	1.0	6.6	0.9
Coastal - Persian Gulf	7.0	1.4	11.0	1.5
Sestan - Bulushistan	12.5	2.5	20.6	2.8
Sub - Total	13[illegible].0	27.[illegible]	[illegible]09.5	[illegible].5
Grand Total	50[illegible].0	100.0	735.0	100.0

(1) For details see Appendix I and VIII

4.00 Technical Aspects of Production

4.10 Urea

4.11 Ammonia is a gas that must be handled in pressure vessels which are costly and cumbersome. The ammonia is, therefore, converted into urea, di-ammonium phosphate (DAP), ammonium nitrate and ammonium sulfate for ease in handling, distribution and application. A relatively new technique of applying gaseous ammonia directly to the soil or to irrigation waters has some important advantages that will recommend the direct use of ammonia in the future.

4.12 In US in 1970, 3,491,000 s. tons of anhydrous ammonia were used in agriculture out of a total of 11,751,000 s. tons of nitrogenous fertilisers, i.e. 30% of the total (Chemical Economics Handbook, Stanford Research Institute, February 1971).

4.13 A major advantage in the direct use of anhydrous ammonia as a fertiliser is that on irrigated land, which is the chief agronomic base in Iran, it can be applied in the irrigation water and the consumption of the ammonia by the growing crops leaves no undesirable salt residues to build up in the soil and reduce its fertility or render it sterile. However, the direct use of ammonia as a fertiliser in Iran must wait on the development of a complex of transportation, strategically located pressure storage depots and application facilities and equipment.

Even though ammonia as such is expected to gain a significant place for itself in agriculture - it is expected to reach, perhaps 20,000 to 25,000 m. tons in 1980 - the basic work-horse of nitrogenous fertilizer is, and will continue to be urea. Urea contains a high proportion of nitrogen (46% N), is safe and easy to handle, is cheap to produce in large quantities, and is almost universal in its applicability to all agricultural needs. Also, it compounds well in mixed or NPK fertilizers. At present urea constitutes 40% of total fertilizer nutrients and 68% of N-nutrients.

4.20 Ammonium Sulfate

4.21 This is one of the oldest of the nitrogenous fertilizers and has lost place to urea because it contains slightly less than one half of the nitrogen value of urea (21%N), and it leaves a residue of sulfuric acid in the soil. The latter may be desirable for a time in strongly alkaline soils, but is undesirable in the long run, especially in irrigated soils, because it tends to build up possibly sterilizing salts in the soil.

4.22 Essentially all of the ammonium sulfate initially produced up to 1356 will be as a by-product in the coking of coal for steel production. As a by-product, the production will become a function of steel production and bears no relation to the agricultural demand for this material.

4.23 Plans are being developed for a plant to produce 35,000 m. tons/ann. of caprolactam. This operation will require 50,000 to 70,000 m. tons ammonia (the amount depending on the process selected) as raw material feed and will yield a by-product of approximately 4.0 to 4.5 m. tons of ammonium sulfate per ton of caprolactam produced, i.e. roughly around 150,000 m. tons of ammonium sulfate per year. All of this by-product will become available for use in agriculture, there being no large scale competitive uses to utilize this material. Preferably the use of ammonium sulfate as a fertilizer should be channelled to semidesert alkaline soils where its acidic quality can be used advantageously.

4.24 It is important to observe that except for about 20% of the input ammonia which remains as a component part of the caprolactam primary product -, all the ammonia that appears as ammonium sulfate is, in fact, introduced as ammonia. From an input-output point of view, none of this ammonium sulfate represents any new addition to the total supply of nitrogenous fertilizer, except in so far as it may be viewed as "industrial ammonia" being diverted to "agricultural ammonia".

4.25 Currently NPC is studying a scheme to produce approximately 150,000 mta of ammonium sulfate from ammonium carbonate and by-product gypsum.

4.30 <u>Ammonium Nitrate</u>:

4.31 This has been a valuable nitrogenous fertilizer from the early days when nitrogen fixation processes yielded nitric acid. Its high Nitrogen content (35% N) and its good agronomic characteristics are counterbalanced by its explosive, corrosive, and hygroscopic properties. By mixing it with ground limestone, a product containing only 26% N, is produced. It is called calcium ammonium nitrate and is freed from most of its handling problems. Nevertheless, it has no real advantages over urea and some disadvantages and it has steadily lost favour in competition with urea. The output of ammonium nitrate in Iran is fixed by the size of a nitric acid plant by oxidation of ammonia at Marv Dasht and temporarily by an inadequate supply of ammonia. That facility can produce about 40,000 m. tons of calcium ammonium nitrate fertilizer. In recent years, however, with the major shift in mining explosives away from dynamite to the much safer and cheaper ammonium nitrate, the output of this fixed facility could shift away from fertilizer use to explosives. No accurate estimates exist on the projected demands for explosives, but the trend would seem to indicate that by 1982, the explosives market will have pre-empted the entire output for ammonium nitrate. No plans exist at present for enlarging the facilities to produce ammonium nitrate. There appears, however, to be no agricultural need for ammonium nitrate that cannot be met satisfactorily by the use of urea.

4.40 Diammonium Phosphate (DAP) (NH_4) 2 H. PO_4

4.41 This is a modern fertilizer of preference, especially for mixed NPK fertilizers. It is readily prepared by partially neutralyzing wet-process phosphoric acid with ammonia. Theoretically, DAP should contain 21.2% N and 53.5% P_2O_5, but actually because of impurities in the wet-process acid and the presence of some mono ammonium phosphate $NH_4H_2PO_4$, it has a composition approximating 18% N and 46% P_2O_5. At present all phosphoric acid production is centered at Bandar Shahpur with a capacity of 132,000 m. tons/a of contained P_2O_5 of which approximately 50,000 m. tons/a of P_2O_5 is being consumed in the production of either 100,000 mt/a of DAP or 143,000 mt/a of Triple super-phosphate (TSP). - or a combination of the two. The balance of the phosphoric acid production is available for export and subsequent growth in domestic fertilizer demand.

4.42 Future plans for fertilizer production in Iran will emphasize the production of DAP at the expense of TSP, since it is desired to simplify the entire production processes so that the fewest number of fertilizer products will meet the total demand. Essentially such a plan reduces all fertilizer production to urea and DAP. This may not be entirely wise, since the application of TSP to n: rogen-fixing forage crops would be more economical than applying DAP containing the unneeded 18% N.

4.50 Other Phosphate Fertilizers

4.51 M.A.P. : - Mono-ammonium phosphate has a higher ratio of phosphoric acid to ammonia than DAP, and is therefore preferred where nitrogen nutrient is not necessary or desirable.

4.52 Triple Super Phosphate (TSP) : - This is a desirable fertilizer for use in : -
Mixed NPK fertilizers
Forage crops, e.g. alfalfa (lucerne) and clover, and leguminous crops, where natural nitrogen fixation makes the application of the nitrogenous component unnecessary.

4.60 Potassium Fertilizers

4.61 Most of the arable soils in Iran contain adequate levels of potassium. However, as these soils are worked, crops will consume much of this potassium, and in order to maintain proper levels of soil fertility, potassium-containing fertilizers will be needed, usually in the form of NPK dressings.

4.62 Since no potassium minerals rich enough for commercial production of potassium chloride or sulfate exist in Iran, all of this component must be imported, and domestic production of potassium chloride or sulfate is not envisaged.

4.70 Mixed Fertilizers

4.71 Since most soils need both nitrogen and phosphorous for maximum productivity, and since the desired ratios of nitrogen to P_2O_5 is seldom 18:46 as provided by DAP, the method most advantageous and economical of labor is to compound fertilizer mixtures to meet specific requirements and apply the mixture in a single application. At present, no mixing facility to produce NPK exists in Iran, all NPK mixtures being imported.

4.72 Because of application economies to the farmer and the nicety with which fertilizer compositions can be tailored to the needs of specific crops on lands of specific fertility levels, the consumption of NPK mixtures will grow vigorously. However, in Iran, satisfying this need must wait on the development of suitable mixing and distribution facilities. A first such facility is now under construction at Shiraz (Marv Dasht) and should be operational by late 1973 to produce:

30,000 mta	20 : 20 : 0 and
20,000 mta	15 : 15 :10

In mixed fertilizers the numbers refer to the proportion of N : P_2O_5 : K_2O nutrients in alphabetical order.

