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FERTILIZER USE and DISTRIBUTION

in the

YEMEN ARAB REPUBLIC

A Study Prepared for the

Ministry of Agriculture and Fisheries

and the

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by

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TABLE OF CONTENTS

Acknowledgements..... i

Table of Contents..... iii

List of Tables..... v

List of Figures..... vi

List of Appendices..... vi

0. Executive Summary..... 1

0.1 Objectives of the Study..... 1
0.2 Findings of the Farmer Survey..... 1
0.3 Soils, Fertilizer Response and Fertilizer Requirements..... 4
0.4 Marketing and Distribution..... 6
0.5 Recommendations..... 8

1. Introduction..... 11

1.1 Apparent Obstacles to Increased Fertilizer Use..... 11
1.2 Information Needed for Related Planning and Research..... 14
1.3 Objectives and Scope of Work..... 14

2. Farmer Experience with Fertilizer Use..... 16

2.1 Previous Studies of Fertilizer Use by Yemeni Farmers..... 16
2.2 Background and Organization of the 1987 Survey..... 18
2.3 Results of the Fertilizer Survey..... 20
2.4 Analysis of Factors Which Promote Fertilizer Use..... 32
2.5 Concluding Remarks..... 33

3. The Estimation of Yemen's Fertilizer Needs..... 36

3.1 Soil Characteristics..... 36
3.2 Implication of Soil Characteristics for Fertilizer Needs and Fertilizer Management..... 36
3.3 Basis Used for Arriving at Estimates of Nutrient Needs..... 39
3.4 Long Run Estimates of Nutrient Requirements..... 42
3.5 Projecting the Future Timing of Fertilizer Requirements..... 51
3.6 The Economics of Fertilizer Demand..... 52
3.7 Summary and Future Research Needs..... 59

TABLE OF CONTENTS (Continued)

4.0 Institutional and Marketing Considerations..... 61

4.1 Background..... 61
4.2 The Fertilizer Market, Past and Present..... 62
4.3 Current Role and Capabilities of the Private Sector..... 67
4.4 Current Organization and Management of the Import System..... 69
4.5 A Renewed Role for the Agricultural Credit Bank..... 71
4.6 Reseach and Extension..... 72
4.7 Foreign Governments and International Organizations..... 74
4.8 Recommended Improvements and Policies..... 75

References..... 80

LIST OF TABLES

Table 1-1 Use of Inorganic Fertilizers in the Yemen Arab Republic and Other Countries, 1983..... 12

Table 2-1 Fertilizer and Manure Costs as a Percent of Cash Outlays for Wheat, Maize, and Deciduous Fruits in the Dhamar Area, 1987..... 19

Table 2-2 Cropping Pattern of Survey Farms Compared to Yemen's Average National Crop Area Allocation..... 22

Table 2-3 Availability of Food Commodities and Farm Inputs.... 22

Table 2-4 Ownership of Vehicles and Equipment..... 23

Table 2-5 Use of Fertilizer Among Sample Farmers in 1987 and in Prior Years..... 23

Table 2-6 Source of Fertilizer Used in 1987..... 24

Table 2-7 Levels of Fertilizer Application and Related Inputs for Crops Grown by Survey Farmers in 1987..... 25

Table 2-8 Source of Information about Inorganic Fertilizers... 28

Table 2-9 Frequency of Contact with Agricultural Officials and Offices..... 28

Table 2-10 Fertilizer Prices Reported by Survey Farmers for the 1987 Crop Year..... 29

Table 2-11 Current and Past Prices Paid for Fertilizers as Reported by Survey Farmers, with Comparison to Rural Grain Prices..... 30

Table 2-12 Sources of Credit for Farm Equipment and Fertilizer..... 31

Table 2-13 Coefficients in the "Best" Equation for 4 of 5 Regions Using all Survey Respondents..... 34

Table 3-1 Long Range Fertilizer Requirements per Hectare, by Type of Crop and Moisture Regime..... 44

Table 3-2 Agricultural Area by Type of Crop, Irrigation or Rainfall Level, and Region..... 47

Table 3-3 Total Long Range Fertilizer Requirements, by Type of Crop and Region..... 48

LIST OF TABLES (Continued)

Table 3-4 Total Long Range Fertilizer Requirements, by Rainfall Regime and Region..... 49

Table 3-5 Increases in Levels of Fertilizer (Nutrient) Use in Near-by Countries with Desert Soils..... 51

Table 3-6 Projected Increase in Fertilizer Use Under Different Growth Scenarios..... 53

Table 3-7 Summary of Selected Response Trials at Dhamar Agricultural Improvement Centre, 1978-82..... 57

Table 3-8 Relative Prices of Crops to Urea Prices in Yemen and Other Countries, 1986..... 58

Table 4-1 Yemen Fertilizer Imports, 1971-87..... 62

Table 4-2 Fertilizer Loans Made by the Cooperative and Agricultural Credit Bank, 1982-1985..... 64

