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SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT

IRAN

Volume I

GENERAL REPORT

UNITED NATIONS DEVELOPMENT PROGRAM
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Volume I : General Report

Volume II : Details of Fertilizer Experimentation in Iran

Volume III: Results of Fertilizer Experiments in Iran

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FINAL REPORT

on a

SOIL FERTILITY SURVEY AND THE ESTABLISHMENT OF A SOIL FERTILITY UNIT

in

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VOLUME 1

GENERAL REPORT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

UNITED NATIONS DEVELOPMENT PROGRAM Rome, 1966

The final Report presented by FAO consists of the following three volumes :

COMPOSITION OF FINAL REPORT

Volume I : General Report

This volume describes the background of the Soil Fertility Project in Iran and summarizes the results of a five-year period when more than 10,000 experiments were carried out under actual farming conditions in 15 representative areas of the country. It explains the recommendation of fertilizer rates which ensure a high monetary return and a maximum profit. Recommendations are made for organizing future research on soil fertility, developing a sound economic policy of fertilizer investment, enlarging credit facilities for small farmers, and training Iranians for the specialized field of soil fertility.

Volume II : Details of Fertilizer Experimentation in Iran

This volume gives a technically detailed account of the Project's program in Iran and describes the physiography and agriculture of the areas in which the fertilizer experiments were carried out. Separate chapters concern statistical analysis, work done in four field laboratories, and investigations on such specialized subjects as the relation between control yields and fertilizer responses, the residual effects of fertilizers, trace elements, correlations and other factors of plant production.

Volume III : Results of Fertilizer Experiments in Iran

This volume presents the full results of all fertilizer experiments carried out during the Project : annual yields of fertilizer rates trials; yields and profits of fertilizer rates trials combined over the years; nitrogen carrier trials; phosphorus carrier trials; and demonstrations. These results are grouped first crop by crop and then subgrouped according to the areas in which a crop is grown.

GLOSSARY

Bongah	State organization
Cation exchange capacity	Milliequivalents of cations which can be absorbed by 100 grams of air dry soil at a specific pH.
Champa rice	Japonica type of rice
High monetary return rate (HMR rate)	Rate of fertilizer giving a high return on the money invested in fertilizers.
Maximum profit rate (MP rate)	Rate of fertilizer giving the highest profit per ha.
pH	Negative logarithm of the hydrogen-ion activity in the soil suspension
Qanat	An underground conduit, sometimes 20 km in length, designed to bring water to the surface from a water-bearing stratum. Shafts are sunk at intervals, and the conduit connects the bottom of each shaft. The slope of the conduit is less than that of the ground surface, and the water is discharged where the two slopes meet.
Sadri rice	Indica type of rice.

CURRENCY, WEIGHTS AND MEASURES

1. Currency

Rials		U.S. Dollars		Sterling
1	=	0.0013	=	1d.
100	=	1.33	=	9s.4d.
1,000	=	13.33	=	£4.13s.5d.
10,000	=	133.33	=	£46.14s.7d.

2. Weights and measures

1 kilogram	=	1,000 grammes	=	2,2046 lbs
1 ton (metric)	=	1,000 kilograms		
1 metre	=	100 centimetres	=	3,281 feet = 1.09 yards
1 sq. metre	=	10.764 sq. feet	=	1,196 sq. yards
1 hectare	=	10,000 sq. metres	=	2,4736 acres
1 sq. kilometre	=	100 hectares	=	247 acres

1 kg/ha is about equal to 1 lb/acre.

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INTRODUCTION

1. BACKGROUND AND HISTORY OF THE PROJECT

Iran is a sparsely cultivated country. Though its total area is 165 million hectares only 18.5 million ha are cultivated. Of the cultivated area, one third is under cultivation in any one year.

The chief limiting factor is the scarce amount of available water. The region which borders the Caspian Sea has abundant rainfall, but more than two thirds of Iran is an arid Plateau.

Out of a total population of 22 millions, about 15 millions live in 50,000 villages. The size of each village is determined by its water supply. So is the extent of the neighbouring land under cultivation. Thus the population of an average village is 250 in a country where the national average is only 13 people per sq. km.

There is a population pressure. The people whom a village and its cultivated land cannot support must migrate to the towns. Teheran's population was 200,000 at the beginning of the century; it is more than two millions. Before 1939, Iran was self-sufficient for wheat and used even to export it. The population pressure has since made it a wheat importer. Over the past five years the country has imported an annual average of 430,000 tons of wheat. If Iran could abolish these imports, there would be an annual saving of US$ 34,400,000 in badly needed foreign currency reserves.

The remedy lies in more irrigation, a fuller use of fertilizers and, in consequence, a change in the traditional methods of agriculture.

During the nineteen-fifties the Government of Iran intensified a campaign to modernize the national economy. It set up a central planning authority known as Plan Organization. Meanwhile other Government agencies began collecting information on the use of fertilizers. The Seed Improvement Institute, for example, made many fertilizer experiments on wheat, rice, cotton and sugarbeet. Most of its experiments, however, were made in research stations where the levels of fertilization and crop management were high. More significant from the economic viewpoint were the simple fertilizer trials which, in co-operation with the Plant Science Department, the Agriculture Extension Service carried out in the actual fields of farmers.

These showed that, even under the prevailing system of farming in Iran, fertilizer use could increase economic gains in most of the main agricultural areas. As a result, the drain on foreign currency reserves would be reduced. It could also be reduced still further if Iran produced its own fertilizers, instead of importing them. In 1957, Plan Organization asked the Development and Resources Corporation of New York to help in assessing the potential market for fertilizer factories within the country.

The Corporation, which was already working in the Province of Khuzistan, agreed that their agents, Khuzistan Development Service, should carry out a survey. Thus began the Khuzistan Fertilizer Program, in which FAO participated, to determine the fertilizer needs of the main crops in that province.

Its report, published in 1962, showed that nitrogen and phosphorus gave economic returns on most soils in Khuzistan with irrigated crops. On most soils, potassium levels were adequate and no responses to this nutrient were observed.

The highest monetary returns came from fertilizers applied to rice, sugarbeet, cotton, sugarcane and vegetables. Returns from wheat and barley, however, were generally lower.

It was now obvious that the increased use of fertilizers would benefit not only the farmers, but also the entire nation. The more immediate problem was to determine the right rates of application for the various crops in each agricultural region. A country-wide survey of responses to fertilizers had become essential.

The Government of Iran, therefore, made a request for United Nations Development Programme (Special Fund) financial and technical assistance. The request was favourably received, and the Plan of Operation was approved and formally signed on 7 November 1960.

The purpose of the Project was to assist the Government of Iran in establishing a Soil Fertility Unit, to carry out soil fertility surveys in various parts of the country, and to train Iranian technicians in this specialized field.

It was the task of the Soil Fertility Unit to supply information on the fertilizer and manurial needs of crops under all soil, water and agronomic conditions. The information, developed on an ever increasing scale, would be the basis not only for advice to the farmers on the use of fertilizers, but also for the national planning of fertilizer production.

The Unit was also responsible for launching new experimentation in the field, for co-ordinating work already done by other agencies and for assembling the results. Its overall objective was to raise the general productivity of Iranian soils.

2. FINANCIAL CONTRIBUTIONS

Originally, the total sum agreed to be made available from the Special Fund was US$ 524,640 excluding agency costs. In December 1961, the Plan of Operation was amended so that, from August 1962, the contribution (not personal services) was made available in cash and placed under the control of FAO through the Project Manager. This new arrangement freed the Project from possible delays in securing supplies.

Two further amendments to the Plan of Operation, in October 1963 and April 1964, increased the contribution from the Special Fund by US$ 41,000, and from the Government of Iran by $ 77,680. They also made the timing of payments from Government contributions more flexible. This additional contribution from the Government covered the costs of an unforeseen expansion of the work into the northeastern province of Khorassan in 1964.

The total allocation for the five-year period was, therefore, US$ 1,145,680 from Iran plus 15 percent local facilities and US$ 565,640 from the Special Fund plus an agency charge.

3. ORGANIZATION OF THE PROJECT

The soil fertility survey began on 1 January 1961. Two months later, field operations started with six stations. Three - Shiraz, Fassa and Kazerun - were in Fars region, which is a main agricultural zone in southern Iran. The other three - Gilan, Mazandaran and Gorgan - were in the Caspian region, the country's rice granary, in which the climate differs markedly from that of the Plateau. In 1963, a station was opened at

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1/ The United Nations Special Fund and the Expanded Programme of Technical Assistance were merged into the United Nations Development Programme on 1 January 1966.

Esfahan, in the Central region, where there is a high standard of farming and an intensive crop rotation. In that year, too, three stations - Ghazvin, Maragheh and Rezayeh - were opened in the Azerbaijan region, where the greater altitudes and colder climate create special farming problems.

Before the survey ended in February 1966, a total of 15 stations and 23 substations had been opened in seven different regions which together provided a fully representative cross-section of Iran's agriculture.

The management was in the hands of the FAO Project Manager and his Iranian counterpart, the Co-Manager. The Project Manager was responsible for the general operation of the Project. He co-ordinated the activities of the staff and represented the Project in discussions involving FAO and the Iranian Government.

In the provincial stations outside Teheran, Iranian field engineers, one in each station with three or four assistants, were responsible for carrying out the experimental programmes. Each got in touch with the farmers in this area and selected the sites for experiments. This was followed by fertilizer trials, field observations, pest control where necessary, harvesting and recording yields.

The total staff at maximum strength in 1965 was 135, of whom 109 were working in the field stations. Ten of these were administrative workers; 81 were technicians, who thus became the nucleus of a technically well trained corps which can have a permanent value for agriculture in Iran. The remaining 44 staff members were drivers, guards, etc.

4. RELATIONSHIP WITH OTHER ORGANIZATIONS

Recommendations for fertilizer use were circulated to farmers in different areas by: (a) the Agricultural Extension Service; (b) the farmers' co-operatives; (c) the Chemical Bongah; (d) literacy corps; and (e) Government monopolies and State Organizations other than the Chemical Bongah.

The Project's field teams worked constantly with the farmers in their areas. They were always ready to give direct advice about the most efficient use of fertilizers. Particularly helpful was the support given to them by the Agricultural Extension Service. In co-operation with the local Extension Officer they laid down simple two or three plot demonstrations. Altogether several hundreds of demonstrations were planted in the Project areas, and they gave consistently higher yields than did the trials.

The recommended treatments were always clearly labelled in the demonstrations, which wherever possible, were located beside a busy road or close to a village. They gave a visual proof that fertilizers are effective, and they roused the farmers' curiosity. If in the past ten years, fertilizer use in Iran has increased from 10,000 tons to 50,000 tons in 1964, the collaboration between the Project, the organizations and the farmers themselves has played a notable part.

The Project readily gave information and advice whenever it was consulted by the Extension Service and other organizations concerned with fertilizers. For this purpose, a Soil Fertility Co-ordinating Committee was formed in 1961. It met at least once a year and included representatives from the Ministry of Agriculture, the Ministry of Industry and Mines, Plan Organization, the Agricultural Faculty of the University of Teheran and independent State Organizations. Ideas were exchanged on such subjects as the future lines of research and the regional distribution and stocking of fertilizers.

At the request of Tahal, a firm from Israel conducting an agronomic development scheme in the Ghazvin plains, experimental designs were prepared and fertilizer experiments were laid down in close co-ordination on several pilot farms, in 1965.

There was also fruitful co-operation with: (a) US-AID, mainly in the field of agricultural extension; (b) French Technical Assistance (Cotton Specialists group); (c) the Belgian Group of specialists on sugarbeet development; (d) CENTO Farm-machinery school, Soil Conservation investigations, and foliage analyses in their laboratories on isotope research; and (e) the West German Scheme of pilot and training farms.

5. ACKNOWLEDGMENTS

Work done by the Iranian national staff of the Project (in particular, the field engineers supported by the junior field staff, together with the senior technical staff, members of the soil test laboratories, statistical section, administrative and auxiliary staff) is gratefully acknowledged. Their joint efforts greatly contributed to the successful establishment and achievments of the Soil Fertility Unit within the short period of five years.

Greatly appreciated was the help given by the Senior Officials of the Ministry of Agriculture, and by the United Nations Liaison Officer, who untiringly encouraged and supported the organization through its initial difficulties on the road to full recognition.

Gratitude is also due to the Directors of the Chemical Bongah, Senior Officials of the Ministry of Industry and Mines, Seed Improvement Institute, Agricultural Bank and Co-Operatives and other independent State Organizations, such as the Tea, Tobacco, Cotton, and Sugarbeet Monopolies, for their whole hearted support and highly valued advice.

CHAPTER I - SUMMARY

PART ONE : PRINCIPAL ACCOMPLISHMENTS AND FINDINGS

1. GENERAL

Agriculture in Iran has been traditional for centuries. The soil alone has sustained its cropping system. The only outside factor has been a limited use of animal manure. Productivity was regenerated by fallow periods.

The use of fertilizers involves a complete revision of this system. Their restoring action is several times more effective than that of the fallow periods. Except in dry farming areas where the annual rainfall is below 300 mm, where the building up of subsoil moisture is required, fallow periods can be abolished or, at least, reduced.

An example, of the traditional system is the fallow which follows a summer cash crop and precedes a winter food crop. If fertilizers are applied and the fallow is abolished, the food crop can make full use of the residual effects of the fertilizers which had been applied to the cash crop. A secondary advantage in irrigated agriculture is the accumulation,however small, of organic matter.

As stated in the Introduction, the total amount of the cultivated area in Iran is only 18.5 million ha. It has been estimated, however, that irrigation water, if made available, could increase the land under cultivation to about 40 million ha. This would involve large investments. Meanwhile the use of fertilizers offers a more immediate solution to the problem of making Iran once again a self-supporting - perhaps, even a food-exporting - country.

Inevitably, fertilizers cannot have their fullest effects until some other agricultural methods in Iran are also changed. Improved tillage practices are essential. For instance, crops should be planted or sown in rows. Plants should be thinned down to the correct plant population. Water is used more effectively when the basins for flood irrigation are levelled. Even better is furrow irrigation, which prevents the surface soil from forming a hard crust. Water in the furrows should not come over the top. Then their structure is not damaged.

Just as there is an optimum plant population in the absence of fertilizers, so another and larger population is required when fertilizers are applied. Moreover, although improved varieties usually show a higher response to fertilizers than do the local types of crops, they also demand cleaner weeding, more moisture and higher rates of fertilizers. The use of fertilizers requires, in fact, a far better control of pests, diseases and weeds.

Despite the need to alter the traditional system of agriculture, it is possible to estimate the major results of applying fertilizers only, and without the adoption of other improved practices. The following table is a striking illustration of the expected increases in the production of Iran's seven main crops when fertilizers have been universally applied. The estimated total value of the increases is US$ 188,502,895 per year.

The actual cost of the fertilizers to produce this increase is US$ 41,257,880. When the cost is subtracted, there is a net value of US$ 147,245,015. This gives a return of 456 units for every 100 units invested in fertilizers.

An even more realistic figure is obtained when the latest known value of produotion of the same seven crops - that of 1964 - is subtracted. The result is a final value of US$ 102,851,948.

The table also shows that the estimated national increase of wheat is 587,000 tons. This is more than the average of 430,000 tons of wheat which, as stated in the introduction, have been imported annually for the past five years. If fertilizers were universally applied in Iran, there would be an annual saving of US$ 34.4 millions in wheat imports alone. There would also be import savings with other crops; notably with sugar.

Table I-1: COMPARISON OF THE INCREASES OF PRODUCTION AND VALUESON THE UNIVERSAL APPLICATION OF FERTILIZERS

Crop	Area (ha)	Increase of production (tons)	Value of increase (US$)
Wheat	1,370,272	587,471	46,997,680
Rice	304,190	243,413	26,484,070
Cotton	262,925	55,869	10,447,503
Sugarbeet	64,000	697,306	92,741,698
Tea	21,000	13,818	3,869,040
Alfalfa	75,000	113,340	4,533,600
Tobacco	26,678	-	3,429,304
Other crops (fruits, potatoes etc.)	474,469	unknown	-
Total	2,598,534	-	188,502,895

2. SOIL FERTILITY INVESTIGATIONS

The Soil Fertility Unit set up by the Project was fully operational before the end of 1965. It is now recognized as a Government body, and it is financed not from Development funds, but from the Regular budget. This will guarantee its continuity even after international assistance has been withdrawn.

In each of the Project's 15 field stations, the experiments covered an area of roughly 100,000 ha. Before the last season (winter 1965-66), when 1,500 wheat trials were planted, they averaged 100-120 each season in each station; in other words, one trial for every 1,000 ha. Over the nine separate seasons, 8,812 trials were planted, and 6,917 were harvested. When the figures for the tenth and last season (winter 1965-66) are added, the total number of trials planted exceeds 10,000.

In the first year, experiments were restricted to the seven main food and cash crops grown in Iran; wheat, barley, rice, sugarbeet, cotton, tea and tobacco. In the third year, seven more crops were added: alfalfa, melons (various types), grapes, kenaf, citrus, potatoes and onions. Later four more crops - deciduous fruit (apples and peaches), date palm and pistachio - brought the final total to 18.

2.1. Trials in farmer's fields

The Project adopted a new procedure for its field experiments. In the first place, no trials were laid down in experimental stations, where fertility is carefully fostered and conditions are strictly controlled. Instead, all trials were laid down in farmer's fields.

This technique does not interfere with a farmer's usual practices; he carries on as before. Only two operations are introduced from outside. One is applying the fertilizer. The other is taking a sample cut from each plot at harvest time. Everything else - preparing the seed bed, sowing, weeding and watering - is left to the farmer himself.

Secondly, this new procedure is area-wide. Each trial in a chosen area is the replication of a single experiment. Only one replication is laid down in any one farm. Each covers an area of about 1,000 ha, and equals that of a complete block of an experiment based on randomized blocks. There are as many blocks as trials in the area. According to a standard design, the fertilizer rates trials, each block contains 12 plots.

This method makes it possible to estimate the yield-increasing effects of fertilizers. It also helps economic planners to assess the increase of agricultural production which results from applying fertilizers on an area-wide basis.

The Project conducted three types of trials: (a) fertilizer rates trials; (b) carrier comparison trials; and (c) demonstrations.

Fertilizer rates trials were the most numerous and account for three quarters of the total number. They were repeated each year with three levels of N, P_2O_5 and K_2O so as to study their direct and residual effects and their interaction on a crop's quantity and quality. They showed at which rates N, P_2O_5 and K_2O fertilizers should be applied to give the highest monetary return or the maximum profit per ha.

Carrier comparisons were secondary trials for major crops like wheat, rice, sugarbeet, tea and tobacco. They showed the relative efficiency of different nitrogen and phosphorus carriers.

Demonstrations tested the treatments to be recommended according to the results of the fertilizer rates trials and carrier comparisons. As a rule, they consisted of three large plots.

2.2. High monetary return and maximum profit rates

The trials made it possible to establish the high monetary return rate and the maximum profit rate for Iran's ten main crops. The high monetary return rate (HMR rate) is that fertilizer rate which gives a high return on the money invested; it ensures a minimum of 150 Rials for every 100 Rials invested in fertilizers. The maximum profit rate (MP rate) is that fertilizer rate which gives the highest profit per ha.

The HMR rate is particularly suitable for a country where farmers are using fertilizers for the first time and have very restricted sources of credit. The MP rate is more suitable for the richer farmer who has often used fertilizers before. He represents, however, only a fraction of Iran's farming community.

The following table shows the mean response of each main crop in Iran to the HMR rate. The average increase of yield may vary from 23 percent for rice to about 27 percent for wheat and to as high as 37 percent for sugar beet. Particularly striking are the figures given in its last column. For every 100 Rials which a farmer on the Plateau pays for the fertilizer applied to his irrigated wheat fields, he can expect a return of 192 Rials; for his Sadri rice, the farmer in the Caspian region can expect

531 Rials, while the grower who plants the superior Burley type of tobacco can expect a return as high as 957 Rials.

Table I-2: MEAN RESPONSES OF MAIN CROPS TO THE RECOMMENDED HMR RATE OF FERTILIZERS

		Mean initial yield kg/or tons/ha	Mean response to HMR rate		Return, Rials per 100 Rials
			kg or tons/ha	%	
Wheat	(Plateau	1,667	449	26.9	192
	(Caspian	1,836	323	17.6	149
Rice	(Plateau (Champa)	3,227	712	22.1	467
	(Caspian (Champa)	3,621	896	24.7	481
	(Sadri)	2,948	692	23.5	531
Cotton	(Plateau	1,352	251	18.5	167
	(Caspian	1,328	86	6.5	62
Sugarbeet	(Plateau	29.12/tons	10.67	36.6	507
Tobacco	(Burley	1,263	200	15.8	957
	(Turkish	1,498	65	4.3	487
Tea	(fresh yield)	4,557	658	14.4	364
Grapes	(Plateau (fresh)	15.71/tons	3.01	19.1	549
Potatoes	(Plateau	13.78 "	4.04	29.3	516
Alfalfa	(Plateau (top-dress)	8.72 "	1.84	21.1	490

2.3. Other investigation results

If the initial yields of wheat trials which received enough irrigation water are grouped into classes with equal yield-increasing intervals, it can be established that fertilizers are decreasingly effective with increasing initial yield until, at a yield of 3,300 kg/ha and over, the rates used by the Project are insufficient to induce an additional yield above this very high initial yield. At this ceiling not only are higher rates of nitrogen and phosphorus required to further yield increases, but they should also be applied in combination with potassium. This was the first occasion during the Project's five years that a marked effect could be attributed to this nutrient.

The rates of maximum profit established for each yield class show a similar inverse relationship. The high monetary return date is less affected by the magnitude of the initial yield, though this applies only to yields up to 3,300 kg/ha. Under proper conditions, as the trials showed, irrigated wheat can achieve very high yields of about 4 tons/ha.

The Project clearly established the residual effects of fertilizers. Where wheat followed a fertilized cotton crop, there were significant residual effects of phosphorus and to a leser extent of nitrogen. Understandably, these effects were more significant for the higher rates of fertilizer. Further, where nitrogen and phosphorus were applied together, larger residual effects were recorded. On the average, with wheat after cotton, the mean of the residual effect of all fertilized treatments in the trials was 12 percent of the control yield, about half the average direct effect. In a rice monoculture, on the other hand, phosphorus was the only residual agent. There was no residual nitrogen effect.

The three phosphorus carriers - triple superphosphate, ammonium phosphate and basic slag - were tested in three consecutive seasons for their direct and residual effects on rice. Ammonium phosphate was consistently higher yielding than the two other carriers and gave the best economic results, but the yield differences between them were not significant. In the first residual year, when for the first time fertilizer is not applied, an average decrease of 14 percent in profits can be expected. In the following year, if again fertilizers are not applied, there is a further decrease to 31 percent.

Trials with rice and sugarbeet to investigate the effects of seven trace elements produced no evidence that they were needed on an average soil in Iran. With perennial crops, however, there is a different situation. Lime-induced iron chlorosis is rather widespread and quite serious in Khorassan province, especially on peaches. Its control by chelates is economically justified, especially where the EDDHA (far more effective than the EDTA) compound of the iron chelates is used on alkaline soils.

To ensure the continuing value of fertilizer experimentation in the field, the Project investigated correlations between crop responses and the results of chemical soil tests as well as soil units classified in soil surveys.

Significant relationships, but of a low degree of correlation, were established between soil analyses data and the yields of irrigated wheat and sugarbeet. For both crops, a significant negative logarithmic correlation was established between soil phosphorus and the main effect of phosphorus at the lower increment. Thereafter, significant negative linear correlations were established for each crop between soil phosphorus and the rate of phosphorus fertilizer which gives the maximum yield.

To discover whether there is a relationship between soil series and inherent productivity, the Projected conducted a semidetailed survey in Fassa area, which has mixed alluvial soils and represents a good average of the Plateau's agricultural land. The survey showed that the soil series produced significant differences in the initial yields of irrigated wheat and sugarbeet. A lower initial yield on the colluvial series is significantly increased on the Terrace soils, and still more significantly increased on the fertile river levee soils.

Efforts to establish a relationship between electric conductivity data of the saturation extract and initial wheat yields met with only partial success because there were too few trial sites with a sufficient high conductivity. Most showed a conductivity of less than 2 millimhos/cm. Wherever it exceeds 10 millimhos/cm, a decrease of about 20 percent in wheat yields can be expected.

The tolerance limits of crops to salinity established in the U.S.A. are too low for Iran. A revision is needed.

The influence of the number of irrigations on yields differs from crop to crop. A minimum of four irrigations is usually recommended for wheat. On applying 30-30-0, this gives a gross profit of 233 Rials/ha for each irrigation. At six irrigations, however, the gross profit for each is increased to 411 Rials/ha.

For cotton, a minimum or more irrigations is recommended, but the gross profit on applying 45-45-0 is only 60 Rials versus 56 Rials/ha for each of 13 and less irrigations.

For sugarbeet, with 15 or more irrigations, the gross profit for each irrigation on applying 45-45-0 is 460 Rials/ha. This increases to 500 Rials/ha with 25 and more irrigations. Still higher figures (660 and 750 Rials/ha) are gained on applying 90-45-0. Under identical treatments, the gross profit from each irrigation is higher for sugarbeet than for wheat.

No additional benefits were obtained by applying nitrogen to irrigated wheat as a split dressing (one part at seeding time and the other in spring, when wheat resumes growth) rather than as a full dressing at seeding time. In other words, nitrogen is not leached beyond the reach of the crop roots by the winter rains.

Investigations showed that early planting is more beneficial than late planting for wheat and even more so for sugarbeet. Wheat planted in October may yield and respond to fertilizers as much as 20 percent lower than when it is planted in September. With later seeding, the higher rates of fertilizers become progressively less effective than the lower rates. Initial yields of sugarbeet may decrease by about 13 percent from February to March, but by as much as 25 percent when fertilizers are applied.

An essential element in a sound fertilizer policy is the selection of improved varieties. A good example of a successful selection is in the Caspian region, where an improved rust-resistant wheat variety replaced a local variety within two years. The improved variety outyielded the local one nearly three times, and its mean response to fertilizers was about twice as much. Two other wheat varieties introduced in the colder areas are making a slower process. Yet already they respond twice as much to fertilizers as the local varieties.

3. EXPECTED INCREASES OF FERTILIZER CONSUMPTION

In a forecast of the increase in the use of fertilizers for crops, it is useful to consider a fixed period of years. The following table shows first the estimated increase during the present five-year period from 1965 to 1970, and then for the next five-year period from 1970 to 1975.

Table I-3: ESTIMATED INCREASE OF FERTILIZER CONSUMPTION

A: from 1965 to 1970

Crop	Est.incr. % per year	Nitrogen (tons)			Phosphorus (tons)			Potassium (tons)
		Total N	Urea	Ammonium nitrate	Total P_2O_5	Triple superph.	Ammonium phosph.	Potass. sulph.
Wheat	5	9,997	12,350	16,595	10,278	22,319	-	-
Sugarbeet	12	1,728	662	7,886	1,728	3,756	-	-
Cotton	5	3,048	4,179	4,323	3,048	6,617	-	-
Rice	12	5,477	11,902	-	5,477	11,902	-	-
Tobacco	10	200	155	207	400	869	-	800
Tea	10	945	2,050	-	315	683	-	-
Alfalfa	8	360	-	-	1,350	586	2,160	-
Others	2	2,299	2,308	2,560	2,704	4,949	851	-
Total increase		24,054	33,606	31,571	25,300	51,681	3,011	800
Consumption 1965		3,632	5,601	4,060	5,828	12,669	-	1,075
Conversion (a)		6,900	15,000	-	8,740	19,000	-	2,000
Total consumption 1970		34,586	54,207	35,631	39,868	83,350	3,011	3,875

B: from 1970 to 1975

Wheat	4	7,998	9,880	13,276	8,222	17,855	-	-
Sugarbeet(b)	15	1,152	442	5,258	1,152	2,504	-	-
Cotton	10	6,097	8,358	8,646	6,097	13,234	-	-
Rice (b)	15	3,651	7,935	-	3,651	7,935	-	-
Tobacco(b)	10	200	155	207	400	869	-	800
Tea (b)	10	945	2,050	-	315	683	-	-
Alfalfa	8	360	-	-	1,350	586	2,160	-
Others	2	2,299	2,308	2,560	2,704	4,949	851	-
Total increase		22,702	31,128	29,947	23,891	48,615	3,011	800
Consumption 1970		34,586	54,207	35,631	39,868	83,350	3,011	3,875
Total consumption 1975		57,288	85,335	65,578	63,759	131,965	6,022	4,675

(a) Several NPK compounds were imported during 1964-65. They are included in the Table through their conversion into urea, triple superphosphate and potassium sulphate.

(b) Fully fertilized in 1975.

These estimates are conservative because they are based on the HMR rate, which is a moderate one. Rates are bound to increase when fertilizers become more widely used. None the less, the HMR rate can be used in estimating the total fertilizer consumption both in 1980 and in the summit year - at present unknown - when the entire agricultural area recorded in the 1960 Census will be fertilized.

In 1980, consumption will be: Total nitrogen, 70,814; as urea, 131,335; as ammonium nitrate, 40,000; total P_2O_5, 78,409; as triple superphosphate, 161,678 metric tons.

In the summit year, consumption will be: Total nitrogen, 88,556; as urea, 169,904; as ammonium nitrate, 40,000; total P_2O_5, 97,150; as triple superphosphate, 195,904 metric tons.

The actual summit year is estimated to be in the 1980's. It may well be earlier.

4. SOIL CHEMISTRY

During each Project year, the Soil Fertility Unit analyzed an increasing number of soil samples. At first, the analyses were carried out in the Teheran Central Soils Laboratory; but, after 1963, separate laboratories were set up in four different areas - Shiraz, Rasht, Mashad and Rezayeh - and the analytical work was gradually shifted to them. Before the Project ended, they were analyzing all the soil samples from the trials. They did a total of nearly 6,000 soil samples, which is equal to about 35,000 analyses.

The amount of samples from private sources was negligible: only about 1 percent.

The determinations for soils were: saturation percentage, pH in paste, electric conductivity, organic carbon (Walkley and Black), available phosphorus by Olsen, and exchangeable potassium in neutral ammonium acetate solution. The following table shows the total averages for Iran's two main ecological zones: the Plateau and the Caspian littoral.

Table I-4: MEAN RESULTS OF SOIL ANALYSES

	Plateau	Caspian region
Saturation percentage	38.2	61.7
pH, in paste	7.7	7.4
Conductivity, mmhos/cm	2.01	1.96
Organic carbon, %C	0.96	2.39
Phosphorus, ppm P	11.0	11.0
Potassium, ppm K	369	265

The soils of the Plateau have a coarser texture and higher alkalinity. The organic carbon content, and consequently nitrogen, is low, but high in the soils of the Caspian region. On the average, potassium is high in both ecological zones, while phosphorus tends to be low. There is, however, a great variation between different soils.

5. TRAINING

In addition to the field engineers already trained under the Khuzistan Development Service, 18 (apart from resignations) were trained for practical field work under the

Project's national and international Field Experiment Officers. They had all graduated at an agricultural college of the University of Teheran. Seven were granted fellowships, mostly in the U.S.A., to supplement their theoretical background; five were in the field of soil fertility.

Each engineer in charge of a field station was responsible for carrying out the experimental programme sent to him by the Teheran Head Office at the beginning of each of the Project's nine seasons; and each had three or four assistants working with him. As a rule, the assistants were holders of a high school diploma with a farming background or had passed through an agricultural school. In their second year, when they had some experience in technical matters and in arranging for experiments with farmers, some were sent to more distant villages and entrusted with the simpler phases of the experimental programme in a subarea.

From time to time, the Field Experiment Officers held courses for the engineers and assistants in experimental field technique. At a later stage, the more promising senior assistants were sent to Israel to follow a field course arranged each year by that country's Fertilizer Development Council. Altogether 49 field assistants were trained within the Project.

Nor was the Project's training confined to the field engineers and assistants. Senior members of the administrative and accounts section were trained before their engagement, but its junior members were trained under the Project. Each of the four field laboratories was staffed with two assistants trained in chemical routine analyses suitable for alkaline soils. They were recruited from local high schools and trained under the international soil chemist and his associate.

The statistical section was staffed by one engineer, a graduate of the Agricultural College, and two assistants, both with school diplomas. All three were trained by the international statistician in agricultural statistics and computation. They were thus qualified to plan the designs of field experiments and to analyze their results. Before the Project ended, they could carry out the routine work independently. The engineer was awarded a fellowship in the U.S.A.

PART TWO: RECOMMENDATIONS

1. SOIL FERTILITY INVESTIGATIONS

1.1. Field experimentation

The decision to carry out all the Project trials in the farmer's fields has been fully justified by their results. The procedure should continue. It is far more effective than conducting trials in an experimental station. When an experimental station is in the middle of a more or less primitive agricultural community, the farmer fails to see that its methods have any bearing on his own needs. Moreover, a single experimental station cannot be representative of the conditions found in a large urea under survey.

For those crops for which the trials have already established the high monetary return (HMR) and maximum profit (MP) rates, future field operations should be directed chiefly to demonstrations and to introducing the recommendations on a large scale. At the same time, investigations into these crops should be continuous and more intensive. Trials should concentrate more on introducing higher fertilizer rates combined with better practices, split application of fertilizers, improved varieties, estimates of optimum plant population, and a full control of weeds, pest and diseases. They should aim at higher yields and at fertilizing rotations rather than single crops.

For crops for which one or both rates of recommendation are not yet known, trials should continue until the rates are finally established.

The following investigations are suggested:

Wheat: Fertilizer rates trials should be scaled down for irrigated wheat on the Plateau. A switch should be made to investigating wheat as part of a rotation; for example, immediately following cotton, planting improved varieties only, and applying higher rates of fertilizers, thus supplementing the residual effects of the fertilizers and aiming at still higher profits. Rates trials in the Caspian region and in the dry farming areas should continue as before to establish the HMR and MP rates, if any.

Trials should continue with irrigated and dry farming barley.

Rice: Investigations should continue, especially on the Plateau, (Esfahan area) where the trials were too few for reliable estimates of rates and profits. In the Caspian region, trials with Champa should be switched to the promising Champa 346 variety. Plant population trials combined with row planting, fertilization of nurseries, etc. should begin, meanwhile introducing higher fertilizer rates. Investigations should include potassium treatments. Split dressings of nitrogen should be tested, especially their interaction with other factors.

Cotton: Investigations as carried out in the past should be discontinued. In any future trials, other yield improving factors (for example, planting in rows on ridges, sufficient irrigation and control of pests and diseases) should be combined with fertilizer investigations. Plant population and split nitrogen dressings should also be investigated.

Sugarbeet: Past trials were too few. They should continue in Central, Khorassan and (to a lesser extent) Azerbaijan regions. In Fars region, a switch should be made to experiments with improved practices; in particular, row planting, optimum planto population sufficient irrigation and proper control of pests and diseases. Nitrogen top dressings need to be investigated.

Tobacco: The only alteration should be a change in the design for both types of tobacco. It should consist of the 3^2 PK (0-30-60 kg/ha), plus three additional treatments; 15-30-30, 15-60-60; and 30-60-60; a total of 12 plots per replication.

Tea: Nitrogen rates need to be increased to 90 and 180 kg/N ha, and phosphorus to 45 kg P_2O_5/ha. Split replication of nitrogen in spring and autumn needs to be investigated at ratios 1:1 and 2:1. So does the time of applying phosphorus (in autumn versus the following spring). The combined phosphorus - nitrogen carrier trials should continue unaltered to investigate the long-term effects of the carriers. Later, split applications should be investigated.

Grapes: Trials as carried out in 1965 should continue until recommendations can be made conclusive. With the present 2 tree/treatment, trials per area and season should be increased to a minimum of 40 replications. Later there should be investigations into split, time and placement applications.

Potatoes: The present rates are low and can be effectively increased. Rates of nitrogen and phosphorus at 60 and 120 kg/ha are recommended.