4.73 No plans for additional NPK facilities have yet been indicated.

5.00 Existing and Planned Production Capacities

5.01 The planned production figures of fertilizers are subject to continual revision, and the latest available figures are those contained in a paper presented in May 1973 at the first Iranian congress of chemical engineers.

5.02 These figures show that in addition to expansions up to 1356, at Bandar Shahpour previously made known, a new urea plant having a capacity of 330,000 tons per annum, and a mono-ammonium phosphate plant of 200,000 tons capacity is scheduled to be built by 1356, and these capacities are supported by the necessary sulphuric acid, phosphoric acid and ammonia plants.

5.03 The total urea planned production capacity due for completion by 1356 exceeds the forecast domestic requirements for 1361, and therefore a margin for export will exist.

5.04 The planned DAP and MAP production up to 1356, will be insufficient to meet the projected internal demand by 1361, and in this case, no further plants are reported to be planned.

5.05 Table 6, brings together the planned increases in capacity, and indicates that with the plant developments set out in the technical paper referred to, there should not be any shortage of urea in the next decade, but additional phosphatic fertilizer capacity will probably be required.

5.06 Existing production problems should prove to be a temporary restraint.

Table 6

Planned Production Capacity - All Fertilisers

Urea Production Capacity (in thousand tons)

	1351 Plants on Stream	1351 - 56 Additional Expansion	1351 - 56 New Plants	1356 Total Capacity
Bandar Shahpour	164*	76	310	550
Marv Dasht	50	20	-	70
	214	96	310	620
Equivalent Ammonia (.58)	124	56	180	360

*Actual Production was 86,000 tons in 1351

DAP Production Capacity

	1351 Plants on Stream	1351 - 56 Additional Expansion	1351 - 56 New Plants	1356 Total Capacity
Bandar Shahpour	160	120	-	280
Marv Dasht	-	17	-	17
	160	137	-	297
Equivalent Ammonia (.27)	43	37	-	80
Equivalent 54% P_2O_5 (.74)	118	102	-	220

Table 6 (Continued)

Planned Production Capacity - All Fertilizers

	1351 Plants on Stream	1351 - 1356 Addi-tional Ex-pansion	New Plants	1356 Total Capa-city
MAP Production Capacity				
Bandar Shahpour	-	-	200	200
Equivalent Ammonia (.14)	-	-	28	28
Equivalent 54% P_2O_5 (.86)			172	172
Ammonium Nitrate Capacity				
Marv Dasht (Fertilizer)	18	22	-	40
(Explosives) (1)	-	-	?	?
Equivalent Ammonia	9	11	-	20
Sodium Tripoly Phosphate Capacity (Detergent) (2)				
Marv Dasht	-	-	30?	30?
Equivalent 54% P_2O_5	-	-	24?	24?
Ammonium Sulphate Capacity				
From Coking (3)	5	5	10	20
From Caprolactum Plant (4)	-	-	150	150
	5	10	170	170

Notes

(1) Ammonium nitrate requirements for explosives is not known.

(2) The detergent market is not known.

(3) Ammonium sulphate from coking figures are approximate.

(4) The caprolactum plant is not a firm project.

Table 6 (Continued)

Planned Production Capacity - All Fertilizers

	1351 Plants on Stream	1351 - 1356 Additional Expansion	1351 - 1356 New Plants	1356 Total Capacity
Ammonia and P_2O_5 Required To Supply Plants Listed				
Total Ammonia Required	176	109	208	488
Total 54%. P_2O_5 Required	118	102	172	392
Ammonia and 54% P_2O_5 Capacity Projected to be Installed				
Ammonia	339	-	330	669
Phosphoric Acid (54% P_2O_5)	290	-	290	580

6.00 Economics of Production and Site Location

6.01 There are three main variables contributing to the total cost of fertilizers.

(i) The source and cost of raw materials at the plant

(ii) The capital investment

(iii) The cost of delivering the finished products to port or to farms

6.02 A fourth important variable is the size of the plants, particularly the ammonia plant, which are assumed in the initial calculations, with justification, to be adequate in all cases to achieve economies of scale.

6.03 The first step is to ensure that factors other than those enumerated, may be disregarded, either because they contribute little to the cost or because no sensible difference as between one location or another would be likely.

6.04 In a Research Centre report dated November 1968, both capital costs and production costs were estimated, and these have been up-dated to provide a more realistic cost analysis. Table 7, brings together all the costs of urea production and Table 8, breaks down the cost of DAP.

In the up-dated figures, the price of gas is assumed to be 20 Rials per 1000 cu.ft., Sulphur at $28.00 per ton and phosphate rock at $14.56 per ton. The percentage increases in all other items have been checked, as far as possible but the capital cost of plant, which is the most important single factor, can only be approximately assessed at 80%.

TABLE 7

APPROXIMATE ANALYSIS OF THE COST OF UREA
RESEARCH CENTRE REPORT
1969

		Per Ton of Ammonia	.58 Ton of Amm.	Additional Cost Per Ton of Urea	Total Cost Per Ton of Urea	%	Adjustments to 1973 Rates	Adjusted Total Cost Per Ton	%
1.	Raw Material	8.10	4.70		4.70	10.28		4.70	6.32
2.	Water	.20	.12	.06	.18	.39	+ 15%	.21	.28
3.	Steam	-	-	1.44	1.44	3.15	+ 30%	1.87	2.51
4.	Power-Electric	.85	.49	.85	1.34	2.93	+ 15%	1.54	2.07
5.	Labour	1.16	.67	.62	1.29	2.82	+ 30%	1.68	2.26
6.	Maintenance	3.11	1.80	2.22	4.02	8.79	+ 50%	6.03	9.18
7.	Supervision	.47	.27	.33	.60	1.31	+ 30%	.78	1.05
		13.89	8.05	5.52	13.57	29.67		17.61	23.67
8.	Transport	-	-	-	-	-		-	-
9.	Factory Overhead	1.90	1.10	1.15	2.25	4.92	+ 30%	2.93	3.94
10.	Depreciation	11.54	6.69	7.90	14.59	31.90	+ 80%	26.26	35.25
11.	Interest	10.73	6.22	9.11	15.33	33.52	+ 80%	27.59	37.09
12.	Total	38.06	22.06	23.68	45.74	100.01		74.39	99.95
			45.74						

TABLE 8

APPROXIMATE ANALYSIS OF THE COST OF DAP - RESEARCH CENTRE REPORT

1968

	Per Ton of 100% Phosphoric Acid $	.87 Ton of 54% P_2O_5 $	Additional Cost for .23 Ton of Amm. $	Additional Cost Per Ton of DAP $	Total Cost Per Ton $	%	Adjustments to 1973 Rates	Adjusted Total Cost Per Ton $	%
1. Raw Material	91.20	42.85	1.86	-	44.71	46.27	- $7.05	37.66	39.65
2. Water	.35	.16	.05	-	.21	.22	+ 15%	.24	.25
3. Steam	-	-	-	.10	.10	.10	+ 30%	.13	.14
4. Power	2.45	1.15	.20	.19	1.54	1.59	+ 15%	2.00	2.11
5. Labour	3.70	1.74	.27	.44	2.45	2.54	+ 30%	3.19	3.36
6. Maintenance	4.22	1.98	.72	.49	3.19	3.30	+ 70%	5.42	5.71
7. Supervision	.88	.41	.11	.40	.92	.95	+ 30%	1.20	1.26
	102.80	48.29	3.21	1.62	53.12	54.97		49.84	52.48
8. Transport	-	17.40	-	-	17.40	18.00		-	-
9. Factory	4.96	2.33	.44	.96	3.73	3.86	+ 30%	4.85	5.11
10. Depreciation	10.34	4.86	2.65	2.00	9.51	9.84	+ 80%	17.12	18.01
11. Interest	10.77	5.06	2.47	5.35	12.88	13.33	+ 80%	23.18	24.40
Total	128.87	77.94	8.77	9.93	96.64	100.00		94.99	100.00
		96.64 (sum of the three preceding columns)							
Per Ton of 54% P_2O_5	69.59								

6.05 In the case of urea, the most important variable is that resulting from the capital investment, - depreciation and interest, accounting for 72% of the factory cost. Raw material, in this case cleaned natural gas, represents only 6% of the factory cost and maintenance at 9% is not likely to vary as between one location and another, and all other items, provide a relatively small percentage contribution to the total cost.