Table 4-3 Total Fertilizer Imports, 1982-87..... 65

Table 4-4 Foreign Government Fertilizer Donations, 1982-87.... 66

Table 4-5 Estimated Private Sector Imports, 1982-87..... 66

Table 4-6 Marketing and Distribution Costs for Fertilizer in Selected African and Asian Countries, 1983-85 (U.S. dollars per ton)..... 76

Table 4-7 Estimated Competitive Retail Price for Urea, 1988..... 78

LIST OF FIGURES

Figure 1-1 Imports of Fertilizer..... 13

Figure 3-1 Response of Wheat to N at Dhamar Trials..... 40

Figure 3-2 Projected Increase in Fertilizer Use..... 54

LIST OF APPENDICES

Appendix A Fertilizer Survey Questionnaire - 1987..... 83

Appendix B 1987 Fertilizer Survey: Sample Description, Detailed Tables..... 84

Appendix C Fertilizer Terminology and Common Nutrient Forms... 85

FERTILIZER USE AND DISTRIBUTION IN THE YEMEN ARAB REPUBLIC

0. EXECUTIVE SUMMARY

The use of inorganic fertilizers was unknown in Yemen until the late 1960's. Although the use of fertilizers has increased dramatically since that time, growth has been sporadic, and there has been a sharp reduction in supply since 1983 (Table 4-1). There is currently no domestic production of inorganic fertilizer in Yemen, and the entire supply must be imported.

With an average application of 12.4 kg of total nutrients per hectare in 1983, Yemen's fertilizer use was among the lowest in the world (Table 1-1). Although the 1983 use level in Yemen was higher than in Eithiopia (3.5 kg/ha) and the Sudan (6.7 kg/ha), by 1987 Yemen's use had dropped to only 5.5 kg/ha, a level comparable to that of the latter two countries.

Due to relatively low agricultural productivity--for example, grain yields of less than one ton per hectare, which have been increasing at less than one percent per year --it has not been possible for Yemen to meet growing food demand with domestic production. Thus, food imports have grown dramatically, placing a serious burden on limited foreign exchange. The current five year plan calls for a 3.5 percent annual rate of growth in agricultural production. Increased use of fertilizer is essential if plan goals are to be met and food imports reduced.

0.1 Objectives of the Study

- To learn how farmers have used fertilizer, including levels of use, practices, and problems.

- To examine available information about soils and fertilizer response in Yemen, and thus to estimate Yemen's fertilizer requirements.

- To examine the problems and capabilities of the current fertilizer marketing and distribution system.

- To identify obstacles to expanded fertilizer use and to recommend changes in policy in order to overcome these obstacles.

0.2 Findings of the Farmer Survey

In late 1987 a survey of 400 farmers was conducted by the fertilizer study team, in cooperation with the Ministry of Agriculture and Fisheries (MAF) Department of Statistics. Survey farmers were chosen from 16 different districts located in seven provinces.

To ensure that enough information about fertilizer would be obtained, districts and farms were chosen from areas expected to have higher than average fertilizer use. The average survey farm was about twice the national average farm size, and survey farmers had a higher proportion of irrigated area than the national average.

Fertilizer use reported in the survey averaged 18 kg/ha, which was more than three times the national average use (5.5 kg/ha) in 1987. Higher use among survey farms appears to be related to the relatively high proportion of irrigated area, but it may also be due to some fertilizer being obtained through channels which are not reported by official data sources.

Of the 400 farmers interviewed, 45 percent reported using fertilizer in 1987, and others reported using it in prior years, bringing the total with fertilizer experience to 54 percent (215 farmers). Use varied widely from region to region, with the highest level occurring in the Southern Uplands and the lowest in the Coastal Region, as shown in Table 2-5.

A close relationship was found between irrigation and fertilizer use, although fertilizer was also applied to rainfed fields in many cases, especially in the higher rainfall zones. While 31 percent of the sorghum area was irrigated, only 13 percent received inorganic fertilizer, and the average nitrogen application to sorghum was only 10 kg/ha. In contrast, 83 percent of the wheat area was irrigated and 47 percent received fertilizer, with an average application of 53 kg/ha of nitrogen (Table 2-7).

Urea accounted for 84 percent of the fertilizer applied by survey farmers, while three percent was triple super-phosphate (TSP), and 13 percent was various N-P and N-P-K compounds. More than 95 percent of farmers interviewed mentioned urea or nitrogenous fertilizers as being the "most important" or "also important" fertilizers to benefit their crops, whereas less than 10 percent cited phosphates, and even fewer mentioned compounds. Phosphates were recognized as being important for a few specific crops, such as tomatoes and watermelon.

Farmers' overall pattern of fertilizer application seems to reflect technical and economic logic. They apply more N to wheat than to sorghum, for example, and wheat is known to be more responsive to nitrogen. The same logic would dictate that more fertilizer be applied to irrigated crops and to higher valued crops. Survey farmers were found to apply high rates of N to potatoes, papaya and oranges, all of which are high valued and are mostly irrigated.