Alfalfa: Investigations into the fertilizer influence on the establishment and top dressing of alfalfa should continue until the rates of application are more accurately established. More attention should be paid to water supplies.

Melons: Trials should continue unaltered.

Other crops: Trials with kenaf and onions should continue unchanged until there is enough information. Investigations were started only recently for such perennials as citrus, deciduous fruit trees, pistachio and date palm; and no immediate results are expected. Trials begin with a two-year uniformity period. Thereafter fertilizers are applied annually. The totals of the paired fertilized years are corrected for inherent genetic variation. This is done by means of the co-variance analysis through the paired uniformity year totals. Paired totals are needed to remove the influence of periodicity. Experimentation should aim at increasing replication between sites rather than within sites, where only two trees are taken for each treatment.

There should be further investigations into the quality of the fruit and the influence of lime induced trace element deficiencies on yield and quality.

1.2. Organization of future research

Although five years of relatively simple experimentation by the Project gave promising results, it became clear that further progress in Iran's agriculture may soon be impossible without a greater concentration on research.

Agricultural research has two aspects: short range and long range. Examples of long range research needed in Iran are: re-afforestation of the denuded and overgrazed watersheds; re-establishment of the original climax vegetation; investigations into the most suitable and balanced rotations for irrigated and rainfed agriculture; inclusion of the right leguminous crops in the rotations; plant breeding; improved livestock introduction; improved standards of nutrition alike for people and for animals; and control of protein deficiencies.

Short range research is needed for many subjects; for example, improved tillage practices to control the crust problem of irrigated soils.

These improvements can be assessed by experiments in the main agricultural regions; but, like the trials carried out by the Project, they should be introduced right down at the farmer's own level. Then the farmer can himself apply them. Contact with a small group of neighbouring farmers is established. Guided by the extension service and research organizations, the group of farmers introduce the improved practices into their own farms. They also pay for the improvements. The new practices are safeguarded by contracts between the Extension Service and the group of farmers. A number of groups are brought together through a pilot project.

Another classification is into basic and applied research. Basic research is pure research without any thought of practical application and with the sole objective of increasing human knowledge. The fundamental purpose of agricultural research, however, is to solve the farmer's problems.

Laboratory services are available at the Soil Institute, which carries out routine analyses for the farmers in the various regions. Meanwhile the central laboratory in Teheran is available for any applied research needed at this stage of the country's agricultural development. This does not mean that there is no place for basic research in Iran. With intensified agriculture problems may often turn up which need basic research for their solution, but it can be introduced only after the most pressing problems of an applied nature have been solved; when, perhaps, the second stage of development has settled down.

At that time the central laboratory should gradually undertake basic research and the field laboratories and field centres should carry out applied research, as well as routine investigations for advisory purposes. All centres should be distributed according to ecological zones, and concentrate increasingly on local problems.

Research projects will multiply as agriculture becomes more intensified. A scale of priorities will be needed. Priority should depend first on a crop's importance for the national output and then on the estimated value of the result if the research is successful.

Close ties between research and the farming community are absolutely essential. Briefly, the three indispensable conditions for agricultural development in Iran are (a) applied research; (b) communication between research and the farmer through the extension worker and through many small pilot projects and (c) the means which enable the farmer himself to make the improvements.

The Durudzan pilot project planned in the Shiraz area already provides an excellent means of introducing various factors needed for an intensified agriculture. Research can be done right down at the farmer's level.

2. FERTILIZER RATES

Table 1-5 shows the HMR and MP rates which have been so far established for ten crops by the Project's experiments.

Table I-5: RECOMMENDED HMR AND MP RATES FOR MAIN CROPS (KILOGRAM NUTRIENTS OF N, P_2O_5 AND K_2O PER HECTARE)

Crop	PLATEAU								CASPIAN	
	Fars		Central		Azerbaijan		Khorassan			
	HMR	MP	HMR	MP	HMR	MP	HMR	MP	HMR	MP
Wheat	30-30	45-45	30-30	60-45	30-30	60-60	30-30	-	Behshar Gorgan	30-30 (15+15)-30
Rice (Champa	30-30	60-60	30-30	60-60	-	-	-	-	30-30	60-45
Rice (Sadri	-	-	-	-	-	-	-	-	30-30	60-45
Cotton	45-45	-	45-45	-	45-45	-	45-45	-	-	-
Sugarbeet	45-45	90-45	45-45	90-90	45-45	90-90	45-45	75-75		
Tobacco (Burley					-	-			15-30-30	-
Tobacco (Turkish					15-30-30	-			15-30-30	-
Tea (a)										90-30
Grapes					45-45	-				
Potatoes (a)					45-45	90-45				
Alfalfa (a)										
1) establishment					0-45	-				
2) top-dressing					15-45	22-60				
Melons (a)			45-45	-						

(a) Awaiting confirmation or change after more trials.

With very few exceptions, the HMR rates for each crop apply throughout Iran. This is because the rate is fairly low and less sensitive to varying ecological conditions. The MP rate, which are higher, usually differ from region to region. For wheat, for example, the rate of nitrogen of the MP rates closely follows changes of temperature. The colder the climate, the higher are the nitrogen fertilizer requirements.

Table I-5 also indicates that most of the recommended rates are on a 1:1 basis between N and P_2O_5 nutrients. It would be advisable, therefore, to adopt this ratio, though with a sufficient degree of flexibility, for any mixed fertilizers to be imported or home produced in the future.

3. KINDS OF FERTILIZERS

Nitrogen carrier trials have shown that the four tested fertilizer materials do not differ significantly in their yield effects. The two types manufactured in Iran - urea and ammonium nitrate - are generally recommended for wheat, cotton, sugarbeet, potatoes, melons and grapes. The two imports - ammonium sulphate and ammonium sulphate nitrate - are less profitable. On a pure nutrient basis, however, ammonium nitrate is about 15percent more expensive than urea and more hygroscopic. This makes it unsuitable for the more humid Caspian region. It is also unsuitable for rice when, under the prevailing anaerobic conditions, there are gaseous losses of nitrogen.

The agricultural co-operative organization has a special system for distributing the two types manufactured in Iran. This takes into account the humidity of each region and its distance from the factory in Shiraz. The distribution is:

Urea: Caspian region, Azerbaijan, Khuzistan, Kerman, Baluchistan and Sistan.
Ammonium nitrate: Central, Esfahan, Khorassan, Kurdestan, Lorestan and Fars.

Phosphorus carrier trials have generally shown no significant differences of direct yield effects between the three tested types - ammonium phosphate, triple superphosphate and basis slag - although the first was consistently higher-yielding than the second and about 20 percent cheaper on a pure nutrient basic. Residual effects, tested for rice only, were stronger for both these fertilizers than for basic slag, and they increased with the rate of application.

Because of its direct as well as its residual effects, ammonium phosphate is more profitable than triple superphosphate, which in turn is more profitable than basic slag. Triple superphosphate is generally recommended as the most suitable type for seedbed application, and ammonium phosphate for topdressings.

Nowhere have any significant yield effects of potassium been detected, apart from an influence on the quality of tobacco. There are, however, strong indications that, at some future time, potassium fertilizers will be needed when agriculture is intensified and soil potassium resources are further depleted. Potassium sulphate is recommended for crops which, like tobacco, at present require potassium.

4. SOIL CHEMISTRY

The number of samples from experiments is not expected to increase much more. This is not true, however, of samples from private sources. Some action should be taken to enlarge the capacity of the field laboratories. The farmers' interest should be stimulated by having their soils analysed and fertilizer recommendations made by the appropriate authorities. Three changes are suggested.

First, the fees charged for each single analysis are considered to be too high. They should be lowered, possibly by Geovernment subsidies. Secondly, the laboratory staffs should be increased; at first by one staff member for each laboratory. Thirdly, the laboratories should be increased to nine so as to meet the changing needs of the whole country.

Four - in Rezayeh (in operation), Gorgan, Esfahan, and Kerman - would be run on a routine advisory basis. The other five laboratories, designed as main laboratories, should be staffed with one additional analyst. They should do water analyses in addition to some routine tests on soils for advisory purposes. These main laboratories would be in Shiraz, Rasht, Mashad (all three in operation), Tabriz and Kermanshah.

The future expansion of the analytical routine work of the field laboratories should include nitrate-nitrogen, size distribution of soil particles, cation exchange capacity, iron, and exchangeable magnesium. Plant analyses should be carried out on fodder crops to determine their quality and fodder value.

5. SOIL SURVEY

Maximum use should be made of soil survey information in planning the location of future soil fertility trials and in interpreting the results obtained. Knowledge of the distribution of differing soil units should be used, when available, to ensure that trials are located in sites representative of the agriculturally most important and extensive kinds of soil. In interpreting the results of fertility trials, knowledge of soil distribution provides a valid basis for generalizing fertilizer recommendations on an area basis, separate recommendations being prepared for areas indicated by surveys as differing in their soil or environmental conditions wherever trial results show this to be necessary.

During the course of the Project the desirability of locating trials on identified and representative soil units was fully recognised but a shortage of soil maps at suitable scales limited the application of this principle in practice. Fortunately, in Iran, agriculture is concentrated on certain kinds of soil which are remarkably uniform in their general characteristics. Thus, the shortage of soil survey data did not raise a serious difficulty in siting or interpreting the Project trials almost all of which were located in areas of intensive agriculture. Nevertheless, as more detailed soil survey data become available it may prove valuable to relate the results of individual Project trials to the various soil units which are recognised.

6. OTHER YIELD INCREASING RECOMMENDATIONS

Where the rotation so permits, wheat immediately following cotton is a good sequence. The grain crop makes use of the residual effects of the fertilizers, chiefly nitrogen and phosphorus, applied to cotton. Trials with irrigated cotton often showed that losses from the direct effects of fertilizers can be transformed into profits if followed by wheat. An average increase of profit of 75 percent has been recorded. Where such a rotation is feasible, the higher rates are recommended.

In monocultures like rice, which is planted annually and interspersed with winter fallows, the use of residual effects can be recommended by omitting phosphorus in alternating years. In these years, when only nitrogen is re-applied, there will be a mean decrease of profit of 14 percent.

As a rule, fertilizers may be broadcast, except for such widely spaced crops as tea, grapes, melons and fruit trees, and for the more closely planted row crops, such as tobacco, when they are placed in a continuous band along the base of the plants. For other row crops, such as potatoes and cotton, fertilizers may also be broadcast.

Trials for investigating the time of application were restricted to wheat. It was found that a split application of nitrogen in spring gave no additional benefits when compared with the standard and full application in the seedbed. Until substantially more evidence is obtained from similar trials with other crops (including phosphorus) the full application in the seedbed is recommended.

7. FERTILIZER INVESTMENT POLICY

In the late fifties, the annual consumption of fertilizers in Iran was about 10,000 tons. This is negligible when compared with the 2.6 million ha which could be fertilized. Even then, the small amount was imported for such cash crops as tobacco and tea.

Table I-3 showed the estimated increase of fertilizer consumption first from 1965 to 1970 and then from 1970 to 1975. The following table indicates the expansion of fertilizer consumption from 1960 to 1964 and then brings the estimate of future expansion up to 1980. This comes close to the summit year, at present unknown, when the entire agricultural area recorded in the 1960 Census will be fertilized.

Table I-6: RECORDED AND ESTIMATED ANNUAL CONSUMPTION OF FERTILIZERS FROM 1955-1980 (METRIC TONS)

Year	Nitrogen N	Phosphorus P_2O_5	Fertilizers
1955-1960	-	-	10,000
1961	7,600	4,300	36,145
1964	11,591	12,946	57,202
1970	34,586	39,868	180,074
1975	57,288	63,759	282,654
1980	70,814	78,409	351,602

The local production of ammonium nitrate (40,000 tons/year) will equal home consumption by 1971, and that of urea (40,000 tons/year) in 1969. A new fertilizer plant in Bandar Mashur is planned to produce 500 tons/day of urea and 1,000 tons/day of liquid ammonia; and it will start producing in 1968. At 300 days per year, this is an output of 150,000 tons/year of urea. The home demand of urea reaches the 150,000 ton mark after 1980. Export markets will be needed.

A decision must still be made on whether to produce phosphate fertilizers and, if so, which type. The choice rests between di-ammonium phosphate and triple superphosphate. On a pure nutrient basis, di-ammonium phosphate is cheaper, but in other countries, triple superphosphate is thought to be superior in residual effects. Triple superphosphate is suggested rather than di-ammonium phosphate.

Vast supplies of natural gas in the oil industry enable Iran to produce sulfuric acid on a large scale, and triple superphosphate is at present made chiefly with the wet process phosphoric acid. As most wet acid plants are based on procuring phosphate rock and/or sulfuric acid at costs below those in the open market, it may be economic for Iran to import the phosphate rock, while producing its own supply of phosphoric acid.

In the U.S.A., phosphoric acid plants with a capacity of 100 tons/day P_2O_5 equivalent are regarded as uneconomic. A fertilizer plant should have at least an output of 300 tons/day of P_2O_5 equivalent in triple superphosphate or about 600 tons/day of fertilizer: that is, 180,000 tons/year of triple superphosphate. Iran's own production of triple superphosphate before 1980, therefore, is justified only if external markets can absorb the surplus.

A plant with a capacity of 180,000 tons/year at US$ 50 costs about $ 9 millions to build. Importing this amount by 1980 would cost $ 16.4 millions (1964 price). If this is produced as di-ammonium phosphate, there will be a far larger production than the country can absorb.

If the total area is fully fertilized with the MP rate, and not with the HMR rate, consumption increases by about 50 percent. The figures then become:

Total nitrogen	: 133,620 tons	Total	: 135,007 tons
as urea,	: 267,847 tons	as triple superphosphate	: 276,414 tons
and as amm. nitrate:	40,000 tons	and as amm. phosphate	: 15,714 tons

If, however, there is no ceiling of 40,000 tons for ammonium nitrate, the consumption figures become 178,102 tons of urea and 198,772 of ammonium nitrate.

8. ORGANIZATION OF CREDIT AND EXTENSION

A farmer wants his net income to be as large as possible, but his funds are limited. He may have to choose strictly between fertilizers and some other aid to increased production; for example, control of pests and diseases, improved varieties, irrigation, more labour or machinery. He often finds it very difficult to decide what particular combination could maximize his net income. Yet few of the other production factors which he can buy add so much to his income and to his output - and within so short a time - as do fertilizers. By contrast, investment in machinery is more often a device for saving labour than a means of increasing production.

8.1. Credit

This greatly influences the use of fertilizers. Large-scale farmers who grow crops for export can get credit directly from private credit institutions or from the fertilizer trade. The small scale farmer who grows food crops for a home market must rely on Government-owned or sponsored credit. At this credit is scarce, he must borrow from the general merchant, his landlord or a moneylender. His gain from using fertilizers will be reduced, if not eliminated, by excessive rates of interest.

More promising for the small farmer in need of credit for his fertilizer purchases are the farmers' co-operatives. About 4,500 co-operatives are now functioning; roughly one co-operative to every ten villages.

In the neighbouring co-operative, the farmer should be able to place his advance order for fertilizers, while at the same time applying for a loan secured by his future crop, which his co-operative can market for him. The loan should be in kind and not in cash. It would be paid off as a first charge against the proceeds.

At the present time, short term loans of maximum 10,000 Rials are quoted by the co-operatives. Of this amount a minimum of 1,000 Rls must be spent on fertilizers. Since, however, the application of the HMR rate is seen to be a safe investment, there may be a good case for augmenting the cash loans for farmers who want to enlarge the fertilized areas of their own farms.

8.2. Extension

The extension worker is the immediate link between research and the farmer, He can arrange the field days and demonstrations which show the actual results of improved practices.

Iran's Agricultural Extension Service co-operated with the Project in its demonstrations to show the advantage of fertilizer use. Future demonstrations, however, should also indicate the advantage of combining fertilizer use with a number of other improved practices. Even in terms of response to fertilizer use, they may give better results than a campaign conducted solely in favour of fertilizers. Eventually there should be enough demonstrations for each farmer to see one on a farm resembling his own.

There is always a time-lag between scientific development and its application to ordinary farms. The purpose of an extension service is to bridge the gap. For this reason, it is helpful to choose local leaders from the more progressive farmers, who, when they are fully instructed, can help their own neighbours.

The farmer, however, progressive he may be, needs advice on soils, crops and fertilizers on his own farm. Behind him, therefore, should be the services of a good field laboratory. Technical assistance is needed to plan a specific land use adapted to individual farms. One duty of extension officers is to make the farmer far more familiar with the services which are, and can be, rendered by the co-operatives. This, in its turn, requires a much closer co-ordination between the co-operatives and the Extension Service.

8.3. Distribution of fertilizers

Everything depends on ensuring that fertilizers reach the farmer at the right time. The general purpose co-operatives can organize their distribution very efficiently.

The Chemical State Organization, (Chemical Bongah), should expand its activities to include the distribution of fertilizers at subsidized prices not only to its agents in the major towns, but also to the villages with co-operatives. This will make fertilizer supplies available to farmers everywhere at identical prices. In other countries, the transport of the fertilizers to the farm is mostly carried out by private enterprise or by the farmer's co-operatives at a small additional charge.

9. TRAINING

The new experimental policy aims at higher yields improved practices in agriculture. Thus it sets a pattern for the future training of field engineers and assistants. They will be more intensively trained for experimental investigations. There will also be more fellowships; for example, fellowship in soil survey, soil and water management, conservation, reclamation, soil chemistry/physics and fertility, statistics and microbiology.

Training of the laboratory assistants, for instance, should be widened to include such new routines as incubation nitrogen, texture, cation exchange capacity, iron, and exchangeable magnesium. Whenever the number of private samples increases beyond the capacity of a field laboratory, its staff should be increased.

Annual seminars should be held in the Central Soils Laboratory.

Since the number of field stations will be increased during the next five years, the computing staff of the statistical section will need to be enlarged. For a start, there should be one more computer. The senior post should be reserved for a fully qualified statistician with a sound knowledge of agriculture.

CHAPTER II - PHISOIGRAPHY, AGRICULTURE AND FERTILIZER CONSUMPTION

1. PHYSIOGRAPHY 1/

1.1 Geomorphology and relief

Iran, formerly known as Persia, is part of the Plateau between the Tigrus and the Indus and has a total area of 1.64 million sq. km (see Map 1). There are five geographical regions: (a) in the north, the Elborz mountains are parallel ranges which gradually descend towards the Caspian Sea; (b) in the west, the Zagros mountains are a long wall with peaks often rising to a height of 4,500 m., and they largely determine the distribution of the country's rainfall; (c) between the two mountain ranges in the Plateau, mostly desert, with altitudes varying from 500 m to 2,500 m.; (d) the Khuzistan plain consists of the flood plains and deltas of rivers which flow into the Persian Gulf; and (e) the Caspian region, which borders the landlocked Caspian Sea (see Map 2).

The mountains and landscape are due to recent processes in the geological time scale (see Map 3). In the Cambrian period, a great sea engulfed the former land surface, and its sediments included limestones, shales, rock-salt and gypsum. Intense volcanic activity accompanied the lifting of the mountains and the Plateau in the Pliocene and Miocene periods. The following period - the ice age - contributed greatly to the present landscape.

1.2 Climate

Iran's elevation makes the winters fairly cold, while the lack of rainfall makes the summers extremely hot. Rain occurs chiefly in the winter, when the Elborz and Zagros mountains derive most of the moisture from easterly moving depressions (see Map 4). The area to the south and east of the highlands is the arid Plateau.

The Caspian region has by far the greatest precipitation (400-2,000 mm). Unlike the rest of Iran, it is a green landscape with thick forests on the mountain slopes. For six months its rainfall is abundant. In January, its relative humidity averages nearly 90 percent and does not drop much below 75 percent in the summer.

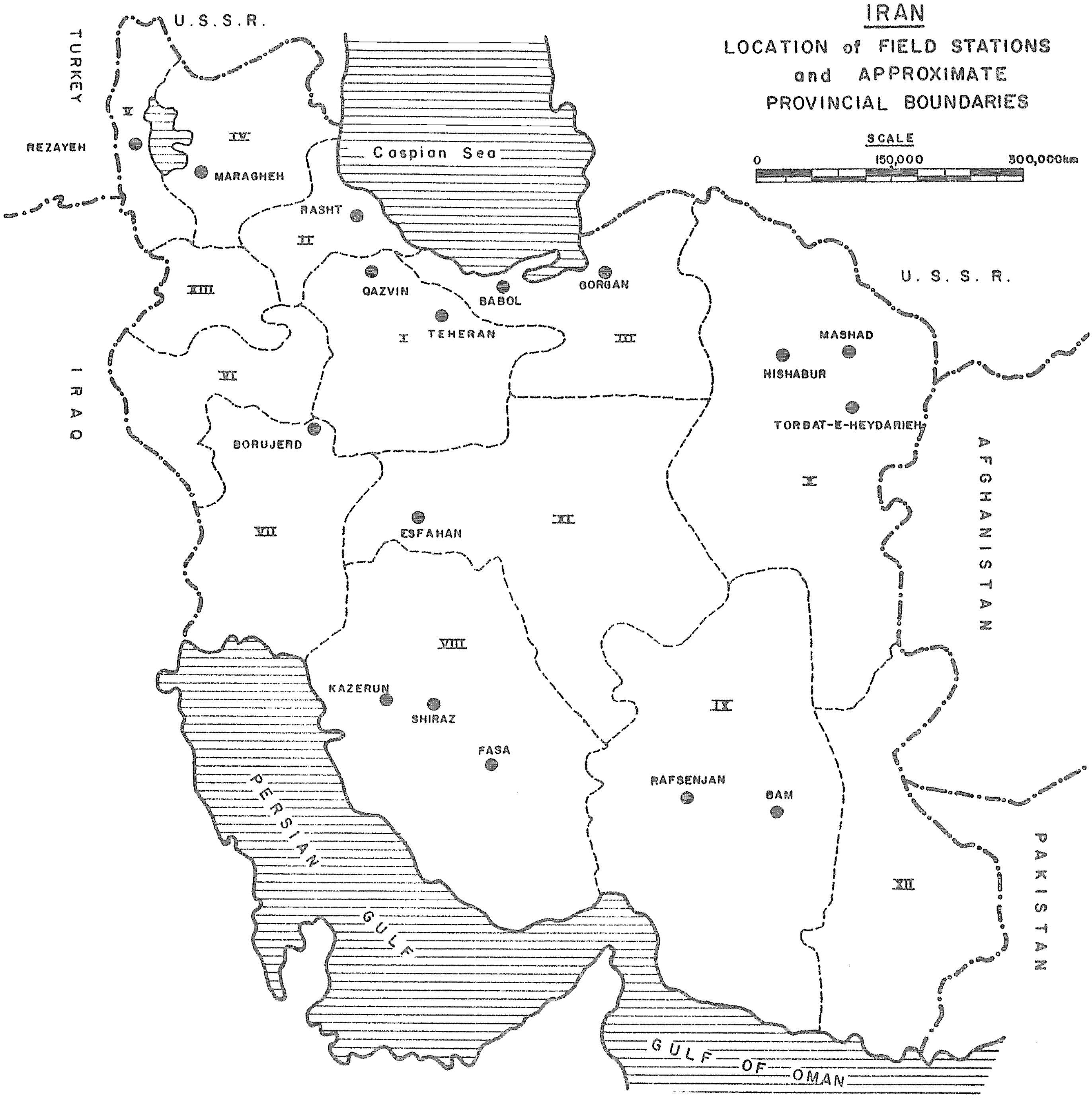
In southern Iran (rainfall 150-500 mm), however, the humidity can drop to between 15 and 20 percent in the afternoon, and the air over the Khuzistan plains can be completely dry.

1.3 Population

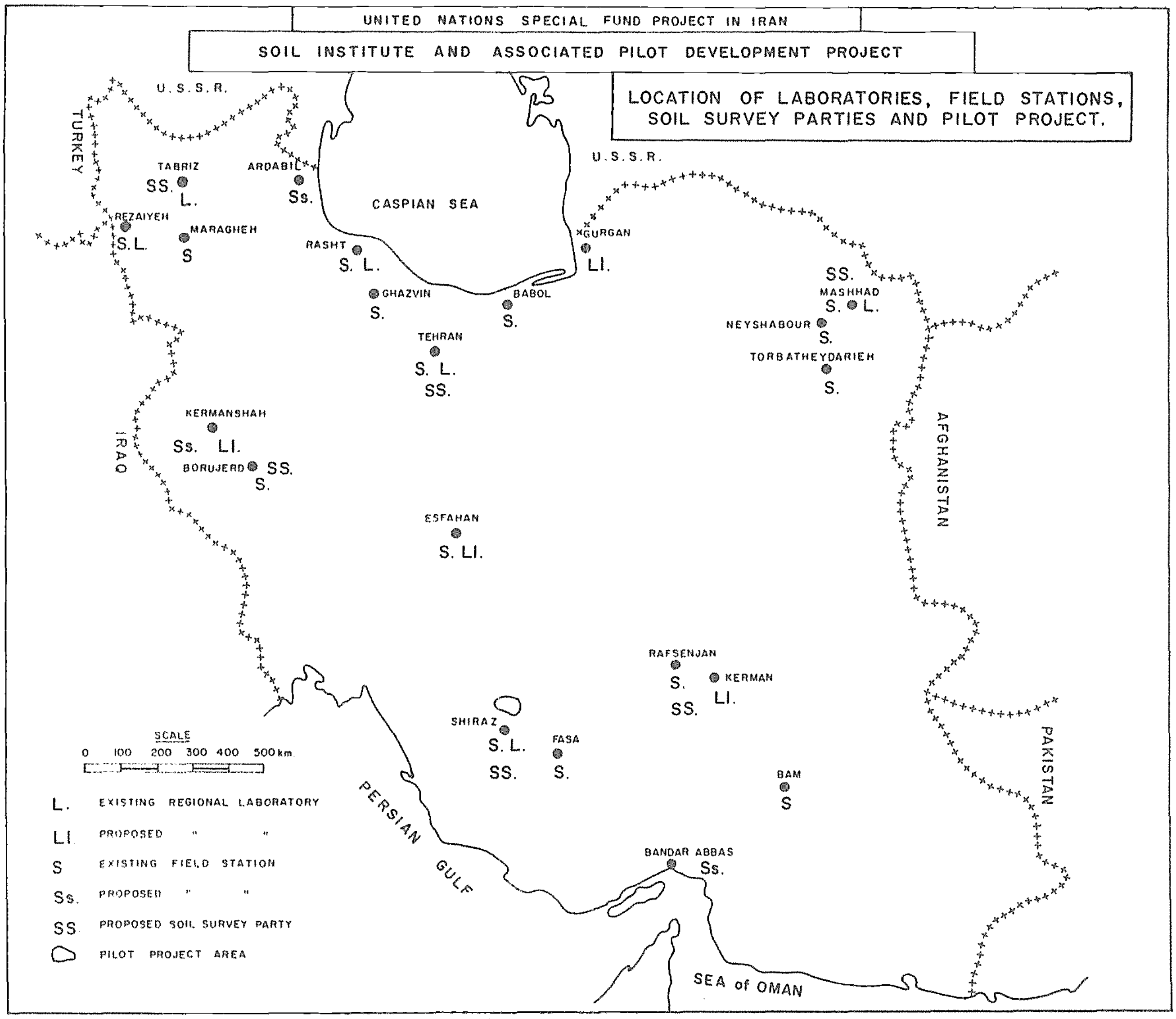
In 1965, the population of Iran was estimated to be about 22 millions, of whom 15 millions live in 50,000 villages. Human life is entirely conditioned by the availability of water. Apart from the Caspian region, the villages are scattered through the desert or semidesert. The great interior deserts are not inhabited. The village is the cornerstone of rural life, but its average population is only 250. The national average is 13 people per sq. km.

The general aridity creates a population pressure. The amount of cultivated land round each village completely depends on water. A farmer's individual share of the water limits the amount of land which he can himself cultivate. Land, in turn, can be subdivided only up to a ceiling which a bare subsistence will allow. Migration to the towns must follow.

1/ For a full description of Iran and the project areas, see Volume II, Chapter I.



I	Teheran	VIII	Fars
II	Gilan	IX	Kerman
III	Mazandaran and Gorgan	X	Khorassan
IV	East Azerbaijan	XI	Esfahan
V	West Azerbaijan	XII	Baluchistan and Sistan
VI	Kermanshah	XIII	Kurdestan
VII	Khuzistan		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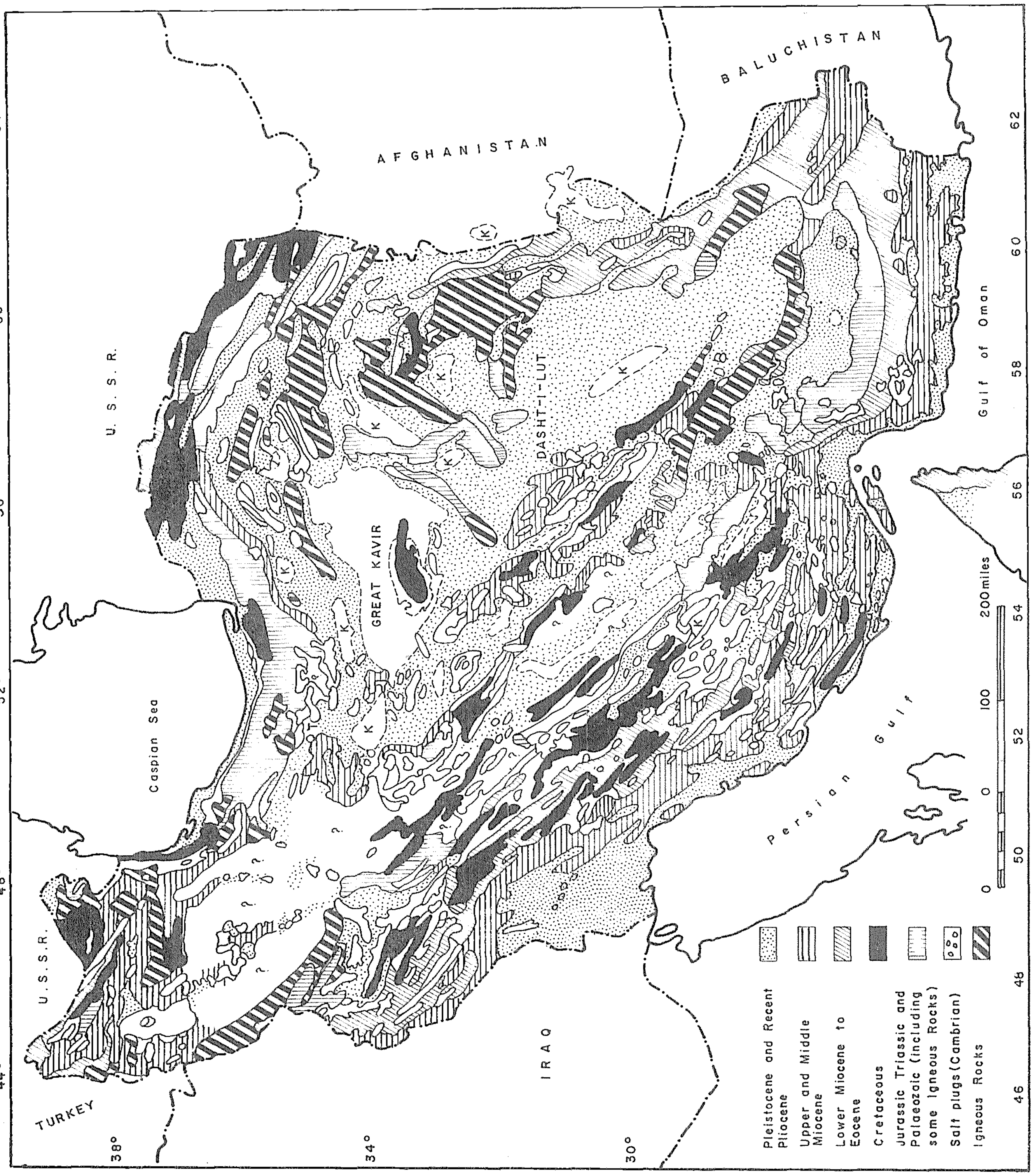
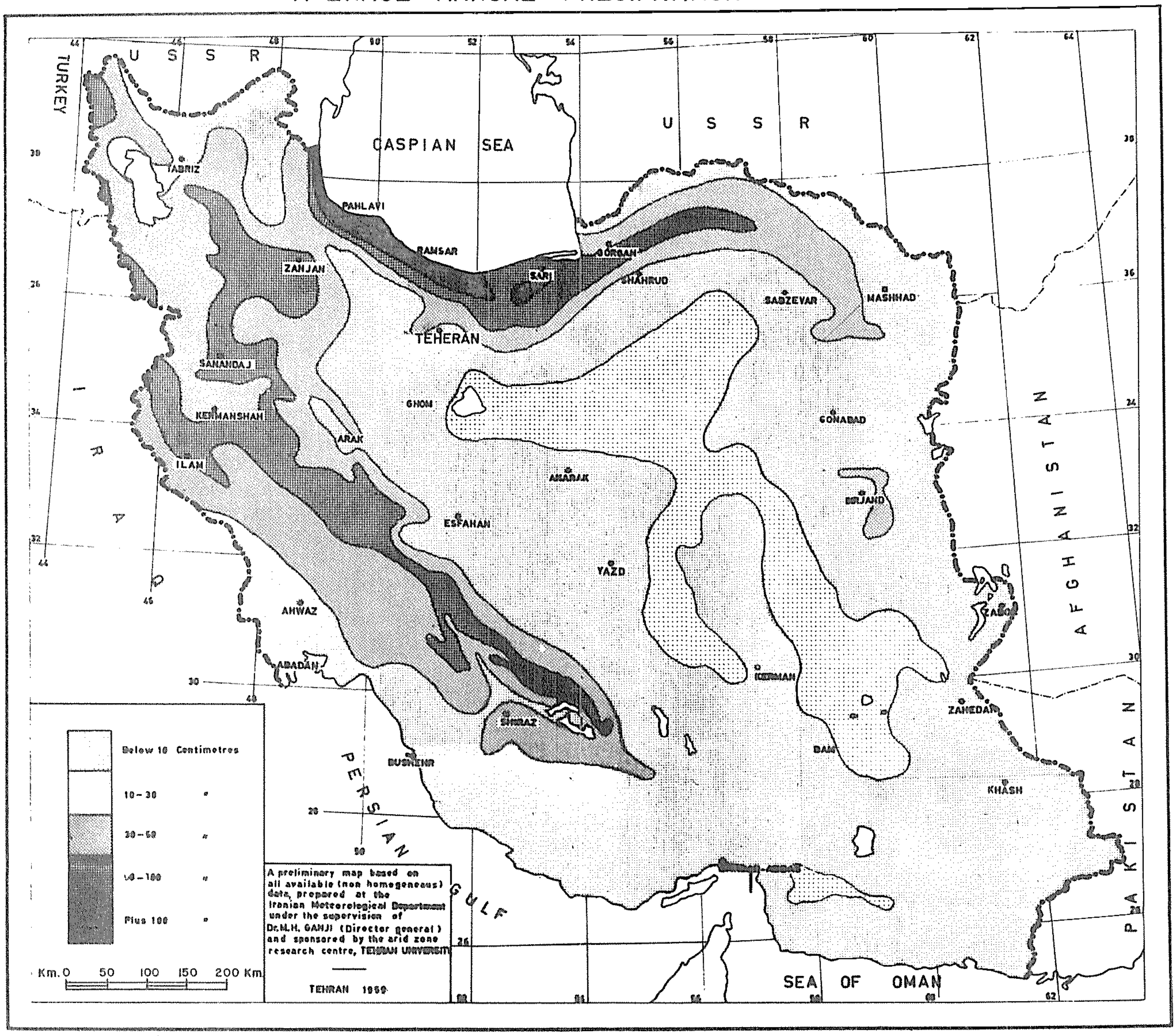
U.S.S.R.
TURKEY
IRAQ
AFGHANISTAN
PAKISTAN
CASPIAN SEA
PERSIAN GULF
SEA of OMAN
TABRIZ SS. L.
ARDABIL Ss.
REZAIYEH S.L.
MARAGHEH S
RASHT S. L.
GHAZVIN S.
BABOL S.
GURGAN Ll.
TEHRAN S. L. SS.
MASHHAD SS. S. L.
NEYSHABOUR S.
TORBATHEYDARIEH S.
KERMANSHAH Ss. Ll.
BORUJERD SS. S.
ESFAHAN S. Ll.
RAFSENJAN S. SS.
KERMAN Ll.
SHIRAZ S. L. SS.
FASA S.
BAM S
BANDAR ABBAS Ss.
SCALE
0 100 200 300 400 500 km
L. EXISTING REGIONAL LABORATORY
Ll. PROPOSED " "
S EXISTING FIELD STATION
Ss. PROPOSED " "
SS PROPOSED SOIL SURVEY PARTY
PILOT PROJECT AREA


AFGHANISTAN
BALUCHISTAN
U. S. S. R.
Caspian Sea
TURKEY
IRAQ
Persian Gulf
Gulf of Oman
GREAT KAVIR
DASHT-I-LUT
0 100 200 miles
Pleistocene and Recent Pliocene
Upper and Middle Miocene
Lower Miocene to Eocene
Cretaceous
Jurassic Triassic and Palaeozoic (including some Igneous Rocks)
Salt plugs (Cambrian)
Igneous Rocks

AVERAGE ANNUAL PRECIPITATION IN IRAN



1.4. Soils

In 1964, M.L. Dewan and J. Famouri published a systematic classification of Iranian soils. They divide the country into four physiographic zones: (a) plains and valleys (30.5 million ha); (b) Plateau (47 million ha); Caspian Piedmont (350,000 ha); and (d) dissected slopes and mountains (86.2 million ha).