6.06 DAP, provides a different analysis in that the cost of raw material is a most important variable, accounting for 40% of the total cost, while depreciation and interest together account for 42%.

6.07 The relative importance of plant location on fertiliser distribution costs within Iran may be gauged from the fact that current distribution costs from Bandar Shahpour average $14.85 per ton, or about 16% of the total plant operating cost for DAP, and 20% of the plant operating cost of urea.

6.08 Having assessed the relative importance of the cost components, the next step is to analyse the distribution of fertiliser demand as a basis for establishing possible plant locations, and then evaluate the relative cost of raw materials at the plant locations and the area fertiliser distribution costs.

6.09 It is clear, that in addition to the planned expansion of the existing plants at Bandar Shahpour, complete new plants will need to be constructed. The question is at what location.

6.10 The Distribution of Demand

6.11 A visual inspection of the distribution of projected demand in 1361 shown in Table 5 is sufficient to indicate that there are three main areas of demand, the north-west, the north-east and the south-east.

6.12 The approximate centre of distribution for the whole country is obtained by calculating the average transport distance per ton for each geographical area, from two axes at right angles to each other.

$$\bar{x} = \sum_{1}^{n} \frac{tx}{T} \quad \text{and} \quad \bar{y} = \sum_{1}^{n} \frac{ty}{T}$$

Where n = number of geographical areas.

x and y = the distance of the centre of each area.

t = the tonnage demand in each geographical area.

T = total tonnage demand within the area under consideration.

6.13 In this calculation the total demand for each state was assumed to be concentrated at the main city of each province, and for convenience the percentage tonnages were used rather than tonnages.

6.14 Similar calculations were made for the north-western area alone, comprising Gilan, Mazandaran, Gorgan, West Azerbaijan, East Azerbaijan, Zanjan, Central Ostan and Semnan. A third calculation was made for the north-eastern area comprising Khorassan, Mazandaran, Gorgan and Semnan.

The results of these calculations are given below:-

Area	Approximate Centre of Distribution
Iran (Total)	Kashan
N.W. Area	East of Rasht
N.E. Area	Esferain

6.20 The Calculation of Distribution Costs

6.21 Bandar Shahpour is already established as a fertiliser production centre from which the products are transported by road and rail to all areas of demand throughout Iran. The Fertiliser Distribution Company state that the average cost of transport by road and rail is $14.85 per ton and the average distance transported is 1225 km.

6.22 The calculated distance of the centre of distribution for the whole of Iran is approximately 600 km. from Bandar Shahpour, on a straight line. The ratio 600 : 1225 :: 1 : 2.04 is a measure of the circuitous road and rail connections imposed by the terrain.

6.23 Rasht and alternatively Ghasvin were tentatively selected as being suitable locations for the first new fertilizer plant outside Bandar Shahpour to serve the north-western area comprising Gilan, Mazandaran, Gorgan, West Azerbaijan, East Azerbaijan, Zanjan, Central Ostan and Semnan. The mean transport distance from Rasht was calculated to be 306 km. away in a straight line, or 624 km. actual road/rail mileage.

6.24 Here it has been assumed that the ratio of 1 : 2.04 derived for all deliveries throughout Iran is also applicable to particular areas. This is an approximation which could be refined by a detailed study of road and rail distances within each area.

6.25 The supply of fertilisers to the north-west from a plant located at Rasht or Ghasvin, reduces the distribution area from Bandar Shahpour and consequently the average transport distance and cost. This is indicated in Table 9.

6.26 Another plant, if located in the Mashad area, would further reduce the average transport distance and cost, of fertilizers distributed from Bandar Shahpour. Table 9 refers.

6.27 It is envisaged that development will take place in three phases. In Phase I, it is envisaged that the existing and planned extensions at Bandar Shahpour will be complete and fully operational.

6.28 Phase II considers the options of establishing a new plant at Bandar Shahpour, Ghasvin or Rasht and the effect of distribution costs is analysed. The alternatives of installing a urea plant and a DAP plant using phosphate rock from U.S.S.R., and a urea plant only if U.S.S.R. rock should prove not to be available, are considered.

TABLE 9

DISTRIBUTION COSTS AND DISTANCES FOR EXISTING AND PLANNED EXTENSIONS AT BANDAR SHAHPOUR - IN 1000 TONS

	Production	Available for Export	Average Transport Distance	Distribution Cost Per Ton $	Distribution Area from Bandar Shahpour
Urea	310	-	1225	14.85	Iran
DAP	300				
With a plant operating in the North-West (Rasht or Gaavin)			1060	12.84	North-East, West Central and South East
With one plant operating in the North-West, and one in the North-East (Mashad)			450	5.46	West, Central South and South-West

TABLE 10

DISTRIBUTION COST AND DISTANCES FOR POSSIBLE NEW PLANTS - PHASE II

	Production 1000 Tons	Available for Export 1000 Tons	Average Transport Distance Km.	Distribution Cost Per Ton Km. $	Distribution Area
(i) New Urea and DAP Plants					
Bandar Shahpour					
Urea	300	100(i)	1225	14.85	Iran
DAP	250	-			
Rasht					
Urea	300	100(i)	624	7.56	North, N. W. & Central Ostan
DAP	250	-			
Ghazvin					
Urea	300	100(i)	570	6.91	North, N. W. & Central Ostan
DAP	250	-			
(ii) New Urea Plant Only - In 1000 tons					
Rasht	400	200(ii)	624	7.56	North, N. W. & Central Ostan
	400	200(iii)	940	11.40	North, N. W. & Central Ostan N. E. and West & Central Region
Ghazvin	400	200(ii)	570	6.91	North, N. W and Central Ostan
	400	200(iii)	908	11.01	North, N. W. and Central Ostand N. E. and West and Central Region

(i) Export must be made about equally both from Bandar Pahlavi to USSR and through Bandar Shahpour

(ii) If 150 tons exported through Bandar Pahlavi and 50 tons through Bandar Shahpour.

(iii) If 200 tons exported through Bandar Shahpour.

6.29 Phase III presumes that, Phase II has been implemented, either with a 400,000 ton urea plant, or with a 300,000 ton urea plant and 250,000 ton DAP plant in the north. The Iranian projected demand for DAP in 1361 at 735,000 tons is still sufficient to support a DAP unit of 250,000 tons in the north-eastern area, but further urea production, would have to be exported. Exports would be made through Bandar Pahlavi and Bandar Shahpour.

TABLE 11

DISTRIBUTION COST AND DISTANCES FOR POSSIBLE NEW PLANT

PHASE III

	Production 1000 Tons	Available for Export 1000 Tons	Average Transport Distance km.	Distribution Cost Per Ton $	Distribution Area
Mashad					
Urea	300	400	450	5.46	Khorassan, Masandaran, Gorgan Semnan
DAP	250				

* Export must be made in approximately equal quantities through Bandar Pahlavi and Bandar Shahpour.

6.30 **Transport Economy of the 42" Northern Pipeline-Capital and Operating Charges**

6.31 Construction of the 42" pipeline to the north was completed in October 1970, a distance of 1100 km, at a cost of $700,000,000 approximately, having a capacity of 1,000,000,000 cubic feet per day. It is planned to install further compressors to boost the throughput to 1,600,000,000 cubic feet per day, and this will entail additional capital cost and additional maintenance costs. An average load factor of .8 is assumed over the life of the pipe, which is assumed to be 20 years, and calculations are based on the original capacity of 1,000,000,000 cubic feet per day.

6.32 The pipeline construction was financed with the aid of several low interest foreign loans, and an interest rate of 5% is assumed

Interest per annum (5%)......	$35,000,000
Depreciation (5%)............	$35,000,000
	$70,000,000
+ 2% Metering Losses.......	$ 3,000,000
	$73,000,000

6.33 In the absence of information on actual operational costs being experienced, it is assumed, based on figures in the USA, that capital charges represent 75% of the total operating cost, operation and maintenance 22.5%, and power 2.5%. On this basis the cost of operation, maintenance, and power may be estimated at $23,000,000.