While farmers' application patterns do make technical and economic sense, there is obvious room for improvement. For example, it is not apparent why tomatoes should be receiving lower levels of nutrients than wheat or maize, or why they should receive only one sixth the N that potatoes do. All alfalfa in the sample was irrigated, and Yemeni research has shown that alfalfa responds to phosphates; yet no phosphates were applied to the surveyed alfalfa fields.

Application methods may be a source of inefficiency in fertilizer use. Only 36 percent of those interviewed said they tilled the fertilizer into the soil immediately after application. While there does appear to be an awareness of the potential for nitrogen volatilization from urea, many farmers are not following practices that would avoid it.

The Ministry of Agriculture and Fisheries and affiliated organizations are important sources of information about fertilizers. Forty-five percent of the fertilizer users said that information about fertilizers had been obtained from an extension agent, an MAF official or an agricultural project. Only a few farmers cited merchants, radio or television as sources of information.

When asked to identify problems with fertilizer, 50 percent of the users cited high prices and 35 percent listed non-availability.

Almost 80 percent of the fertilizer users reported obtaining their fertilizer from merchants. Of these, 16 percent were merchants in the farmer's own village or a nearby village, whereas 84 percent were located in a town or a city. MAF offices and government agricultural projects were less important as sources of fertilizer, with only 16 percent of farmers citing these sources.

Statistical regression analysis was used to analyze the farm survey data and to help determine why some farmers apply higher rates of fertilizer than others. Formal education (number of years spent in school) was shown to have a positive influence on fertilizer use, as was knowledge of how to apply fertilizer properly. Truck, car and tractor ownership were associated with higher fertilizer use levels. Farmers who obtain fertilizer through an MAF office or agricultural project were found to use more fertilizer. Also, it was found that higher rates of fertilizer are applied by smaller farms.

Price is obviously an important factor in fertilizer use. Research shows that the cost of inorganic fertilizer can constitute from 20 to 45 percent of total cash outlays for Yemeni farmers following improved farming practices. Survey farmers reported paying an average of YRls 286 per bag for urea in 1987. This represented more than twice the estimated cost of importation, handling and distribution. This high price reflects the scarcity of fertilizer. The supply is so limited relative to the demand that the price is bid up until the market is equilibrated.

Based on prices which farmers reported for 1987 and for prior years, historical price series were developed for urea and TSP. These were compared to grain prices reported by MAF (Table 2-11). While fertilizer prices are high in Yemen, so are crop prices. Grain prices rose relative to fertilizer prices during the drought of 1983-84, but they began to decline in 1985. By 1987, the ratio of grain to nitrogen prices was still somewhat higher than it had been in 1982, suggesting that the relative cost of fertilizer was no higher in 1987 than before the fertilizer scarcity began.

0.3 Soils, Fertilizer Response and Fertilizer Requirements

Soil surveys in Yemen show that most of the agricultural soils have properties that are characteristic of arid region soils elsewhere. Significant crop yield increases are possible from the use of fertilizer on these soils.

Most of Yemen's soils are calcareous, and they tend to be alkaline, with pH of 7.0 or higher in many cases. There is a low level of organic matter, which means that the soils have very low capacity for providing avaiable nitrogen for a crop. Generally speaking, they test in the low to medium range for phosphorous and have high levels of exchangeable potassium.

Assuming that crop varieties with a capacity to utilize high levels of soil fertility are available, Yemen's soils will ultimately require supplemental nitrogen for virtually all crops except legumes. Nitrogen requirements are the highest for irrgiated areas. Some nitrogen is required for rainfed crops, even at low levels of rainfall; more is required in higher rainfall areas.

Often, phosphorous deficiencies do not begin to show up until levels of nitrogen application become substantial. At that point, further yield increases from nitrogen will be limited unless phosphates are added.

Yemen's soils are generally high in potassium. However, some crops, such as grapes, bananas, certain other tree fruits, tomatoes and potatoes often require more potassium than is ordinarily released by the soil; these crops will ultimately require supplemental potassium applications.

Availability of micro-nutrients for plant uptake is reduced at higher levels of soil pH, especially where soils are rich in lime, as in Yemen. In these conditions, zinc availability may be limited and boron availability may be reduced. Where such soils are irrigated, iron deficiency is a common occurance. Micro-nutrient deficiencies have been observed by research and extension officals, often in relation to horticultural crops. However, such deficiencies have yet to be systematically identified and dealt with on a regional, crop-by-crop basis.

The preferred method of estimating fertilizer needs is to base them on results of field experiments from which a yield response function can be developed. Normally, such a function needs to be obtained for each crop, each nutrient, each rainfall zone and each distinctly different soil region. Experimental results should then be verified through on-farm trials. Economic analysis should be used to assist in the interpretation of both experimental and on-farm trials.