Each zone is in turn subdivided into soil associations. These are groupings of geographically associated soil units which broadly correspond with climatic and physiographic units. They form the most suitable mapping units for the soil map of Iran (1:2,500,000) and each is named after a dominant soil within the group.

In the plains and valleys, the main associations are the fine and coarse-textured Alluvial soils, the Colluvial and Humic Gley soils and their saline phases. On the Plateau over 80 percent are the Brown, Chestnut, Desert and Sierozem associations. The dominant soils in the Caspian Piedmont are associations of Brown Forest soils, including the Grey Podzolic soils. The slopes and mountains mainly consist of Lithosols; as a rule, they are calcareous with odd pockets of Rendzinas and Brown or Yellow Podzolics.

About three quarters of the total agricultural area are spread in roughly equal proportions over the soil associations of the plains and valleys and the Plateau. Irrigated agriculture is concentrated chiefly in the associations of the plains and valleys, and particularly in the fine textured alluvial soils, which cover 23 percent of the total cropped area. In the Caspian littoral 55 percent of the total cropped soils are fine textured Alluvial soils (nearly seven percent of all Alluvial soils in Iran) and 21 percent are Brown Forest soils of the Caspian Piedmont. Dry farming with its wheat-fallow system is mainly restricted to the Brown and Chestnut soils, which cover 38 percent of the total cropped area.

The soil map of Iran (see map at the end of Volume II) shows clearly that the main agricultural areas are on fine textured alluvial soils. The Project distributed most of its irrigated and rainfed trials over them in all its field stations, apart from Gorgan. Its dry farming trials were mainly on the Brown and Chestnut soils of the Plateau. The trials in Gorgan were on the Brown Forest and Grey-Brown Podzolic associations which, when cleared of forests, are intensively cultivated. Iranian farmers have always recognized the value of alluvial soils, and their major crops are grown on them. They are the most important agricultural soils of Iran. They are composed of relatively recent sediments and derived from parent materials which are dominantly calcareous. They have little or no profile development. The layers of alluvial deposition, however, are often clearly defined by their differences in texture, depth and colour. They are normally free of salt.

The capacity of an alluvial soil to produce a crop ranges from a low level to a very high one. The initial yield of irrigated wheat, for example, can vary from as little as 700 kg/ha to more than 3,000 kg/ha as trials have shown. Most alluvial soils are fine-textured clays, silty clays, clay loams or silty clay loams, and they have a slow internal drainage. Almost all are high in free calcium carbonate (30-40 percent) and potassium (200-400 ppm) with a pH varying from 7.5 to 8.0. The content of available phosphorus (2-10 ppm), of nitrogen and of organic matter (less than 2 percent), is low to very low.

On the alluvial deposits in the Caspian littoral, most of the cultivated fields extend over bottom land and levee sites.

The bottom land soils are found on the low-lying flat areas between the rivers or between former river beds. They often have a high (perched) water table which produces a gley horizon and a heavy mottled zone in the profile. The texture throughout the profile is a silty clay loam to silty clay. In the western part of the Caspian Piedmont, most bottom soils are used for growing rice. In the eastern part, however, they are often used for wheat, barley and cotton.

Levee soils are found in bands alongside rivers and on the ridges of the smaller water courses. Their texture is moderately fine; as a rule, it is silty loam to silty clay loam. The water table is normally low and more than 150 cm, but it becomes shallower towards the foot of the levees. These soils are used for a number of crops. The most important are tea, citrus, kenaf, tobacco and cotton.

Brown, Chestnut, Desert and Sierozem soils are the other major soil associations on which crops are planted. They have a great importance in Iran's dry farming belts and, next to Alluvial soils, they are the most productive. They are used almost entirely for the small grain-fallow system. Wheat is the main crop grown on them, but small and relatively unimportant areas are planted with barley.

These soils are medium to very deep and moderately permeable, and a low rainfall of 200 to 300 mm limits their productivity. In their chemical composition they are similar to Alluvial soils. They are very low in available phosphorus and organic matter, but mostly high in exchangeable potassium. They all contain plentiful to excessive amounts of calcium, with 30 to 50 percent as carbonates. None the less, moderate yields of small grains are produced when there is enough moisture.

The chief causes deterioration in irrigated land are salinity, alkalinity and water logging. Parent materials are often already rich in salts, and the low rainfall prevents them from being leached out of the soil, which remains salty. In areas with a high ground water table, the capillary rise of the ground water with its dissolved salts often creates a salinity which no crop can endure. There are often similar effect when, in a period of water scarcity, irrigation is too scanty.

1.5 Vegetation

The Caspian region has a mixed flora of salt marsh and fresh water plants. Thick forests - chiefly of witch-hazel (Parrotia persica), oak (Quercus castaneifolia), and hornbeam (Carpinus betulus) - cover the lower zone of the northern slopes of the Elborz mountains. By contrast, the vegetation on their drier southern slopes consists of various herbs as low shrubs, and there are no trees, apart from junipers, willows and poplars along some water courses. Trees on the lower slopes of the Zagros mountains are the remnants of former forests and are chiefly oak shrubs. In town and villages, poplars, willows and occasional plane trees are planted along water courses. The flora in the interior basin is chiefly halophytes and xerophytes. Brackish water produces a salt-marsh vegetation. Large desert areas are without plant life.

2. AGRICULTURE

2.1 Land use

Although the total area of Iran is estimated to be 165 million ha, only about 11 percent, or 18.5 million ha, is cultivated. Moreover, only about one third of the cultivated area - 6.1 million ha, or 3.7 percent of Iran's total surface - is under cultivation in any one year. Each year about 2.5 million ha, including orchards, are irrigated.

In Iran, in fact, agriculture has an oasis-like character, and small areas of land are cultivated round widely scattered villages. As wheat and barley together cover more than three quarters of the total area under crops, all other crops are cultivated on slightly more than 1 million ha. Table II-1 shows an estimate of land use in 1960.

TABLE II-1: ESTIMATED UTILIZATION OF THE LAND SURFACE IN 1960

Utilization		Area (in 1,000 ha)	Percentage (total)
Crops			
Irrigated crops	2,300		0.1
Irrigated fruits and nuts	200		1.4
Nonirrigated crops	3,600		2.2
Under crops (incl. orchards)		6,100	3.7
Fallow (in crop rotation)		12,400	7.5
Total cropped area (incl. fallow		18,500	11.2
Permanent pastures	10,000		6.1
Forest and woodland	19,000		11.5
Potentially arable, not used	20,000		12.2
Potentially pastures, not used	11,000		6.7
Waste-lands, deserts, mountains	86,000		52.3
Total uncropped land		146,000	88.8
Grand total		164,500	100.00

2.2. Cropping system

Iran's cropping system has scarcely changed over the centuries. With one important exception it is similar to the Mediterranean system. It devotes the greatest possible area to wheat (of which one third is irrigated) mainly as a winter crop. Where the rainfall is marginal, 250 mm and less, wheat is replaced by barley, which is mostly dry farmed. Even where barley is irrigated, water supplies are often withdrawn in favour of other crops. The remaining area is devoted to other crops, mostly grown in the Summer. Apart from rice, they are mainly cash crops; only a few are fodder crops. These summer and winter crops rotate in a sequence interspersed by fallows.

Common irrigated rotations are: wheat - fallow (9 months) - summer crop - fallow (1 year) wheat, or wheat - fallow (9 months) - summer crop - wheat. Rice is almost exclusively grown in unbroken monoculture, interspersed by winter fallows.

The one important difference which distinguishes agriculture in Iran from that in the Mediterranean countries is the part played by irrigation. About 40 percent of the total cultivated area is based on irrigation. This percentage is much higher than in other countries and is due to the very marginal rainfall over vast areas. Dewan and Famouri have estimated that close on 40 million ha could be put under cultivation if irrigation water were available.

Cultivation in Iran can be divided into three classes according to the water supply: irrigated, rainfed and dry farming. Rainfed areas have an annual rainfall over 370 mm, and dry farming areas have less than 300 mm. Between them is an intermediary range from 300 to 370 mm, where the decisive factor is the actual distribution of the rainfall.

The standard of farming is still traditional. Most crops are sown broadcast. Levelling methods are poor. Water distribution is uneven and often wasteful. Before the land reform of 1962, the average farmer on the Plateau was a tenant farming about 2.5 to 3.5 ha, with perhaps a small orchard and 3 to 5 head of sheep or goats. His annual income was about 15,000 Rials, or US$ 200.

One major missing link in this system is animal husbandry, which has a paramount influence on efficient fertilizer use within the cropping system. Only a minor part of the rotation contributes to feeding animals (chiefly sheep and goats). Their manure usually takes the place of wood as fuel. Grazing is restricted to ranging in the dry land areas, and this denudes their vegetation. Thus yields of meat, milk and wool are low. The separation of arable farming and animal husbandry is typical of the traditional cropping system.

Fallow restores productivity. Under good conditions, nitrogen is built up by the decomposition of soil organic matter, however small, and by the action of certain soil micro-organisms which fix nitrogen from the air. Subsoil moisture is also built up by the absorption of rains when there is a clean weeded cultivation. For the fallow in the irrigated rotations this is less important.

The two restoring factors can be contradictory as well as interactive. If subsoil water storage is sufficient, supplies of soil nitrogen may not be enough to support satisfactory growth; supplemental nitrogen from outside sources is required. As a rule, small grain does not respond to nitrogen in areas with a rainfall less than 12 in. (300 mm). Between 12 and 15 in. (370 mm) nitrogen may be effective if rainfall distribution is favourable. Over 15 in. it is nearly always effective.

The effects depend very much on which crops preceded the grain. When grain follows grain, the response to nitrogen will be greater than when it follows a fallow. Dry land grain is very susceptible to outside factors, the level of initial fertility, soil moisture, and the total amount of the rainfall as well as its distribution.

Responses on irrigated land are less susceptible, and the amounts of fertilizer applied are higher than in dry or rainfed farming. In an irrigated rotation, the grain's response to fertilization is largely related to the preceding crop and fertilizer practices. When grain follows highly fertilized crops, it usually shows little or no response to additional fertilizer. This is because of the residual effects. When, however, it follows other cereals, responses to fertilizers, especially nitrogen, can be expected.

The present cropping system makes its heaviest demands on irrigation in the summer, when the rainfall is lowest. In the autumn, winter and spring, water supplies are much more satisfactory, but nearly everywhere wheat is the only crop on the ground, apart from barley and a late sugarbeet or alfalfa crop. Another crop for the winter period is needed to make use of the water surplus. A leguminous fodder crop might be considered.

Fodder crops are limited because grazing is mainly restricted to the dry land areas. Their production should be increased in these areas before they are actually introduced into the irrigated rotations; for this is practicable only if prices equal or exceed those of the main cash crops. This introduction is best achieved in the warmer areas of south Iran and in the Caspian region, where the winters are mild and where many cattle are found on communal grazing along road sides and depressions. An annual clover on the river levee soils may be considered. Bottom land soils, however, are undrained in winter.

There is an even stronger case for growing a leguminous food crop such as pulses. The average person's diet is based on bread. The daily calory intake is about 2,000 calories against a 3,000-3,200 per capita in industrialized countries. About 75 percent is absorbed through wheat flour and about 10 percent through sugar consumed with tea.

The intake has a strong bias towards the carbohydrates, and is low in proteins. The lack of fresh vegetables leads to a deficiency of vitamin A and, to a lesser extent, vitamin C. This lowers resistance to infectious diseases, particularly of the skin. Until meat becomes cheap, the best solution is to bring beans or peas mixed with wheat or rice into the daily diet. On the average, protein content varies from 20 to 25 percent in beans against 10 to 12 percent in wheat, and has a better quality. One disadvantage is that a leguminous food crop is cultivated in the summer. It then absorbs a part of the badly needed irrigation supplies needed for such higher priced cash crops as sugarbeet, cotton and melons. The farmer would not accept such a crop unless its price was higher than those of the cash crops.

2.3. Irrigation

Dry-farming and rainfed agriculture are possible only in the northwest and the Caspian region. Elsewhere the people must use other methods for obtaining their water. The scattered and isolated settlements on the Plateau depend on water tapped from the surface streams or from underground water supplies. Khorassan region has the largest irrigated area, 415,000 ha; and Kurdistan has the smallest, 40,000 ha.

Most villages on the Plateau still obtain their water from hand-dug wells, springs, rivers and qanats. Rice plantations in the Caspian region are nearly always irrigated by diverted river water. In general, the first irrigation is heavier than the next ones; with wheat for the first time a head of about 15 cm is applied, and in later irrigations only about 6 cm.

2.4. Land tenure and land reform

Before the land reform of 1962, the rural population consisted of (a) big landowners, numbering less than one percent, though owning 60 percent of the total cultivated area; (b) medium landowners, about 5 percent; (c) peasant proprietors, 10 to 15 percent; and (d) crop sharing tenants and landless labourers, who represented more than 80 percent of the peasant population.

The land reform has two stages. The first reduced all holdings to a maximum of one village; the second, when completed, will decrease holdings within a village by restricting their size according to their location and crop. Thus the maximum holding by any person in Gilan and on all rice plantations will be 30 ha. On the Plateau, the holding will depend on the local situation and may vary from 100 to 200 ha. Hitherto the crop sharing tenant had no incentive to spend on fertilizers or other improvements. Now he can benefit directly from extra yields and profits.

2.5. Farmers' co-operatives

The land reform also sanctioned the farmers' co-operatives. In September 1965, they amounted to 5,382 and had a membership of about 750,000, or an average of 140 members for each co-operative. All can give short-term loans to their members and the majority can supply improved seeds, fertilizers and insecticides. In 1964, farmers contributed about $ 8,000,000, or about $ 10 per member, to their societies. The Agricultural Bank gives loans to each co-operative equal to four times its capital.

2.6. Agriculture in the national economy

The gross national product was calculated to be (in thousand millions) in 1958, US$ 3.3; in 1959, US$ 3.8; in 1960, US$ 3.9; and in 1961, US$ 4.0.

Agriculture's contribution was estimated at 26.5 percent or US$ 1,000 millions in 1961. As about 65-70 percent of the people derive their incomes from agriculture, the differences in income between the rural and urban population are marked.

Table II-2: COMPARISON OF AGRICULTURE'S CONTRIBUTION TO THE NATIONAL INCOME

Commodities	Amounts in US$ millions	Percentages
Grains and cereals	340	32.5
Animal products	290	27.4
Fruits	230	21.3
Industrial raw material	80	8.2
Vegetables	50	4.6
Poultry	34	3.3
Forestry	19	1.9
Spices	2	0.2

Cereals, fruits and vegetables, all directly responsive to fertilizers, comprise 59 percent of the agricultural contribution. In 1961, they contributed US$ 620 millions with scarcely any assistance from fertilizers. Properly fertilized, their contribution might be very greatly increased. Even one percent increase in their yields would contribute US$ 6.2 millions to the gross national product.

Exports of cotton and dried fruit brought in US$ 43.1 millions for 1962 and US$ 48.8 millions for 1963. During the same period food imports (cereals, tea and raw and refined sugar) amounted to US$ 22.2 for 1962 and US$ 30.1 millions for 1963. An overall increase of 4 percent in crop production would close the food import gap, or at least balance it financially.

3. FERTILIZERS

3.1 Consumption

The reason why the yearly cropped area in Iran is only about one third of the total cultivated land is because the traditional crop-fallow system still prevails. This system should change with a fuller use of fertilizers.

All fertilizer was imported until, in 1963, the new Shiraz factory started to produce urea and ammonium-nitrate. Since then, as Table II-3 shows, there has been a fairly large increase of fertilizer consumption.

Table II-3: SUMMARY OF ANNUAL FERTILIZER USE FROM 1955 TO 1965 (TONS)

Year	Imported	Manufactured (Shiraz)	Exported	Total consumption
1955-60	10,000	-	-	10,000
1960-61	36,145	-	-	36,145
1961-62	39,980	-	-	39,980
1962-63	47,306	-	-	47,306
1963-64	49,541	9,279	4,000	54,820
1964-65	47,541	23,661	14,000	57,202

Between 10 and 30 percent of the imported fertilizers were in the form of NPK compounds. Details are not available to calculate exactly the total separate imports of nitrogen, phosphorus and potassium. A close estimate, however, can be made for 1960-61. The 36,145 tons of imported fertilizer contained approximately 7,600 tons of nitrogen, 4,300 tons of P_2O_5 and 1,500 tons of K_2O.

Estimates on the 1960 Census figures give the fertilized area as 1,103,192 ha., or 17 percent of the total crop area. When these figures are combined, it appears that even the fertilized land received only: 7 kg/ha of N; 4 kg/ha of P_2O_5; 1.5 kg/ha of K_2O. At a rough estimate, a yield increase of about 5 percent would be expected from these rates. Over the 17 percent of the area fertilized, this would amount to less than 1 percent increase in overall production.

3.2 Imports

Fertilizers are imported by the Chemical Bongah - an independent Governmental organization - and, in larger amounts, by six commercial firms.

Table II-4: COMPARISON OF FERTILIZER IMPORTS BY PRIVATE FIRMS AND CHEMICAL BONGAH

	1961	1962	1963	1964
Private firms	26,230	36,106	31,527	29,091
Chemical Bongah	13,750	11,200	18,014	18,450
Total	39,980	47,306	49,541	47,541

Before the factory in Shiraz started making urea and ammonium-nitrate, about 30 kinds of different fertilizers were imported every year. This large variety was confusing alike to farmers and merchants. After 1964, however, the number was greatly reduced. In 1964 only the following straight and mixed fertilizers were imported:

Ammonium sulphate	3,500 tons
Triple superphosphate	12,669 tons
Di-ammonium phosphate	11,043 tons
Potassium sulphate	1,075 tons
20-20-0	7,980 tons
N-P-K mixtures	11,274 tons
Total	47,541 tons

The import of N-P-K mixtures increased from 3,022 tons (1960-61) to 11,274 tons during 1964. A recent import regulation stipulating the minimum content of N at 10 percent and P_2O_5 at 15 percent, the maximum content of K_2O at 10 percent and a minimum total of 40 percent, has greatly limited the number of different compounds. Private firms can import fertilizers only if they adhere to the regulations made by the Chemical Bongah.

3.3. Distribution

Fertilizers, imported or manufactured in Iran, are distributed by: (a) the Chemical Bongah; (b) the State Tobacco Monopoly, the Tea Organization and the National Sugarbeet Organization; (c) the farmer's co-operatives and (d) private firms.

Private firms have about 150-200 agents throughout the country. The Chemical Bongah has 400 agents as well as 250 within the newly created farmer's co-operatives. The organizations mentioned under (b) often distribute fertilizers together with improved seed or plant material and insecticides. All organizations offer credit facilities.

Urea and ammonium-nitrate, the two fertilizers manufactured in Iran, are distributed to the co-operatives in the provinces according to the distance from the Shiraz-based factory and the region's relative humidity. Urea, which contains about 46 percent N, is a much more concentrated product than ammonium-nitrate and is allocated for areas far from Shiraz, so as to reduce transport costs. The high hygroscopicity of ammonium-nitrate forbids its use in the humid Caspian region. Thus its provinces receive urea only. The distribution of nationally produced fertilizers through the co-operatives in each province is:

Urea	Ammonium-nitrate
Gilan	Central Province
Mazandaran and Gorgan	Esfahan
West Azerbaijan	Khorassan
East Azerbaijan	Fars
Kerman	Kurdestan
Baluchistan and Sistan	Kermanshah
Khuzistan	

Loans for fertilizers are given by the co-operatives in kind or in cash. When in kind, the amount is generally limited only by the area which the farmer can fertilize. When a short term-loan is granted, the maximum is 10,000 Rials, provided that at least 10 percent of the loan is used for fertilizers. The maximum duration of the loan is then an agricultural year with an interest charge of 6 percent.

During 1964, when the number of farmers' co-operatives increased from 2,251 to 4,367, about 8,000 tons of fertilizer were sold through the co-operatives to the farmers. Although this amount is small in comparison with the national fertilizer consumption of 57,000 tons, the expansion of the co-operative may greatly increase fertilizer consumption in future years. The fertilizer recommendations given by the co-operative personnel or the agents of the Chemical Bongah in the co-operatives are usually those which were prepared by the Project and distributed as leaflets.

CHAPTER III

ORGANIZATION OF WORK AND EXPERIMENTAL PROGRAM

1. PROJECT AREAS

Iran has two major and sharply contrasting ecological zones: the Plateau and the Caspian region. On the arid Plateau, crops are mostly irrigated. In the humid Caspian region apart from rice, they are mostly rainfed.

As a whole, agriculture is more advanced in the Caspian region than on the far larger Plateau and it has a greater importance for the country's economy. Inevitably both major ecological zones were represented in the Government's first selection of the agricultural areas to be studied under the Project.

Of the six field stations opened in 1961, the Project's first year, three were in the Caspian region and three in the Fars region, which is agriculturally one of the most important on the southern and warmer reaches of the Plateau.

The three field stations in the Caspian region were in Gilan, Mazandaran and Gorgan areas. Gilan and Mazandaran are Iran's rice granary. They also grow tea, citrus, tobacco and kenaf. Gorgan produces about 30 percent of all the cotton grown in Iran. It has also many large farms on which modern farming methods are used. Except for drilling, almost all wheat operations are mechanized.

The three field stations in the Fars region were in Shiraz, Fassa and Kazerun. Shiraz, which is the region's main sugarbeet area, has a very favourable climate and a long record of irrigated agriculture. Its selection may have been also influenced by the eventual establishment, in 1963, of Iran's first fertilizer factory.

Fassa produces sugarbeet and is the chief citrus-growing area in southern Iran. Kazerun was selected because there was an irrigation project in the area. Its agricultural potential, however, is very limited, and in 1963 it was made a substation under Shiraz. Esfahan, in the central region, then took its place as a full field station.

Esfahan, where cropping is often intensive, has the highest standard of farming on the Plateau. It produces, rice, sugarbeet, cotton, melons and onions as well as the standard wheat crop.

According to the Plan of Operations, three field stations were to have been opened in the Azerbaijan Province in 1963, but the Project recommended that only two stations - Rezayeh and Maragheh - should be opened. At the Government's invitation, however, a third field station was opened in the same year in Ghazvin, where large development plans had been started after a serious earthquake. Azerbaijan is one of the colder regions of northwest Iran, where the summers are short and the winters severe. Its products include grapes and potatoes, and dry farming wheat is more extensively cultivated than elsewhere in the country.

In 1964, the Government invited the Project to take a step not anticipated in the Plan of Operation by extending its activities to the Khorassan region, where climatic conditions are similar to those of the Azerbaijan region and where 50 percent of Iran's sugarbeets are grown as well as most of its deciduous fruit.

The three areas opened in this region were Mashad, Neyshabur and Torbat-e-Heydarieh. Mashad produces melons and sugarbeet. Neyshabur is its chief cotton-growing area. Torbat-e-Heydarieh is another sugarbeet centre.

In 1965, the Project's last year, two stations opened in the coastal province of Kerman. Though Kerman has a low standard of farming and little agricultural importance, it produces pistachio and dates. The two stations selected were Bam as the chief inland date centre, and Rafsanjan as the pistachio centre.

The original proposal to select a third station on the coast was abandoned largely through the lack of road communications. Instead, and at the Government's suggestion, a third station was opened in the Lorestan region, in western Iran, where wheat dry farming is practiced on a large scale.

According to the Plan of Operation, the Project should have ended with 12 field stations opened. The total number opened was, in fact, 15.

The Project's field stations and substations are listed in Appendix I together with their main areas of crops under cultivation. This Appendix also includes a table which shows the altitude, mean annual rainfall and mean January and July temperatures of each field station.

2. MAIN CROPS

The areas studied under the Project represented a good cross-section of Iran's rainfed, irrigated and dry farming agriculture. They also gave the Project a suitably wide arena in which to make fertilizer experiments on Iran's main crops.

In 1961 the Project began its fertilizer experiments with six crops. From 1963 onwards, there was a move each year into new areas. The crops on which experiments were made gradually increased until, in the last summer season (1965), they numbered 18 and included nearly all the crops grown in Iran.

If the Project gave priority to wheat, this was not solely because it is the country's staple food or because its average annual consumption is 125 kg per head. It was also because Iran had been self-sufficient in wheat before 1939 and used even to export it. By 1964, however, the situation was so completely reversed that wheat imports totalled 900,000 tons and cost US$ 63.9 millions. The drain on foreign currency reserves is serious.

About one third of Iran's total area under wheat is irrigated; the other two-thirds are under rainfed wheat. In 1964, about 15 percent of the cultivated wheat consisted of improved varieties. The present target is to cover the entire area with improved varieties by the end of 1969. The farmer receives 6 Rials/kg.

Other main crops are:

Barley: This crop is planted over a much smaller area, about 1,200,000 ha, of which one quarter is irrigated. It gives a smaller return and profit than wheat. The farmer, who is paid 4 Rials/kg, gives barley fields a low priority when water is short.

Rice: Production rose from 709,362 tons in 1960 to 890,765 tons in 1964 (see Photo 5). This increase followed the building of a dam to control the waters of the Sefid-Rud river. Average consumption in Iran is about 30 kg per head per year, but in the Caspian region it may increase to as much as 150 kg. Two main types are grown - Champa (Oryza japonica) and Sadri (Oryza indica). The former has a maturity period varying from 100-165 days. The price of Champa paid to the farmer has varied from 7.0 to 7.7 Rials, while about 10 Rials/kg are paid for Sadri. Lower grade exports to the U.S.S.R. have totalled 30,000 tons.

Cotton: Since American varieties were introduced in the twenties, cotton has become Iran's most important cash crop (see Photo 6). In 1960, half the crop was irrigated. Of the rainfed cotton, 95 percent is grown in the Caspian region. It accounts for about 44 percent of the value of all Iranian experts other than mineral oil. In 1964, total production was 320,510 tons seed cotton.

Sugarbeet: Iran is well adapted for sugarbeet. Its production is rapidly expanding, although poor cultivation practices cause the yields to be low (see Photo 9). The production of sugar rose from 97,505 tons in 1960 to 141,809 tons in 1964. The average yield per ha is 14-15 tons. As about 300,000 tons of sugar are imported annually, there is a growing need to produce more sugar within Iran.

Tobacco: For a very long time, only the Turkish type of tobacco was grown in Iran. In 1962, however, a sudden outbreak of blue-mould (Peronospora tabacina) wiped out a great part of the crop in the more humid areas. The more resistant Burley type is now being planted. In 1960, about 28,000 ha were under tobacco, and of these, 20,000 ha received additional irrigations. In that year, the total production was about 16,000 tons. The produce is graded into twelve classes, each with its own price which varies from 25 to 87 Rials/kg flue cured leaf. There are no imports.

Citrus: The tree, which has been introduced into Iran (see Photo 8), is not well adapted to its environment. The quality of its fruit is poor, chiefly because the sugar acid ratio is not satisfactory. There are, however, prospects of improvements. Production in 1960 was estimated at 33,734 tons, or an average yield of 10 tons per ha. Good potential markets are in the U.S.S.R. and Afghanistan. An average price per kg is 15-20 Rials.

Tea: National consumption of tea is about 22,000 tons, of which 12,500 is home grown (see Photo 7). Tea is grown exclusively in the Gilan Province where it was originally introduced shortly after 1900. The Assam as well as the Chinese types are planted under conditions far from ideal for tea; half the precipitation falls in the non-growing period and the soils are not sufficiently acid. The total area (1964) is about 22,000 ha. The average yield per ha is 2,500 kg fresh leaves.

Grapes: The total area under vines was estimated in 1960 to be 80,000 ha, with an annual production of 350,000 tons. More than 30 varieties are grown; some for dessert fruit, some for drying (raisin), pickling or making wine (see Photo 10).

Dates: The present number of trees is estimated at 21 millions, and the production in 1962 was 325,000 tons, of which about 20,000 tons were exported at a value of US$ 1,200,000. Dates are a staple food in the Persian Gulf region.

Melons and watermelons: Of the 130,000 ha cultivated in 1960 with melons, watermelons and cantaloupes, 80,000 ha were nonirrigated. Their yields are about 8-10 tons/ha. Under irrigation, yields are 10-16 tons/ha. In many places they are the main source of the farmer's cash income (see Photos 2 and 3).

Pistachio: The cultivation is very old in Iran, and large tracts are under a natural vegetation of wild species. The only species actually cultivated is Pistacia vera, chiefly in Rafsajan (Kerman), where almost all groves are irrigated. Total production in 1961 was 7,600 tons, harvested from an estimated number of 12,200,000 trees of which about half are fruit bearing and the other half are young trees. About half the annual crop is exported, mainly to the USA, at a value of US$ 3,400,000.

Other crops: Alfalfa, onions, lettuce, kenaf and potatoes were included in the experimental program. Many different types of fruits are produced in Iran. Among the less hardy ones are peaches, nectarines, figs and pomegranates. The hardy are pears, medlars, plums, quinces and apples. Nuts include almonds, walnuts and hazelnuts. Olives are grown solely in a very restricted area in the Elborz mountains.

Winter crops comprise wheat and barley, although a small percentage of the land under them is planed with a spring crop and, more as an exception than as the rule, sugarbeet is grown in the winter in some hot southern areas. Among the greater assortment of crops grown in the summer, eight were chosen for experiments: cotton, sugarbeet, rice, tobacco, kenaf, potatoes, melons and onions. The eight remaining crops are perennial: tea, alfalfa, grapes, citrus (oranges), deciduous fruits (apples and peaches), pistachio and date palm.

3. PRINCIPLES OF FIELD EXPERIMENTATION

As a term, "Soil Fertility Survey" can be narrowly or widely interpreted. When interpreted narrowly, it means a survey of initial soil fertility. It involves taking sample cuts from unfertilized fields which have been selected at random and are, perhaps, grouped according to soil units. The data which it provides can be used for various purposes: for example, assessing the production of an area and the tax to be imposed.

A soil fertility survey is given a wider interpretation when it is used for estimating the increase in an area's production which can result from applying fertilizers. The information may even be a basis for agricultural development plans.

Until recently there was a tendency to carry out soil fertility investigations only on experimental farms. This approach has great disadvantages. Experimental farms are widely separated from each other and often do not represent the real conditions of the large area which is under survey.

The location for an experimental farm is often selected for reasons other than the physiographic conditions of the area which it serves; for example, its proximity to a town, road, railway or river. Moreover, the soils of experimental farms have usually been more efficiently managed. In consequence, their soils have a higher fertility than those of the surrounding farms.

A new approach was developed in India by Drs. Stewart and Crowther. They shifted investigations to the ordinary farm where the controlled conditions of an experimental farm do not exist.

The principle of this new approach was (a) first to establish economic rates of fertilizer applications in farmers' fields for the major food crops; (b) then to extend them to cash crops; and (c) to assess their economic results rather than, as hitherto, only their yield effects. It fertilizers were universally applied, this new approach could also provide a true estimate of the increase of food production.

Briefly, the new approach can (a) establish the kinds of fertilizers and their rates of application needed for farmers' fields to secure substantial increases in yield and (b) ensure at the same time a safe return of the money invested in the fertilizers under many different conditions. It involves a network of trials in a particular area distributing single replications over a number of randomized sites. Together the single replications form one large area-wide experiment.

The area-wide average then comes as near as possible to the true average of the area. The average density is one replication to every 1,000 ha. per season.

3.1. Experimental procedures.

First come fertilizer rates trials. They are repeated for several years to assess seasonal variations and to estimate the economic rates of fertilizer application. There are also nitrogen and phosphorus carrier comparisons for selecting the right types of fertilizers. Later come demonstrations to show farmers what are the actual rates and types which have been recommended.

Before an experimental season begins, its program is sent to the engineer in charge together with a list of random selected villages. The sites are selected from 1:50,000 semi-detailed soil maps (or a geographical map) with a randomized allocation within each soil series. Wherever information is scarce, questionnaires are prepared for the owners of the chosen sites. Their information helps to assess the potential crop production if fertilizers are applied on an area-wide basis.

Information contained in standard field sheets on the agricultural practices of each chosen site also helps to interpret the experimental results. They include data on variety, soil types, planting and harvesting dates, numbers and dates of irrigations and pickings, cropping and manuring history, flowering dates, pests and diseases. All these investigations are conducted under actual farming conditions.

The number of trials laid out influences the degree of precision. A minimum number of 12 trials is needed for most, but not all, crops under irrigation, and 16 under dry farming.

3.2. Economic aspects of experimental results. 1/

The profitability of using fertilizers and the rate of application depend very much on: (a) the expected increase in output from each increment in fertilizers applied; (b) the price of the crop; (c) the cost of the fertilizers and their application; (d) the additional cost of harvesting and marketing the larger crop; and (e) the residual value of the fertilizers applied.

Before results from the field can be expressed in economic terms, the response to fertilizer for each treatment must be established. This is done by taking the difference between the treatment and the control yields and multiplying each response by the price paid to the farmer. From this value, the costs of the fertilizers are subtracted. The remainder is considered to be the farmer's gross profit.

The ordinary farmer in Iran does his own transporting of the fertilizers and the increased produce. No extra costs are involved. It is unlikely, to say the least, that the time which he takes to transport and apply the fertilizer could be used in a more remunerative way. What is strictly gross profit is reckoned to be net profit.

For estimating the return, the value of the yield increase (yield response x price of the crop) is divided by the costs of fertilizers and multiplied by 100. This return expresses the number of units received for every 100 units invested. A return of 150 for every 100 units means, in fact, an interest of 50 percent.

1/ For experimental designs and field technique and for a full interpretation of the economic data derived from the Project trials, see Volume II, Chapter III.

3.3. Recommended fertilizer rates.

Throughout this Report, the recommended rates of fertilizers are :

(a) the high monetary return rate, the HMR rate
(b) the maximum profit rate, the MP rate

The high monetary return rate, hereafter called the HMR rate, is that rate of fertilizer which gives a high return on the money invested in the purchase of fertilizers. It should ensure (a) a significant yield response and (b) a minimum return of 150 units on the money invested, even when conditions are not favourable.