Capital Charges	$70,000,000
Metering Losses	$ 3,000,000
Op. Maintenance Power	$23,000,000
	$96,000,000

6.34 <u>Total Cost per 1000 cu. ft. of Gas Delivered</u>

Pipeline Capacity 1,000,000,000 cu. ft. per day

Load Factor .8

$$\frac{96,000,000 \times 100}{1,000,000 \times 365 \times .8} = 33 \text{ cents per thousand cubic feet}$$

This figure may be reduced to approximately 25 cents per thousand cu. ft., when the pipeline capacity is boosted to 1.6 billion cu. ft. per day.

6.35 Both operating and capital costs are proportionate to distance and approximately the cost of transporting gas to Rasht and Ghasvin are as follows:

		Current	After Boosting
Ahwas to Russian Border	1100 Km.	33 cents	25 cents
Ahwas to Rasht	950 Km.	28.5 cents	21.5 cents
Ahwas to Ghasvin	800 Km.	24 cents	18 cents

6.36 It is useful to compare these rough estimated costs with the charges being made by the Iranian National Gas Company for gas for industrial purposes. These are policy prices which do not reflect the real costs involved in transporting the gas. However, the estimated total operating costs are broadly in relation to the normal industrial tariffs, and the estimates establish a reasonable differential in costs as between Bandar Shahpour, Ghasvin and Rasht.

6.37 Special prices, for example, the price being paid by Russia (about 20 cents per 1000 cu. ft.), or the price being charged to the fertilizer company at Bandar Shahpour (reported to be about 2 cents per 1000 cu. ft.), can have no bearing on the real differential in cost as between Ahwaz, Ghazvin and Rasht.

6.38 The published industrial rates for gas supplied by the Iranian National Gas Company, based on $1 = 67.5 Rials, are reproduced below:

Monthly Consumption in Cu. Ft.	Tehran* Zone	General** Zone	Khuzestan***
	(Cents Per 1000 Cu. Ft.)		
From 0 - 706,400	50.3	46.1	33.5
From 706,435 - 7,064,000	46.1	41.9	29.4
From 7,064,350 - 70,643,500	41.9	37.7	25.2
From 70,643,500 and up	37.7	33.5	25.2

* Teheran zone includes areas supplied by Teheran City Gate Station

** General zone includes all areas in Iran other than Teheran and Khusestan zones

*** Khusestan zone includes areas in which fuel oil is sold at Rials 750 per cubic meter.

6.40 <u>The Calculation of the Cost of Transport of Materials</u>

6.41 The materials required to produce 300,000 tons of urea are:-

6,003,000 Thousand cu. ft. of Gas → 174,000 tons Ammonia
+
231,000 tons Carbon Dioxide
→ 300,000 tons Urea

6.42 The materials required to produce 250,000 tons of DAP per annum are:-

470,000 tons Phosphate Rock →
105,750 Sulphur →
→ 217,500 tons phosphoric acid (54%)

1,984,750 thousand cu. ft. natural gas → 57,500 tons Ammonia

→ 250,000 tons DAP

6.43 The estimated basic rates for the transport of gas are set out in the section entitled - "Transport Economy of the 42" northern pipeline". Rail freight for sulphur and phosphate rock has been taken as 1.40 Rials per kilometre - mile, and the same products by road at 1.33 Rials per kilometre - mile. The transport of phosphoric acid by special rail tanker has been estimated at 2.1 Rials per kilometre - mile based on the railway freight rate of 1.6 Rials for kerosene by tanker and 1.8 for ammonia in containers. Road transport of phosphoric acid has been taken as 50% above the cost of transporting solids that is 2.0 Rials per ton.

6.44 These material transport rates and the gas transport rates set out in Paragraph 6.34 have been used to prepare Tables 12 and 13, to give total transport costs, and calculated from this, the transport cost of raw materials per ton of urea and per ton of DAP produced.

TABLE 12

Cost of Transporting Materials for 250,000 Tons Urea Production

	Quantity	Average Distance km.	Unit Cost $	Total Transport Cost $ Million	Cost Per Ton of Urea $
Bandar Shahpur					
Gas	6,003,000 thousand cu. ft.	0	0	0	0
Rasht					
Gas	6,003,000 thousand cu. ft.	950	28.5	1.711	6.84
Ghazvin					
Gas	6,003,000 thousand cu. ft.	800	24.0	1.441	5.76
Mashad					
Gas	6,003,000 thousand cu. ft.	125	6.75*	.405	1.62

* Unit cost for gas transport by a 16" pipeline has been estimated from the figures for the 42" pipeline.

TABLE 13

Cost of Transporting Materials for 250,000 Tons DAP Production

	Quantity	Average Distance km.	Unit Cost $	Total Cost of Transport $ Mill.	Cost Per Ton of DAP $
Bandar Shahpour					
Phosphate Rock	470,000 T	0	0	0	0
Sulphur	105,750 T	0	0	0	0
Gas	1,904,750 thousand cu. ft.	0	0	0	0
Rasht					
USSR Phosphate Rock	470,000 T	0	0	0	0
Sulphur (B.S.)	105,750 T	1213 road	16.13	1.706	6.82
Gas	1,904,750 thousand cu. ft.	990 pipe	.298	.566	2.26
Alternative					
B.S. Phosphate Rock	470,000 T	1213 road	16.13	7.581	30.32
Alternative					
B.S. Phosphoric Acid	217,500 T	1213 road	24.26	5.277	21.11

TABLE 13 Continued

Cost of Transporting Materials for 250,000 Tons DAP Production

	Quantity	Average Distance km.	Unit Cost $	Total Transport Cost $ Mill.	Cost Per Ton of DAP $
Qhazvin					
B.S. Phosphate Rock	470,000 T	1250 rail	17.50	8.225	32.90
Sulphur (B.S.)	105,750 T	1250 rail	17.50	1.851	7.40
Gas	1,904,750 thousand cu. ft.	800 pipe	24	.476	1.90
Alternative					
B.S. Phosphoric Acid	217,500 T	1250 rail	26.25	5.709	22.84
Alternative					
USSR Phosphoric Rock	470,000 T	193 road	2.57	1.208	4.83
Mashad					
USSR Phosphoric rock	470,000 T	520 road	6.92	3.252	13.01
Sulphur (B.S.)	105,750 T	125 road	1.66	.176	.70
Gas	1,904,750 thousand cu. ft.	125 pipe	.675	.134	.54

6.50 Summary of Production and Transport Costs

6.51 It is assumed that the operating costs at any location would not be very different, except for the three main variables which have now been analysed. For clarity these variables are repeated below.

(i) The source and cost of raw materials at the plant.

(ii) The capital investment.

(iii) The cost of delivering the finished products to port or to farms.

In Table 14, the comparative costs of urea at Bandar Shahpour, Ghazvin, Rasht and Mashad are brought together, and in Table 15 the DAP costs are shown, but these do not make allowance for charges on the increased capital investment in northern plants due to the cost of transporting the plant and equipment from Bandar Shahpour. If these are assumed to be 5% of the value of the plant this is equivalent to $2.70 per ton on the cost of urea and $2.02 per ton on the cost of DAP.

TABLE 14

Urea - Comparative Costs Per Ton

	Bandar Shahpour $	Ghazvin (Phase II) $	Rasht (Phase II) $	Mashad (Phase III) $
Works Cost	74.39	74.39	74.39	74.39
Gas Transport	-	5.76	6.84	1.62
Distribution Cost (Urea & DAP)	14.85	6.91	7.56	-
Distribution Cost (Urea Only with export to USSR & through Bandar Shahpour	-	6.91	7.56	5.46
Distribution Cost (Urea Only with exports only through Bandar Shahpour)	-	(11.01)	(11.40)	-
	89.24	87.06	88.79	81.47

Savings in distribution cost ex-Bandar Shahpour due to Rasht or Ghazvin - $2.01

TABLE 15

DAP - Comparative Costs Per Ton

		P H A S E I I				Phase III
	Bandar Shahpour	Ghaz-vin	Ghaz-vin	Rasht	Rasht	Mashad
	(2) $	(1) $	(2) $	(1) $	(2) $	(1) $
Works Cost	94.99	94.99	94.99	94.99	94.99	94.99
Gas Transport	-	1.90	1.90	2.26	2.26	.54
Sulphur Transport (B.S.)	-	7.40	7.40	6.82	6.82	.70
Phosphoric Acid Transport	-	-	21.11	-	22.84	-
Phosphate Rock Transport	-	4.83	-	-	30.32	13.01
Distribution Cost (Urea and DAP)	14.85	6.91	6.91	7.56	7.56	5.46
Distribution Cost (Urea Only) with exports to USSR and through Bandar Shahpour	-	6.91	6.91	7.56	7.56	5.46
Distribution Cost (Urea Only) with exports through Bandar Shahpour Only	-	(11.01)	(11.01)	(11.40)	(11.40)	
	109.84	116.03	133.31	111.63	134.47	114.70

Distribution Savings due to Rasht or Ghazvin -$2.01 (from Bandar Shahpour)

Distribution Savings due to Mashad and Rasht/Ghazvin -$9.39 (from Bandar Shahpour)

(1) Figures based on phosphate rock imported through Bandar Shahpour.