In Yemen, experimental response trials have been made for some crops in some regions. Much has been accomplished along these lines, especially considering that the Agricultural Research Authority was

founded less than 20 years ago. However, response trials still need to be done for more crops, in more regions, and under a wider range of available water situations. In other instances, it is not clear that response trials have been conducted for the latest varietal releases. Also, there is a need for more on-farm verification trials.

In view of the incomplete status of response trials and analysis, the study team found it necessary to use other sources of information in order to make estimates of Yemen's fertilizer requirements. These included discussions with research and extension personnel and field staff of development projects. Experiences in other countries with conditions similar to those of Yemen were also used.

An item that caused the study team to be conservative in estimating nutrient requirement rates was that the upper yield levels obtained by researchers in the YAR often did not result in yields as high as could be expected, even when relatively high rates of nutrients were used.

To estimate requirements, the study team first considered changes that needed to be combined with increased fertilizer in order to achieve higher crop yields. These included improved crop varieties, improved management of soil moisture and irrigation, and better fertilizer application methods. Then, assuming that progress is made in these areas, the team developed requirements per hectare for each major crop group, for various rainfall zones and methods of irrigation (Table 3-1). The requirements were multiplied by the appropriate areas (Table 3-2) to obtain the nutrients needed for each crop group in each region (Table 3-3). It must be stressed that the per hectare requirements and the resulting national and regional requirements can only be attained in the long run, as other improvements in Yemeni agriculture are also accomplished.

Total long run fertilizer requirements are estimated to be 125,738 nutrient tons, which would amount to 270,000 tons of fertilizer material, or more, depending on the particular types of product which are chosen.

The estimates indicate that fruits and other tree crops, which occupy only 11 percent of the land area, will require 28 percent of the N, 23 percent of the P and 75 percent of the K. Vegetables, with only 5 percent of the land area, will require 10 percent of the N, 11 percent of the P and 18 percent of the K. While irrigated areas account for only 22 percent of the total cropped area, they will require 46 percent of the total fertilizer nutrients. The Eastern Region, some parts of which are highly irrigated, will account for 16 percent of the country's total nutrient requirements although it has only 10 percent of the cropped area.

The long run fertilizer requirement would be almost ten times the level used in 1982-83, and more than 20 times the 1987 level of use. An important question is, how long before this level of application is reached?

To get a better sense of likely growth rates, historical changes in usage were studied for other nearby countries with desert soils (Table 3-5). Morocco, which was utilizing 13.0 kg/ha in 1970, was able to increase use to 29.3 kg/ha by 1983, equivalent to an annual growth rate of 6.5 percent. Jordan went from 2.0 to 39.4 kg/ha during the same period, an annual growth rate of 25.8 percent. If fertilizer use in Yemen were to first return to its 1982-83 levels, at a 25 percent annual rate of growth, it would take just over 10 years for the country to reach its long run projected fertilizer needs.

Another way to look at the timing of Yemen's fertilizer needs is to consider the country's current agricultural development plan, which calls for an average rate of growth of 3.5 percent in overall production. The fertilizer study team made a rough calculation based on the nitrogen that would be required to sustain this rate of growth in cereal grains. It was estimated that it would take 22 years to reach the full long term levels of nitrogen use.

The preceding analysis indicates that it would take from 10 to 22 years to reach the long run requirement levels projected in the study. However, reaching these levels is not automatic. Yemen's recent history demonstrates that use can decline as well as increase, if suitable conditions do not exist. Growth to the projected levels will require further research, the establishment of a stronger extension program, increased availability of complementary inputs such as improved seeds, a growing and stable supply of fertilizer, and the establishment of a viable credit system.

0.4 Marketing and Distribution

There has been a series of changes and reversals in Yemen's fertilizer marketing and distribution policy since the early 1970's. The private sector supplied almost the entire market during the 1970-76 period. At this time there were accusations that the two main importing companies set high prices in order "maximize short term profits."

Based on an influx of donated urea from Saudi Arabia, the Agricultural Credit Bank began distributing fertilizer in 1976. Reportedly, the Bank's entry into the market had the effect of driving the price down to about half of what had been charged by the private merchants. This caused some private merchants to abandon the fertilizer trade. Others continued to import small quantities of TSP and compound fertilizers.

Eventually, after about 1980, the Saudi Arabian donations expanded to the point where the Cooperative and Agricultural Credit Bank (CACB) found it difficult to handle it all, and some of the donated urea was sold to private sector merchants. Until 1983 the CACB and private merchants competed in distributing the Saudi urea.

Merchants maintain that competition from CACB was unfair because the bank was allowed to purchase the donated urea at a lower price than the merchants and because the bank's selling price to farmers did not

reflect its full cost of doing business. CACB officials reply that the private merchants often held back their stocks until the bank had finished selling its supply and that the merchants then sold their fertilizer at higher prices.