Its universal application under different conditions of climate or soil makes it a safe investment for a farmer who uses fertilizers for the first time and has only very limited credit facilities. The rate is low enough to be safe.

The maximum profit rate, hereafter called the MP rate, is that rate of fertilizer which gives the highest profit per ha. It is higher and much more fluid than the HMR rate. It is more sensitive to such influences on growth as water, pests and diseases, plant population. Thus it may vary from season to season, but where conditions under the farmer's control are favourable, more substantial profits can be made than with the HMR rate. This MP rate, to which greater risks are attached, is more suited for the financially stronger farmers (a minority in a developing country) who can afford a higher standard of farming and who have often used fertilizers before.

The MP rate can be established (a) by response curves, and (b) by fitting a three dimensional profit surface through a series of points. Both estimations are extensively used in the following chapters.

Full details of response curves are given in Volume II, Chapter III. Briefly, it can be said that if increasing doses of fertilizer are applied, the additional crop yield increases by at first rising proportionately to the amount of fertilizer used. Eventually, however, the yield increases begin to decline when further quantities of fertilizer are applied. Thus doubling the fertilizer rate does not normally double the yield increase. Heavy doses of fertilizer can actually decrease crop yields.

This response to increasing rates of fertilizer can be drawn as a curve which at first rises steeply, then gradually flattens out to reach a crest, and then begins to fall. From the response curves it is mathematically possible to establish the rate of one fertilizer which gives a maximum profit. There are, however, instances when too light a fertilizers dressing may produce no response, or else a very slight one.

Similarly, where two fertilizers are applied together, it is possible to estimate a combination of rates which gives the maximum profit. This, however, is done solely by means of the three dimensional profit surface, which is obtained by plotting profit response curves in the three dimensional space.

4. EVOLUTION OF THE PROGRAM

4.1. Types of experiments.

In the introduction to this Report, the Project was a direct consequence of the encouraging results obtained by the Khuzistan Development Service. The experience gained by that Service greatly influenced the Project's programming in its first two years. This applied especially to experimental procedure, types of design and rates of fertilizers

Development along the lines laid down by the Khuzistan Development Service continued until the Project's third season (summer 1962), when a particular 12-plot design was introduced. It was composed of two parts. One part included nine treatments of all possible combinations between nitrogen and phosphorus, each at three levels. The other part included three extra treatments with the first level of potash.

The object was to study the response curves and response surfaces for N and P and the linear effects for K. All these twelve treatments were laid out in one compact block in a farmer's field, where they formed a single replication of an area-wide experiment.

This design was very successful and apart from a few modifications for individual crops, it became the Project's standard fertilizer rates design. After a few years of experimentation with the design and after obtaining ample information on the economic suitability of rates and types of fertilizers for certain crops, the time came for introducing the demonstrations. The first were with wheat. They began during the fourth season (winter 1962-63).

Meanwhile, in the second season (winter 1961-62) nitrogen carrier comparisons had been introduced to establish which carriers were the most suitable for the different regions. For the next three years they formed a recurring part of the program. These trials gave consistent results. It became unnecessary therefore to continue them after the seventh season (summer 1964).

In the fourth season (winter 1962-63), phosphorus carrier comparisons were introduced. They were continuing even after the end of the Project period because carrier trials of this type are not completed until the residual effect have been studied for at least two seasons.

Variety comparison trials were introduced at a very early stage. At first they were concerned exclusively with wheat and compared the local nonimproved with the improved types, especially those in the Eastern Caspian Region. The Project used its standard fertilizer rates design for these investigations.

At an early stage, too, a few residual effect trials were started and continued throughout the remaining period. They were important because investigations into fertilizer application cannot be completed without assessing the residual effects. Unfortunately, the rotational system in Iran makes it very difficult to investigate residual effects, except in a few areas. As most crops in Iran are still interspersed with fallows, it was always difficult for the Project's team to find the desired crop sequence without fallows. For example, if wheat immediately followed cotton - or possibly sugarbeet - which had received fertilizers, it would benefit from the residual effects.

Although the good fertilizer rates design found and adopted by the Project will remain basic for some years to come, it has its own evolution. With wheat, for example, its successful use indicated that investigations should concentrate more on the range 30 to 60 kg nutrients/ha. The special purpose design made it possible to introduce an intermediate rate. Crops like tobacco, tea and alfalfa, have some particular requirements. Separate fertilizer rates designs, therefore, were made for them.

The program was never intended to be rigid, and it will change with the years. This is indicated by the changing proportions between fertilizer rates trials and demonstrations. It is also shown by the data given in Table 2 of Appendix 2 which enumerates the trials conducted during the Project period and tabulates them according to the types of experiment and areas.

4.2. Range of crops.

The large number and scope of the Project's experiments on crops are clearly indicated in two tables given in Tables 1 and 3 in Appendix 2. The first summarizes the experiments with crops in the separate regions and shows their planting and harvesting times. The second shows the numbers of experiments for each crop during each of the Project's nine seasons.

Out of a total of 8,812 trials recorded, not less than 6,917, or 78.5 percent, were harvested. This table does not include the trials which were planted for the winter season 1965-66 and numbered about 1,500. Altogether the Project's trials amounted to more than 10,000.

Wheat, barley, rice and the two main cash crops, cotton and sugarbeet, accounted for about 85 percent of the experimental program. As wheat and barley, which account for 40 percent, are the only winter season crops, the full seasonal program was available for them.

Table 3 of Appendix 2 also shows a gradual shift from the main food and cash crops to fruit trees, vegetables and annual fruits.

For most crops the principles of field experimentation are the same. They are subject to the same sources of variation but there are differences in degree. For example, rice and cotton are contrasts. Rice, unlike cotton, is almost continuously irrigated. This has both a regularizing effect on seasonal variation and a blanketing effect on soil differences within the experimental plot. Under these conditions, transplanting and full survival of young plants ensure a uniform plant population. The only threats to a low variation in the results are human influence, pests and diseases.

In Iran, experimentation with cotton is subject to a greater degree of variation. Irrigation is often inadequate. After emerging from the hard crust of the surface soil, which destroys many germinating plants, the survivors are weakened and become more susceptible to pests and diseases. Even where pests and diseases are controlled, such other factors as an erratic plant population still have an adverse influence on variation.

Thus results are much less varied with rice than with cotton, which requires repeated experimentation over a longer period as well as a larger harvest area per plot. Here comparison of the co-efficient of variation of both crops is a good indicator.

Wheat and sugarbeet have an intermediary position between rice and cotton.

Apart from a proper selection of experimental sites, a major contributor to a low variation is a uniform plant population. It changes overall variation very much for the better.

Another source of variation is introduced when tests are made on quality as well as quantity. A good example is tobacco. Its yield increases due to applying fertilizers are relatively unimportant, but the influence on quality, particularly on the shift into higher grades, has a paramount importance. This, when added to the influence of yield, increases overall variation.

Where trials are numerous, a special study can be made of the variation sources, and particularly the systematic ones. Thus there were special studies of variations with wheat due to differences in the numbers of irrigations, varieties, planting times, times of fertilizer applications, and influences of control yields.

Many trials are needed because other variation factors must also be uniform if estimations are to be made possible. Chief among them is the influence of enough water. With wheat, for example, experiments with less than four irrigations have to be eliminated. This greatly reduces the workable number of trials.

5. LABORATORY WORK

During the Project's three first years all soil samples from the field experiments were analysed at the Central Soils Laboratory in Teheran. Later, four separate field laboratories were opened in important agricultural centres.

In 1964, one field laboratory was opened in Shiraz for the arid zone, and another in Rasht for the humid Caspian region. Later, a third laboratory was opened in Khorassan's capital, Mashad. In 1965 and at the Ministry of Agriculture's request, a fourth laboratory was established in Rezayeh, in West Azerbaijan.

The northern field laboratory in Rasht is situated 350 km away from the Central Laboratory. The western, southern and eastern field laboratories are each about 1,000 km distant from Teheran.

Large amounts of money and efforts are now saved by doing the soil testing locally. Each laboratory was housed in the building of the provincial field station, which is well known to extension and farmers, and from which the field trials work was handled. Thus each field laboratory served as powerful propaganda for modern views on farming.

All four laboratories were identically equipped. Instruments were supplied by the Special Fund. Glassware and chemicals were bought, and all the laboratory furniture and installations were made, locally. The program of work and type of chemical analyses done on soil samples from field experiments were similar to those used in the Khuzistan Fertilizer Project.

5.1 Routine tests.

A simple program of routine tests, scheduled to be run on samples from all the fertilizer experiments, consisted of the following chemical analyses: (a) pH; (b) saturation percentage; (c) electric conductivity; (d) organic matter; (e) available phosphorus; (f) exchangeable potassium; (g) calcium carbonate equivalent (only in Shiraz laboratory). The applicability of the methods chosen was systematically examined at the Central Soils Laboratory during 1958 to 1961. It was described in detail in the FAO Report no. 1287, "The Development of Soil and Water Analyses" to the Government of Iran by J.M. Dewis. After installing laboratories and training the new staff, actual soil testing work started in the provinces in May 1964. By the end of June 1965, all four laboratories were in operation.

Fruit testings on citrus were carried out in Rasht and Shiraz. The fruit originated from the Project's fertilizer tests. This was done to determine fertilizer effects on the quality of the citrus fruit.

The following determinations were made on samples of 10 fruits per fertilizer treatments (a) colour and texture of the skin; (b) diameter of the fruit and skin thickness; (c) juice percentage; (d) citric acid content of juice; (e) ascorbic acid content (vitamin C) of juice; and (f) sugar content of juice.

The annual number of analysed soil samples increased from 1,223 in 1961 to 2,943 in 1965 (1 Figure).

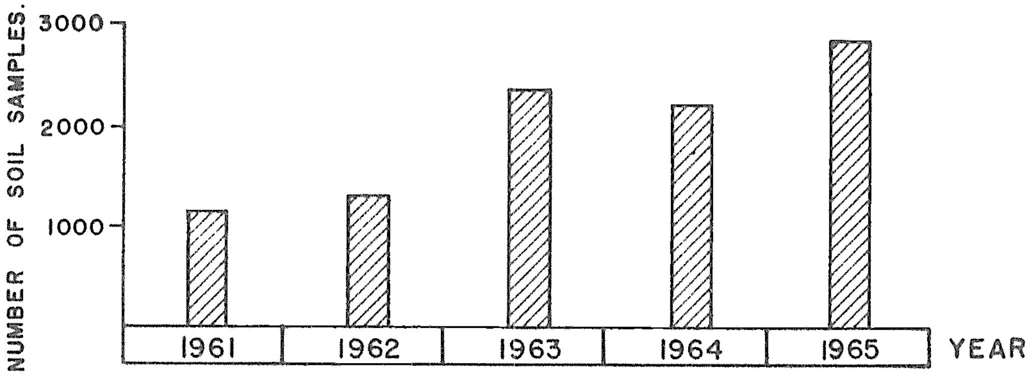


Figure 1: Analysed number of soil samples

5.2 Main chemical characteristics of soils. 3/

Plateau soils under wheat, cotton, and sugarbeet were very similar. Under other crops, such as rice, melon, or fruit trees, the chemical characteristics varied according to the crops grown. It is not known yet whether the soils were specially selected to suit the requirements of the crops or whether the crops and the practices involved in growing them influenced the chemical characteristics of the soils.

Table III-1: AVERAGE CHEMICAL SOILS DATA OF THE PLATEAU AREAS

Area	Number of analyses	Saturation percentage	pH	Conductivity mmhos/cm	Organic carbon%	P ppm	K ppm
Shiraz	197	-	7.5	1.81	1.03	21.8	505
Fassa (incl. Darab, Jahrum)	259	-	7.4	1.95	1.04	9.5	382
Kazerun	114	-	7.1	2.13	1.11	14.7	275
Esfahan	111	-	7.4	3.71	1.01	9.9	366
Maragheh	179	45.7	7.8	0.62	0.88	7.4	436
Rezayeh (incl. Shahpur)	171	39.0	8.0	0.77	0.97	8.9	425
Ghazvin	122	36.5	8.0	1.59	0.58	7.9	390
Mashad	167	32.8	7.8	1.99	0.86	8.1	201
Neyshabur	140	36.4	7.8	3.26	1.00	8.5	273
Torbat-e-Heydarieh	80	36.3	7.9	4.48	1.09	11.1	352
Mean	1,540	38.2	7.7	2.01	0.96	11.0	369

3/ The results of the soil analyses for the season 1964 and 1964-65, carried out in the field laboratories, are fully discussed in Volume II, Chapter V.

There is a little variation in soil texture on the Plateau. According to the association between saturation percentage and texture, as given by Jackson, the soils mainly consist of coarse textured silt loams. They are mostly of alluvial origin. The pH values range from neutral to alkaline with the highest values in the areas of Ghazvin and Rezayeh, where the pH reached an average of 8.0.

Only a limited number of soil samples with substantial salt content was found in all the Plateau areas. The salt content was determined by measuring the electrical conductivity of the saturated soil extract.

On the average, higher salt contents were found mainly in the areas of Torbat-e-Heydarieh, Esfahan, Neyshabur, and Kazerun. Here the yields of sensitive crops might be restricted by an excess of salt, but the soils under different crops were often different in their chemical characteristics. Most samples with a higher salt content were found under more salt-tolerant crops, such as rice and melon.

The content of organic carbon, on the average, was close to 1.0 percent C, which is equivalent to 1.7 percent of organic matter. A higher percentage of organic matter occurred only in rice soils, where its accumulation is favoured by waterlogged anaerobic conditions.

Comparing the analytical results of the cultivated Plateau soils, it seems that the organic matter content has adjusted itself on a level typical for climatic and cultural conditions. With long periods of drought and high temperatures typical of the Plateau areas, a higher level of organic matter in soil would probably be difficult to attain.

The average phosphorus content of the Plateau soils is low to medium. The quite high results given in Table III-2 for Shiraz are largely influenced by data from the analyses of the rice soils. For 17 experiments under this crop the average was found to be 91.9 ppm P with a highest result of 325 ppm. The results need further investigations.

The Plateau soils are generally high in content of available potassium. The results were grouped in levels, and their frequency within them is expressed in percentages of the total number of analyses:

0 - 50 ppm K:	0 percent
50 - 100 ppm K:	3 percent
100 - 200 ppm K:	14 percent
200 - 400 ppm K:	51 percent
over - 400 ppm K:	33 percent

The high potassium contents are characteristic of regions where evaporation generally exceeds precipitation.

In the Caspian region the areas of Gilan, Mazandaran, and Gorgan are distinguished. Situated between the Elborz mountains and the Caspian coast, they are characterized by high rainfall and a humid climate. The average annual precipitation is over 1,000 mm in Gilan, decreasing eastwards to Mazandaran and Gorgan, at the southeast corner of the Caspian sea, where the annual rainfall is about 500 mm only. The region's average soil data are shown in Table III-3.

Table III-2: AVERAGE CHEMICAL SOILS DATA OF THE AREAS OF THE CASPIAN REGION

Area	Number of analyses	Saturation percentage	pH	Conductivity mmhos/cm	Organic carbon%	P ppm	K ppm
Gilan	231	62.8	6.9	2.64	3.63	10.7	193
Mazandaran	188	62.8	7.8	1.48	2.29	12.0	342
Gorgan	85	56.2	7.6	1.16	1.97	9.4	292
Mean	504	61.7	7.4	1.96	2.39	11.0	265

These soils are mainly of alluvial origin and differ greatly from those of the Plateau. The texture, roughly estimated from saturation percentage, is finer and often of a clayey nature. To some extent, the results of the saturation percentage may be influenced by a relatively high content of organic matter. The organic carbon content of the soils decreased from west to east (from Gilan to Gorgan), following the rainfall pattern.

The pH values in the eastern, drier part of Mazandaran and Gorgan were similar to those of the Plateau, but the soils in the humid region of Gilan were lower and averaged a pH of 6.9 only. In Gilan more than 20 percent of the total number of soil samples were below pH 6.5, and 9 percent, mostly taken from the tea experiments, were below pH 5.5.

The measurement of the electric conductivity gave high values for the soils of Gilan, where more than 50 percent of the samples were taken from the rice fields. This indicated high conductivity. The pattern of distribution of the results, on the average, was similar in both the Plateau and the Caspian regions. In both, too, 70 percent of the results of the analysed samples were within the range from 2 to 4 mmhos/cm.

The phosphorus content of the agricultural soils of the Caspian region ranged from low to medium. The average values for potassium were lowest in the Gilan area. Those of the soils of Mazandaran and Gorgan areas are higher and approach the levels found on the Plateau.

The distribution pattern of potassium figures for the Caspian region are :

0 - 50 ppm K : 2 percent
50 - 100 ppm K : 10 percent
100 - 200 ppm K : 29 percent
200 - 400 ppm K : 42 percent
over - 400 ppm K : 17 percent

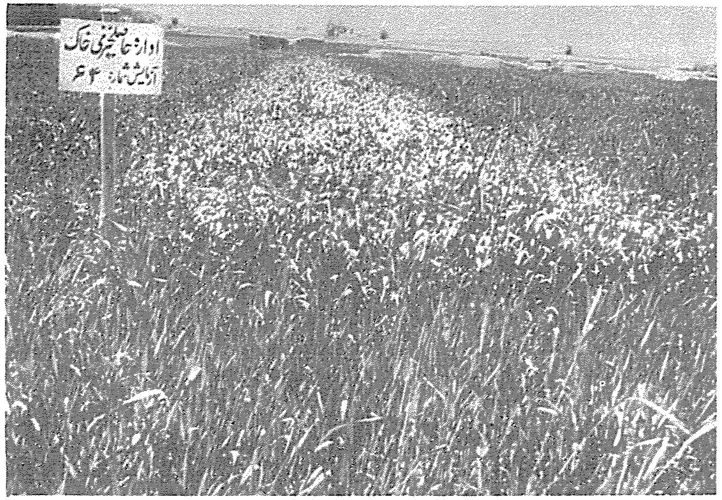


Photo 1: Wheat demonstration trials near Borujerd.

Photo 2: Field of melons (Garmak) near Esfahan.

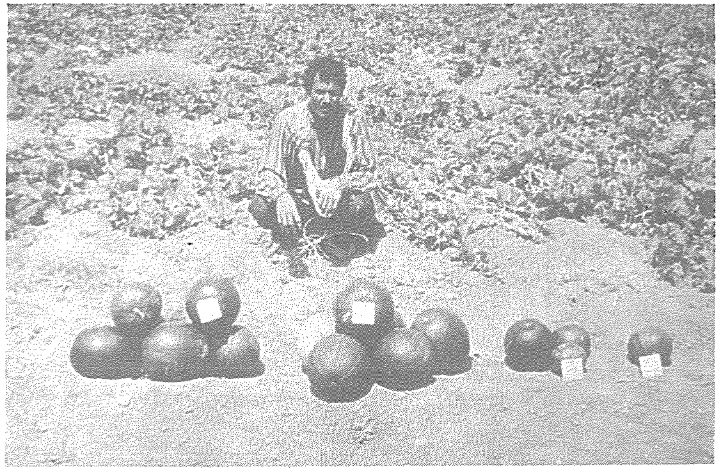


Photo 3: Watermelons (Ghazvin). From right to left control, 45-0-0, 45-45-0 and 90-45-0.

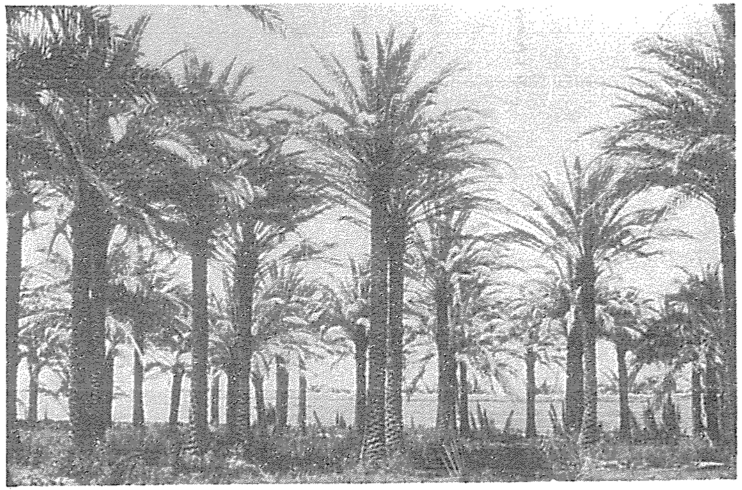


Photo 4: Date garden near Bam.

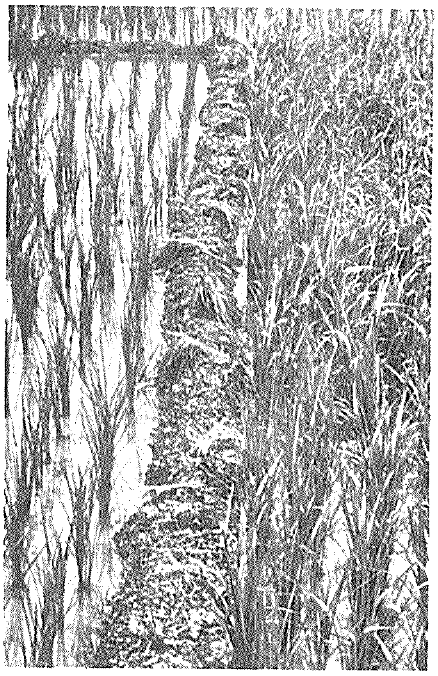


Photo 5: Rice field in Gilan. Plot at left received fertilizer dressing N_{30} P_{30}

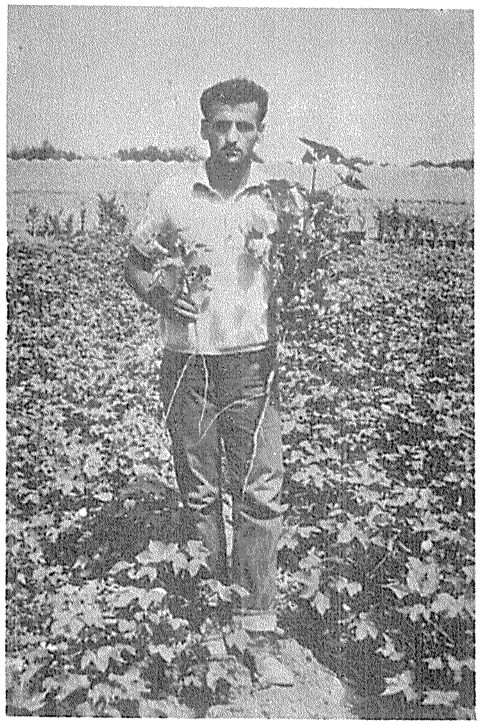


Photo 6: Cotton field in Ghazvin. Left control, right N_{90} P_{90}

Photo 7: Tea garden near Lahijan (Gilan). Site selected for a fertilizer experiment.

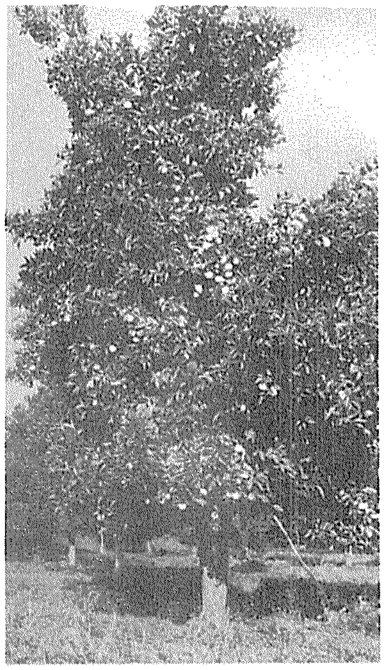


Photo 8: Orange tree, near Shahsavar (Gilan). Note narrow, elongated shape of crown.

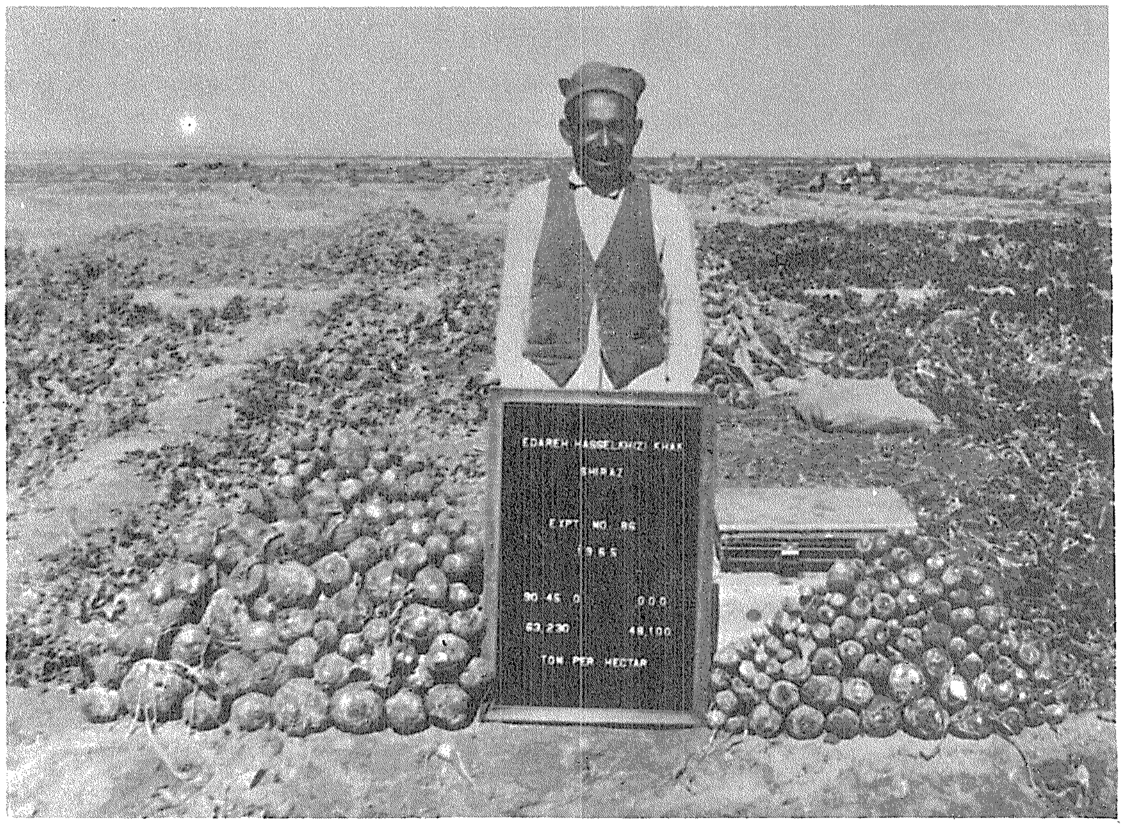


Photo 9 : Harvesting a sugarbeet fertilizer experiment in Shiraz.

Photo 10 : Grape garden in northwest Iran after emergence of the first new leaves. Note high ridges to collect snow in harsh winters and to reduce frost damage to the vines.

CHAPTER IV – FERTILIZER RESPONSES AND RECOMMENDED RATES

1. FACTORS IN FERTILIZER USE

A farmer's use of fertilizer depends on a number of factors. Perhaps, the chief one is whether it pays him to use these materials. The application of fertilizer must not only increase the yields of crops; it must also secure a profit for the farmer.

Sometimes the national interest may conflict with that of the individual farmer. From a national standpoint, it may be necessary to increase crop production as a means of reducing the amount of imports paid for with foreign currency. If, however, fertilizers are too costly for the farmer, a Government may take action to reduce their prices for him. Fortunately in Iran, under most climatic and physiographic conditions and with most crops, profitable yield increases have been obtained by the use of fertilizer.

Yield increases as well as the monetary gain from fertilizer use are discussed in this chapter. Mention is also made of the suitability of various fertilizer materials.

Another was the opening of the Shiraz fertilizer factory, which, in 1963, enabled Iran to produce its own nitrogenous fertilizers: urea and ammonium nitrate. These two home products were cheaper for the farmer than the two other nitrogenous materials which were imported. A third reason was the granting of loans, in kind or cash, for fertilizer materials.

In bulk, ammonium nitrate is the cheaper home product. In nutrient content, however, urea is cheaper than ammonium nitrate. The Chemical Bongah, which is a State organization, buys most of these two fertilizers. It pays 7,650 Rials/ton for urea and 4,450 Rials/ton for ammonium nitrate. It then sells the fertilizers at a fized price throughout the country. The price for the farmer is 10,000 Rials/ton for urea and 6,500 Rials/ton for ammonium nitrate. The difference in the buying and selling prices covers the cost of transport, storage, a five percent commission and one percent charge for expenses and losses.

When fertilizer prices paid by the farmer are compared on a kg nutrient basis with those paid in other countries, they are seen to be high. The following comparisons are based on the prices of <u>non</u>-subsidized fertilizers.

Differences are greatest for nitrogen and phosphorus fertilizers. In the U.K., for instance, prices are about one third of those in Iran. In the U.S.A. and Japan, they are slightly more than half for phosphorus fertilizers and about two thirds for nitrogen fertilizers. Differences are, however, less for potassium fertilizers, and prices in the U.K. and Japan are about two thirds of those in Iran.

On the other hand, prices for nitrogen fertilizers are about 15 percent higher in Taiwan. They are 12 percent higher for phosphorus fertilizers in Ghana and Ecuador, and 11 percent higher for potassium fertilizers in Peru.

If the subsidies in Iran and elsewhere are taken into account, differences become smaller. None the less, fertilizers in Iran remain comparatively expensive, but the application of fertilizers is economic because, quite apart from good responses, crop prices are fairly high.

One factor which governs the choice of a particular home-produced fertilizer is its suitability for a particular area. A second is the cost of its transport.

Ammonium nitrate is too hygroscopic to be applied in the humid Caspian region, but is suitable for the arid Plateau. Urea, which is alone suitable for the Caspian region, is much more concentrated than ammonium nitrate and is, therefore, less costly to transport.

It was shown in Chapter II that the farmer's co-operatives and other organizations have worked out a system for distributing the two home-produced fertilizers. It is based primarily on the distances between the Shiraz fertilizer factory and the different provincial centres.

Farmers' co-operatives play an active part not only in distributing fertilizer materials throughout the regions, but also in giving their members the credit facilities for obtaining fertilizers as well as improved seeds and insecticides.

When farmers' co-operatives give loans in kind, the amount is generally limited only by the area which the farmer can fertilize. When a short-term loan is granted, the maximum is 10,000 Rials, but it is stipulated that at least 10 percent of the loan must be spent on fertilizers.

A farmer who has obtained a maximum loan must thus spend 1,000 Rials on fertilizers. At present prices and with the recommended HMR rate, however, this sum would enable him to fertilize no more than half a hectare of sugarbeet or cotton, or alternatively three quartersof a hectare of wheat. Yet the size of a small farm in Iran normally varies from 2.5 to 3.5 ha.

Since the application of the HMR rate is a safe, and indeed a conservative investment, there seems to be a good case for enlarging the loans needed for fertilizer use.

2. SELECTION OF FERTILIZERS

Four nitrogen fertilizers materials were tested in trials: the two home products, urea and ammonium nitrate, and two imports, ammonium sulphate and ammonium sulphate nitrate.

Urea is the cheapest fertilizer. Ammonium sulphate is the most expensive fertilizer, but one of its great advantages is its non-hygroscopic condition.

Meanwhile triple superphosphate was the standard phosphorus material for all experiments, except for top-dressings, when ammonium phosphate was used instead. Phosphate carrier trials, however, showed that ammonium phosphate was equal to, if not better than, the standard superphosphate.

Basic slag was also tested in carrier trials. It is widely assumed that basic slag is suitable only for acid soils, and not for soils with pH over 7. None the less, it stood the test extremely well. A fatal drawback is its higher cost, which makes it unattractive if not prohibitive, for the farmer. For this reason, it was imported only for experiments.

The fourth phosphate was potassium metaphosphate, which contains phosphorus and potassium with a nutrient content of nearly 100 percent. Tests were confined to tobacco.

With potassium fertilizers, only potassium sulphate was used. The cheaper and more concentrated potassium chloride, which is unsuitable for tobacco and some other crops, was occasionally tested in 1965.

Phosphorus and potassium fertilizers were everywhere applied as triple superphosphate and potassium sulphate.

Throughout the Project, the fertilizer rates were kept unchanged for experiments. Once the right range of rates had been selected, it was essential to maintain it for a period long enough to complete the investigations. If there are two rates, they should be selected at a 1 : 2 ratio and in such a way that the application rate which gives the maximum profit comes between them. The application rates of fertilizers for the Project's experiments were :

30 and 60 kg/ha of N, P_2O_5 or K_2O : wheat, barley, rice, kenaf and tobacco (N applied at one rate only, 15 kg/ha).

45 and 90 kg/ha of N, P_2O_5 or K_2O : cotton, sugarbeet, potatoes, alfalfa (N at 15 and 30 kg/ha), grapes, melons, onions, tea (P_2O_5 at 30 kg/ha only, and K_2O also at one rate, 45 kg/ha), citrus and deciduous fruit trees if aged less than 10 years ; if older, 60 and 120 kg/ha.

Potassium was used chiefly at one rate only: mostly the lower rate. This was done to detect any possible effect in applying potassium.

No evidence of potassium effect, however, was found during any experiment with wheat, rice, cotton, sugarbeet, grapes, potatoes, tea, alfalfa and melons.

Table IV-1: RECOMMENDED RATES IN KG PURE NUTRIENTS OF N, P_2O_5 AND K_2O PER HA, WITH PROFITS AND RETURNS IN RIALS

Crop		PLATEAU								CASPIAN	
		Fars		Central		Azerbaijan		Khorassan			
		HMR	MP	HMR	MP	HMR	MP	HMR	MP	HMR	MP
Wheat	rate	30-30	45-45	30-30	60-45	30-30	60-60	30-30	–	Behshahr Gorgan	30-30 (15+15)-30
	profit	1,652	1,870	1,814	2,212	1,304	1,703	2,228		622 –	– –
	return	218	189	229	189	193	161	259		148 –	– –
Rice	rate (Ch (a) (Sa (b)	30-30 –	60-60 –	30-30 –	60-60 –					30-30 30-30	60-45 60-45
	prof (Ch (Sa	5,933 –	8,519 –	2,971 –	4,022 –					5,075 5,287	6,211 7,331
	ret. (Ch (Sa	555 –	427 –	328 –	254 –					489 488	376 421
Cotton	rate	45-45	–	45-45	–	45-45	–	45-45	–	–	–
	prof.	697	–	291	–	3,735	–	2,867	–	–	–
	ret.	133	–	114	–	278	–	236	–	–	–
Sugarbeet	rate	45-45	Sh 90-45 Fa 90-90	45-45	90-90	45-45	90-90	45-45	75-75	–	–
	prof.	10,227	Sh 13,302 Fa 16,314	9,478	12,994	3,764	5,078	9,697	11,358	–	–
	ret.	586	Sh 512 Fa 488	551	409	292	230	561	421	–	–
Tobacco	rate (Burley (Turkish					– 15-30-30	– –			15-30-30 15-30-30	– –
	prof (Burley (Turkish				–	– 7,086	– –			12,491 5,640	– –
	ret. (Burley (Turkish				–	– 586	– –			957 487	– –
Tea (c)	rate									–	90-30-30
	prof.									–	9,926
	ret.									–	364
Grapes	rate					45-45-0	–				
	prof.					8,780	–				
	ret.					549	–				
Potatoes	rate					45-45	90-45				
	prof.					8,144	10,666				
	ret.					516	464				
Alfalfa	rate (est. (d) (top. (e)					0-45-0 15-45-0	– 22-60-0				
	prof (est. (top.					– 4,389	– 4,786				
	ret. (est. (top.					– 490	– 420				
Melons	rate (Gar (f) (Khak (g)			45-45-0 45-45-0	– –						
	prof (Gar (Khak			4,242 4,557	– –						
	ret. (Gar (Khak			302 317	– –						

(a) Champa; (b) Sadri; (c) to be confirmed; (d) established; (e) top dressing; (f) Garmak; (g) Khaki

It should be pointed out that all fertilizers must be covered as soon as they are applied. Otherwise they break down when they are exposed to the sun and moist soil conditions. This is especially true of nitrogen fertilizers.