(2) Figures based on phosphate rock imported through Bandar Pahlavi.

6.60 The North-Western Area

6.61 The centre of distribution of the north-western area has been shown to be to the east of Rasht, and Rasht with the adjacent port of Bandar Pahlavi is therefore a possible location to be considered. Further it is on the route of the 42" northern pipeline.

6.62 An alternative location for consideration is at Ghazvin, because it is at the termination of the railway system, and Ghazvin too is on the route of the 42" pipeline.

6.63 In the case of DAP production, in the northwest, the cost of transporting sulphur, and phosphoric acid or phosphate rock from Bandar Shahpour is shown to be prohibitive. On the other hand, if phosphate rock of suitable quality could be imported from the USSR through Bandar Pahlavi, at prices no higher than the rock imported from Florida, USA, through Bandar Shahpour, then DAP production in the north-west becomes a possibility. Preliminary inquiries indicate that a suitable phosphate rock may be available from the USSR.

6.64 Further, provided Iran's excess sulphur production can be exported, through Bandar Shahpour, a further reduction in production cost would ensue from importing the DAP plant's sulphur requirements from the USSR, but this has not been taken into account in estimating the costs.

6.65 Urea production in the north-west would be economic, provided the capacity of the supporting ammonia plant was at least 700 tons per day. If the whole of this ammonia production were to be converted into urea, then a urea capacity of 400,000 ton per annum would be required. This quantity, together with the expanded production in the south, would total approximately 700,000 tons, as compared with the projected demand of 500,000 tons, leaving 200,000 tons for export either from Bandar Shahpour or Bandar Pahlavi.

6.66 This dependency on exports would be reduced if a DAP plant, using phosphate rock from the USSR were to be constructed, in the north-west, having a capacity of 250,000 tons per annum. The expanded capacity at Bandar Shahpour of 297,000 tons is short of the estimated demand for DAP by 438,000 tons per annum. A DAP plant of 250,000 tons capacity requires 58,000 tons of ammonia, equivalent to 100,000 tons of urea, and in this case the urea plant could be designed for 300,000 tons, leaving a reduced national balance of 100,000 tons for export.

6.67 From this it emerges that it would be desirable to have a plant in the Ghazvin or Rasht areas to produce 300,000 tons of urea using gas from the 42" pipeline together with a DAP plant of 250,000 tons capacity using phosphate rock from the USSR. Because Ghazvin is connected to the railway system, it is probably a more suitable location for a urea/DAP complex than Rasht, provided the requisite water supply is available, but should a rail link be made between Ghasvin and Rasht, then Rasht would probably be more advantageous.

6.68 If after a full investigation into the possibility of obtaining phosphate rock from the USSR, the proposal has to be discarded, then a 400,000 ton urea plant located in the Ghasvin area is an economic unit, provided a sustained export to Russia of 150,000 tons per annum of urea is possible, and 50,000 tons through Bandar Shahpour.

6.70 The North-Eastern Area

6.71 The centre of distribution of the north eastern area has been shown to be west of Mashad in the Esferain locality, but the projected quantity of fertilizers required, as compared with the north-western area, is considerably less.

6.72 At a date around 1361, as a third stage after the construction of a fertilizer plant in the north-west, when demand may well exceed the projected demand in 1361, the north-eastern area has some distinct advantages as a venue for a fertilizer plant, even though the factory production cost may be unavoidably higher with a smaller plant.

6.73 A 16" pipeline, 125 km. in length, from the gas field east of Mashad to Mashad, is nearing completion, and compared with Bandar Shahpour, the relatively small additional cost of gas transport is more than off-set by the considerable reduction in the cost of fertilizer distribution. The factory production cost of urea at Mashad could be up to $8.00 a ton more than at Bandar Shahpour and still be an economic proposition. The projected demand for urea in 1361 in Khorassan, Mazandaran, Gorgan and Semnan is 140,000 tons, while the DAP demand is projected at 190,000 tons.

6.74 DAP production using phosphate rock imported from the USSR through Bandar Shah, employing a specially constructed jetty and improved roads to Mashad, is an economic possibility. Assuming the same landed cost for phosphate rock at Bandar Shah as at Bandar Shahpour, and the same cost of natural gas, the production and distribution cost of DAP at Mashad, is a little more expensive than Bandar Shahpour but still ranks as a possibility. It is further assumed that the gas analysis is such that the sulphur required to make sulphuric acid will be available from the gas field.

6.75 There are more unknown factors in the north-eastern area, for example the availability of water in the required quantities at Mashad or to the west of Mashad, but in view of the indicated economies of distribution, and the Government policy of regional development, a detailed feasibility study covering optimum plant size, distribution costs and the possibility of phosphate rock imports from the USSR may well result in the eventual construction of a fertiliser plant in this area.

APPENDICES

APPENDIX I

Method of Estimating Fertilizers Consumption by Provinces, 1361

(a) The estimated nitrogen and phosphate plant nutrients requirements by type of crop (Appendix VIII) were used as the starting point for the calculation of provincial requirements. Distribution by individual provinces was estimated on the basis of their respective share of irrigated crop area for each individual crop in 1356 and this is detailed in Appendix III/2. For certain crops actual figures on crop areas reported by the Ministry of Agriculture in the latter table differ from those of Appendix II which are based on Plan Organisation data. The requirements of plant nutrients N and P_2O_5, for each province as calculated from the individual irrigated crop areas were increased proportionately to cover for the dry crop areas and the non-coverage. Plant nutrients coverage in calculations was 74% of total.

(b) Plant nutrients were then converted to fertilisers products as follows: Limited increase was assumed in the growth of calcium ammonium nitrate and ammonium sulphate. Mixed fertilisers were assumed to have approximately the same share in 1361 as in 1356. Potassium nutrients were estimated at 34,000 tons. After allowing for plant nutrients (N.P_2O_5:K_2O) incorporated into mixed fertilisers, calcium ammonium nitrate and ammonium sulphate, the residual nutrients in terms of N, P_2O_5 and K_2O were converted to urea, di-ammonium phosphate and potassium sulphate.

(c) The total requirements by type of fertiliser products thus derived were distributed by provinces. In the case of calcium ammonium nitrate and ammonium-sulphate, the share of the respective provinces in 1350 were assumed to prevail in 1361. For urea the weighted share of N in 1361 as derived under (a) were used for distribution by provinces. For di-ammonium phosphate, the weighted share of P_2O_5 calculated under (a) were used. For mixed fertilisers and potassium sulphate, the weighted share of both N and P_2O_5 as derived under (a) were used.

APPENDIX II

AREA UNDER CROPS, 1349/50, 1355/56 & 1360/61

(in 1,000 hectares)

Crops	1349/50			1355/56			1360/61 (1)		
	Irrigated	Dry	Total	Irrigated	Dry	Total	Irrigated	Dry	Total
Wheat	1,533	3,650	5,183	1,600	3,000	4,600	1,700	2,800	[illegible]
Barley	286	1,000	1,286	307	800	1,107	330	770	[illegible]
Rice	392	-	392	392	-	392	392	-	[illegible]
Other Cereals	21	7	28	77	10	87	90	5	[illegible]
Pulses	108	54	162	126	55	181	150	30	[illegible]
Alfalfa & other fodders	230	130	363	390	294	684	440	240	[illegible]
Oil Seeds	26	54	80	80	62	142	90	50	[illegible]
Cotton	231	69	300	250	50	300	270	30	[illegible]
Sugar Beet	154	-	154	175	-	175	200	-	[illegible]
Sugar can	4,5	-	4,5	18,5	-	18,5	40	-	[illegible]
Tobacco	8	6,5	14,5	16	11	2,5	12	7	[illegible]
Watermelons & Persian melon etc.	60	55	115	60	55	115	70	45	115
Tomatoes	9	1	10	11	1	12	13	1	[illegible]
Other vegetables	53,8	7,6	61,4	54,8	8,4	63,2	60	8	[illegible]
Onions	10	2	12	11	2	13	12	-	[illegible]
Potatoes	40	-	40	42	-	42	45	-	[illegible]
Apple	27	-	27	32	-	32	40	-	[illegible]

../..