After 1983, the MAF decided to discontinue the sale of fertilizer through the CACB. The reason for this is not clear. One reason is said to have been the reduced supply of donated fertilizer from abroad. Other reasons may have been that the bank proved itself to be inefficient as a fertilizer distributor and that it had a poor record of collecting loans. Less than four percent of the farmers surveyed had ever obtained credit for fertilizer. With the withdrawal of the Credit Bank from the fertilizer business, a potential source of credit for fertilizer was lost.

With the bank at least temporarily out of the fertilizer business, the market would have been left largely to private merchants. However, Yemen instituted strict import licensing and control of foreign exchange in 1983. This resulted in eliminating private fertilizer imports almost entirely during 1984-86. Foreign government donations became virtually the only source of supply.

While the Saudi Arabian government did donate 20,000 tons of urea in 1985, the only fertilizer available during 1984 and 1986 was 1,400 tons of TSP and compounds each year, donated by Japan. During this period of scarcity, the MAF itself acted as the main distributor. After satisfying the needs of the research stations and development projects as well as possible, some fertilizer was sold to private merchants and some was sold directly to larger farmers.

The Ministry sold its supplies at moderate prices, in the hope of holding the price down at the farm level. With such scarcity, however, it was inevitable that the price would be bid up as supplies were stretched in the market to match demand. In 1987, for example, the price charged by MAF for compound fertilizers ranged from YRls 150 to 175. However, survey farmers reported paying an average YRls 261 per bag for this fertilizer.

The import licensing system has not worked well. The MAF has formulated an annual foreign exchange budget which is intended to designate certain amounts of foreign exchange for private imports of agricultural inputs. Based on this budget, the MAF has given its approval to private traders for fertilizer import licenses. During 1984-86, however, very few of these licenses were approved by the Ministry of Economy, Trade and Supply (MOETS) or by the Central Bank.

The situation improved in 1987, when import licenses were granted for 10,000 tons of private urea imports. Traders indicate that the situation has improved still more in 1988. The government is evidently being more liberal in granting import licenses now that Yemen has begun to receive revenues from oil exports. However, there is still no assurance that a high enough priority will be assigned to fertilizer or that adequate levels of imports will be allowed in the future.

0.5 Recommendations

The current system of import licensing has been a major obstacle to adequate fertilizer availability. MAF must develop realistic estimates of total national requirements. The procedures used in Chapter 2 of this report should be of use in this regard. An immediate increase to the 75,000 tons of fertilizer per year envisioned in the current five year plan is unrealistically high and would glut the market.

MAF must establish more effective communication and coordination on fertilizer needs with the MOETS and the High Committee on Trade. MAF must also maintain regular communications with MOETS and customs officials, to obtain timely information on the quantities of imports which have been approved and the quantities which arrive in country.

Short supplies and high prices have been a major obstacle to expanded fertilizer use. The limited and unpredictable nature of imports has provided an opportunity for some merchants to speculate by withholding their supplies from the market, in expectation of being able to obtain higher prices. The most effective means of bringing the price of fertilizer down is not through price regulation or through government control of marketing but through increasing the available supply of fertilizer. The private sector appears to have the capacity to distribute a much larger supply of fertilizer than has been available, and it can be expected to do so at lower prices if the supply is expanded in a steady, predictable manner.

Experience in other countries has shown that government bodies are not very efficient at marketing fertilizers. In Yemen the MAF has recently played an active role in the marketing of fertilizers donated by foreign governments. This places a heavy burden on the Ministry's limited staff, which is thereby distracted from duties in planning, regulating and devising policies. It is recommended that the MAF remove itself from the sale and distribution of fertilizers and that this be left to the private sector.

The absence of ready sources of credit is an obstacle to fertilizer use, especially for smaller farmers. The MAF should encourage the Cooperative and Agricultural Credit Bank to develop new procedures for extending credit to farmers who need it to purchase fertilizers. At the same time the MAF may wish to consider authorizing the CACB to engage again in the sale and distribution of fertilizers. However, in addition to providing credit for its own fertilizer sales, the bank should be required to develop a mechanism for loaning farmers the money to purchase fertilizer from private dealers.

If the CACB sells fertilizer it should be instructed to sell at the import cost plus an operating margin which reflects its full cost of doing business. If the bank receives donated fertilizers, it should price them as if they had been imported at the full international cost, in order not to compete unfairly with the private sector.

Additional research is required in order to provide a more complete set of information on fertilizer response in Yemen. Research should gradually be expanded to include more on-farm trials and economic analysis. The government of Yemen and international donor agencies must ensure that the Agricultural Research Authority (ARA) has adequate support for its fertilizer and soils research program to fill these needs.

The recently-approved UNDP program for detailed soils mapping in the Northern and Eastern regions will make a useful addition to the base of information, but this project should follow the same classification system as Yemen's existing soil studies. It should be at a scale (1:40,000 or 1:50,000) which is suitable for use by local technical staff and extension agents. For example, it should be useable for developing local area fertilizer recommendations.