A typical example is urea. Within two or three days it can lose as much as 30 percent of its nutrients in acid soils. Losses increase to nearly 40 percent in alkaline soils.

3. SUMMARY OF RESULTS

A few words of explanation are needed on Table IV-1, which summarizes the recommended fertilizer rates for Iran's ten main crops. These are the high monetary return (HMR) rate and the maximum profit (MP) rate. Estimated profits and returns are shown region by region. The blank spaces in this table indicate one of three things: (a) the crop is not grown in that region; or (b) conditions were unfavourable; or (c) the trials were too few. To mention one conspicuous omission, the table shows no recommended rates for the vast dry farming areas on the Plateau. This was because more experimental seasons as well as more trials were needed.

First in the table come the four Plateau regions: Fars (Shiraz, Fassa and Kazerun), Central (Esfahan), Azerbaijan (Ghazvin, Mareghehand Rezayeh), and Khorassan (Mashad, Neyshabur and Torbat-e-Heydarieh). All four are regions where the crops are mostly irrigated. They are followed by the Caspian region (Rasht, Babol and Gorgan), where the crops are generally rainfed.

Chapter IV in Volume II concerns the combined results of the fertilizer experiments made during the Project's five years, with quotations of crop and fertilizer prices for the five year period.

It gives due weight to the monetary benefits of fertilizer use. The prices used for the experiments are those for 1965. A fixed year enables regional comparison to be made more easily.

The following summary shows the recommended rates of fertilizer, the increases in yield expected from their application, and the monetary benefits.

3.1. Wheat

Fertilizer rates trials. During four winter seasons, irrigated trials on the Plateau numbered 570. Rainfed trials in the Caspian region numbered 195. Ammonium nitrate was the nitrogen carrier on the Plateau, and urea the carrier in the Caspian region.

The average yield without fertilizer for irrigated wheat on the Plateau was 1,667 kg/ha. On applying the HMR rate 30-30-0, this was increased by 449 kg/ha, or 26.9 percent. The initial yield varied from 1,301 kg/ha in the Azerbaijan region to 1,987 kg/ha in Central region.

The HMR rate 30-30-0 is the same for all the Plateau regions. The average return is 190 Rials for every 100 Rials invested, with a gross profit of 1,300 Rials/ha. This rate is a very profitable investment for a low-priced food crop, for which the farmer is paid 6 Rials/kg.

The MP rates, on the other hand, vary from 45-45 in Fars region to 60-60 in Azerbaijan region. The average maximum profit is 1,500 Rials/ha or about 15 percent more than the average profit of the HMR rate. No MP rate is available for Khorassan region, where trials were limited to one season.

Owing to differences in temperature, the rates of nitrogen in the MP rates differ on the Plateau from region to region. In the colder regions, the rates of nitrogen are higher because the lower temperatures reduce bacterial activity. There is less nitrogen for the plants.

In the Caspian region, where are two distinct rainfall areas, only two HMR rates and no MP rates are recommended. In the lower rainfall area of Gorgan (400 mm) an HMR rate of 15-30-0 is recommended at planting time. An additional rate of nitrogen at 15 kg/ha can be given in the spring when the rainfall is favourable. In the higher rainfall area of Behshahr (570 mm) the recommended HMR rate is 30-30-0. As the rainfall is higher, the nitrogen can be applied in full.

Initial yields in the Caspian region are roughly similar to those of irrigated wheat on the Plateau. This is largely due to the fertility of the soils from which the forest has recently been cleared. On the other hand, their dependence on the rainfall made the yields less responsive. In the lower rainfall area of Gorgan, the average initial yield was 1,783 kg/ha which increased on the application of (15+15)-30-0 by 326 kg/ha, or 18 percent. In the higher rainfall area of Behshahr the recommended HMR rate 30-30-0 increased an initial yield of 1,890 kg/ha by 321 kg/ha, or 17 percent. The gross profit in this area was about 622 Rials/ha with a monetary return of 148 Rials for every 100 Rials invested.

In the dry farming areas of Azerbaijan region, where altitudes may exceed 1,500 m, severe winters prevail. Even with a very low rainfall of 250 mm and less, responses to nitrogen are recorded, apart from the expected responses to phosphorus which are common under dry farming conditions. This response to nitrogen is probably a result of the slowed down nitrification due to the low temperatures. In this region, an average yield of 481 kg/ha was recorded which is a normal yield for dry farming wheat throughout Iran. The average increase due to fertilizer application was only 91 kg/ha. This meant financial loss.

In the dry farming areas of the Caspian region, where winters are milder, the much higher initial yield of 1,752 kg/ha was recorded. Though the increase on applying 30 kg P_2O_5/ha was only 164 kg/ha, or 9.4 percent, it resulted in a gross profit of 332 Rials/ha and a return of 151 Rials for every 100 Rials invested.

Though these results were restricted to two seasons, they showed a reaction typical for dry farming areas, where a response solely to phosphorus is expected. Small monetary gains were recorded. None the less, trials need to continue for a very long time before any pattern of seasonal behaviour can be detected.

Nitrogen carrier comparisons. The four tested carriers - urea, ammonium nitrate, ammonium sulphate and ammonium sulphate nitrate - are almost equally effective in increasing yields. The superiority occasionally claimed for ammonium sulphate nitrate is not important and seldom significant. Under irrigation, their mean effect in the presence of phosphorus was to increase the initial yield of 1,732 kg/ha by 737 kg/ha. Under rainfed conditions, the initial yield of 2,629 kg/ha was increased by 489 kg/ha.

Monetary benefits are the differentiating factor. From this viewpoint, urea is the superior carrier. Under irrigation, it gives a mean gross profit of about 2,800 Rials/ha and a mean return of about 280 Rials. Under rainfed conditions, it gives a mean gross profit of 1,300 Rials/ha and a return of 180 Rials.

Under irrigation, ammonium nitrate - the other fertilizer now manufactured in Iran - gives a profit and return both about 15 percent lower than those given by urea. Under rainfed conditions, they are still lower. Moreover, only urea is suitable for the Caspian region.

With a rather higher profit, but always a lower return, ammonium sulphate nitrate may very closely follow ammonium nitrate. As an import, however, it is more expensive. At the bottom of the list is ammonium sulphate with a profit and return about 25 percent lower than those of urea.

Phosphorus carrier comparisons. The three tested carriers are equally effective in increasing yields, although basic slag has been consistently, but not significantly, lower than ammonium phosphate with irrigated wheat. On the Plateau, they increased an average initial yield of 1,449 kg/ha for irrigated wheat by 428 kg/ha, or 29 percent. In the Caspian region, they increased an average yield of 2,502 kg/ha by 346 kg/ha, or 14 percent.

Ammonium phosphate is the cheapest fertilizer and gives the highest profit and returns. In the combined results, a mean profit of about 1,200 Rials/ha was obtained for irrigated wheat compared with about 480 Rials/ha for rainfed wheat : that is, about 2.5 times less. This was, however, mainly due to the high initial yield of the fertile soils in the Caspian region.

The next most profitable fertilizer is triple superphosphate. It gives a gross profit about two or three times smaller than that of ammonium phosphate. Basic slag barely returns the money invested.

No test of phosphorus carriers is complete until not only the direct, but also the residual effects are investigated for at least two years. 1/

3.2. Rice

Fertilizer rates trials . During five summer seasons, trials on the japonica type Champa rice and the indica type Sadri rice numbered 345. The recommended rates are given for the Caspian region, which is the main rice-growing area. On the Plateau, rice cultivation is less important, and only the japonica type is planted. Prices paid to the farmer varied from 7 Rials/kg in the Caspian region to 7.5 or 8.5 Rials/kg on the Plateau for Champa rice and to 10 Rials/kg for Sadri rice. Urea was the nitrogen carrier.

The HMR rate 30-30-0 is the same for both types of rice in all rice growing areas. On the Plateau, the average initial yield for Champa rice without fertilizer was 3,227 kg/ha. On applying the rate 30-30-0, it increased by 712 kg/ha, or 22 percent. In the Caspian region, the average initial yield for Champa rice was 3,621 kg/ha and for Sadri rice 2,948 kg/ha. On applying the rate 30-30-0, the yield of Champa rice was

1/ This aspect is discussed in Chapter V, section 2.

increased by 896 kg/ha, or 25 percent, and the yield of Sadri rice was increased by 692 kg/ha, or 25 percent.

On the Plateau, the returns on every 100 Rials invested range from 330 to 550 Rials. They are the same, nearly 500 Rials, for both types in the Caspian region. The gross profits, about 5,000 Rials/ha, are also the same for both types in the Caspian region. The monetary advantage of the higher priced Sadri rice is cancelled by the higher yielding and more responsive Champa rice.

The MP rates differ from region to region. The rate of phosphorus recommended for the Plateau is higher than for the Caspian region, but the nitrogen rate should always be 60 kg/ha. Maximum profits may vary from as little as 4,000 Rials/ha to as much as 8,500 Rials/ha. For both types of rice in the Caspian region they are about 20 percent higher than the profits obtained from applying the HMR rate.

Nitrogen carrier comparisons. Urea or ammonium sulphate is recommended as a nitrogenous fertilizer for rice. If ammonium sulphate was rather less effective (but not significantly) in the Champa trials, this was because the number of trials was limited. It is, however, more expensive than urea.

The average initial yields were 3,894 kg/ha for Champa rice and 3,058 kg/ha for Sadri rice. As a result of applying urea and ammonium sulphate, the average yield of Champa rice increased by 1,333 kg/ha, or 34 percent, while the average yield of Sadri rice increased by 881 kg/ha, or 29 percent.

Ammonium nitrate was consistently and significantly lower yielding than urea. There was, in fact, a decrease of about 150 kg/ha for Sadri rice and a decrease of 200 kg/ha for Champa rice. Its nitrogen is in the form of nitrate which, under rice - growing conditions, results in denitrification and gaseous losses of nitrogen.

Urea, when applied to Sadri rice, gave a mean gross profit of about 7,000 Rials/ha and a return of 540 Rials in the presence of triple superphosphate at 30 kg P_2O_5 /ha. When ammonium sulphate was applied, these figures decreased to about 6,900 Rials/ha and 440 Rials. For Champa rice, however, gross profits decreased from about 8,000 Rials/ha with urea down to 6,900 Rials/ha for ammonium sulphate.

Phosphorus carrier comparisons. Trials to test the direct effects of ammonium phosphate, triple superphosphate and basic slag on Sadri and Champa rice in the Caspian region showed that each fertilizer is roughly equal in increasing the yield in the year of application.

The average yield without fertilizer was 3,628 kg/ha for Champa rice and 2,578 kg/ha for Sadri rice. The average effect of all the three phosphorus carriers - was to increase yields by 1,372 kg/ha, or 38 percent, for Champa rice and by 913 kg/ha or 35 percent, for Sadri rice. This was, however, the direct effect. The consistent and slightly higher yield increasing effect of ammonium phosphate is never significant. No tests are complete unless the residual effects for the following two years are also taken into consideration. 2/

2/ See Chapter V, Section 2.

As the cheapest fertilizer, ammonium phosphate gives the most favourable monetary results, followed by triple superphosphate and then by basic slag. In this order, the average gross profits for Sadri rice were about 7,000, 6,300 and 5,500 Rials/ha. For Champa rice they were about 8,200 (perhaps, on the high side), 6,400 and 5,800 Rials/ha. Returns range roughly from 400 to 280 Rials. There was a basal dressing of 60 kg N/ha.

3.3. Cotton

Fertilizer rates trials. Trials with irrigated cotton on the Plateau numbered 576, and trials rainfed cotton in the Caspian region numbered 243. Ammonium nitrate was the nitrogen carrier. The price paid to the farmer is 14 Rials/kg seed cotton.

A poor standard of cotto-growing makes the benefits marginal and precarious. The initial yield on the Plateau, for example, averaged 1,352 kg/ha. On applying the rate 45-45-0, this was increased by 250 kg/ha of seed cotton, or 18 percent. It gives a gross profit of about 1,400 Rials/ha and a return of only 160 Rials for every 100 Rials invested.

Response to fertilizer is even lower in the Caspian region. The average initial yield of 1,465 kg/ha was increased by only 135 kg/ha, or 9 percent. This meant financial loss. In two of four seasons, the money invested invested in fertilizers was barely returned.

An HMR rate of 45-45-0 is recommended for the Plateau only. Even here, where doubt exists, it is better to apply only phosphorus in the seed bed and to add nitrogen as a top dressing when the crop is progressing satisfactorily. Nowhere can MP rates be recommended.

3.4. Sugarbeet

Fertilizer rates trials. During five summer seasons trials numbered 505. Ammonium nitrate was the nitrogen carrier. The price paid to the farmer was 1,000 Rials/ton.

The average initial yield of this irrigated crop on the Plateau is 29.12 tons/ha. It varies from about 21 tons/ha in the Central region to 30 tons/ha in Fars region. On applying the rate 45-45-0, the initial yield is increased by 10.67 tons/ha, or 37 percent.

A single HMR rate of 45-45-0 is recommended for all four Plateau regions. This gives are turn of 500 Rials for every 100 Rials invested in fertilizers and a gross profit of 8,600 Rials/ha. It makes sugarbeet a very profitable cash crop.

There are, however, regional differences for the MP rate. Within Fars region there are even different rates for Shiraz and Fassa areas. Rates vary from 75-75-0 in Khorassan region to 90-90-0 in Azerbaijan and Central regions. The average maximum profit is 11,600 Rials/ha. Compared with the gross profit of the HMR rate, this represents an increase of about 36 percent.

Apart from a small and not significant effect of phosphorus, the fertilizer influence on the sugar content of sugarbeet is negligible. The average content may vary from 17.3 percent in the warmer areas to 18.8 percent in the colder.

Phosphorus carrier comparisons. Ammonium phosphate, triple superphosphate and basic slag have roughly equal yield-increasing effects. Ammonium phosphate is slightly, but not significantly, higher yielding than the two others. The mean effect of the three carriers is to increase an initial yield of 27.83 tons/ha by 16.11 tons/ha.

Ammonium phosphate is the cheapest carrier on a kg pure nutrient basis. It gives a mean gross profit of about 13,500 Rials/ha and a return of 510 Rials. It is followed by triple superphosphate and then by basic slag, which gives a gross profit of 11,000 Rials/ha. This is about 2,000 Rials less than the gross profit of ammonium phosphate.

3.5. Tobacco

Trials with Burley tobacco in Gilan area numbered 39, and trials with Turkish tobacco in Gorgan and Rezayeh areas numbered 40. Burley tobacco was first introduced into Gilan in 1962 and is more resistant to the blue mould disease than Turkish tobacco.

Increases of yield due to applying fertilizer are less important than the effect on quality. Leaves are collected from an average of four to seven pickings. Each picking is separately cured, and each leaf is graded according to its quality. Four main grades are each divided into three sub-classes, each with its own price. The effect of fertilizers is to shift the leaves into higher quality grades which command higher prices. This is greater with Burley tobacco, which shifts mainly into grade I, the highest grade.

With the Turkish type this shift is less pronounced and is mainly into grade II. The Turkish type fetches the higher price, but Burley tobacco secures the greater profits and returns.

For Burley tobacco, only one rate, 15-30-30, is recommended. It is often an HMR as well as an MP rate. Its monetary benefits are quite spectacular. The rate gives a gross profit of 12,500 Rials/ha and a return of about 950 Rials for every 100 Rials invested.

By contrast, the influence of the rate 15-30-30 on the yield of Burley tobacco is small. It increases an initial yield of 1,263 kg/ha of cured leaves by 200 kg/ha, or 16 percent.

For the Turkish type, the same rate 15-30-30 is recommended, but only as an HMR rate. It gives a gross profit of 5,640 Rials/ha and a return of about 490 Rials. Trials with the Turkish type should continue to investigate the MP rates.

Again the fertilizer influence on yield has only a minor importance. On applying the rate 15-30-30, an average initial yield of 1,498 kg/ha is increased by 65 kg/ha, or only 4 percent.

Urea, triple superphosphate and potassium sulphate are recommended. The trials in Rezayeh area compared the newer phosphorus carrier, potassium metaphosphate (0-56-37), with the standard triple superphosphate. They failed, however, to indicate any difference between the two carriers. The former is about 16 percent cheaper. It costs 1,212 Rials/ha for the 15-30-30 rate and 1,458 Rials/ha for the same rate based on triple superphosphate.

3.6. Tea

Fertilizer rates trials. Trials in Gilan, the main tea-growing area, numbered 64. Nitrogen is the major yield increasing nutrient and gives a response which increases with the two rates 45 and 90 kg/ha. Phosphorus is not effective, except in the presence of the high rate of nitrogen. Potassium is also not effective and, under certain conditions, has a depressing effect on yield. The standard price for the fresh produce is 21 Rials/ha.

Yields are the total of an average number of 13.5 pickings during a 33-weeks' season from March to November. The average initial yield is 4.56 tons green leaves/ha. Two tons/ha are produced in the summer season and about 1.3 tons in the spring and autumn each. A delayed yield pattern follows the rainfall distribution at intervals which, according to the temperature, vary from two to four weeks.

The recommended rate is 90-30-0. It increases the average initial yield by 0.66 tons fresh leaves/ha, or 14 percent. Until results of more trials with higher and split applications of nitrogen are available, it can be regarded as a high profit rate. It gives a gross profit of nearly 10,000 Rials/ha and a return of about 360 Rials for every 100 Rials invested.

Nitrogen has a depressing influence on quality. This, however, can be so effectively overcome by phosphorus and potassium that the quality is significantly improved.

Phosphorus-nitrogen carrier comparisons. Urea has a consistent, but very slight and not significant, higher yield effect than ammonium sulphate. It is cheaper and more profitable. Its mean gross profit is about 30 percent greater. The mean initial yield is 3.32 tons/ha.

3.7. Grapes

Trials with irrigated grapes in Azerbaijan region numbered 38. The recommended HMR rate is 45-45-0. Its application increased the average initial yield of 15.71 tons fresh grapes/ha by 3.01 tons/ha, or 19 percent. Phosphorus significantly increases the number of bunches and also improves their quality, whereas nitrogen impairs it. The HMR rate gives a gross profit of about 8,800 Rials/ha and a return of 550 Rials for every 100 Rials invested.

Urea is the nitrogen carrier. The price of grapes is 4 Rials/kg for the best grade and 2.5 Rials/kg for the second grade. At present no MP rate can be recommended.

The average raisin percentage is 24.7 for unfertilized grapes.

3.8. Potatoes

As potatoes are a minor food crop in Iran, the trials, which numbered 58, did not begin until the Project's third year. They were, however, sufficient to show that the application of fertilizer is at least as beneficial for them as for other crops.

The HMR rate 45-45-0 increases the average initial yield of 13.78 tons/ha by 4.04 tons/ha, or 30 percent. It gives a return of about 500 Rials and a gross profit of about 8,000 Rials/ha. The price is 2.5 Rials/ha. Urea is the nitrogen carrier.

3.9. Alfalfa

Trials in Azerbaijan region from 1963 to 1965 numbered 71. Yields are low in the year of establishment.

An establishment rate of 0-15-0 is suggested. If applied as triple superphosphate at planting time, it would increase an average yield of 1.5 tons hay/ha by 0.2 tons/ha, in one or, at the most, two cuts. This is an increase of only 14 percent, and it often does not pay for the investment in fertilizers. Although effects are not immediately apparent, a phosphate application may be beneficial, it not at first, then at a later stage. This is because it promotes a good root system and stronger plants. In the second and later years, they may have a higher yield and become more responsive to fertilizers.

From the second year onwards, however, yields increase roughly sixfold to about 8.5 tons hay/ha in about three cuts per year. Responses to fertilizers also increase about 50 percent. It then becomes necessary to add nitrogen so as to counterbalance the more frequent cuttings. The nitrogen supplied by rootknot bacteria is not sufficient for this level of yield.

A top-dressing of 15-45-0 from the second year onwards is suggested. Ammonium phosphate (18-50) at 90 kg/ha increases the average initial yield of 8.7 tons/hay/ha by 1.8 tons/ha, or about 21 percent. It gives a gross profit of 4,400 Rials/ha and a return of nearly 500 Rials. If applied as triple superphosphate, however, yields become significantly lower and profits are about 30 percent less.

The MP topdressing rate is 22-60-0 for ammonium phosphate. This gives a profit of 4,800 Rials/ha and a return of 405 Rials. The price is 3 Rials/kg hay. Urea is the nitrogen carrier.

For established alfalfa the factor for converting fresh yields into hay is 25.5 percent. The crude protein content of first year alfalfa is about 18 percent. It increases to about 21 percent for second year and older alfalfa. Fertilizers do not influence this protein content.

3.10. Melons

Trials with the Garmak cantaloup numbered 42, and trials with the Khaki melon in Esfahan area numbered 43.

The HMR rate 45-45-0 increases the initial yield of 15.33 tons/ha for the Garmak cantaloup by 4.23 tons/ha, or 27 percent. It increases the initial yield of 15.75 tons/ha for the Khaki melon by 2.22 tons/ha, or 14 percent. Thus the initial yields of both are roughly similar, but the Garmak cantaloup's response to the HMR rate is about twice that of the Khaki melon. None the less, the monetary difference is cancelled because the khaki melon receives twice the price of the Garmak cantaloup.

Rate 45-45-0 secures for the Garmak cantaloup a gross profit of 4,200 Rials/ha and a return of 300 Rials for every 100 Rials invested. The return is also about 300 Rials for the Khaki melon.

The favourable effect of 45-45-0 is due chiefly to phosphorus, and not to nitrogen. This in turn is a result of a significant increase in the number of fruits. There is no MP rate for either type of fruit. This needs to be investigated further.

4. CONTRASTS IN MONETARY BENEFITS

The degree of the response yield combined with a favourable relationship of crop and fertilizer prices provides the most affirmative answer to the question whether it pays to use fertilizer materials.

One conspicuous example is Burley tobacco. Its initial yield is increased by 15.8 percent, while the monetary return is 950 Rials for every 100 Rials invested. This means that the tobacco-grower gets almost a tenfold return on his fertilizer investment.

More moderate are the returns from fertilizer applied at the HMR rate to rice and sugarbeet. This rate increases the initial yield of rice by 23 percent and the initial yield of sugarbeet by 36 percent. On the other hand, the monetary return is roughly equal for both crops: about 500 Rials for every 100 Rials invested. This means a fivefold return for the farmer's investment.

The HMR rate, when applied to irrigated wheat, may give a less striking result; for while increasing the initial yield by 27 percent, it gives a monetary return of only 192 Rials for every 100 Rials invested. This is, none the less, a valuable gain because it almost doubles the monetary return on a low-priced crop. Moreover, this return is very stable and consistent.

Cotton, on the other hand, has a disappointing record in the Caspian region. In two of four experimental seasons, the results showed that a farmer might have obtained a bare return on his money invested in fertilizers. In the other two seasons, he would have lost money.

On the surface, these failures seem to indicate that it is useless to apply fertilizers to cotton in the Caspian region. In the reality, however, they emphasize the truth that the application of fertilizer must always be combined with other yield-producing factors; for instance, planting in rows, sufficient irrigation and plant protection.

Fertilizers, when universally applied, will not only make Iran once again self-supporting in its food supplies. They will help greatly to improve the farmer's standards of living and the general health of all the people.

CHAPTER V

FACTORS AFFECTING CROP PRODUCTION

1. RELATION BETWEEN CONTROL YIELD LEVELS AND FERTILIZER RESPONSES 1/

The control yields of 493 fertilizer rates trials with irrigated wheat (four or more irrigations) in four Plateau regions were grouped into ten separate classes with 300 kg intervals to show the relationship between each control yield level and its particular response to fertilizers. (Table V-1).

With fields yielding up to 1,800 kg/ha, the low initial fertility results in very profitable increases on fertilizer application. Rates can be as high as 60 kg/ha for both N and P_2O_5. At this rate, a response of about one ton may be recorded.

From 1,800 kg/ha to 2,400 kg/ha, as Table V-1 shows, initial fertility increases and the rate of phosphorus may be conveniently decreased to 30 kg/ha. Responses and profits decrease, however, often as much as 25 percent.

From 2,400 kg/ha to 3,000 kg/ha, no additional benefits are obtained by applying rates over 30 kg/ha for nitrogen and phosphorus each. Responses may even decrease a further 25 percent and reach a level of about 500 kg/ha.

From 3,000 kg/ha to 3,300 kg/ha, in spite of a high initial fertility, a heavy crop cannot be carried, and profitable benefits are again obtained with such high rates as 60 kg/ha for nitrogen and phosphorus. Above the 3,300 kg/ha mark, even these rates are not high enough to induce yield increases. Rates of fertilizers higher than 60 kg/ha are then required to obtain further increases. They are combined for the first time with potassium.

Together the ten classes showed the universal suitability of the HMR rate 30-30-0. Up to 3,300 kg/ha, it gives reasonable responses varying from 400-700 kg/ha. Profits range from 1,000 to 2,700 Rials/ha, and returns from 170 to 300 Rials. MP rates, however, depend on the initial fertility to a greater extent than do the HMR rates. Unless the right rates are applied, there can be losses. With the rates now established (see Table V-1), maximum profits may vary from 1,600 to 3,400 Rials/ha. These profits average about one third more than those of the HMR rate.

When no fertilizers are applied, the medium and higher yielding fields are the chief contributors to overall production. With fertilizer application, however, the lower producing fields contribute the larger share of the increased production. For example, fields yielding up to 2,100 kg/ha contribute 45 percent of the total production without fertilizers. When, fertilizers are applied universally, these fields will contribute nearly 75 percent of the overall increase of production.

1/ For a detailed discussion, see Volume II, Chapter VII.

Table V-1: RELATION BETWEEN CONTROL YIELD LEVELS AND THEIR ECONOMIC EVALUATION

Control yield classes, kg/ha	No. of fields % of total	Mean control yield kg/ha	Mean yield response to fertilizers		High return rate, 30-30-0		Maximum profit		
			kg/ha	%	Profit	Return	Rate	Profit	Return
1. 900 or less	13.6	697	772	110.8	2,786	299	45-45	2,868	236
2. 900-1,200	10.3	1,062	786	74.0	1,922	237	60-60	3,388	221
3. 1,200-1,500	15.6	1,360	782	57.5	2,618	287	50-50	2,881	223
4. 1,500-1,800	13.8	1,669	580	34.8	1,016	172	60-60	1,600	157
5. 1,800-2,100	11.2	1,961	678	34.6	2,042	246	40-40	2,350	226
6. 2,100-2,400	9.1	2,264	560	24.7	1,076	177	40-30	1,715	204
7. 2,400-2,700	6.7	2,548	570	22.4	1,658	218	30-30	1,658	218
8. 2,700-3,000	6.1	2,856	464	16.2	1,604	214	30-30	1,604	214
9. 3,000-3,300	5.9	3,128	658	21.0	1,610	215	60-60	2,230	180
10. 3,300 and over	7.7	3,869	154	4.0	-1,108	21	unknown, higher rate NPK mixture		

2. RESIDUAL EFFECTS OF FERTILIZERS

A crop uses only part of the fertilizers applied to a field. The rest is retained in the soil for indirect benefit of the next crop. These residual effects decrease with each succeeding crop.

Not all the residual fertilizer, however, is available for the next crop. Its effects can be decreased, for example, by losses through leaching or by gaseous losses due to chemical reactions. The fertilizer can also acquire forms less available for plants.

The existence of residual effects is clearly shown when wheat is planted immediately after the harvesting of a cotton crop to which fertilizers had been applied. They can even convert a loss into a profit.

When 67 fertilizer rates trials with cotton were immediately followed by wheat trials in Fars region, they showed a mean residual effect for wheat which amounted to 12 percent of the initial yield. This substantial figure is about half the direct effect for trials in the region. Residual effects become stronger with increasing rates of application. The conomic benefits for cotton alone, and for cotton and wheat combined, are shown in Table V-2.

Table V-2: ECONOMIC EVALUATION OF DIRECT EFFECTS AND DIRECT PLUS RESIDUAL EFFECTS COMBINED WITH COTTON AND WHEAT - PERIOD 1962-1964

Treatments kg/ha N P_2O_5 K_2O	Direct effects (cotton)				Direct effects (cotton) plus residual effects (wheat)		
	Value of yield incr. Rials/ha	Costs of fertilizer Rials/ha	Gross profit Rials/ha	Return per 100 Rials invested	Value of yield incr. Rials/ha	Gross profit Rials/ha	Return per 100 Rials invested
0 0 0	-	-	-	-	-	-	-
45 0 0	1,638	1,125	513	146	1,854	729	165
90 0 0	2,296	2,250	46	102	2,764	514	123
0 45 0	1,848	978	870	189	2,196	1,218	225
45 45 0	2,982	2,103	879	142	3,648	1,545	173
90 45 0	3,402	3,228	174	105	4,416	1,188	137
0 90 0	3,164	1,956	1,208	162	3,974	2,018	203
45 90 0	2,996	3,081	-85	97	3,932	851	128
90 90 0	3,402	4,206	-804	81	5,838	1,632	139
0 45 45	3,052	1,698	1,354	180	3,094	1,396	182
45 45 45	3,430	2,823	607	122	4,732	1,909	168
90 45 45	2,170	3,948	-1,778	55	4,222	274	107
Mean	2,762		271	126	3,697	1,206	159

The improvement of the profit and return data when the residual effects are included is considerable. This is especially clear from the 90-90-0 treatment.

Similar trials were carried out with a rice monoculture. Fertilizers were applied to a rice crop in 1963, but not to the following crop in 1964. These trials showed that the principal agent for residual effects is phosphorus; nitrogen has only very minor effects.

Phosphorus carrier comparisons were made to estimate the direct and residual effects with three carriers and Champa and Sadri rice in 1963, 1964 and 1965. They showed that there were strong residual effects and that they could be advantageously used.

Although there were no significant differences of yield between the three carriers, ammonium phosphate was slightly, but consistently, higher yielding than triple superphosphate and basic slag. It also gave the best economic results. In the third year, 1965, residual effects were almost non-existent, apart from triple superphosphate and ammonium phosphate (for Champa only). By comparison with 1963, the year of fertilizer application, a decrease in gross profits of 14 percent in 1964 (the first residual year) is expected. It increases to about 31 percent in 1965, the second residual year.

Table V-3 shows the residual effects, as percentages for all carriers and for both Champa and Sadri rice. The gross profit for the year of application (1963) is represented as 100 percent.

Table V-3: RELATIVE PROFIT VALUES FOR RESIDUAL EFFECTS EXPRESSED AS PERCENTAGES OF PROFITS FOR THE YEAR OF APPLICATION FOR TWO TYPES OF RICE AND THREE PHOSPHORUS CARRIERS

	Champa				Sadri			
	TS[a]	AP[a]	BS[a]	Mean	TS	AP	BS	Mean
1963	100	100	100	100	100	100	100	100
1964	88	76	85	83	75	83	81	79
1965	69	59	69	66	59	70	66	65
Mean	86	79	84	83	78	84	82	81

(a) TS = triple superphosphate; AP = ammonium phosphate; and BS = basic slag

If a fall in profits of about 14 percent is accepted, the application of phosphorus fertilizers in alternating years (one residual season) can be recommended. The use of two residual seasons can be recommended only if (a) a profit decrease of 31 percent is acceptable, (b) Champa is planted, and (c) either triple superphosphate or ammonium phosphate is applied at 60 kg P_2O_5 per hectare. In all cases, nitrogen must be re-applied annually.

3. TRACE ELEMENTS

Investigations into the influence of six trace elements (manganese, iron, copper, zinc, boron and molybdenum) and one secondary nutrient (magnesium) were started for sugarbeet and rice in the summer season of 1963. The seven nutrients were applied as manganese and iron sulphates each at 15 kg/ha, copper - and zinc sulphates each at 10 kg/ha, borax at 20 kg/ha and ammonium molybdate at 1 kg/ha, and finally magnesium sulphate as the secondary nutrient at 80 kg/ha.

For sugarbeet, grown on alkaline soils, the molybdate was omitted, and the rates of iron and manganese sulphates were doubled. Generally, ree extra plots were added to the standard fertilizer rates trials. The nutrient mixture was added to each extra treatment in powder form and carefully blended before broadcasting.

The investigations clearly showed that, at agriculture's present stage in Iran, these seven nutrients are not required. To meet, the possible needs of more intensified agriculture, however, the trials should be periodically renewed.

The situation is very different for such perennial crops as pears, apples, oranges and particularly peaches. Notably in Khorassan region, they suffer from iron deficiency induced by calcareous soils. "Lime induced iron chlorosis" is fairly widespread. Trials to test control measures - such as ferrous sulphate versus two compounds of iron chelates - were started by the Project. The first observations were merely visual.

Iron chelates are reagents which bind the iron ion through two or more positions within their structures and prevent it from forming an insoluble compound. The two compounds tested were EDTA and EDDHA, each applied at rates varying from 5-15 kg/ha, according to the compound and the crop. The applications were at three different rates (iron sulphate at three times the rate of the chelates) and at three different stages according to the severity of the deficiency.

Though the trials are not yet completed, they indicate that, even after accounting for differences in chelate and total iron content, the EDTA compound is only slightly more effective than ferrous sulphate, and that the EDDHA compound is superior to the EDTA preparation. This confirms what has been found elsewhere in the world with agriculture on alkaline soils; the EDTA compound is more suitable for acid soils.

On the whole, the price of the chelates is high, but they are recommended more for the valuable cash crops.

Photo 11: Iron deficiency in a young apple tree in Khorassan.

If future programming includes studies of iron deficiency in annual crops, they may help to explain why the people of the Khorassan region have a tendency to anaemia.

4. CORRELATIONS

To ensure the continuing value of fertilizer experimentation in the field, crop responses should be correlated with the results from chemical soil tests and with the soil units classified in soil surveys.

In order to give the right advice to farmers, it is important to establish a relationship between responses to fertilizers in the field and the chemical soil data. This is still more important when the soil series established in soil surveys differ significantly in their productivity, when each should have its own relationship between fertilizer response and chemical soil data. Another factor of the soil's productivity which can be correlated with initial yield is the Storie index. This index is mainly based on the physical features of the soil profile.

The following three sections deal with (a) correlations of the responses of irrigated wheat and sugarbeet with the data on soil phosphorus; (b) relationships between soil units and initial yields and fertilizer responses, and also with the Storie index; and (c) correlations between electric conductivity data of the saturation extract (salt content) of the soil samples and the initial yield.

4.1. Correlations of crop yields with soil phosphorus

Efforts to establish relationships between soil phosphorus extraction data and the yields of irrigated wheat and sugarbeet have been moderately successful. The degree of correlation was low.

At first a straight line relationship for wheat was established between soil phosphorus and the yield increase due to phosphorus fertilizer, but the degree of correlation was too low. An improvement was later obtained with a curved relationship. It merely indicated, however, that when soil phosphorus is at a given level and triple superphosphate is applied at 30 kg P_2O_5/ha, a certain average increase in yield can be expected. It has little practical value for the farmer. He wants advice on how much phosphorus fertilizer to apply as a result of the chemical analysis of the soil samples taken from his own farm.

These can be done by correlating the rates of phosphorus which give maximum yields with the soil phosphorus data. The rates are estimated by establishing for each trial a response curve through three points representing the mean yield effects of phosphorus fertilizer at 0,30 and 60 kg P_2O_5 per ha. The rate of P_2O_5 which gives the maximum yield in a particular trial is established for each curve and then correlated with the trial's soil phosphorus extraction figure.

A significant straight line relationship was established in this way. The present stage of agriculture in Iran, however, makes it premature to recommend any fertilizer rates aimed at maximum yields because they bring lower economic benefits. Rates should be based not on maximum yield, but on a high monetary return or a maximum profit.