AREA UNDER CROPS, 1349/50, 1355/56 & 1360/61 **APPENDIX II (Cont'd)**

(Contd.)

(in 1000 hectares)

	1349/50			1355/56			1360/61[(1)]		
	Irrigated	Dry	Total	Irrigated	Dry	Total	Irrigated	Dry	Total
Other fruits	73	7	80	84	18	102	100	30	130
Grapes	50	30	80	54	25	79	65	15	80
Cetrus	27	33	60	35	23	58	40	20	60
Dates	140	-	140	140	-	140	140	-	140
Almonds, pistachios	56	-	56	60	-	60	60	-	60
Tea	10%	20%	30	15%	20%	35	15	20	35
Others	30	72	102	38	100	138	70	80	150
Grand Total	3,582.3	5,190.6	8,772.9	4,067.3	4,534.4	8,601.2	4,400	4,180	8,600

Source: Fifth Five-Year Development Plan of Iran 1352-1356 and Ministry of Agriculture - Planning Bureau.

(1) Estimates based on an additional 400,000 hectares of irrigated land. Distribution among crops based partly on trend in 5th Plan. No change in crop area made for rice, cotton, tea, tobacco, dates and pistachios.

APPENDIX IV

AREAS UNDER MODERN IRRIGATION SYSTEM, 1351, 1356 & 1361

(1000 hectares)

	1351	1356	1361
Azerbaijan	30	125	245
Western Region	4	20	20
Khuzestan	35	146	193
Fars	6	51	61
Kerman - Bandar Abbas	-	26	33
Sistan & Belouchestan	-	52	95
Kermanshah	-	10	25
Sefid Rud	3	183	293
Teheran	11	127	164
Esfahan	1	76	101
Total, (net area)	90	785	1,230
Gross area (including canals, wastage etc.)			1,393

Source: Ministry of Water & Power, Bureau of Planning
Mr. Mobasshiri, Nov, 6, 1972.

APPENDIX V

FERTILIZERS RECOMMENDATIONS
(Fertilizers Programs)

By The Soil Institution of Iran

East Azerbaijan

1. **Wheat**

Maragheh	70 kg urea +		70 kg Triple Super phosphate/Hectare			
Ajabshir	130	"	130	"	"	"
Marand	130	"	130	"	"	"

2. **Sugar Beets**

Miandoab	400	"	200	"	"	"
Maragheh	175	"	200	"	"	"

3. **Potato**

Ajabshir	200	"	200	"	"	"
Tabriz	200	"	200	"	"	"

4. **Grape**

Miandoab	200	"	200	"	"	"

5. **Onion**

East Azerbaijan in general	200	"	200	"	"	"

West Azerbaijan

1. **Wheat**

Rezaieh	100 kg urea +		80 kg Triple Super phosphate/Hectare			
Khoy	120	"	70	"	"	"

2. **Sugar Beets**

W. Azerbaijan	400	"	200	"	"	"

3. **Tobacco**

Rezaieh	45	"	80	"	"	"

4. **Grape**

Rezaieh	200	"	100	"	"	"

APPENDIX V (Cont'd)

Esfahan

1. Wheat						
Esfahan	175 kg urea +	115 kg	Triple	Super	phosphate/hectare	
Shahre Kord and Faridan	130	"	130	"	"	"
Mahyar and Bra-ar	180	"	180	"	"	"
2. Potato						
Esfahan	400	"	250	"	"	"
3. Onion						
Esfahan	300	"	200	"	"	"
4. Sugar Beet						
Esfahan	400	"	100	"	"	"

Khorassan

1. Wheat						
Mashhad	80	",	95	",	"	"
Torbat Heydarieh	80	"	95	"	"	"
Nishaboor	130	"	130	"	"	"
2. Cotton						
Nishaboor	200	"	200	"	"	"
3. Sugar Beet						
Mashhad	200	"	175	"	"	"
Nishaboor	350	"	250	"	"	"
Torbat Heydarieh	200	"	150	"	"	"
4. Water Melon & Melon						
Khorassan	100	"	100	"	"	"
5. Apple						
Mashhad & Nishaboor	100	"	-			

APPENDIX V (Cont'd)

Fars

1.	**Wheat**						
	Shiraz	70 kg urea	+	70 kg Triple	Super	phosphate/hectare	
	Marvdasht	70	"	70	"	"	"
	Kazeroon	105	"	80	"	"	"
	Fasa	130	"	130	"	"	"
2.	**Cotton**						
	Shobasar(Shiraz)	200	"	200	"	"	"
	Kovar "	-		100	"	"	"
	Fasa	100	"	100	"	"	"
	Darab	130	"	130	"	"	"
	Kazeroon	-		80	"	"	"
3.	**Sugar Beet**						
	Shiraz	300	"	300	"	"	"
	Fasa	230	"	230	"	"	"
4.	**Citrus Fruits**						
	Jahroum	130	"	130	"	"	"

Kerman

1.	**Wheat**						
	Bam	130	"	100	"	"	"
	Bardsir	200	"	130	"	"	"
	Kerman	70	"	70	"	"	"
2.	**Sugar Beet**						
	Bardsir	400	"	270	"	"	"
3.	**Citrus Fruits**						
	Bam	300	"	-			
	Jiroft	130	"	130	"	"	"
4.	**Date**						
	Kerman & Bam	300	"	300	"	"	"

APPENDIX V (Cont'd)

5.	**Pistachio**						
	Rafsanjan (young trees less than 20 years)	450 gr urea		+ 450 gr/tree Triple super phosphate			
	trees more than 20 years	650 gr	"	650 gr/tree	"	"	"
6.	**Water Melon & Melon**						
	Jiroft	200	"	-			
7.	**Cucumber**						
	Jiroft	400	"	200 kg Triple Super Phosphate/hectare			
Kermanshah							
1.	**Wheat**						
	Kermanshah	-	"	35	"	"	"
2.	**Potato**						
	Kermanshah	250	"	200	"	"	"
3.	**Sugar Beet**						
	Kermanshah	250	"	250	"	"	"
4.	**Beans**						
	Kermanshah	35	"	180	"	"	"
Gilan							
1.	**Tea**						
	Lahijan	200	"	70	"	"	"
	Lakan	200	"	70	"	"	" + 100 kg potassium sulphate
	Langaroud	200	"	-			
2.	**Jute**						
	Gilan	130	"	-			
3.	**Tobacco**						
	Gilan	45	"	90	"	"	" + 90 kg potassium sulphate

APPENDIX V (Cont'd)

4.	**Rice**						
	Gilan	130	kg urea +	90	kg	Tripple Super	phosphate/hectare
5.	**Orange**						
	Shahsavar	200	"	-			
Gorgan							
1.	**Wheat**						
	Gorgan	70	"	70	"	"	"
	Aliabad	70	"	70	"	"	"
	Kardkoy	130	"	130	"	"	"
2.	**Cotton**						
	Gorgan	100	"	100	"	"	"
3.	**Tobacco**						
	Gorgan	45	'	90	"	"	" + 90 kg K_2SO_4/hect.
Lorestan							
1.	**Wheat**						
	Lorestan	130	"	130	"	"	"
2.	**Soya (oil seed)**						
	Lorestan	35	"	135	"	"	"
Masandaran							
1.	**Wheat**						
	Teartash	70	"	70	"	"	"
	Shahabad	130	"	70	"	"	"
	Behshahr	70	"	70	"	"	"
2.	**Cotton**						
	Masandaran	100-200	"	100	"	"	"
3.	**Rice**						
	Masandaran	200	"	130	"	"	"

APPENDIX V (Cont'd)