Currently, there is a lack of information about availabile soil moisture in different soils, in the various rainfall zones and under different irrigation management systems. Studies of this nature would assist in improving fertilizer recommendations and the efficiency of fertilizer use.

A greater number of on-farm demonstrations related to fertilizers will be required. Currently, the regional authorities do not always have adequate budget for such trials. The government of Yemen and international donor agencies should consider expanding the support for such trials.

There are numerous indications that farmers lack information about fertilizer and that this is an obstacle to expanded and more efficient fertilizer use. This points to the need for a more effective information and demonstration program. Such a program should emphasize appropriate application methods for nitrogen fertilizers and phosphates, and it should particularly work to develop on-farm demonstrations which are effective at convincing farmers of the value of phosphates.

While the extension units of the regional development organizations are the logical choice to carry out the improved extension program, this requires coordination by MAF and the ARA. The ARA has recently begun to hold a joint annual meeting with regional development authorities to exchange information, ideas and needs for an improved extension and research program for fertilizers. This program shows great promise and should be supported by the government of Yemen as well as international organizations.

Recently, MAF has approved a proposal by FAO, funded by the Danish government, to establish a Fertilizer Unit in the Planning and Statistics Directorate of the Ministry. This unit, headed by a foreign counterpart, would concentrate on planning and coordination of research

and extension. It is suggested that this unit be specifically directed to give attention to the recommendations outlined herein.

1. INTRODUCTION

The application of increasing quantities of inorganic fertilizers has been recognized around the world as one of the main factors leading to increased agrciultural production. Fertilizer use in the Yemen Arab Republic reached an average of 12 kilograms of plant nutrients per hectare in 1983, but this was very low relative to most other countries (Table 1-1).

Yemen's agricultural production has been growing at less than one percent per year, and the low level of fertilizer use has been recognized as one of the major constraints to increased agricultural production. If Yemen is to increase overall agricultural production by 3.5 percent per year, which is the goal of the current five-year plan, increased fertilizer use is essential.

1.1 Apparent Obstacles to Increased Fertilizer Use

Several factors have been cited as possible obstacles to increased fertilizer use. Yemen's recent shortage of foreign exchange and resulting limitations which have been placed on imports have caused shortages of many agricultural inputs, including fertilizers [7].

Due primarily to import limitations, Yemen's available supply declined from an average of 27,400 tons of fertilizer materials per year in 1981-83 to 8,800 tons per year during 1984-87, a decrease of 68 percent. Measured in total nutrients, the fertilizer supply declined from an average of 11,900 tons in 1981-83 to 4,000 tons per year during 1984-87 (Figure 1-1). See Appendix A for a discussion of common fertilizer materials and terminology.

Even before the import restrictions, however, various marketing problems were evident [21]. Whereas the private sector was originally relied upon to market and distribute fertilizers, in 1976 the Agricultural Credit Bank was given the responsibility of distributing urea which was donated by Saudi Arabia. This brought charges from the private sector of unfair competition and subsidized pricing. For its part, the government charged the private sector with oligopolistic behavior that resulted in high prices.