Similar relationships were also established for sugarbeet. So far, they have been less satisfactory than the relationships for wheat, but investigations should continue. There will be greater correlation and accurancy if these relationships are established for each region, or even for each area or soil series.

4.2. Correlations of crop yields with soil series

In 1962, the Soil Survey Department collaborated with the Project in a soil survey of Fassa area, which has mixed alluvial soils and represents a good average of agricultural land on the Plateau. The classification made in this survey became a basis for determining a possible relationship between the initial yields of wheat and sugarbeet trials and different soil series.

The soil profile of each trial site was identified with the soil classification. The soil map of Fassa area in the Appendix of Volume II indicates the distribution of the trials.

Although seven series are distinguished, most trials are concentrated in the group of the River Valley soils; in particular, the Nowbandagan, Fidishkun and Fassa Rud series. These three are closely related, but its good physical characteristics give the Fassa Rud series a greater agricultural value. The two other series are not as favourable, but they are still too young to develop characteristics which result in a much lower yield. Their salty phase is important because it affects yields negatively. Only a few trials have been conducted on the series of the Upland soils.

Table V-4 shows the mean control yields and responses of 80 trials with irrigated wheat carried out during the 1962-63 and 1964-65 seasons and distributed over five out of the seven soil series. It also presents the means of the Storie indices.

The Storie index is the percentage obtained by multiplying the percentages of four factors, A x B x C x X. Factor A evaluates all the physical characteristics of the soil profile, except the texture of the surface soil. Factor B rates the soil on the basis of the surface soil characteristics, independently of subsoils. It is representative of soil texture, consistence of soil aggregates, porosity, permeability and tilth. Factor C makes allowance for slope. Factor X is the percentage evaluating drainage, alkali or salt content, general nutrient level, erosion, acidity and microrelief.

Table V-4: MEAN CONTROL YIELDS AND RESPONSES OF WHEAT ON FIVE SOIL SERIES IN FASSA AREA

Soil series	No. of trials	Mean control yield, kg/ha	Mean response to fertilizers	Percentage response	Storie index
UPLAND SOILS					
Colluvial soils					
Nazarabad series	10	1,685	571	34	74
Alluvial Fan soils					
Jelian series	5	2,296	771	33	82
RIVER VALLEY SOILS					
River Levee soils					
Fassa Rud series	12	2,567	727	28	83
Younger Terrace soils					
Nowbandagan series	27	2,231	594	27	81
gypsic phase	5	2,031	311	15	68
salty phase	5	1,617	155	9	53
Older Terrace soils					
Fidishkun series	5	2,348	852	36	77
salty phase	11	2,198	557	25	59

Comparisons indicate that the two main Terrace series, the younger Nowbandagan and the older Fidishkun series, do not differ significantly in yield, apart from the Nowbandagan salty phase. On an average, they yield about 2,200 kg of wheat per hectare. The Nazarabad series derived from colluvial soils is of a significantly lower fertility, and yield about 1,700 kg/ha. At the other end of the scale, the Fassa Rud series derived from river levee soils is significantly more productive than the Terrace soils, yielding about 2,600 kg/ha. These results were also confirmed by sugarbeet.

The Storie indices also show a certain, though not close, relationship with the initial yields. A correlation of the control yields of all the trials with their Storie indices revealed a correlation coefficient of 0.295** (1 percent significant). This positive relationship may be improved with an increase of trials.

4.3 Correlations of wheat yields with electric conductivity data

Soils on the Plateau are saline, but their average conductivity is low, mostly less than 2 millimhos/cm. Wheat is seldom adversely affected, except in Esfahan and Fassa, two areas which show the higher conductivity data on the Plateau. But even in Esfahan, only in 8 percent of the sites of trials did the conductivity data exceed 10 millimhos/cm. The figures in the Table V-5 show the negative relationship.

Table V-5: RELATIONSHIP BETWEEN INITIAL YIELDS OF WHEAT AND ELECTRIC CONDUCTIVITY DATA

millimhos/cm	Number of trials	Control yield kg/ha	Responses
2 and less	41	1,832	-
2 - 4	48	1,838	6
4 - 6	40	1,857	25
6 - 8	21	2,015	183
8 -10	14	1,846	14
10 and more	14	1,472	-360

Standard error of a difference: ± 125 kg/ha

It appears, therefore, that wheat yields are only negatively affected when the conductivity exceeds 10 millimhos/cm. In the trials, it resulted in a yield decrease of about 20 percent. Investigations in the U.S.A. have shown that, at this level of conductivity, a decrease of 50 percent may be expected with wheat. This difference may be because the varieties used in the trials were chiefly local; over the years they have acquired a great salt tolerance. The salt tolerance limits of crops in Iran are probably higher than those grown in the U.S.A. This should be investigated further, especially in Khuzistan region, where soil salinity is more serious.

5. TIME OF APPLYING NITROGEN TO IRRIGATED WHEAT

Fertilizers for grain are normally applied slightly before, or at the time of, planting. Top-dressings of nitrogen, however, may be beneficial in seasons with a high rainfall, when nitrogen is leached, or when denitrification occurs because soils become waterlogged during the winter, or when favourable winter moisture supplies indicate a higher than usual production potential. They should be applied early enough for the winter or spring rain or irrigation to move the nitrogen into the root zone.

The Project carried out 33 pairs of trials from 1962-64 in Fars region. On each site, one trial received the nitrogen in full at planting time. The other trial received half at seeding time and half as top-dressing in spring, when the wheat resumes growth. Ammonium nitrate was the nitrogen carrier.

The results showed no significant differences between either time of application. They indicated that nitrogen is not leached out of reach of the roots of wheat by the winter rains, and that it is better to apply all the nitrogen at seeding time than as split dressing. The trials, however, also indicated a significant phosphorus effect in favour of the split dressing. This needs to be further investigated and confirmed.

6. INFLUENCE OF THE NUMBER OF IRRIGATIONS ON INITIAL YIELDS, RESPONSES AND PROFITS

Investigations into the influence of number of irrigations on the yields of wheat, cotton and sugarbeet, their responses to fertilizers and profits have clearly shown that crops differ in their efficient use of irrigation water.

This section groups the results of 259 irrigated wheat trials in Fars region in 1962-63 according to the number of irrigations, which varied from 1 to 7 or more, and averaged 4.2. The quantities of irrigation water applied to wheat are variable. The initial irrigation averages 15 cm of water. Each subsequent irrigation is about 6 cm. With an average number of 4.2 irrigations, plus an allowance for an average rainfall of 8 inches (20 cm), the total water quantity amounts to 60 cm per growing season.

Table V-6: INFLUENCE OF NUMBER OF IRRIGATIONS ON YIELD AND PROFITS OF WHEAT

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Number of irrigations	Number of fields % of total	Mean check yield	Mean increase of yield with: 30-30-0		60-60-0		Gross profit 30-30	Gross profit 30-30 for one irrig.	Return for 30-30	Response curve 00-11-22 Max. prof.		Surface Max. profit	
		kg/ha	kg/ha	%	kg/ha	%	Rls/ha			rate	prof.	rate	prof.
1	3.1	577	134	23.2	477	82.7	-598	-598	57	Minimum		saddle	
2	11.6	1315	265	20.2	769	58.5	188	94	113	Minimum		saddle	
3	22.8	1726	370	21.4	541	31.3	818	273	158	36-36	838	34-23	849
4	23.9	2005	389	19.4	576	28.7	932	233	166	38-38	975	-	-
5	20.1	1922	548	28.5	820	42.7	1886	377	235	49-49	2223	11-126	2578
6 (and more)	18.5	2347	713	30.4	1068	45.5	2876	411	305	55-55	3630	44-65	3758
Mean (4.2 irrig)		1864	455	24.4	728	39.0	1328	316	195	51-51	1608	42-47	1528

Each additional irrigation over the generally recommended four irrigations is economically very beneficial. Profits as well as returns increase steeply with five and more irrigations. The law of diminishing returns does not begin to apply until there have been more than six irrigations.

Where four irrigations are applied, the yield is increased from 2 to about 2.4 tons/ha, and the gross profit per single irrigation is 233 Rials/ha as a result of applying 30-30-0. With 6 irrigations, the yield is increased from 2.3 to 3 tons/ha, and the gross profit per single irrigation is increased to 411 Rials/ha. Apart from increases of the control yields and responses to 30-30-0 with an increasing number of irrigations, the trend is also reflected in the gross profits and returns, and in the MP rates established from the 00-11-22 response curve.

An initial irrigation costs the farmer about 300 Rials/ha and each subsequent irrigation about 200 Rials/ha. Thus the cost of four irrigations can be covered by the gross profit from the increased yield due to fertilizers.

On the assumption that the sites of trials in each irrigation group were really distributed at random, it is possible to estimate the influence which each irrigation group has on area-wide production (with and without fertilizers). About two thirds of the area-wide production (without fertilizers) come from fields with 4 or more irrigations. When 30-30-0 is universally applied, the fields with four or more irrigations contribute not two thirds of the area wide increase of production, but three quarters.

With cotton, however, this upwards trend is much more limited and variable because such other factors as plant population, pests and diseases, and certain cultivation practices greatly offset the influence of the amount of water.

The results of 368 trials with cotton, carried out in Fars region from 1962-65, were grouped, like those for wheat, according to the number of irrigations. The initial yield, which at first increases with the number of irrigations, levels out at 14 irrigations. When the results are put into two separate groups - the first, including the data of all trials which received 13 and less irrigations, and the second, those which received 14 and more irrigations - the values shown in Table V-7 are obtained.

Table V-7: INFLUENCE OF NUMBER OF IRRIGATIONS ON THE YIELDS AND PROFITS OF COTTON

Number of irrigations	Average No. of irrigations	Number of fields % of total	Mean control yield kg/ha	Mean increase of yield with: 45-45-0 kg/ha	%	Gross profit 45-45-0 Rls/ha	Gross profit 45-45-0 per 1 irr.	Return for 45-45-0
13 and less	10.1	68.5	1,203	189	15.7	543	56	126
14 and more	17.2	31.5	1,768	223	12.6	1,019	60	148

Two thirds of the fields are insufficiently irrigated. The other third gives 50 percent more yield, and a response about 18 percent greater, but even with these adequate water supplies, the economic benefits are not spectacular. The gross profit on a single irrigation basis for wheat is about six times greater than that for cotton, if both are adequately irrigated. In contrast with wheat, the costs of irrigations cannot be covered by the gross profit from the increased yield due to fertilizers. Not until all the other factors which influence cotton yields are improved can the efficiency of water use be increased.

Greater efficiency of water use is achieved with sugarbeet, even more than for wheat. The results of 311 trials with sugarbeet, carried out in Fars region in 1962-65, were also grouped according to the number of irrigations.

The upward trend is again noticeable for the initial yield of sugarbeet. It is soon stabilized after about 15 irrigations. This does not apply, however, to the responses of two fertilizer rates, 45-45-0 and 90-45-0, which increase with the number of irrigations. They become proportionately rather stronger for the higher fertilizer rate.

Where 15-19 irrigations are applied, the gross profit per single irrigation for the HMR rate 45-45-0 is about 460 Rials/ha, which increases to 500 Rials/ha with 25 irrigations. The corresponding figures for the 90-45-0 rate are 660 and 750 Rials/ha. This shows an increasing efficiency of water use with increasing rates of fertilizers. The profit per irrigation for sugarbeet is higher than for wheat with a comparable fertilizer treatment, but this difference progressively narrows down with the increasing number of irrigations.

7. INFLUENCE OF PLANTING TIME ON WHEAT AND SUGARBEET YIELDS

Investigations into the influence of time of planting on the yields of wheat and sugarbeet clearly show that early planting is more beneficial than late planting.

Winter wheat planted in October may yield as much as 20 percent lower than wheat sown in September. If fertilizers are applied at the lower rates, yields also decrease at about the same rate. With early planting the higher rates of fertilizers may be more effective than the lower rates. Thereafter, the effect becomes less until it roughly equals that of the lower rates.

By planting sugarbeet in Fassa area in March instead of February, yields may decrease by 13 percent. If fertilized, the decrease is greater and about equal (25 percent) for high as well as low rates. The drop in profit is much more serious with sugarbeet than with wheat, for its value decreases by nearly 50 percent. Thus, in order to obtain high yields, the early planting is even more important for sugarbeet than for wheat, especially when fertilizers are applied.

8. COMPARISON OF IMPROVED AND NONIMPROVED WHEAT VARIETIES

Two improved varieties, Omid and Roshan, were introduced in the colder Plateau areas. They are equal in initial yielding power compared with the local nonimproved types (Rezakhani, Red Kavari), but the difference is clear from the mean response to fertilizers. This is shown in Table V-8.

Table V-8: COMPARISON OF IMPROVED AND NONIMPROVED IRRIGATED WHEAT VARIETIES

Treatment	Improved		Nonimproved
		(± 139.6)	
0 - 0	1,628		1,733
30 - 30	2,272		2,051
60 - 30	2,507		2,114
30 - 60	2,265		2,016
60 - 60	2,575		2,193
		(± 69.8)	
Mean response	777		360

The improved varieties, Omid and Roshan, show a response about twice as large (43 percent of the control yield) as that of the others (19 percent).

In the rainfed eastern Caspian region Akova, which is a rust resistant variety, replaced a very susceptible local nonimproved Siah type. It gave a much higher initial yield and response to fertilizers.. In the results of trials carried out in the seasons 1961 and 1962, the average initial yield for Akova was 1,451 kg/ha and 457 kg/ha for Siah. The discrepancy was mainly due to the effect of rust under rainfed conditions. Corresponding figures for the mean responses to fertilizers were 357 and 181 kg/ha, about half. The introduction of this new variety was completed in a few years.

CHAPTER VI

FERTILIZER REQUIREMENTS AND CROP INCREASES

A farmer requires some knowledge of the methods of using fertilizers before he can apply them effectively. At the same time, many economic and social factors exert their influence. For example, the price relationship between fertilizers and crops must be favourable. Otherwise, a farmer cannot be sure of a profit, and then he has no incentive to invest in fertilizers.

The relationship between fertilizers and crops is already favourable in Iran. This is because the experimental results show that, under the present farming and price conditions, it pays to apply fertilizers. In a developing country - especially in one which devotes a fair proportion of its foreign currency reserve to food crops - it may be less costly to subsidize the fertilizers than to support food crop prices.

None the less, the use of fertilizers depends very largely on good conditions of land tenure, the farmer's basic income and the availability of credit on fair terms.

Even when fertilizers are widely applied, they cannot become fully effective unless the farmers improve their own management practices, and particularly their soil management. Fertilizers, moreover, involve a radical change in the irrigated cropping system. With their use, a fallow is no longer needed.

1. AMOUNTS AND TYPES OF FERTILIZERS NEEDED

Estimates apply to the main food and cash crops: wheat, rice, cotton, sugarbeet, tea, tobacco, alfalfa, and other crops. They are based on the universal application of the HMR rate to all agricultural land under each crop, except marginal dry farming areas.

Tables at the end of this Chapter give fuller details on the fertilizer requirements for the total area of each main crop and the expected increases of production.

1.1. Wheat

Fertilizers have proved effective not only with irrigated wheat, but also with rainfed wheat in the Gorgan and Mazandaran areas of the Caspian region. Here, as elsewhere, 30-30-0 was the HMR rate. Only in the small and drier area of Gorgan was 15-30-0 taken instead.

1.2. Rice

Fertilizer requirements are based on an HMR rate of 30-30-0. Urea is the only recommended nitrogen carrier.

1.3. Cotton

The HMR rate of 45-45-0 monetary is universally recommended for the Plateau. Though trials in the Caspian region indicated losses with its application, there is little doubt that the standard of cultivation will improve and that the rate will also be recommended.

1.4. Sugarbeet

The HMR rate of 45-45-0 is generally recommended. The total area in 1964 was estimated at 64,000 ha, compared with 33,534 ha in the Census year 1960. Figures showing how the area in 1964 was distributed over the provinces are not recorded. To double the 1960 Census figures for each province is to arrive at a fair estimate of the situation in 1964.

1.5. Tea

Trials indicated a provisional high profit rate of 90-30-0. Urea is the most suitable carrier so far. The results are based on urea as the most suitable nitrogen carrier and triple superphosphate as the phosphorus carrier.

1.6. Alfalfa

The area under alfalfa is estimated at 75,000 ha. If an average age for a sward is five years, 15,000 ha will be planted with first year swards which receive a seedbed dressing. The remaining 60,000 ha will receive a top dressing.

The recommended seedbed rate is 0-45-0 as triple superphosphate, and 15-45-0 as top dressing in the form of ammonium phosphate. To fertilize the area fully, the amounts required are :

Seedbed dressing (15,000 ha)	Topdressing (60,000 ha)
Total P_2O_5 - 675 tons	Total P_2O_5 - 2,700 tons
Triple superph. - 1,465 tons	Amm. phosph. (18-50) - 5,400 tons

1.7. Tobacco

The HMR rate of 15-30-30 is universally recommended. The provincial areas are taken from the 1960 Census. Provinces in which less than 1,000 ha were planted with tobacco are omitted.

1.8. Other crops

They occupy only a small part of the total agricultural area. For some, the HMR rates of application are unknown and the given rates are those for which a good return of investment can be safely expected. The areas are based on the data of the 1960 Census.

Table VI-1 summarizes the fertilizer requirements of the main crops when their total areas are fertilized with HMR rates. Table VI-2 summarizes the monetary values of these fertilizer requirements.

Table VI-1: FERTILIZER REQUIREMENTS OF CROPS ON FERTILIZING OF TOTAL AREA WITH HMR RATE (METRIC TONS)

Crop	Area ha	Nitrogen			Phosphorus		Potassium
		Total N	Urea	Ammonium nitrate	Total P_2O_5	Triple superph.	Potassium sulphate
Wheat	1,370,272	39,990	49,400	66,379	41,112	89,277	-
Rice	304,191	9,128	19,837	-	9,128	19,837	-
Cotton	270,786	12,194	16,715	17,293	12,194	26,467	-
Sugarbeet	64,000	2,880	1,104	13,144	2,880	6,260	-
Tea	21,000	1,890	4,101	-	630	1,367	-
Alfalfa	75,000	-	-	-	3,375	1,465(a)	-
Tobacco	26,678	400	635	415	790	1,739	1,600
Other crops	474,469	22,074	23,085	44,063	27,041	49,492(a)	-
Total	2,606,396	88,556	114,877	141,294	97,150	195,904	1,600

(a) plus ammonium phosphate (18-50%) - required a total of 13,914 tons.

Table VI-2: VALUES OF FERTILIZER REQUIREMENTS

Fertilizers	Rials	US$
Nitrogen - 88,556 tons		
Urea: 114,877 x Rls 10,000	1,148,770,000	15,316,930
Ammonium nitrate: 141,294 x Rls 6,500	918,411,000	12,245,480
Phosphorus - 97,150 tons		
Triple superphosphate: 195,904 x Rls 10,000	1,959,040,000	26,120,530
Ammonium phosphate: 13,914 x Rls 12,500	173,925,000	2,319,000
Potassium - 1,600 tons		
Potassium sulphate: 1,600 x Rls 8,000	12,800,000	170,670
Total	4,212,946,000	56,172,610

2. EXPECTED INCREASE OF PRODUCTION DUE TO THE HMR RATE

This section estimates the increased production of the seven main crops as from 1964 (the last year for which production figuresare at present available) if the HMR rate is applied and the areas are fully fertilized.

2.1. Wheat

Yield responses to 30-30-0 are different for irrigated wheat on the Plateau and rainfed wheat in the Caspian region. On the Plateau, the increase of yield is 450 kg/ha for all irrigations; in the Caspian region it is about 320 kg/ha for both the higher and lower rainfall areas.

For a better estimate, the increase obtained with the present application of fertilizers should be subtracted. . In 1964, the fertilizer area was estimated at 170,000 ha. If it is assumed that this area was also divided in the same proportions of irrigated and rainfed wheat, an increase of 72,876 tons is obtained for the year. Thus the closest estimate of an increase of wheat production is: 587,471 - 72,876 = 514,595 tons of wheat. At $80 per ton, this amounts to US$ 41,167,600.

The 27 percent increase of production of irrigated wheat on application of the HMR rate, increases to 33 percent if the MP rate is universally applied instead.

2.2 Rice

Yield increases at the HMR rate 30-30-0 vary for different areas. In Fars, Esfahan, Khuzistan and Caspian regions the figures are 854 kg/ha, 570 kg/ha, 883 kg and 896 kg/ha, all for Champa rice, and 692 kg/ha for Sadri rice in the Caspian region. The areas planted to Champa and Sadri in the Caspian are about 1:1-

The total rice area fertilized in 1964 was estimated at 70,000 ha. If this area is proportionally divided over the first three areas, and if farmers applied the same HMR rate, the estimated yield increase for 1964 would be 56,123 tons of rice; 33,743 of Champa and 22,380 tons of Sadri rice. Thus the estimated increase is 187,290 tons.

In monetary terms, it is (115,849 x $93) + (71,441 x 134) = US$ 20,347,051, where the costs for Champa is $93/ton and 134/ton for Sadri.

2.3 Cotton

Yield increases differ from area to area when the HMR rate 45-45-0 is universally applied.

It is estimated that about 10 percent of the total area is fertilized. If the HMR rate was universally applied, the increase of production in 1964 would have been 5,587 tons. The estimated increase of production is thus 55,869 - 5,587 = 50,282 tons of seedcotton. At $187/ton this gives a value of US$ 9,402,734.

2.4 Sugarbeet

Yield increases again differ from area to area when the HMR rate 45-45-0 is applied.

No estimate of the area fertilized is available. Otherwise, the estimated value of the increased production at $ 133/ton is $ 92,741,698.

2.5. Tea

The area is estimated at 21,000 ha. The recommended rate 90-30-0 gives an increase of 658 kg fresh leaves per ha. Under fully fertilized conditions, the increase of production of fresh leaves is 21,000 x 0.658 tons = 13,818 tons.

The total area fertilized in 1964 was estimated at about 10,000 ha. If the rate 90-30-0 was applied, the increase of production would have been 6,580 tons. The estimated increase of production is thus 13,818 - 6,580 tons = 7,238 tons fresh leaves. At $ 280 per ton of fresh leaves, this gives a value of US$ 2,026,640.

2.6. Alfalfa

The area is considered to be 75,000 ha, of which 15,000 ha are under first year alfalfa and 60,000 ha are under two years and older alfalfa (average age 5 years).

For newly established alfalfa the recommended rate 0-45-0 gives an increase of 196 kg/ha hay per ha. For top dressing the recommended rate 15-45-0 gives an increase of 1,840 kg/ha of hay. Under fully fertilized conditions the increase of alfalfa production is :

15,000 x 0.196 = 2,940 tons

60,000 x 1.84 = 110,400 tons

113,340 tons hay

The total area fertilized is at present negligible, and this increase of production can be accepted as the estimated total increase. At $ 40 per ton of hay, the present value of the increase is $ 4,533,600.

2.7. Tobacco

The high return rate 15-30-30 is generally recommended for both the Turkish and the Burley types. Fertilizer influence is small on yield, but strong on quality. Thus the increases in the value of the yield are taken instead.

No estimate is yet available of the fertilized area. The total converted into dollars - US$ 3,429,304 - does not take the present fertilized area into account.

Table VI-3 summarizes the increase of production and its value when the areas under these crops are fully fertilized with the HMR rate.

Table VI-3: SUMMARY OF THE INCREASE OF PRODUCTION AND ITS VALUE WITH FULL FERTILIZATION AT THE HMR RATE

Crop	Increase of production (tons)	Value of increase (US$)
Wheat	587,471	46,997,680
Rice	243,413	26,484,070
Cotton	55,669	10,447,503
Sugarbeet	697,306	92,741,698
Tea	13,818	3,869,040
Alfalfa	113,340	4,533,600
Tobacco	-	3,429,304
Other crops	unknown	-
Total		188,502,895

3. ECONOMIC BENEFITS

When the actual costs of fertilizers for the seven main crops are subtracted from the value of increase as shown in Table VI-3, the net value of the increase of production is US$ 188,502,895 - 41,257,880 = US$ 147,245,015.

To estimate the actual value of the increase of production compared with 1964, the value of the production increase due to fertilizer application in 1964 must be subtracted. This value is estimated at $ 34,393,067 (excluding other crops). Thus the net value of the production increase under fully fertilized conditions compared with 1964 is estimated at:

US$ 147,245,015 - 34,393,067 = US$ 102,851,948

The estimated national increase of 587,000 tons of wheat per year is more than the average of 430,000 tons per year imported to meet the increasingly frequent food shortages of the past five years (1960-65). If fertilizers were universally applied now, these imports could be abolished. There could be an annual saving of US$ 34,400,000 in badly needed foreign currency reserves.

The estimated value of the increased production of the seven major crops listed in Table VI-3 is US$ 188,502,895. The actual cost of fertilizers to produce this increase is US$ 41,257,880. This gives a return of 456 units for every 100 units invested. It shows clearly that fertilizer application in Iran is a highly profitable short-term investment.

This chapter concludes with two series of tables. Series A (pp 82 to 84) shows the fertilizer requirements for each main crop at a regional level when the HMR rate is universally applied; and Series B (pp 85 to 86) shows the resulting increases of crop production.

A. TABLES SHOWING FERTILIZER REQUIREMENTS FOR TOTAL AREAS OF EACH MAIN CROP

Table VI-4: FERTILIZER REQUIREMENTS ON FERTILIZING OF TOTAL WHEAT AREA (METRIC TONS)

Region	Area ha (a)	Nitrogen (tons)			Phosphorus (tons)	
		Total N	Urea	Amm. Nitr.	Total P_2O_5	Triple Superph.
Gilan (incl. Zanjan)	49,965	1,500	3,258	-	1,500	3,258
Mazandaran and Gorgan	224,269	5,606	12,185	-	6,728	14,600
Khorassan	182,268	5,468	-	21,034	5,468	11,870
Teheran	144,019	4,321	-	16,620	4,321	9,380
West Azerbaijan	89,601	2,688	5,842	-	2,688	5,842
East Azerbaijan	171,208	5,136	11,163	-	5,136	11,163
Kurdestan	28,982	870	-	3,344	870	1,890
Kermanshah	60,156	1,805	-	6,942	1,805	3,917
Khuzistan	178,320	5,350	11,626	-	5,350	11,626
Central	45,618	1,370	-	5,264	1,370	2,973
Fars	114,170	3,425	-	13,175	3,425	7,432
Kerman	46,703	1,401	3,045	-	1,401	3,045
Sistan and Baluchistan	34,993	1,050	2,281	-	1,050	2,281
Total	1,370,272	39,990	49,400	66,379	41,112	89,277

(a) Agricultural census 1960.

Table VI-5: FERTILIZER REQUIREMENTS ON FERTILIZING OF TOTAL RICE AREA (METRIC TONS)

Region	Area ha	Nitrogen		Phosphorus	
		Total N	Urea	Total P_2O_5	Triple superph.
Gilan	168,451	5,054	10,983	5,054	10,983
Mazandaran	102,710	3,081	6,697	3,081	6,697
Khuzistan	22,727	685	1,486	685	1,486
Esfahan	2,658	79	173	79	173
Fars	7,645	229	498	229	498
Total	304,191	9,128	19,837	9,128	19,837

Table VI-6: FERTILIZER REQUIREMENTS ON FERTILIZING OF COTTON TOTAL AREA (METRIC TONS)

Region	Area ha	Nitrogen			Phosphorus	
		Total N	Urea	Amm. Nitr.	Total P_2O_5	Triple Superph.
Mazandaran and Gorgan	155,444	7,000	15,190	-	7,000	15,190
Khorassan	58,011	2,610	-	10,050	2,610	5,670
Fars	20,600	927	-	3,570	927	2,012
Teheran	14,745	665	-	2,560	665	1,443
Azerbaijan	8,748	395	857	-	395	857
Esfahan	5,377	242	-	932	242	525
Others	7,861	355	668	181	355	770
Total	270,786	12,194	16,715	17,293	12,194	26,467

Table VI-7: FERTILIZER REQUIREMENTS ON FERTILIZING OF TOTAL SUGARBEET AREA (METRIC TONS)

Region	Area ha	Nitrogen			Phosphorus	
		Total N	Urea	Amm. Nitr.	Total P_2O_5	Triple Superph.
W. Azerbaijan	8,626	388	844	-	388	844
Fars	15,848	713	-	2,743	713	1,550
Kerman	2,661	120	260	-	120	260
Khorassan	32,284	1,453	-	5,588	1,453	3,158
Esfahan	2,000	90	-	346	90	196
Central	2,581	116	-	4,467	116	252
Total	64,000	2,880	1,104	13,144	2,880	6,260

Table VI-8: FERTILIZER REQUIREMENTS ON FERTILIZING OF TOTAL TOBACCO AREA (METRIC TONS)

Region	Area ha	Nitrogen			Phosphorus		Potassium
		Total N	Urea	Amm. Nitr.	Total P_2O_5	Triple S.	Pot. Sulf.
Gilan	6,048	91	198	-	182	396	364
Gorgan and Mazandaran	2,371	35	76	-	70	152	140
East and West Azerbaijan	11,063	166	361	-	322	722	664
Fars	1,595	24	-	92	48	104	96
Kurdestan	5,601	84	-	323	168	365	336
Total	26,678	400	635	415	790	1,739	1,600

Table VI-9: FERTILIZER REQUIREMENTS ON FERTILIZING OF VARIOUS CROPS (METRIC TONS)

Crop	Rate of fertilizer	Area ha	Nitrogen			Phosphorus		
			Total N	Urea	Amm. Nitr.	Total P_2O_5	Triple superph	Ammonium phosph.
Melons	45-45-0	34,907	1,572	677	4,851	1,572	3,411	-
Potatoes	45-45-0	12,212	550	510	1,213	550	1,194	-
Vegetables	60-60-0	19,189	1,152	475	3,592	1,152	2,500	-
Legumes (beans)	20-60-0	70,946	-	-	-	4,257	-	8,514
Other fodder crops	60-60-0	41,753	2,505	1,786	6,476	2,505	5,436	-
Oilseeds	45-45-0	41,490	1,867	3,335	1,270	1,867	4,051	-
Spices	45-60-0	47,341	2,130	-	8,200	2,840	6,163	-
Fibre crops	45-45-0	6,631	298	650	-	298	650	-
Fruit trees	60-60-0	200,000	12,000	15,652	18,461	12,000	26,087	-
Total		474,469	22,074	23,085	44,063	27,041	49,492	8,514

B. TABLES SHOWING PRODUCTION INCREASES ON FERTILIZING TOTAL AREAS OF EACH MAIN CROP

Table VI-10: PRODUCTION INCREASES ON FERTILIZING OF TOTAL WHEAT AREAS

Region	Area (ha)	Increase (kg/ha)	Total increase (tons)
Plateau (irrigated)	1,146,003	450 (27%)	515,705
Caspian (rainfed)	224,269	320 (17.6%)	71,766
Total	1,370,272		587,471

Table VI-11: PRODUCTION INCREASES ON FERTILIZING OF TOTAL RICE AREAS

Region	Area (ha)	Increase (kg/ha)	Total increase (tons)	
			short gr.	long gr.
Caspian region-short grain	135,580	896	121,480	-
Caspian region-long grain	135,580	692	-	93,821
Khuzistan	22,727	883	20,068	-
Esfahan	2,658	570	1,515	-
Fars	7,645	854	6,529	-
Total	304,190		149,592	93,821

Table VI-12: PRODUCTION INCREASES ON FERTILIZING OF TOTAL COTTON AREA

Region	Area (ha)	Increase (kg/ha)	Total increase (tons)
Mazandaran and Gorgan	155,444	135	20,985
Khorassan	58,011	355	20,594
Fars	20,600	200	4,120
Teheran	14,745	380	5,603
Azerbaijan	8,748	417	3,648
Esfahan	5,377	171	919
Total	262,925		55,869

Table VI-13: PRODUCTION INCREASES ON FERTILIZING OF TOTAL SUGARBEET AREA

Region	Area (ha)	Increase (tons/ha)	Total increase (tons)
Fars	15,848	12.33	195,406
Esfahan	2,000	11.58	23,160
Teheran	2,581	7.43	19,177
Azerbaijan	8,626	5.72	49,341
Khorassan	32,284	11.80	380,951
Kerman	2,661	11.00	29,271
Total	64,000		697,306

Table VI-14: MONETARY INCREASES ON FERTILIZING OF TOTAL TOBACCO AREA

Region	Area (ha)	Values (Rls/ha)	Total value (Rls)
Gilan	6,048	13,949	84,363,552
Gorgan	2,371	7,098	16,829,358
Azerbaijan	11,063	8,544	94,522,272
Others	7,196	8,544	61,482,624
Total	26,678		257,197,806

APPENDIX I - FIELD STATIONS IN THE PROJECT AREAS

The following is a brief statement on the field stations and substations opened during the Project period from 1961 to 1965. The table gives the mean annual rainfall and the mean January and July temperatures in the Project areas.

Table. SUMMARY OF MEAN ANNUAL RAINFALL AND MEAN JANUARY AND JULY TEMPERATURES IN THE PROJECT AREAS

Field station	Altitude (m)	Mean annual rainfall (mm)	Mean January temp. (C°)	Mean July temp. (C°)
Plateau				
Shiraz	1,530	416	6.5	28.9
Fassa	1,255	328	10.7	32.6
Kazerun	735	356	9.7	33.3
Esfahan	1,590	135	4.0	29.2
Ghazvin	1,301	274	0.4	26.8
Maragheh	1,485	260	-1.2	25.7
Rezayeh	1,332	402	-0.5	25.9
Mashad	985	236	0.7	25.9
Neyshabur (a)	1,213	-	-	-
Torbat-e-Heydarieh	1,330	198	2.1	26.8
Rafsanjan	1,757	199	5.6	23.1
Bam	1,062	61	10.6	32.3
Borujerd	1,768	414	-0.8	27.4
Caspian region				
Rasht (Gilan)	3	1,247	7.1	24.7
Babol (Mazandaran)	6	822	7.9	26.3
Gorgan (Gorgan)	120	520	8.9	27.1

(a) Data incomplete

1. Fars region. The field station in Shiraz was opened in 1961. Subareas are Marvadasht (50 km), Kavar (30 km) and Shubazar. The estimated total area of arable land (including fallow) is 50,000 ha. It includes (under irrigation): wheat, 28,500; barley, 5,800; rice, 700; sugarbeet, 6,750; and cotton, 1,800 ha. Under dry farming are: wheat, 4,860; and barley, 1,500 ha.

Fassa was opened in 1961. Subareas are Fidishkun (25 km), Naubandagan (25 km), Jahrum (75 km) and Dharab (100 km). Estimates of the total area of arable land and the areas planted to the different crops are uncertain. The most important food crop grown is wheat, which is grown under both irrigated and under rainfed conditions.

Cotton is the major cash-crop in the Dharab subarea, while in the immediate Fassa area sugarbeet is the most important source of the farmer's cash income. Cotton and sugarbeet are only grown under irrigation. Citrus is planted in the subarea of Jahrum.

Kazerun was opened in 1961. Subareas are Shahpur (30 km) and Mamasani (100 km). Estimated total area of arable land (including fallow) is 64,500 ha. Irrigated are: wheat, 11,500; barley, 1,500; and cotton 650 ha. Under dry farming are: wheat, 9,000; and barley 5,000 ha. Sugarbeet is newly introduced.

2. Central region. Esfahan was opened in 1963. Subareas are Ghohab, Barkhar, Jay and Lenjan. Estimated total area of cultivable land under irrigation is 25,000 ha; wheat, 5,000; barley 2,000; rice, 5,000; cotton, 4,000; sugarbeet, 5,000; and melons 4,000 ha.

3. Azerbaijan region. Ghazvin was opened in 1963. Estimated total area of cultivable land is 90,000 ha. Under irrigation are: wheat, 30,000; barley, 13,000; cotton, 5,000; sugarbeet, 1,400; melons, 2,000 ha. Nonirrigated are: wheat, 23,000; and barley , 9,000.