4.	**Water Melon & Melon**					
	Mazandaran	100 kg urea + 100 kg Triple Super Phosphate/hectare				
5.	**Jute**					
	Mazandaran	130	"	-		
Central Province						
1.	**Wheat**					
	Tehran	130	"	130	" "	"
	Ghazvin	75	"	20	" "	"
	Garmsar	200	"	130	" "	"
	Varamin	200	"	130	" "	"
	Karadj	130	"	130	" "	"
	Shahriar	130	"	130	" "	"
2.	**Cotton**					
	Garmsar	200	"	200	" "	"
	Varamin	200	"	200	" "	"
3.	**Sugar Beets**					
	Ghazvin	100	"	200	" "	"
	Karadj	400	"	200	" "	"
4.	**Potato**					
	Damavand	200	"	-		
	Ghazvin	240	"	-		
5.	**Grape**					
	Ghazvin	100	"	100	" "	"
6.	**Water Melon & Melon**					
	Central Province	100	"	100	" "	"
Hamadan						
1.	**Potato**					
	Hamadan	100	"	80	" "	"
	Malayer	140	"	140	" "	"

2. **Wheat**

Hamadan	130 kg urea +	130 kg Triple	Super Phosphate/hectare			

Other Agricultural Products

1. **Visor, Sun flower**

Nahavand	200	"	100	"	"	"
Mahabad and other areas	100	"	100	"	"	"

2. **Alfalfa***

All areas	200 kg Ammonium Phosphate/Hectare

3. **Wheat - dry farming**

All areas which have at least 400 mm rainfall	65 kg urea + 65 kg Triple Super Phosphate/hectare.

APPENDIX VI

SALE OF FERTILIZER PRODUCTS BY PROVINCES, 1350 FERTILIZERS DISTRIBUTION CO. 1350

	Months Total	Urea	Ammonium Nitrate	Super Phosphate Triple	Di-Ammonium phosphote	Potassium Sulphate	Sulphate Ammonium	15-15-1	Other Fertilizer	Total
W. Azerbjan	Months	22	5	20	-	2	-	-	-	49
	Total	6927	738	830	2008	6	10	130	11	[illegible]
E. Azerbajan	Months	-12	9	5	-	-	-	1	-	[illegible]
	Total	4792	2547	69	2424	5	11	169	63	[illegible]
Gilan	Months	3	-	-	-	1	313	4	-	[illegible]
	Total	14830	161	11261	2901	28	9714	14	-	[illegible]
Zanjan	Months	22	-	-	200	-	-	-	-	[illegible]
	Total	511	389	80	500	4	2	53	-	[illegible]
Mazandaran	Months	3233	-	5	3210	-	36	7	1	6492
	Total	35803	369	18086	8485	60	1499	187	320	[illegible]
Khorasan	Months	2525	1429	2483	1850	2	11	-	4	[illegible]
	Total	19784	5219	10423	6677	43	52	210	45	[illegible]
Semnan	Months	11	23	-	6	-	5	3	-	58
	Total	1278	597	189	610	87	463	30	-	[illegible]
Central Ostan	Months	176	263	526	21	-	11	25	-	1021
	Total	13462	3817	3931	2779	75	624	1201	26	24915
Kordestan	Months	-	-	-	-	-	-	-	-	-
	Total	344	-	163	159	10	-	-	-	576
Kermanshah	Months	-	-	-10	-	-	-	-	-	-10
	Total	2791	33	257	4876	3	-	10	-	7970
Hamadan	Months	116	-	10	191	-	-	-	-	[illegible]
	Total	2954	1611	742	1634	3	232	46	-	[illegible]
Elam	Months	-	-	-	-	-	-	-	-	-
	Total	283	-	-	332	-	-	-	-	615
Lerestan	Months	-150	-2	-	-	-	-	-	-	[illegible]
	Total	2328	446	245	903	1	-	59	3	[illegible]
Esfahan	Months	168	451	4	735	8	80	13	-	1459
	Total	11429	12478	277	16664	8	170	276	101	41401
Yazd	Months	32	91	-	5	-	-	-	-	118
	Total	854	1387	-	261	-	2	-	-	3504
Chahar Mahal	Months	-	-	-	-	-	-	-	-	-
	Total	1137	101	195	553	-	-	62	16	2064
Khezestan	Months	246	31	17	-19	-	3	5	-	283
	Total	8634	253	1706	2655	6	42	512	44	[illegible]
Boer Ahmad	Months	-	-	-	-	-	-	-	-	-
	Total	406	100	37	523	-	-	-	-	1066
Fars	Months	129	68	44	32	-	-	1	-	274
	Total	6703	825	1033	2356	2	-	40	-	10859
Coastel Gulf	Months	120	2	-	3	-	20	-	11	156
	Total	578	13	-	181	13	30	29	32	875
Kerman	Months	54	11	73	178	-	24	5	-	345
	Total	4319	1425	663	2411	32	100	63	22	9035
Sistan Baluchestan	Months	13	17	1	-	-	-	-	-	31
	Total	219	47	260	30	-	-	-	-	556
Total	Months	6708	2307	3186	6412	13	480	64	16	19283
	Total	137266	32553	50447	88821	306	13961	3076	886	297388

SALE OF FERTILIZER PRODUCTS BY MARKETING OUTLETS-1359

FERTILIZER DISTRIBUTION CO. **APPENDIX VII**

	Months Total	Licensed Dealer	Sales Agents	Special Projects	Co-operatives	Sugar Fact.	Misc.	Total
W. Azerbajan	Months	29	-	-	-	20	-	49
	Total	1,483	636	4,922	869	2,620	100	10,660
E. Azerbajan	Months	18	-	-	-13	-	-	5
	Total	4,457	128	5,465	35	-	-	10,085
Gilan	Months	306	20	-	-	-	-	326
	Total	3,873	236	26,000	-	8,800	-	38,909
Zanjan	Months	-	22	-	200	-	-	222
	Total	-	518	745	211	-	50	1,524
Mazandaran	Months	44	48	6,400	-	-	-	6,492
	Total	9,881	833	50,948	25	1,200	122	63,009
Khorasan	Months	7,275	207	-715	39	1,500	-	8,306
	Total	22,444	2,833	9,317	1,211	6,594	4	42,453
Semnan	Months	-	39	-	19	-	-	58
	Total	-	858	1,872	340	53	31	3,231
Central Ostan	Months	3	395	60	-	-	563	1,021
	Total	1,264	12,414	6,118	1,473	1,930	1,714	21,915
Kordestan	Months	-	-	-	-	-	-	-
	Total	-	30	270	278	-	-	579
Kermanshah	Months	-	-10	-	-	-	-	-10
	Total	-	418	4,019	297	3,293	131	7,970
Hamadan	Months	306	16	-	-	-	-	322
	Total	1,632	1,209	2,184	1,717	480	-	7,222
Ilam	Months	-	-	-	-	-	-	-
	Total	-	-	340	75	-	-	615
Lorestan	Months	-	-2	-130	-	-	-	-132
	Total	30	870	2,738	208	400	12	3,985
Esfahan	Months	1,400	3	-	36	-	-	1,439
	Total	19,536	988	3,808	2,937	14,000	132	41,401
Yazd	Months	-	54	-	64	-	-	118
	Total	-	1,826	18	660	-	-	2,504
Chahar Mahal	Months	-	-	-	-	-	-	-
	Total	118	106	640	200	1,000	-	2,064
Khozestan	Months	488	44	-249	-	-	-	283
	Total	4,491	322	8,006	148	880	258	13,854
Boer Ahmad	Months	-	-	-	-	-	-	-
	Total	-	33	32	-	1,000	-	1,065
Fars	Months	46	198	-	31	-	-	274
	Total	900	2,803	3,428	1,528	2,380	-	10,890
Coastal Gulf	Months	156	-	-	-	-	-	156
	Total	402	38	383	88	-	-	875
Kerman	Months	198	17	-13	-	-	143	345
	Total	3,410	1,044	1,407	2,904	113	437	9,033
Sestan-Baluchestan	Months	-	20	-	-	-	11	31
	Total	-	40	141	310	-	46	356
Total	Months	10,266	1,071	5,333	374	1,500	719	19,283
	Total	73,283	27,710	133,166	15,180	44,308	3,064	297,388

Source: Fertilizers Distribution Company.