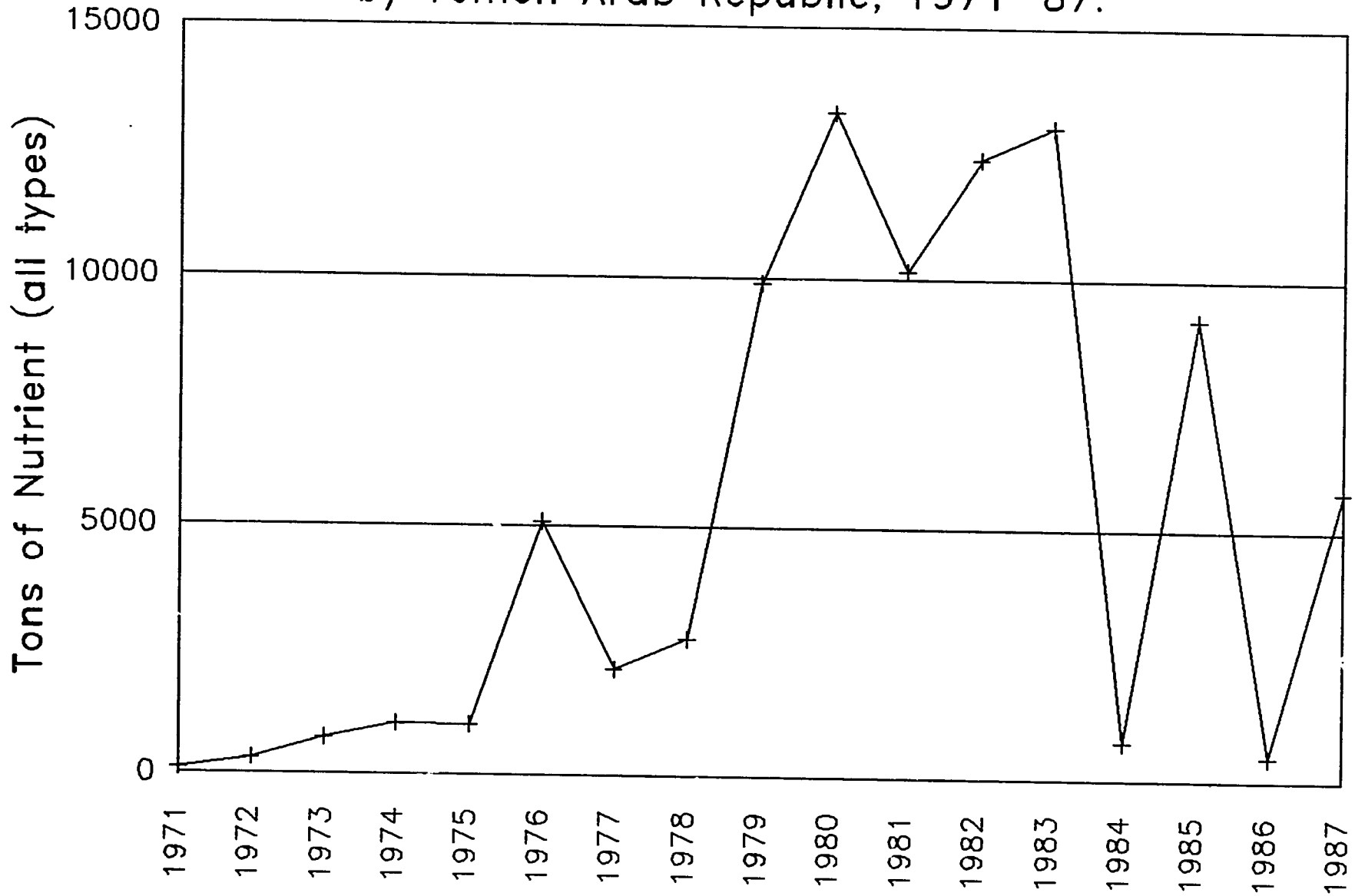
Farmers' lack of information about fertilizers and especially about appropriate application levels and procedures has been cited as a constraint. Farmers have also been reported to have a strong preference for urea or nitrogen but are said not to understand the need for phosphate and fertilizers with other nutrients [14,15]. These problems raise questions about the status and capabilities of related research and extension programs.

Table 1-1. Use of Inorganic Fertilizers in the Yemen Arab Republic and Other Countries, 1983

Country/group	Kg of Plant Nutrient per Ha of Arable Land
Low income economies, average	66.1
India	39.4
China	180.6
Sudan	6.7
Ethiopia	3.5
Middle Income Economies, average	44.3
YEMEN ARAB REPUBLIC	12.4
Yemen, PDR	10.3
Morocco	29.3
Egypt	360.5
Tunisia	16.0
Jordan	39.4
Syrian Arab Republic	32.0
Algeria	21.3
Oil Exporters, High Income, average	91.8
Oman	88.4
Libya	43.2
Saudi Arabia	177.7
Kuwait	420.0
United Arab Emirates	299.1
Industrial Market Economies, Average	123.3

Source: World Bank, World Development Report, 1986, with corrections to Yemen Arab Republic data by the fertilizer study team.

Figure 1-1. Imports of Fertilizer
by Yemen Arab Republic, 1971-87.



Studies in other countries have indicated that inadequate extension programs, lack of credit, and limitations in transportation and storage facilities all can be obstacles to higher fertilizer use [27,31].

1.2 Information Needed for Related Planning and Research

The Ministry of Agriculture and Fisheries (MAF) is responsible for planning national fertilizer usage, seeing that adequate provisions are made for fertilizer in the government's foreign exchange budget, formulating government policy on fertilizer marketing and pricing, coordinating related research and extension, and soliciting fertilizer donations from foreign governments. To carry out these responsibilities effectively, the MAF needs accurate information.

MAF needs a better estimate of how much fertilizer is likely to be required in the near term and in the long run. The 1986-91 five year plan for agriculture indicates that annual import levels should currently be about 75,000 tons of fertilizer material. However, this would appear to be unrealistically high due to lack of marketing infrastructure, limited farmer knowledge, limited funds for procuring fertilizer, and uncertainties about resulting yield increases.

The MAF has expressed a need for better estimates of the quantities of fertilizers that will need to be distributed in each region. It needs corresponding information on the capabilities of existing private and public sector marketing organizations. MAF has also requested guidance on suitable marketing arrangements and pricing policy.

On-farm fertilizer use patterns are largely unknown in Yemen. The MAF, the Agricultural Research Authority and various regional bodies with extension responsibilities need better information about farmers' knowledge of fertilizers and about their practices and levels of fertilizer use. Such information is essential in organizing improved research and extension programs, as well as in formulating better fertilizer policies.