Maragheh was opened in 1963. Subareas are in Afjabshir (40 km) and Miandoab (70 km). Estimated total cultivated land is 80,000 ha; (irrigated and nonirrigated together) wheat, 65,000; barley, 30,000; sugarbeet, 5,000; grapes, 5,000; potatoes, 1,000.

Rezayeh was opened in 1963. Subareas are Shahpur (90 km) and Khoy (140 km), both north of Rezayeh. Estimated total of cultivated land is 130,000 ha. Crop areas are not known completely. Wheat, the main food crop, is cultivated extensively both irrigated and dry-farmed. Tobacco is grown on 10,000 ha; 8,000 ha are planted with grape-vines and 5,000 ha with sugarbeet. Alfalfa is grown throughout the whole area although on a minor scale.

4. Khorassan region. Mashad was opened in 1964. A substation is in Qochan (60 km). Estimated total of cultivated land is 180,000 ha. Irrigated are: wheat, 75,000 ha; barley, 25,000 ha; melons, 12,000 ha; and grapes, 6,000 ha. Nonirrigated are 60,000 ha of wheat. Figures of other nonirrigated crops and fruit are not available.

Neyshabur was opened in 1964. No climatic data are available. Though the area is rather warmer than Mashad, there is no marked difference in the amount of precipitation. Total area of cultivable land is not known, but estimated areas under main crops (irrigated) are: wheat, 10,000 ha; barley, 3,000 ha; cotton, 7,000 ha; grapes, 5,000 ha; melons, 700 ha; and deciduous fruit, 3,000 ha. Nonirrigated are: wheat, 5,000 ha; and melons, 1,500 ha.

Torbat-e-Heydarieh was opened in 1964. Estimated total of cultivable land is 20,000 ha. They include (irrigated and dry farming together): wheat, 10,500; cotton, 400; and sugarbeet, 3,500 ha.

5. Kerman region. Bam was opened in 1965. Estimated total of cultivable land is 14,000 ha. Complete estimates concerning land use are not available. Wheat is supposed to be planted on 7,000 ha, and the area planted to datepalms is calculated at slightly less than 2,000 ha. The extent of the citrus area - a crop as important as dates is not well known.

Rafsanjan was opened in 1965. A substation is in Bardsir (70 km).

Estimated total area of cultivable land (irrigated and dry-farmed together) is about 41,000 ha: wheat, 23,000; cotton, 4,000; and pistachio, 15,000 ha.

6. Lorestan region. Borujerd was opened in 1965. Substations will be opened in Khoramabad, Arak, Malayer and Hamadan. Estimated total area under cultivation (irrigated and dry-farmed) is 130,000 ha; wheat, 36,000 ha; barley, 9,000 ha; cotton, 500 ha;

grapes, 700 ha; and legumes, 2,500 ha.

7. Caspian region. Rasht (Gilan) was opened in 1961. Substations are in Lahijan (40 km) and Sume Sarah (30 km). Estimated total area under cultivation is 230,000 ha; rice (irrigated) 180,000 ha; and (nonirrigated) tobacco, 6,000 ha; tea, 22,000 ha; and citrus, 6,000 ha.

Babol (Mazandaran) was opened in 1961. Substations are in Mahmudabad (30 km) and Behshar (80 km). Estimated cultivated area is 130,000 ha. Rice is planted to about 95,000 ha, cotton in the eastern part on 20,000 ha. Citrus cultivation is very much on the increase (4,000 ha). Wheat is grown on 40,000 ha in the Behshar subarea.

Gorgan was opened in 1961. Subareas are in Kordkuy (30 km) and Aliabad (45 km). Wheat is planted on about 150,000 ha. Cotton is the most important cash crop and annually more than 100,000 ha are planted to it. Tobacco and watermelons (Citrullus vulgaris) are other important sources of cash income.

APPENDIX II - TABLES RELATING TO CROP EXPERIMENTS IN THE PROJECT AREAS

The following three tables relate to crop experiments.

Table 1 summarizes the experiments (harvested) with crops during the Project's period. It includes planting and harvest times.

Table 2 gives the numbers of experiments on winter and summer crops.

Table 3 gives the number of experiments planted per crop and season.

Table 1: SUMMARY OF EXPERIMENTS (HARVESTED) WITH CROPS DURING THE PROJECT'S PERIOD IN THE REGIONS, INCLUDING THE PLANTING AND HARVESTING TIMES

Region and area	Crop	Number of experiments (harvested)	Total No. for all crops	Planting time	Harvesting time
Fars (1961-65)					
Shiraz	Wheat	403		September-October	June-July
	Barley	4		September-October	June-July
	Rice	97		March-April	August-September
	Cotton	197		March-April	September-onwards
	Sugarbeet	296	997	February-March	December-and later
Fassa	Wheat	388		September-October	May-June
	Cotton	229		April-May	September-onwards
	Sugarbeet	285		February-March	November -December
	Citrus	28	930	-	December
Kazerun	Wheat	222		September-October	May
	Barley	33		September-October	May
	Cotton	160		March-April	September-onwards
	Rice	144		June	August
	Sugarbeet	9	568	March-April	November
Central (1963-65)					
Esfahan	Wheat	182		September-October	June-July
	Cotton	37		April-May	September-onwards
	Sugarbeet	62		March-April	November
	Rice	108		June	September-October
	Melons	91		March	August-onwards
	Onions	18	498	March	September
Azerbaijan (1963-65)					
Ghazvin	Wheat	89		October-November	June
	Cotton	65		April-May	October-November
	Sugarbeet	85		March-April	November
	Melons	31		March	August
	Grapes	39		-	August-September
	Potatoes	18	327	April-May	September-October
Maragheh	Wheat	191		September	July-August
	Barley	29		September	July
	Sugarbeet	56		April-May	October-November
	Alfalfa	48		April-May	2 months intervals
	Potatoes	67		April-May	September-October
	Grapes	13	415	-	August-September

Table 1: SUMMARY OF EXPERIMENTS (HARVESTED) WITH CROPS DURING THE PROJECT'S PERIOD IN THE REGIONS, INCLUDING THE PLANTING AND HARVESTING TIMES (Cont.)

Region and area	Crop	Number of experiments (harvested)	Total No. for all crops	Planting time	Harvesting time
Rezayeh	Wheat	178		September-October	July
	Barley	3		September-October	June
	Sugarbeet	53		April-May	September-October
	Alfalfa	57		April-May	2 months intervals
	Tobacco	72		May	September
	Grapes	10	373	-	September
Khorassan (1964-65)					
Mashad	Wheat	87		September-October	June-July
	Sugarbeet	4		March	October-November
	(Cotton)	12		May	October onwards
	Melons	30		March-April	August-September
	Deciduous fruit	81	214	-	June-August
Neyshabur	Wheat	77		September-October	June-July
	Cotton	78		April-May	September onwards
	Apples	46	201	-	July-August
Torbat-e-Heydarieh	Wheat	57		September-October	June-July
	Sugarbeet	35		February-March	September-November
	Cotton	42	134	March-April	September onwards
Kerman (1965)					
Bam	Wheat	-		November-December	May
	Date palm	22		-	August-October
	Citrus	30	52	-	November
Rafsanjan	Wheat	-		September-October	June
	Pistachio	46		-	October
	Sugarbeet	17	63	February-March	November-December
Lorestan (1965)					
Borujerd	Wheat	77		August-September	June-July
	Sugarbeet	3		February-March	November
	Grapes	-		-	August-September
	(Cotton)	-	80	April-May	September onwards
Caspian (19161-65)					
Rasht	Rice	442		May	August-September
	Tea	94		-	March-October
	Tobacco	43		May	August-September
	Citrus	34		-	December-January
	Kenaf	7	620	April-May	September

Table 1: SUMMARY OF EXPERIMENTS (HARVESTED) WITH CROPS DURING THE PROJECT'S PERIOD IN THE REGIONS, INCLUDING THE PLANTING AND HARVESTING TIMES (Cont.)

Region and area	Crop	Number of experiments (harvested)	Total No. of all crops	Planting time	Harvesting time
Babol	Wheat	270		October-November	June
	Rice	300		May	August-September
	Cotton	181		May	September onwards
	Kenaf	31		April-May	September
	Citrus	2	784	-	December-January
Gorgan	Wheat	357		October-December	June-July
	Barley	33		October-December	June
	Cotton	209		May	September onwards
	Tobacco	42		May	August-September
	Water melons	17	658	March	August onwards
Total			6,917		

Table 2: NUMBER OF FERTILIZER EXPERIMENTS, WINTER AND SUMMER CROPS, 1961-65

Station	F.R.T.(a)		N.C.		P.C.		NC+PC		Demonstr.		Res.		Total	
	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Shiraz	862	668	100	67	107	88	-	-	148	124	57	50	1274	997
Fassa	796	663	106	87	67	57	-	-	112	95	31	28	1112	930
Kazerun	594	435	58	49	-	-	-	-	68	61	36	26	756	571
Esfahan	411	355	45	39	18	16	16	11	83	68	15	9	588	498
Maragheh	434	357	-	-	25	19	-	-	60	39	-	-	519	415
Rezayeh	399	299	18	13	16	15	-	-	51	39	8	7	492	373
Ghazvin	446	312	-	-	16	5	-	-	43	10	-	-	505	327
Rasht	500	369	24	22	96	88	22	18	75	38	90	85	807	620
Babol	710	548	58	54	100	81	-	-	81	70	44	31	993	784
Gorgan	673	497	95	80	32	28	-	-	65	51	2	2	867	658
Mashad	264	199	-	-	17	15	-	-	-	-	-	-	281	214
Torbat	159	125	-	-	-	-	-	-	6	4	6	5	171	134
Neyshabur	203	187	-	-	-	-	-	-	10	8	7	6	220	201
Bam	65	52	-	-	-	-	-	-	-	-	-	-	65	52
Rafsanjan	70	63	-	-	-	-	-	-	-	-	-	-	70	63
Borujerd	10	3	-	-	-	-	-	-	82	77	-	-	92	80
Total	6596	5132	504	411	494	412	38	29	884	684	296	249	8812	6917

(a) F.R.T., fertilizer rates trial; N.C., nitrogen carrier trial; P.C. phosphate carrier trial; Res., residual effect trial; L., laid out trials; H., harvested trials. The discrepancy between L and H is chiefly due to conditions beyond the experimenter's control.

Most trials were fertilizer rates experiments, except in Borujerd, where field experimentation started in the spring of 1965 and where only wheat topdressing demonstrations could be laid out. Great differences between the total numbers of harvested and laid-out trials are often caused by a failure of the dry-farming wheat trials. In Ghazvin, for instance, out of 30 dry-farming trials none could be harvested after the dry spring of 1964.

Table 3: NUMBER OF EXPERIMENTS PLANTED PER CROP AND SEASON

	Food Crops			Cash Crops					Fodder crops	Fruit and nut trees						Vegetables and annual fruits				Total number of crops and experiments
	Wheat	Barley	Rice	Cotton	Sugar-beet	Tobacco	Tea	Kenaf	Alfalfa	Citrus (orgs)	deciduous Apple	deciduous Peach	Grapes	Pista-chio	Date Palm	Pota-toes	Onions	Melons	Water melons	
Summer, 1961	-	-	165	259	57	26	-	-	-	-	-	-	-	-	-	-	-	-	-	507
Winter, 1961-1962	573	111	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	684
Summer, 1962	-	-	199	258	119	43	20	9	-	-	-	-	-	-	-	10	-	-	-	658
Winter, 1962-1963	648	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	658
Summer, 1963	-	-	324	337	319	59	25	19	29	8	-	-	26	-	-	17	-	30	-	1,193
Winter, 1963-1964	1,093	29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,122
Summer, 1964	-	-	254	355	278	76	24	33	36	32	45	16	24	-	-	25	5	46	25	1,274
Winter, 1964-1965	1,002	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,022
Summer, 1965	-	-	338	350	431	46	25	40	48	74	48	18	47	50	35	50	15	52	27	1,694
Total number of experiments	3,316	170	1,230	1,559	1,204	250	94	101	113	114	93	34	97	50	35	102	20	123	52	8,812
Percentage of total	37.6	1.9	14.5	17.7	13.7	2.8	1.1	1.2	1.3	1.3	1.0	0.4	1.1	0.6	0.4	1.2	0.2	1.4	0.6	

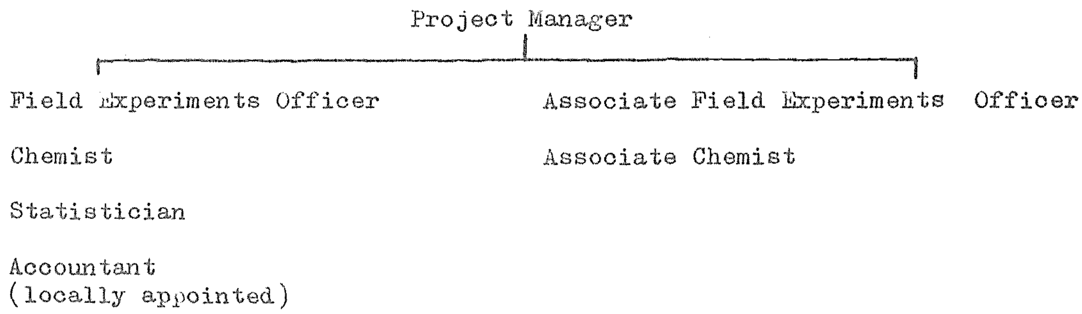
APPENDIX III - PROJECT PERSONNEL

The headquarters' staff were:

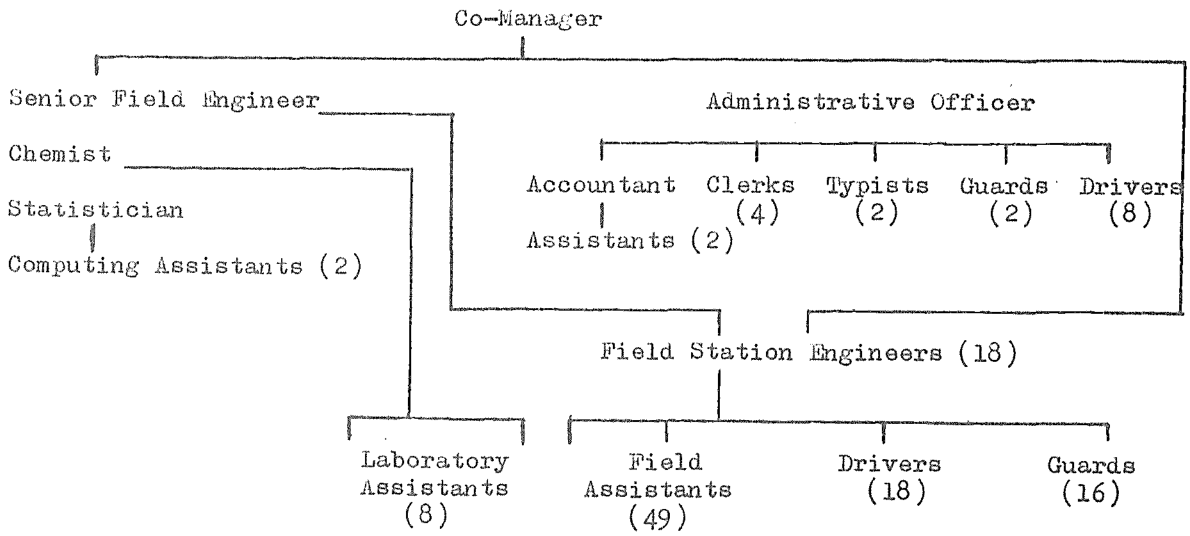
	FAO Staff	Iranian Staff	Associate Experts
Project Manager:	G. Hauser (to 1964) E. Boswinkle (1965)	M. Ghasemi (to 1962) F. Mahdavi (1962-65)	
Field Experiment Officer	E. Boswinkle (to 1964) P. Bergin (1965)	I. Nasseri Toosi (1964-65) M. Rezania (1962-65)	P. van der Goot (Holland, 1964-65)
Soil Chemist:	J. Dewis (1961-62) J. Benjaminsen (1963-65)	M. Hakimian (1964-65)	H. Heuser (W. Germany, 1964-65)
Statistician:	H. Fairfield-Smith (to 1963) Asghar Ali (1963-65)	A. Gamshadzehi	
Chief Administrative Officer:		G. Rafii	
Accountant:	F. Shirazi (locally appointed)	S. Majlesi	

The staff structure was:

1. <u>International staff</u>



2. <u>National staff</u>



<u>Contributors to this report are</u>: Mr. P. Bergin, Mr. Asghar Ali, Dr. H. Heuser and Mr. P. van der Goot of the international staff, and Mr. A. Gamshadzehi and Mr. A. Hubakht, together with the computing staff of the statistical section, under the overall direction of Mr. E. Boswinkle.

APPENDIX IV

PLAN OF OPERATION

UNITED NATIONS SPECIAL FUND PROJECT

IRAN

SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT

Special Fund Allocation:	$ 566,140
Government Counterpart Contribution: (estimated at equivalent of)	$ 1,068,000
Duration:	5 years
Executing Agency:	Food and Agriculture Organization of the United Nations
Cooperating Government Agency:	Ministry of Agriculture, Government of Iran.

For purposes of a Soil Fertility Survey in Iran and for the establishment of a Soil Fertility Unit in the Ministry of Agriculture in Iran, to be undertaken by the Food and Agriculture Organization of the United Nations acting as Executing Agency for the United Nations Special Fund, and the Ministry of Agriculture, Iran, as the Cooperating Agency, this Plan of Operation shall be the Plan of Operation referred to in Article I, paragraph 2, of the Agreement signed on 6th October 1959 by the Government of Iran and the United Nations Special Fund.

I. PURPOSE AND DESCRIPTION OF THE PROJECT

A. Purpose

1. The purpose of the project is to assist the Government to establish a Soil Fertility Unit, carry out soil fertility surveys in various parts of Iran as specified in this Plan of Operation and further train Iranian personnel in this field of specialization. The task of the Soil Fertility Unit is to develop information on the fertilizer and manurial requirements of crops under a variety of soil, water and agronomic conditions. This information is needed as a basis not only for national planning of fertilizer use but also in formulating recommendations to farmers and cultivators on application of the fertilizers. The soil Fertility Unit would be responsible for initiating fertilizer experimentation in the field and laboratory, and for the coordination of this type of work undertaken by other agencies, and for assembling the data on fertilizer responses developed by those agencies. This Unit's overall objective will be to raise the productivity of Iranian soils on a sustained basis.

B. Description of the Project

2. The project which covers experimentation in the field and laboratory and interpretation of the experimental results will include:

(a) establishment of reliable scientifically designed field experiments throughout the country on an expanding scale. These experiments will be conducted not only with crops presently grown in the different areas but will also be tried with new crops. The more important experiments to be undertaken are listed below:

(i) fertilizer trials of several years duration with different levels of N, P and K, singly and in combination, to study the direct, residual and cumulative effects of these elements and their interactions both on the quantity and quality of the produce.

(ii) comparison of the relative efficiency of different nitrogen and phosphorus carriers.

(iii) study of the effects of indigenous manures both singly and in combination with fertilizers.

(iv) experiments on time and method of fertilizer application.

(v) effects of secondary and micronutrient elements.

(b) development of correlations between soil analyses, results of pot experiments and response of crops to fertilizer treatments under field conditions. The results of this work will establish the general fertility status of different Iranian soil types and will help to reduce the number of field trials needed in the future.

(c) investigation of some of the fundamental fertility problems of Iranian soils, e.g.

(1) the low organic matter status

(2) the low phosphate availability

(3) possible micro-element deficiencies and excesses.

3. Useful information resulting from the field, greeenhouse, and laboratory work outlined above will be made available to the Extension Service as a basis for recommendations to farmers and cultivators on efficient fertilizer use. The project will also assist the Extension Service in conducting a large number of simple fertilizer field tests.

4. In planning the field experiments, special emphasis will be given to areas having important agricultural or horticultural potentiality. Thus the high-rainfall areas of Gilan-Mazandaran will receive priority.

5. The field experiments will be supervised by a number of regional offices which will be established and maintained on an expanding scale.

6. The project is conceived as a combined survey and research program. The project also includes training of Iranian soil fertility technicians on the project and abroad.

7. At the end of five years, there will thus be a Soil Fertility Unit with a well-trained supervisory staff at the Main Office and technical staff at 12 regional offices.

8. Details concerning the design of field experiments, fertilizer treatments, plot size, lay-out, and numbers and kind of chemical analyses will be the responsibility of the Project Manager. Such details will be discussed by the International Staff, working as a team, in consultation with the senior Iranian staff and will form an important part of the training of the Iranian personnel. Full advantage will be taken of the results of all experimental work carried out in Iran so far, especially of the experience gained in Khuzistan.

9. Initially, the type of experiment will be chosen to provide information on basic NPK manuring, especially in areas where fertilizers have not so far been used to any considerable extent. Later designs will test different kinds of fertilizers, including indigenous fertilizers, methods and times of application and the use of different varieties of crops or of alternative crops. Throughout these experiments, careful observations will be made to identify minor element deficiencies or excesses with a view to testing the effects of minor elements in the later stages of the project.

10. The actual work under this Project is scheduled for five years. However, in the fifth year, the Project Manager and Field Experiments Officer will be transferring the main responsibility to their counterparts. They will also assist in framing plans for the continuation of the Soil Fertility Unit, together with recommendations to farmers on the wide and efficient use of fertilizers.

II. WORK PLAN

A. Participation and Contribution of the Special Fund

The Special Fund will provide the following through the Executing Agency:

11. Experts:

(i) One Soil Fertility Expert, for five years, to act as Project Manager and be responsible on behalf of the Executing Agency for operating the Project and training Iranian staff. He will, together with the Co-Manager, be responsible for selection of personnel, detailed planning of experiments, administration and execution of the Project, correlation of field and laboratory work, scrutiny and evaluation of results, preparation of technical reports, and organization and supervision of related training programs.

(ii) One Field Experiments Expert, for five years, to supervise all experiments carried out under the Project's program and train personnel in field experimentation.

(iii) One Statistician, for three years, to assist the Soil Fertility Expert in planning of experiments, in the statistical analysis of results and in training of personnel in agricultural statistics and computation.

(iv) One Soil Chemist, for four years, to supervise all analyses to be carried out in the Central Soils Laboratory and in the Field Laboratories attached to the Regional Offices.

(v) Short-term consultants, for a total period of eight man-months, as needed for the efficient operation of this Project.

12. Fellowships:

Six fellowships will be provided by the Executing Agency to the Iranian technicians selected out of project counterparts for training abroad. The selection will be made by the Project Manager and Co-Manager, and will be approved by the Soil Fertility Co-ordinating Committee (para. 50). The training will take place in the second, third and fourth years of operation. The training of four out of the six will be in field experimentation for soil fertility studies. One will be for training in statistics and one in soil and plant chemistry. Fellowships awarded under this Plan of Operation shall be administered in accordance with fellowship regulations of the Executing Agency.

13. Equipment and Supplies:

(i) Transport:

Jeep Station-Wagons	15
Motor Scooters and/or motor bicycles	24
(Spare parts for above)	

(ii) Field equipment for the experiments, such as:

Pentagon prisms and compasses
Cultivators
Seed drills
Fertilizer spreaders
Sprayers for insecticides and fungicides
Sprayers for nutrient solutions
Cutting and threshing machines
Balances and scales
Seed cleaners

(iii) Equipment for associated soil surveys, such as:

Augers
pH kits
Munsell colour charts
Soil survey manuals
Equipment for preparing soil profile specimens
Special paper and inks for preparation of soil maps

(iv) Laboratory equipment:

- Regional Offices: Soil testing kits
  pH kits
  Conductivity bridges
  Glassware, chemicals, etc.

- Central Soils Laboratory, Amirabad:

  Soil grinding machine
  Machine for grinding dry plant specimens
  pH meter
  Electrophotometer for soil and plant analysis
  Flame photometer for Na and K analyses
  Shaking machine
  Selected glassware and chemicals
  Ovens and incubator as required
  Any other equipment as required to supplement existing apparatus

(v) Calculating machines

(vi) Latin typewriters for the main office

(vii) Books and reference materials

(viii) Equipment for the pot experiments, such as plastic pots, water demineralizer, etc.

14. Fertilizers and Supplies

(i) Fertilizers other than those which the Government is manufacturing in Iran, needed for both the field experiments of the Project and for simple tests. These fertilizers would include superphosphate, triple superphosphate, ammonium phosphates, potassium sulphate, potassium chloride, ammonium sulphate, and ammonium nitrate and urea until supplies of the last two fertilizers are available (possibly in 1962) from the Shiraz fertilizer factory.

(ii) Insecticides, fungicides and other agricultural chemicals.

15. Reports

Preparation and printing of the project reports, including maps and charts, and statistical processing of results abroad, if required.

16. Execution of the Project will be carried out by the Executing Agency by direct employment of experts and by purchase of the equipment and supplies as listed above.

B. Participation and Contribution of the Government

I. Government contribution to local facilities:

17. (i) In accordance with Article V, paragraph I, (a) to (d) of the Agreement between the Special Fund and the Government, the Government will contribute the equivalent of $ 47,331 towards local facilities.

(ii) This amount represents 15% of the total cost to the Executing Agency of foreign personnel

(iii) The amount mentioned above shall be deposited by the Government into the United Nations Special Fund account No. 2840, Bank Eatebarat Sanaati, Teheran, and will be made available as follows:

Equiv lent of US $8,249 (in local currency) on signature of the Plan of Operation
Equivalent of US $8,762 (in local currency) on 1st January 1962
Equivalent of US $9,508 (in local currency) on 1st January 1963
Equivalent of US $11,831 (in local currency) on 1st January 1964
Equivalent of US $8,981 (in local currency) on 1st January 1965

Payment of the above amounts, on or before the dates specified above, is a prerequisite to operation.

II. Government contribution to other than local facilities:

18. Counterpart personnel to be appointed at the request of the Project Manager within the limits set out in paragraphs 19 and 20 below.

19. Personnel Selected by the Government:

(i) One Co-Manager, for a period of five years, in the person of the Director of the Soil Fertility Unit of the Ministry of Agriculture. He will implement jointly with the Project Manager the Plan of Operation of this project and will be responsible for the administration of the Iranian personnel engaged on this project.

(ii) One Field Experiments Officer, for a period of five years, to assist the Field Experiments Expert of the Executing Agency in supervising all experiments carried out under this program.

(iii) One Accountant, to work closely with the Senior Administrative Assistant and have special responsibility for financial matters and accounts.

20. Personnel Selected by the Project Manager and Co-Manager

The selection and duration of service of the following Iranian counterpart personnel will be decided by the Project Manager and the Co-Manager:

(a) Technical Staff

(iv) One Senior Statistical Assistant, to assist and be trained in the design of experiments and computation and analysis of results. He will take over from the F.A.O. statistician during the fourth year.

(v) Two Junior Statistical Assistants, to assist the Senior Statistical Assistant, and deal with the expanding volume of results.

(vi) Supervisors - one for each regional office - Graduates of an Agricultural College, to be responsible for the field experiments comtrolled from each regional office and for all allied affairs of the project (e.g. proper storage of fertilizers and equipment, maintenance of records, etc). The number of supervisors will be:

1961 and 1962	6
1963 and 1964	9
1965	12

(vii) Field Assistants - three for each regional office, recruited from suitable local youths, preferably trained at agricultural High Schools and with some knowledge of local farming, to take charge of the day-by-day control of the field experiments. The number of field assistant will be:

1961 and 1962	18
1963 and 1964	27
1965	36

(b) Administrative Personnel

(viii) One Senior Administrative Assistant, who will assist the Project Manager and Co-Manager in administrative and financial aspects of the operation of the project. He will work in close collaboration with the administrative service of the Executing Agency and the United Nations Technical Assistance Board Resident Representative in Iran.

(ix) One Administrative Assistant, to help the Senior Administrative Assistant in routine administrative matters.

(x) One Latin-Farsi Typist and one Secretary

(xi) One Typist-Clerk, engaged in the third year, to deal with the extra typing and clerical work caused by the proposed expansion at that time.

(c) Auxiliary Staff

(xii) Drivers for all the vehicles working on the project. The total number of drivers per year will be:

1st and 2nd years	12
3rd and 4th years	15
5th year	18

(xiii) Guards - one for each regional office - to act as resident caretakers. The number of guards will be the same as the number of Supervisors.

(xiv) Temporary village workers (laborers) - engaged to help with the field experiments (planting, weeding, harvesting, etc.). The numbers required will vary with the experiment and will be at the discretion of the Project Manager and Co-Manager.

21. Accomodation and Furniture

(i) At the Main Office, Soils Department, Amirabad

All the National Staff and International Professional Staff stationed at the main office will be provided with appropriate rooms, fully furnished and having adequate cabinets for the numerous records which will accumulate.

The minimum number of rooms allocated to the Soil Fertility Unit will be 2 large rooms and 4 medium rooms, i.e. a total of 6 rooms.

In order to provide accommodation, which is at present only partly available, the Government will build out of funds allotted for this purpose in the project's budget an extension to the Soil Department at Amirabad, which will be made available to the Soil Fertility Unit. The Government also agrees to supply the Unit with its own telephone communication. In addition to the above offices, the Government will provide storage space in the storerooms of the Soil Department for a reserve of field equipment, laboratory equipment and sampling tools.

(ii) At the Regional Offices

At each selected town, a house and a large garage will be rented to serve as the Regional Office and Duty Station of the Supervisor. It will contain at least:

a) Office accomodation, including filing cabinets and a safe for money needed to pay for local purchases and labour.

b) Storage accomodation for the equipment, fertilizers and supplies needed to carry out the field experiments.

c) Simple laboratory accomodation.

d) Garage accomodation for the Supervisor's vehicle.

e) Living quarters for the Guard and his family.

If the Supervisor does not normally live in the town, the house rented will be large enough to provide him with living accomodation for himself and his family, and in this case, suitable household furniture and heating stoves and fans will be provided.

22. Purchase of Vehicles

The Soil Fertility Unit, on behalf of the Government, will furnish three jeep station-wagons in the fifth year of operation.

23. Operation and Maintenance of Vehicles

The Soil Fertility Unit, on behalf of the Government, will be responsible for the operation, including fuel and lubricants, repair and maintenance of all vehicles used on this project.

The total number of jeep station-wagons to be operated and maintained by the Government per year will be:

1st and 2nd years 12
3rd and 4th years 15
5th year 18

The number of motor bicycles and/or scooters involved per year will be:

1st and 2nd years 18
3rd and 4th years 27
5th year 36

The field assistants will be normally using the motor bicycles and/or scooters.

24. Equipment - Simple field equipment, laboratory apparatus and similar material that is available locally. In addition the maintenance of all equipment in good working order during the period of the project (the Senior Administrative Assistant will have special responsibility for this maintenance).

25. Soil Surveys and Chemical Analyses of Soils and Plants

(i) For suitable selection of the experimental fields, all soil survey information, data and reports would be made available. Where such information is not available or is not in required degree of detail, the Soil Survey Division of the Ministry of Agriculture will undertake the necessary surveys in consultation with this project staff.

(ii) All soil and plant analyses and other laboratory analytical work (excepting those done in the field laboratory of the regions under this project) will be incorporated in the laboratory program of the Central Soils Laboratory of the Government.

26. Co-operative facilities and payment to farmers. Renting of land, if necessary, for the experimental fields, fencing, including barbed wire, stakes, land preparation, ploughing, etc. will be the responsibility of the Government's Soil Fertility Unit.

27. Simple Tests on Cultivators' Fields

The Extension Service of the Ministry of Agriculture and other Departments and Agencies at present carrying out simple fertilizer tests on cultivators' fields will integrate their work with that of the project because the proved usefulness of such simple tests on a large scale makes it absolutely necessary for them to be closely incorporated in any over-all country program on soil fertility.

28. Test Demonstrations

In order to provide information on which Iranian farmers would make efficient use of fertilizers, a number of fertilizer demonstrations will be necessary on recognized soil types with definite cropping and management conditions. The Extension Service of the Ministry of Agriculture also carrying out these demonstrations will integrate this work with that of the project. Such an integration would assure the transmission of the project's work to farmers who should utilize them.

29. Fellowships. The Government and Soil Fertility Unit will continue to pay the salaries of fellows during their training and will meet the costs of their medical examinations, passports and visas.

30. The Government's Soil Fertility Unit will provide stationery, office supplies, postal expenses and telecommunication services.

31. The Government will issue customs free import permits for equipment supplied by the Special Fund to the project, or pay the necessary customs charges upon arrival of the equipment and/or supplies.

32. The Government shall meet the cost of clearance of project equipment, its transportation, insurance, handling and storage within the country and related expenses.

33. The equipment, supplies and materials will be consigned on loan to the Soil Fertility Unit of the Ministry of Agriculture. This Unit will assume responsibility for their safe-keeping, operation, and maintenance in the interest of the project from the date of arrival in Iran until completion of the project or reassignment or transfer of title as foreseen in Article VIII, paragraph 4, of the Agreement between the United Nations Special Fund and the Government of Iran concerning assistance from the Special Fund.

34. Government contributions against other than local facilities shall be made generally in kind. However, for cases where cash payment represents an advantage from the operational point of view, a change from payment in kind into cash can be made by agreement between the Government, the Executing Agency, and the Special Fund.

C. Sequence of Operation

35. The Executing Agency shall commence execution of the project upon receipt of written authorization to do so from the Managing Director of the Special Fund.

36. Promptly after signature of this Plan of Operation, the Executing Agency will proceed with the

i) Employment of experts

ii) Purchase of equipment, details of which have been agreed by the Executing Agency and the co-operating Government Agency.

37. The Project Manager and Field Experiments Expert of the Executing Agency will join duty on about 1 January 1961, which will be the starting date of the project. The Soil Chemist and Statistician will join after the first six months of operation of the project. The Consultants will join as and when required, during the course of the project.

38. The Government has finances for this project in the budget of Iranian year 1340 (starting 22 March 1961). It will, however, take advance steps and allocations (including the provision of cash to meet the first instalment for local facilities which is due before the Iranian year 1340) for appointing the Project Co-Manager and Field Experiments Officer not later than 1 January 1961. The Project Manager, Co-Manager and Field Experiments Expert and his counterpart will use the period between January - March in making preparations for the start of the project, in locating the regional offices and in making preparations for renting of premises.

39. The Government will complete the extension to the Soil Department building (as indicated in paragraph 21) by 30 June 1961.

40. Counterpart personnel, technical, administrative and auxiliary, will be selected and employed as laid down in paragraphs 18, 19 and 20.

41. In the early stages of the project, a summary will be prepared of all available information on fertilizer experiments and soil analysis in Iran, together with their statistical examination where necessary. Furthermore, at all stages of the project's operation, the Government will request any agency carrying out experiments on soil fertility to make its work known and available to the Soil Fertility Unit.

42. Field work will start with the statistically designed detailed field experiments in Spring and Summer 1961. Continual control over the experiments will be maintained on a regional basis, with immediate supervision from the Field Experiments Expert and Officer.

43. Six regional offices will be established during the first year of the project:

i) In the Gilan-Mazandaran area at Resht, Sari (or Babol) and Gorgan

ii) In the Fars area at Shiraz, Kazerun and Fasa.

During the third year of the project, an additional three regional offices in the Azerbaijan area will be established. During the fifth year of the project, three additional regional offices in the Kerman area will be established. Thus by the end of the five year period, twelve regional offices will have been established. These regional offices will handle not less than 1680 experiments during the five year period.

44. The detailed experiments, the tests on farmers' fields and the field scale demonstration conducted in the first three years will form the basis of specific recommendation to the farmers. Beginning the fourth year (1964) the farmers of the first six regional areas could start making efficient use of fertilizers for increased production and thus provide a growing market for the newly established Fertilizer Industry in Iran.