APPENDIX VIII

PROJECTIONS OF FERTILIZERS REQUIREMENTS IN 1361
(In tons of Plant Nutrients)

	[illegible]					
	N	P_2O_5	K_2O	Total	[illegible] Rates applied (N-P-K)	Assumptions
Wheat	90,000	90,000	-	180,000	90-90-0	Assuming fertilisers are used on 8 [illegible]
	16,000	16,000	-	32,000	80-80-0	of irrigated crop area, of which 80% using higher rates.
Barley						
Rice	14,700	9,600	-	24,300	60-40-0	Lower rates applicable to Gilan and
	17,500	9,900	-	26,400	120-60-0	higher applicable to Mazandaran
Other Cereals						
Pulses						
Alfalfa	5,800	24,200	-	30,000	40-110-0	Alfalfa area assumed at 90% of total fodder area(see Appendix table 2)
Oil seeds	8,100	8,100	-	16,000	90-90-0	
Cotton	32,400	24,300	-	56,700	120-90-0	
Sugar Beets	36,000	24,000	-	60,000	180-120-0	
Sugar Cane	3,600	3,600	-	7,200	90-90-0	
Tobacco	300	750	750	1,800	30-60-90	
Watermelons etc.	6,300	4,200	-	10,500	90-60-0	
Tomatoes	1,560	1,170	-	2,730	120-90-0	
Other vegetables	7,200	5,400	-	13,000	120-90-0	
Onions	1,600	1,000	-	3,700	140-90-0	
Potatoes	8,100	5,400	-	13,500	180-120-0	
Apple	4,800	3,600	-	8,400	120-90-0	

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PROJECTIONS OF FERTILISERS REQUIREMENTS IN 1361 (Contd.)
(in tons of Plant Nutrients)

	[illegible]					
	N	P_2O_5	K_2O	Total	Fertilisers Rates applied (N-P-K)	Assumptions
Other fruits	12,000	9,000	-	21,000	120-90-0	
Grapes	5,850	5,850	-	11,700	90-90-0	
Citrus	5,600	2,800	-	8,400	140-70-0	
Dates	6,600 8,700	6,600 8,700	- -	13,200 17,400	150-150-0 90-90-0	Higher rate for Kerman and Fars areas (45,000 hec) lower rates for rest.
Pistachios	7,200 1,200	7,200 1,200	- -	14,400 2,400	300-300-0 200-200-0	Assuming 450 - 650 grams/tree and 12.2 million trees.
Tea	3,150	1,050	-	4,200	90-30-0	
Others						
Total	315,500	260,770	720	[illegible]		
Non-coverage + 10%	347,534	[illegible]	790	[illegible]	About 20% of the irrigated crop area are not covered	
Plus potassium for. 5%	-	-	30,000	[illegible]		
Dry farming - wheat	45,000	45,000	-	[illegible]	30-30-0	Assuming 1.5 million hectares of dry wheat cultivation using fertilisers
Grand Total	[illegible]	[illegible]	[illegible]	[illegible]		

APPENDIX IX

[illegible] (1963-1971)

(Metric Tons Nutrients)

Type of Fertilizer \ Year	1963	1964	1965	1966	1967	1968	1969	1970	1971
Urea (46% N)	1,337	10,668	9,964	19,088	20,500	20,295	20,268	24,100	52,275
Calcium Ammonium Nitrate ([illegible])	2,0[illegible]	3,809	3,857	3,842	3,906	4,724	5,825	7,062	7,006
Compound (20-20-0)	-	-	-	-	2,077	1,337	-	-	-
Diammonium Phosphate (18-46)	-	-	-	-	-	-	-	-	37,953
Triple Superphosphate (46% P_2O_5)	-	-	-	-	-	-	-	-	9,405
TOTAL	3,398	14,477	13,821	22,930	26,483	26,356	26,093	31,462	106,619

[illegible]: National Petrochemical Company, The Fertilizers Marketing System in Iran, Feb. 1973

APPENDIX [illegible]

FERTILIZER IMPORTS (1963 - 1971)

(Metric Tons Nutrients)

Types of Fertilizer / Year	1963	1964	1965	1966	1967	1968	1969	1970	1971
Urea (46% N)	3,330	-	-	-	5,947	10,301	10,819	35,300	18,738
Triple Superphosphate (46 % P_2O_5)	2,323	5,810	3,107	12,754	13,336	5,840	17,187	11,935	21,790
Single Superphosphate (18% P_2O_5)	342	-	765	475	717	-	-	-	-
Ammonium Sulphate Nitrate (26% N)	716	-	-	-	471	-	-	-	-
Ammonium Sulphate (21% N)	647	735	1,306	1,381	3,000	1,007	2,100	2,513	2,200
Diammonium Phosphate (18-46)	8,450	7,063	8,230	14,010	21,310	20,010	29,010	34,587	37,820
Potassium Sulphate (50% K_2O)	1,230	530	50	800	1,100	150	1,600	600	-
Compounds (15 - 15 - 10) (20 - 20 - 0)	6,864	7,700	11,230	3,306	13,305	2,605	64	1,080	-
TOTAL	20,900	21,859	24,810	34,006	58,214	40,403	67,414	78,709	80,378

Source: National Petrochemical Company, The Fertilizers Marketing System in Iran, Feb. 1973.

APPENDIX XI

FERTILIZER RECOMMENDATIONS & COMMON PRACTICES IN ISRAEL

Crop	Nitrogen Kg N per hectare	Phosphorus Kg P_2O_5 per hectare	Potassium Kg. K_2O per hectare	Remarks
*Winter grains (Wheat, barley)	90-100	40 - 60	-	
Maize (Corn)	120-150+ (50-100 as top dressing)	80 - 120	300	Top dressing in light soils, In heavy soils all the quantity is in basic dressing
Grass (Rhodes Grass)	500 - 700 as top dressing	150 - 180	300 in one application in spring	After every cutting and before irrigation 400-500 kg/hec. of ammonium sulphate.
Alfalfa	-	60 - 80	240 - 400 as spring top dressing	Potassium is applied also as basic dressing 300 kg/hec. before ploughing
Clover	-	80 - 120	250 - 300	
Fodder Beet	200 (+ 100 as top dressing)	100 - 200	200 - 350	4 - 6 M^3 of organic manure
Cotton	60 - 120	80 - 100	60 - 140	K fertilization is different with the different varieties-
Sugar Beet	120 - 240	80 - 140	200	N & K depends upon the former crop also, K is important for cotton +3-4 M^3 organic manure,
Groundnuts	120 - 240 or innoculated with bacteria	100 - 120	200	More nitrogen in heavy soils than in light
Potatoes	150 (+60+100 as 2 top dressing)	100 - 120	250 - 300	3 M^3 organic manure
Tomatoes	100 +(60+30 as top dressing)	80 - 150	250 - 600	The low application is in light soils, the high has been found to get response recently for heavy soils,
Strawberry	If methyl bromide was applied consult the instructor as to the N treatment as methyl bromide destroys the nitrifying bacteria	100 - 240	250	10 - 25 m^3 of organic manure according to variety,

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APPENDIX III (Cont'd)

Crop	Nitrogen Kg N per hectare	Phosphorus Kg P_2O_5 per hectare	Potassium Kg. K_2O per hectare	Remarks
Cabbage & Califlower	[illegible]	150	[illegible] - [illegible]	
Carrots, Onions & other	[illegible] - [illegible] +(100+[illegible]) as top	100 - 150	[illegible] - [illegible]	
Bananas	240 in 4 - [illegible] applications	120 basic + 150 every year	400 - [illegible] in [illegible] applications	Fertilization usually with irrigation water.
Citrus ∅**	[illegible]-400 in 1 - [illegible] applications	0 - 100	[illegible]	In Valencia it is recommended to spray with [illegible] Kg/[illegible] KNO_3 to prevent puffed skin
Apples ∅	[illegible] - 120	0 - 100	[illegible] for [illegible] - [illegible] years	
Vineyards	100 - 120	0 - 100	[illegible] for [illegible] years	K applied in furrows [illegible]-[illegible] cm. between the rows
Peaches & Appricots ∅	[illegible] - 100	0 - [illegible]	[illegible] for [illegible] - [illegible] years	

* Usually growing without additional irrigation

** Usually treated by spraying ZnO [illegible], 15% and in Citrus only [illegible] kg/ha., liquid, $MgNO_3$ [illegible]% according to deficiency symptoms.

∅ Need for P is low.

Source: Ministry of Agriculture, Israel.

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