45. Detailed work plans for each operational year will be prepared by the Project Manager, with the assistance of the Co-Manager, at least two months before the end of the preceding year, with the exception of the first year when they will be made during the first two months of the year.

D. Organization

46. Over-all responsibility for the organization of the project rests with the Executing Agency who will plan and direct operations through a Project Manager who will be selected in consultation with the Government. The Project Manager, working in close co-operation with the Co-Manager, will be responsible for the detailed planning, administration, and execution of the project, including the timing and budgeting of the various elements, the preparation of technical reports, and the organization and supervision of related training programs.

47. All the experiments will be carried out with adequate replication, on recognized soil types, at carefully selected sites, in each of the regions selected. The experiments will be primarily with the normal crops of the region, but new crops will also be introduced. Continual control during the growing season will be maintained by the field staff.

48. The periods which are not busy in crops will be utilized for additional training. The international professional staff will be responsible for training the national staff and will arrange any course considered necessary for the purpose. Instructions in field experimentation will most conveniently be given on the experimental sites. Theoretical talks, lessons in statistics and other lectures and laboratory work will be arranged at the main office, and Central Soils Laboratory at Amirabad.

49. The Soil Fertility Unit will be collaborating more closely with both the Soils Department and the Plant Sciences Department of the Ministry of Agriculture.

50. A special Soil Fertility Co-ordinating Committee will be appointed by the Government, with representatives of the following departments and organizations:

i) Ministry of Agriculture - Soils Department, Amirabad
ii) Ministry of Agriculture - Plant Sciences Department
iii) Ministry of Agriculture - Extension Service
iv) Ministry of Agriculture - Chemical Bongah
v) Plan Organization - Agriculture Division
vi) Ministry of Industry and Mines - Fertilizer Bongah
vii) University of Teheran - Agriculture College
viii) Any other Agency that the Government nominates for this Co-ordinating Committee

The above representatives, together with the Project Manager and Co-Manager, will form the Soil Fertility Co-ordinating Committee. The Deputy Minister of Agriculture will be the Chairman of the Co-ordinating Committee, and the Project Manager and Co-Manager will act as Secretaries. The Committee will have the power to co-opt any person it thinks fit to assist in the effective organization and operation of its functions.

51. The terms of reference of the Committee will be:

i) To provide the means of collecting together all results of soil fertility studies carried out to date in Iran by Government and other agencies.

ii) To facilitate co-operation between all agencies working on soil fertility and related problems on the one hand, and the Soil Fertility Unit on the other hand.

iii) To promote a close liaison between the Fertilizer Bongah of the Ministry of Industry and Mines which is responsible for the production of fertilizers in Iran, the Chemical Bongah of the Ministry of Agriculture, which is responsible for the distribution of chemical fertilizers, and the Soil Fertility Unit.

52. The Soil Fertility Co-ordinating Committee will meet at least twice a year.

III. BUDGET

53. In accordance with Article I, paragraph 3, of the Agreement between the United Nations Special Fund and the Government of Iran, the total sum to be made available by the Special Fund through the Executing Agency to assist in the execution of this project is $566,140.

54. Unless otherwise agreed at any time by the Parties, this sum will be disbursed under the main objects of expenditure in amounts and at times as scheduled in the project budget attached as Appendix I.

55. The total cost of the project to be borne by the Government is estimated at the equivalent of $1,115,331 as shown in the project budget, Appendix II.

56. The Government will inform the Project Manager of the procedures whereby their participation and contribution as foreseen in Sections C and D of Chapter II of this Plan of Operation will be made available to the project. This information will be provided on the basis of the first forward work and budget estimates which will be submitted by the Project Manager and Co-Manager to the Ministry of Agriculture on the commencement of the project and thereafter every six months.

57. The Government's counterpart contribution covering expenditures to be made on behalf of the Government by the Soil Fertility Unit will be deposited in semi-annual instalments in advance to an Account in the name of the Soil Fertility Unit at Bank Estebarat Sanaati, Teheran. Authorization for counterpart payment from this Account will be given jointly by the Project Manager and Co-Manager in accordance with the budget headings, Appendix II. Payments will be made on the signatures of the Project Co-Manager, or his authorized representative and the Accountant who will be responsible for submitting financial statements to the Government. Transfers between budget headings may be made on the authorization of the Ministry of Agriculture and the Plan Organization.

IV. REPORTS TO THE SPECIAL FUND

58. The Government and Executing Agency will exchange financial and progress reports. The form, content and frequency of these reports will be agreed in an exchange of letters between the Government and the Executing Agency.

59. The Government and the Executing Agency jointly shall submit to the Special Fund at the end of each calendar year a certified inventory of equipment purchased with the funds allocated by the Special Fund.

V. CONCLUSIONS

60. At the end of this five-year period, after the departure of the Project Manager at the conclusion of this project, the Government of Iran will continue the fertilizer tests with the Unit's staff and equipment, in co-operation with all the departments concerned. This project is a means of acquiring basic information on the fertility needs of Iranian soils and its work will continue in order to expand this information for the benefit of Iranian agriculture. The Soil Fertility Unit will become an integral part of the soils work of the Ministry of Agriculture, which it is hoped will be developed into a Soil Institute of Iran.

61. The equipment supplied by the Executing Agency as described in Chapter II, Section A. 12, will be consigned on loan to the Soil Fertility Unit of the Ministry of Agriculture. On completion of the project, they will be reassigned or transferred as foreseen in Article II, paragraph 4, of the Agreement between the United Nations Special Fund and the Government of Iran.

Agreed on behalf of the Parties by the undersigned:

For the Government of Iran:

Ebrahim Mahdavi (signed)
Minister of Agriculture

and

Khosrow Hedayat (signed)
Minister without Portfolio and Deputy Prime Minister for Plan Organization Affairs, and Chairman of the Co-ordination Committee for United Nations Technical Assistance

Date: 7 November, 1960

For the United Nations Special Fund:

Thomas F. Power, Jr., (signed)
Representative of the Managing Director, United Nations Special Fund

For the Food and Agriculture Organization of the United Nations:

A.M. Mustafa (signed)
Representative of the Food and Agriculture Organization of the United Nations in Iran, for the Director-General of the Food and Agriculture Organization of the United Nations.

Date: 7 November, 1960

ANNEX I

UN SPECIAL FUND PROJECT - SOIL FERTILITY AND RESEARCH PROJECT FOR IRAN
PLAN OF OPERATION

BUDGET AND PLAN OF EXPENDITURE

	Period Man Mos.	Total Project Costs $	1961 Oblig. $	1961 Cash Disb. $	1962 Oblig. $	1962 Cash Disb. $	1963 Oblig. $	1963 Cash Disb. $	1964 Oblig. $	1964 Cash Disb. $	1965 Oblig. $	1965 Cash Disb. $
UN Special Fund Contribution												
A) Personal Services												
Soil Fertility Expert (Project Manager)	60											
Field Experiments Expert	60	305,540	203,203	52,996	16,800	56,414	44,937	61,383	23,600	76,874	17,000	57,873
Statistician	36											
Soil Chemist	48											
Short term consultants	8	10,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
	212	315,540	205,203	54,996	18,800	58,414	46,937	63,383	25,600	78,874	19,000	59,873
B) Fellowships												
4 Fellowships in the field of experimentation for soil fort.	48)											
1 Fellowship in statistics	12)											
1 Fellowship in Soil Chem.	12)	30,000	10,000	10,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
	72	30,000	10,000	10,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000	5,000
C) Equipment and Supplies (Including preparation and printing of report)												
- 15 Jeep station Wagons (with spare parts) - 24 Motor Scooters or Motor Bicycles(with spare parts))		53,600	35,600	35,600	-	-	9,000	9,000	-	-	9,000	9,000
- Field Equipment for Experiments & soil survey (Pentagon prisms & Compasses, Cultivators, Seed drills, fertilizer spreaders, sprayers, cutting and threshing machines, balances and scales, also Augers etc.		37,000	19,000	19,000	-	-	9,000	9,000	-	-	9,000	9,000

	Total Project Costs	1961		1962		1963		1964		1965	
		Oblig.	Cash Disb.	Oblig.	Cash Disb.	Oblig.	Cash Disb.	Oblig.	Cash Disb.	Oblig.	Cash Disb.
	$	$	$	$	$	$	$	$	$	$	$
UN Special Fund Contribution											
C) Equipment and Supplies (cont'd)											
- Laboratory Equipment for Regional Centres and for Central Soils Laboratory: (soil testing kits, pH kits Conductivity bridge, Beckman pH Meter, distilled water apparatus, Electrophotometer Flame Photometer, ovens glassware, chemicals, etc.)	20,000	10,500	10,500	1,000	1,000	4,750	4,750	-	-	3,750	3,750
- Calculating machines and typewriters for main office	1,500	1,500	1,500								
	500	500	500								
- Sundry Supplies of Fertilizers other materials including books and reference materials	42,000	6,000	6,000	6,000	6,000	9,000	9,000	9,000	9,000	12,000	12,000
- Preparation and printing of report	6,000	-	-	-	-	-	-	-	-	6,000	6,000
	160,600	73,100	73,100	7,000	7,000	31,750	31,750	9,000	9,000	39,750	39,750
D) Miscellaneous											
- Transportation within the country	5,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
- Cable and Phone Expenses	7,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500	1,500
- Secretarial Assistance	6,000	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200
	18,500	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700
Total Project Costs	524,640	292,003	141,796	34,500	74,114	87,387	103,833	43,300	96,574	67,450	108,323
Agency Costs (pro-rated)	41,500		11,500		6,000		8,000		7,700		8,300
Total UN Special Fund Allocation	566,140										
Government contribution for local facilities	47,331		8,249		8,762		9,508		11,831		8,981

ANNEX II

UN SPECIAL FUND PROJECT - SOIL FERTILITY AND RESEARCH PROJECT FOR IRAN
PLAN OF OPERATION

BUDGET AND PLAN OF EXPENDITURE
GOVERNMENT COUNTERPART CONTRIBUTION

	Period of Assignment Man-Mos.	Project Costs	1961		1962		1963		1964		1965	
			Oblig.	Cash.Disb.	Oblig.	Cash Disb.	Oblig.	Cash Disb.	Oblig.	Cash Disb.	Oblig.	Cash Disb.
		$	$	$	$	$	$	$	$	$	$	$
Government Contribution												
A) Personal Services												
i) (Counterpart Personnel)												
Co-Manager		20,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000
Field Experiments Officer		16,000	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200
Senior Statistical Assistant		12,000	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Junior Statistical Assistant		6,400	-	-	-	-	1,600	1,600	1,600	1,600	3,200	3,200
Supervisors (1961/62:6 1963/64:9. 1965:12)		100,800	14,400	14,400	14,400	14,400	21,600	21,600	21,600	21,600	28,800	28,800
Field Assistants (1961/62:18, 1963/64:27, 1965:36)		151,200	21,600	21,600	21,600	21,600	32,400	32,400	32,400	32,400	43,200	43,200
ii) (Administrative Personnel)												
Senior Administrative Assistant		12,000	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Accountant		12,000	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Administrative Assistant		6,000	-	-	-	-	2,000	2,000	2,000	2,000	2,000	2,000
Secretary		10,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Latin-Farsi Typist		9,000	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800	1,800
Typist-Clerk		4,800	-	-	-	-	1,600	1,600	1,600	1,600	1,600	1,600
Drivers		63,600	10,800	10,800	10,800	10,800	13,200	13,200	13,200	13,200	15,600	15,600
Guards at regional offices (one for each regional off.)		29,400	4,200	4,200	4,200	4,200	6,300	6,300	6,300	6,300	8,400	8,400
Subsistence of above staff and temporary labour		126,000	20,360	20,360	20,360	20,360	26,200	26,200	26,600	26,600	32,480	32,480
		579,200	89,560	89,560	89,560	89,560	123,100	123,100	123,500	123,500	153,480	153,480

	Period Assignment Man-Mos.	Project Costs $	1961 Oblig. $	1961 Cash Disb. $	1962 Oblig. $	1962 Cash Disb. $	1963 Oblig. $	1963 Cash Disb. $	1964 Oblig. $	1964 Cash Disb. $	1965 Oblig. $	1965 Cash Disb. $
B) Equipment & Supplies (including accomodation & maintenance of vehicles)												
1) Office Accomodation												
a) Construction of extension of the Soil Dept. building at Amirabad		18,000	18,000	18,000	-	-	-	-	-	-	-	-
b) Furniture & maintenance at Main and Regional offices		98,200	25,400	25,400	10,400	10,400	21,200	21,200	15,200	15,200	26,000	26,000
2) Purchase of vehicles		12,000	-	-	-	-	-	-	-	-	12,000	12,000
3) Operation & maintenance of Vehicles		125,230	20,640	20,640	20,640	20,640	26,160	26,160	26,160	26,160	31,680	31,680
4) Equipment Local field equipment and maintenance thereof		29,120	4,160	4,160	4,160	4,160	6,240	6,240	6,240	6,240	8,320	8,320
5) Co-operative Facilities: Like fencing for experimental fields, barbed wire, stakes, land preparation etc; Extension service for simple fertilizer tests. Soil Dept. for soil survey, analysis & other assistance		150,000	20,000	20,000	25,000	25,000	30,000	30,000	35,000	35,000	40,000	40,000
6) Payments to Farmers		22,400	3,200	3,200	3,200	3,200	4,800	4,800	4,800	4,800	6,400	6,400
7) Postal charges and stationery, telephones cables		13,800	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760	2,760
8) Miscellaneous including cost of handling & transpo. of equipment, fertilizers & supplies from port of entry to the Project sites.		20,000	8,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
		488,800	102,160	102,160	69,160	69,160	94,160	94,160	93,160	93,160	130,160	130,160
Total Government Counterpart contribution		1,068,000	191,720	191,720	158,720	158,720	217,260	217,260	216,660	216,660	283,640	283,640
Cash Contribution 15% of Experts services		47,331		8,249		8,762		9,508		11,831		8,981
Total Govt. Contribution		1,115,331		199,969		167,482		226,768		228,491		292,621

AMENDMENTS No. 1 TO PLAN OF OPERATION, SOIL FERTILITY PROJECT, IRAN

1. The Government of Iran, the United Nations Special Fund and the Food and Agriculture Organization of the United Nations acting on behalf of the United Nations Special Fund as Executing Agency for the Soil Fertility project, being desirous of carrying out the project as efficiently and speedily as possible and having taken note of paragraph 34 of the Plan of Operation, which provides that counterpart contributions may be made available in cash where representing an advantage over contributions in kind, have agreed that the total counterpart contribution of the Government estimated at the equivalent of $1,068,000 shall be made available in cash. This is in addition to the cash contribution, the equivalent of $47,331 for 15% of experts' services provided for in paragraph 17 and brings the total Government contribution in cash to $1,115,331.

2. For this purpose it has been decided that:
Paragraph 57 of the Plan of Operation be cancelled and replaced by the following text:

"The Government's counterpart contribution covering the expenditure to be incurred on behalf of the Government by the Soil Fertility Unit will be paid in semi-annual instalments in advance to a bank account to be designated and operated by the FAO Country Representative in Iran. From this account, payments will be made at the joint request of the Project Manager and Co-Manager to the following two accounts:

(i) To the Soil Fertility Unit account at Bank Eatebarat Sanaati, Teheran. Funds paid into this account shall be used to pay on behalf of the Government the salaries and allowances of Iranian counterpart and administrative personnel. Joint authority for payment instructions will be vested in the Project Manager and Co-Manager within the budgetary limits laid down in Appendix II, Section A (Personal Services) of the Plan of Operation. Actual disbursements will be made on the signatures of the Co-Manager or his authorised representative and the accountant. All payments shall be subject to Government regulations in respect of Taxes and Pension Rights. Financial statements shall be prepared by the accountant in a form acceptable to the Government and submitted by the Project Manager and Co-Manager to the Government at agreed intervals, with copies (in English) to the Representative of the Managing Director of the Special Fund in Iran and to FAO Headquarters through the FAO Representative in Iran.

(ii) To an account designated by the Executing Agency (FAO). Funds paid into this account shall be used to defray the expenditure on behalf of the Government as laid down in Appendix II, Section B (Equipment and Supplies) of the Plan of Operation. Authority to incur expenditure from this bank account will be vested jointly in the Project Manager and Co-Manager, and the bank account shall be operated by the Executing Agency. All disbursements shall be subject to the budgetary limits laid down in Appendix II, Section B, of the Plan of Operation. Financial Statements shall be prepared by the Executing Agency and submitted to the Government at agreed intervals. Copies shall be submitted to the Representative of the Managing Director of the Special Fund in Iran, to the FAO Representative in Iran and to the Soil Fertility Unit.

(iii) The total of the Government's Counterpart Contribution has been established at the equivalent of $1,068,000. The value of services provided by the Government up to 28 September has been established at the equivalent of $107,486, i.e. $47,406 for personal services (Section A of Appendix II to Plan of Operation) and $60,080 for other items (Section B of Appendix II to Plan of Operation). The balance, the equivalent of $960,514 shall be made available by the Government to the Executing Agency as follows:

Upon signature of this amendment, the equivalent of $84,234

21 March 1962	1 Farvardin 1341	79,360
22 Sept. 1962	1 Mehr 1341	79,360
21 March 1963	1 Farvardin 1342	108,630
22 Sept. 1963	1 Mehr 1342	108,630
21 March 1964	1 Farvardin 1343	108,330
22 Sept. 1964	1 Mehr 1343	108,330
21 March 1965	1 Farvardin 1344	141,820
22 Sept. 1965	1 Mehr 1344	141,820
	Total	960,514

(iv) Transfers between budgetary headings, between or within Sections A and B of Appendix II of the Plan of Operation, shall only be made upon a written joint authorisation of the Ministry of Agriculture and the Plan Organization, following receipt of a written request for transfer from the Project Manager and Co-Manager. Any funds which remain unspent at the conclusion of Special Fund participation in the Project at the end of 1965 shall be returned to the Soil Fertility Unit, by agreement with the Government.

Agreed on behalf of the Parties by the undersigned:

For the Government of Iran:

Signature: H. Arsandjani
(signed)

Minister of Agriculture

and

Signature: S. Asfia
(signed)

S. Asfia, Prime Minister's Deputy for Plan Organization Affairs and Chairman, Co-ordination Committee for United Nations Technical Assistance

Date: 10 December 1961

For the United Nations Special Fund:

Signature: Daniel K. Hopkinson
(signed)

Daniel K. Hopkinson, Director of United Nations Special Fund Programmes in Iran

For the Food and Agriculture Organization of the United Nations in Iran

Signature: A.M. Mustafa
(signed)

A.M. Mustafa, Representative of the Food and Agriculture Organization of the United Nations in Iran, for the Director-General of the Food and Agriculture Organization of the United Nations.

Date: 10 December 1961

15 October 1963

AMENDMENT No. 2

The Plan of Operation for the Soil Fertility Survey and Establishment of a Soil Fertility Unit in Iran, signed on 7 November 1960, has been amended as reflected in the attached Appendix I.

Agreed, on behalf of the parties, by the undersigned:

Date: 29 December, 1963	Date: 29 December, 1963	Date: 29 December, 1963
Signed: S. Asfias N. Fatémi	Signed: Daniel K. Hopkinson	Signed: A.M. Mustafa
Government of Iran	United Nations Special Fund	Food and Agriculture Organization of the United Nations

15 October 1963

APPENDIX I

UNITED NATIONS SPECIAL FUND PROJECT - IRAN: SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT

Revised Plan of Expenditure

United Nations Special Fund Allocation

	Total Man-Mos.	Total Project Costs $	Estimated Cash Disbursements 1961 $	1962 $	1963 $	1964 $	1965 $
1. Experts							
(i) Soil Fertility and Project Manager	60	107,650	19,356	18,400	22,650	21,700	25,544
(ii) Field Experiments Expert	59	82,390	13,107	16,000	15,500	17,700	20,083
(iii) Soil Chemists (2)	48	60,400	6,718	13,000	15,300	14,600	10,782
(iv) Statistician	49	67,900	10,515	15,194	15,500	16,300	10,391
(v) Soil Surveyor	12	20,500	-	-	-	20,500	-
(vi) Consultants	8	12,000	-	-	4,000	6,000	2,000
	236	350,840	49,696	62,594	72,950	96,800	68,800
2. Fellowships							
4 Fellowships in field exp. for soil fertility	48	20,000	-	-	5,000	10,000	5,000
1 fellowship in statistics	12	5,000	-	-	-	3,000	2,000
1 fellowship in soil chemistry	12	5,000	-	-	-	3,000	2,000
	72	30,000	-	-	5,000	16,000	9,000

APPENDIX I - UNSF PROJECT IRAN: SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT (Cont'd)

	Total Project Costs $	Estimated Cash Disbursements 1961 $	1962 $	1963 $	1964 $	1965 $
3. Equipment and Supplies						
17 Vehicles and 27 motorcycles	53,600					
Field equipment for experiments and soil survey	37,000					
Laboratory equipment for regional centres and for Central Soils Laboratory	20,000					
Calculating machines and typewriters	2,000	61,947	9,868	30,250	35,000	23,535
Sundry supplies of fertilizers and other materials including books and reference materials	42,000					
Preparation of reports and maps	6,000					
	160,600	61,947	9,868	30,250	35,000	23,535
4. Miscellaneous						
Postal and cable charges	1,500	-	-	100	600	800
Secretarial and clerical assistance	10,500	88	396	2,600	3,700	3,716
Contingencies	6,500	-	34	100	1,000	5,366
	18,500	88	430	2,800	5,300	9,882
TOTAL GROSS PROJECT COSTS	559,940	111,731	72,892	111,000	153,100	111,217
5. Executing Agency Overhead Costs	47,300	11,500	6,000	8,000	12,400	9,400
Special Fund Allocation 1/	607,240	123,231	78,892	119,000	165,500	120,617

1/ The Special Fund Allocation includes the equivalent amount of U.S. $47,331 to be paid by the Government towards local operating costs of the project. This amount is payable by the Government in instalments as shown in Section II, paragraph B.I.17 of the signed Plan of Operation.

AMENDMENT No. 3 TO PLAN OF OPERATION
UNSF SOIL FERTILITY PROJECT, IRAN

The Government of Iran, the United Nations Special Fund and the Food and Agriculture Organization of the United Nations, acting as the Executing Agency for the Soil Fertility Project, being desirous of obtaining the maximum possible benefit from this project, have taken into consideration that:

- The contribution of the United Nations Special Fund toward the Soil Fertility Project has been increased by Amendment No. 2 with US$41,000.

- The agricultural area of Iran, which is covered by the project activities can be increased considerably by a relatively small increase of the contribution of the Government toward the project.

- The early inclusion of the province of Khorasan into the soil fertility survey is of high priority, which makes it undesirable to wait longer for the decision whether the Freedom From Hunger Campaign might assist in this fertilizer project of Khorasan.

- It is appropriate to confirm and legalize some deviations from the original project plan of operation, which have been decided on in the course of the past operation because of special needs and therefore have agreed on the following additional provisions which will be implemented as soon as possible after the signature of this Amendment.

1) The UNSF Soil Fertility Project will open three new field stations in the province of Khorasan and will put them into operation in early Spring of 1964. The project will start with the preparations for this extension of the work immediately after signature of this Amendment. This additional expansion of the project's work into Khorasan does not alter the provisions laid down in the Plan of Operation with regard to the project's future work in the province of Kerman.

2) For the implementation of the additional expansion as mentioned under (1), the Government increases its contribution toward the Soil Fertility Project with an amount of Rials equivalent to US$77,680 for the two years 1343 and 1344 over and above the contributions laid down in Appendix II of the project's plan of operation, for these two years.

3) The plan of expenditure for the years 1343 and 1344, as laid down in Appendix II of the plan of operation (Pertaining to the Government Counterpart Contribution) is cancelled and is replaced by the new plan of expenditure for the two mentioned years shown in Appendices I and II attached to this Amendment No. 3.

This new plan of expenditure re-allocates the unspent funds from earlier operational periods, the allocations of the current period, and the additional Government contribution mentioned in paragraph 2, in such a way that funds will be available for all operational and personnel facilities needed to carry out the work foreseen in the original plan of operation and the additional expansion of work into the areas of Khorasan.

4) Amendment No. 1 of the plan of operation of the Soil Fertility Project is cancelled and it, as well as paragraph 57 of the plan of operation are replaced by the following text:

"The Government Counterpart Contribution covering the expenditures on behalf of the Government by the Soil Fertility Unit will be deposited in semi-annual instalments as follows:

(a) The part of the budget earmarked for payment of salaries, per diems, overtime, and other personal payments, as laid down in Appendix I attached to this Amendment No. 3, will be made available by the Government by depositing the instalments into account No. 8063 of the Soil Fertility Unit. Joint authority for payment instructions will be vested in the Project Manager and the Co-Manager or his authorised representative, and the accountant.

The employment of personnel will be done as follows:

(i) All personnel will be employed on a temporary contract basis, the period of which shall not exceed the last day of the Iranian year 1344 (20 March 1966).

(ii) Salaries will be paid according to the budgetary limits specified in the plan of expenditure, attached to this Amendment.

(iii) Per diems, overtime, travel allowances, and any other allowances, including gratifications, will be paid in accordance with the regulations of the Plan Organization and shall be subject to budgetary limitations mentioned under (ii).

(iv) Deductions for taxes and pension rights shall be made according to Government regulations.

(b) The part of the budget earmarked for payments of operational costs (equipment, supplies, maintenance, etc.) as laid down in Appendix II of this Amendment, will be made available by the Government in cash to account No. 2097 of the FAO, with the Bank Eatebarat Sanaati. Authority to incur expenditure from this bank account will be vested jointly in the Project Manager and the Co-Manager, and the bank account shall be operated by the Executing Agency.

Disbursements shall be subject to budgetary limits laid down in Appendix II attached to this Amendment. Financial Statements shall be prepared by the Executing Agency on the same basis as at present, and submitted to the Government. Copies shall be submitted to the Representative of the Managing Director of the Special Fund in Iran, to the FAO Representative in Iran, and to the Soil Fertility Unit.

(c) The cash contribution of 15% for experts services, as provided for in paragraph 17 of the plan of operation, is not affected by the provisions made under (a) and (b).

5) The Government Counterpart Contribution for the years 1343 and 1344, which is increased from the equivalent of US$500,300 to the equivalent of US$577,980 as laid down in paragraph 2 above, shall be made available as follows:

To bank account No. 8063 of the Soil Fertility Unit with the Bank Eatebarat Sanaati the equivalent of:

On 1 Farvardin 1343	21 March 1964	$77,280
On 1 Mehr 1343	22 Sept. 1964	77,280
On 1 Farvardin 1344	21 March 1965	92,270
On 1 Mehr 1344	22 Sept. 1965	92,270
		339,100

To bank account No. 2097 of the FAO with the Bank Eatebarat Sanaati the equivalent of:

On 1 Farvardin 1343	21 March 1964	$62,140
On 1 Mehr 1343	22 Sept. 1964	46,580
On 1 Farvardin 1344	21 March 1965	84,080
On 1 Mehr 1344	22 Sept. 1965	46,080
		238,880

6) It is agreed that all monies allocated to earlier operational periods, which have remained unspent, be carried over automatically to the next periods and are not frozen until the Special Fund participation in the project is concluded. At that date FAO will return all unspent funds earmarked for the Soil Fertility Unit back to this Unit by agreement with the Government.

7) In addition to paragraph 29 of the plan of operation, it is agreed that for each staff member of the Soil Fertility Unit, who has been awarded a fellowship study abroad, a qualified replacement can be engaged by the project in order to assure continuity of operations.

8) With regard to paragraph 43 of the plan of operation and paragraph 1 of this Amendment, it is agreed that locations of field stations of the Soil Fertility Project can be changed with the agreement of the Ministry of Agriculture and the Plan Organization.

Agreed on behalf of the Parties by the undersigned:

For the Government of Iran:

Signature: E. Riahi
(signed)

Minister of Agriculture

and

Signature: S. Asfia
(signed)

S. Asfia, Managing-Director
Plan Organization

and

Chief of the Co-ordinating
Committee for United Nations
Technical Assistance

Date: 19 April 1964

For the United Nations Special Fund:

Signature: Daniel K. Hopkinson
(signed)

Daniel K. Hopkinson, Director of
United Nations Special Fund
Programmes in Iran.

For the Food and Agriculture
Organization of the United Nations
in Iran

Signature: A.M. Mustafa
(signed)

A.M. Mustafa, Representative of the
Food and Agriculture Organization of
the United Nations, in Iran, for the
Director-General of the Food and
Agriculture Organization of the
United Nations.

Date: 19 April 1964

APPENDIX I

United Nations Special Fund, Soil Fertility Survey, Iran

Budget and New Plan of Expenditure
GOVERNMENT COUNTERPART CONTRIBUTION

A. PERSONAL SERVICES	1343 (1964) $	1344 (1965) $
1. Technical Personnel		
Co-Manager	4,000	4,000
Field Experiment Officer	3,200	3,200
Assistant to Field Exp. Officer	2,670	2,825
Senior Statistical Assistant	2,120	2,200
Junior Statistical Assistants (two in both years)	2,360	2,510
Field Engineers (15 in 1343 and 18 in 1344)	33,890	41,730
Field Assistants (44 in 1343 and 53 in 1344)	41,090	52,590
Field Laboratory Assistants (4 in both years)	5,020	5,650
2. Administrative Personnel		
Senior Administrative Assistant	2,400	2,400
Accountant	2,400	2,400
Administrative Assistants (2 in both years)	3,225	3,460
Store Keeper and Supply	1,420	1,490
Latin-Farsi Typist	1,180	1,260
Assistant Accountant	1,100	1,180
Typist Clerk	1,020	1,100
Supply Clerk	1,020	1,100
Filing Clerk	790	870
3. Auxiliary Personnel		
Drivers (24 in 1343 and 27 in 1344)	19,965	23,295
Guards (15 in 1343 and 18 in 1344)	8,240	10,465
Total Salaries	137,110	163,725
Subsistence of above staff (per diems, overtime, travel allowances, gratifications and all other personal payments)	41,140	49,125
TOTAL SECTION "A" PERSONAL SERVICES:	178,250	212,850

APPENDIX II

United Nations Special Fund, Soil Fertility Survey, Iran

Budget and New Plan of Expenditure
GOVERNMENT COUNTERPART CONTRIBUTION

B. EQUIPMENT AND SUPPLIES (including all operational costs)	1343 (1964) $	1344 (1965) $
1. Office Accomodation		
(a) Construction of Store Room in Amirabad	7,850	-
(b) Rents, Furniture, Maintenance of main and regional offices and village store rooms	31,130	33,300
2. Purchase of Vehicles and Machines		
(a) Purchase of cars and motorcycles	25,230	16,710
(b) Trailers and Threshers	5,665	5,665
(c) Calculation Machines	950	-
3. Operation and Maintenance of Vehicles	40,550	45,960
4. Equipment		
Local Field Equipment and Maintenance thereof	8,160	10,200
5. Fertilizers		
For three extra field Stations	3,000	3,000
6. Payments to Farmers and Local Labour		
(a) Payments to Farmers	6,300	7,875
(b) Local and Casual Labour	7,530	9,415
7. Cooperative Facilities including fencing, stakes, wiring land preparation, soil and land classification, other services from other organizations and costs for soil analyses, including those of regional laboratories	30,000	35,800
8. Postal Charges, Cables, Telephone and Stationery	3,465	3,465
9. Miscellaneous and Unforeseen including local transport, clearance of goods and all other items not included above	4,490	4,170
TOTAL SECTION "B" OPERATIONAL COSTS:	174,320	175,560

21 October 1965

UNITED NATIONS SPECIAL FUND

Plan of Operation

IRAN

SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT

Adjustment Advice No. 4

This Plan of Operation previously amended according to Amendments No. 1, 2 and 3 has been adjusted as follows:

1. The attached Appendix I, Plan of Expenditure - United Nations Special Fund Allocation, has been revised as indicated to reflect minor adjustments in the Work Plan.

2. The attached Appendix IV, Schedule of Operations, indicates the main features of the revised Work Plan.

Signed: Paul-Marc Henry, Associate Director
Bureau of Operations

Date: 15 November 1965

UNITED NATIONS SPECIAL FUND

APPENDIX I

UNITED NATIONS SPECIAL FUND PROJECT - IRAN: SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT

Revised Plan of Expenditure

United Nations Special Fund Allocation

	Total Man-Mos.	Total Project Costs $	Estimated Cash Disbursements 1961 $	1962 $	1963 $	1964 $	1965 $	1966 $
1. Experts								
(i) Soil Fertility and Project Manager	59	97,400	19,356	18,400	20,000	18,700	15,800	5,144
(ii) Field Experiments Expert	60	87,400	13,107	16,000	15,500	17,700	20,800	4,293
(iii) Soil Chemist (2)	53	67,100	6,718	13,000	14,300	14,600	14,300	4,182
(iv) Statistician	57-1/2	75,000	10,515	15,194	15,338	14,637	15,200	4,116
(v) Soil Surveyor	12	19,000	-	-	-	19,000	-	-
(vi) Consultants	2-1/2	4,000	-	-	4,000	-	-	-
	244	349,900	49,696	62,594	69,138	84,637	66,100	17,735
2. Fellowships								
5 Fellowships in field exp. for soil fertility	72	31,700	-	-	4,805	6,021	17,100	3,774
1 Fellowship in statistics	12	6,800	-	-	-	5,000	1,800	-
1 Fellowship in soil chemistry	12	3,800	-	-	-	1,800	2,000	-
Study tour		400	-	-	-	-	400	-
	96	42,700	-	-	4,805	12,821	21,300	3,774

APPENDIX I - UNSF PROJECT - IRAN - SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT (Cont'd)

	Total Project Costs $	1961 $	1962 $	1963 $	1964 $	1965 $	1966 $
3. Equipment and Supplies							
17 Vehicles and 27 motorcycles	49,840						
Field equipment for experiments and soil survey	35,000						
Laboratory equipment for regional centres and for Central Soils Laboratory	20,000						
Calculating machines and typewriters	2,000	61,947	9,868	28,436	17,497	24,000	13,092
Sundry supplies of fertilizers and other materials including books and reference materials	40,000						
Preparation of reports and maps	8,000						
	154,840	61,947	9,868	28,436	17,497	24,000	13,092
4. Miscellaneous							
Postal and cable charges	200	-	-	-	-	100	100
Secretarial and clerical assistance	10,900	89	396	2,571	3,770	3,500	574
Contingencies	1,400	-	34	35	284	500	547
	12,500	89	430	2,606	4,054	4,100	221
TOTAL GROSS PROJECT COSTS	559,940	111,732	72,892	104,985	119,009	115,500	35,822
5. Executing Agency Overhead Costs	47,300	11,500	6,000	8,000	12,400	9,400	-
SPECIAL FUND ALLOCATION	607,240	123,232	78,892	112,985	131,409	124,900	35,822

APPENDIX IV

UNITED NATIONS SPECIAL FUND PROJECT

IRAN: SOIL FERTILITY SURVEY AND ESTABLISHMENT OF A SOIL FERTILITY UNIT

Schedule of Operations

1. Manning Table for Professional Staff and Timing of Fellowships

		Months of Service	1961	1962	1963	1964	1965	1966
Internationally recruited experts								
(i)	Soil Fertility and P.M. (2)	59	12	12	12	10	11	2
(ii)	Field Experiments Expert (2)	60	11	12	12	12	11	2
(iii)	Soil chemist (2)	53	6	9	12	12	12	2
(iv)	Statistician	57-1/2	7-1/2	12	12	12	12	2
(v)	Soil Surveyor	12	-	-	-	12	-	-
(vi)	Consultants	2-1/2	-	-	2-1/2	-	-	-
Fellowships								
(i)	Field Exper. for soil fertility	72	-	-	7	20	41	4
(ii)	Statistics	12	-	-	-	11	1	-
(iii)	Soil chemistry	12	-	-	-	6	6	-

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