1.3 Objectives and Scope of Work

In view of the problems and information needs discussed above, the Yemen office of the U.S. Agency for International Development arranged for Washington State University to conduct the present study in cooperation with the Ministry of Agriculture and Fisheries.

The objectives of the study are:

1. To learn how farmers have used fertilizer, including their levels of use and related practices and problems;

2. To examine available information about soils and fertilizer response in Yemen, and thus to estimate Yemen's fertilizer requirements;

3. To examine the problems and capabilities of the current fertilizer marketing and distribution system; and

4. To evaluate obstacles to expanded fertilizer use, and to recommend changes in policy in order to overcome these obstacles.

The study team first visited in Yemen during October- December 1987, at which time the farmer survey was organized and field visits were made to farms, research sites and field extension units. Officials in related government and international agencies were contacted, as were private merchants. The team leader returned to Yemen in February-March 1988, to analyze the survey, to hold further discussions with public officials, and to visit merchants in the port city of Hodeidah.

2. FARMER EXPERIENCE WITH FERTILIZER USE

An important step in understanding Yemen's fertilizer situation is to learn about farmers' experiences with fertilizer. This includes answering such questions as:

*Which crops receive the most fertilizer?

*Which types of farms or farmers apply the most fertilizer?

*Where do farmers obtain their fertilizer?

*Where do farmers learn how to use fertilizer?

*Which factors explain why some farmers use more fertilizer than others?

*What are the most common problems with fertilizer?

To answer questions like these, the study team helped the Ministry of Agriculture and Fisheries to conduct a survey of 400 farmers selected from different regions and agro-climatic zones. The results of that survey are presented in this chapter. First, however, prior studies are reviewed.

2.1 Previous Studies of Fertilizer Use by Yemeni Farmers

A few previous studies of farming practices and farming systems have obtained information about farmers' use of fertilizers in Yemen. Most of these studies relate to the Central Highlands area and have been conducted by the Dhamar Agricultural Improvement Centre. In particular, these include several village studies [12,13,14,15].

In Al Jumah village, a high proportion of farmers were found to be using inorganic fertilizers as well as livestock manure:

> Manure is extensively utilized to maintain soil fertility; inorganic nitrogen fertilizers are also widely used on rainfed crops. Phosphate fertilizers are not applied [12, pp. 1-2].

While inorganic nitrogen fertilizers were being used by irrigation farmers, they were also being applied to a high proportion (18 out of 30) of rainfed sorghum fields in Al Jumah. Although extension agents were recommending phosphate fertilizers for such crops as alfalfa and potatoes, they were often not available through the local markets.

In Qa Bakil village, it was learned that more than half of the irrigated fields received inorganic fertilizers, whereas a very low proportion of rainfed fields (2 out of 40) received them [15, p.27]. In Qa Jahran none of the rainfed fields received inorganic fertilizers, but some 85 percent of the farmers there reported using them on their irrigated crops [14, p.13-16]. Thus, at least in some villages, there

was a definite connection between irrigation and the use of inorganic fertilizers.

A spread in the use of irrigation was noted in these studies. A gap was found between irrigation and dryland farmers in Qa Bakil [15, p.8]:

	Percent of farmers:	
	Dryland	Irrigated
Own no machinery	80	16
Own a tractor	0	32
Own a pump	0	84
Own a vehicle	19	42
Hire machinery	100	68

It was observed that remittances from family members working abroad are an important source of investment for tractors, trucks, pumps and wells [14, p.8]. Thus, remittances from working abroad facilitate irrigation, which in turn leads to higher fertilizer use.

On several occasions the Dhamar village studies noted that fertilizer use varied widely from farm to farm. In Qa Jahran it was found that the rates of nitrogen application varied from 18 to 828 kg of nutrient per ha, while most applications were in the 50-150 kg/ha range. The study observed:

> Use of improved inputs is spreading. However, rates of fertilizer applied are eccentric and often involve nitrogen alone. More and better use of fertilizers under irrigation would result in a significant increase in yields [14, p.ii].

Two of the main implications of these studies were that farmers needed better information about fertilizer and that the supply of nutrients other than nitrogen -- especially phosphate -- needed to be expanded.

A 1986 survey of fruit producers, conducted by Ronco Consultants [5], observed that many micro-nutrient deficiencies -- especially those associated with iron and zinc -- were visible in fruit orchards [p. 165]. While 50 percent of farmers surveyed reported applying manure to establish their orchards, only 18 percent reported using inorganic fertilizers [p. 212].

The Ronco study observed that significant increases in production of some fruits could be obtained through the application of phosphates. For example, FAO experts were quoted to the effect that grape yields could be doubled from 12 to 24 tons/ha. However, the fruit producer survey showed that use of chemical fertilizers is not common and that nutrient sources other than urea were normally not available [p. 11]

The fruit producer survey also observed that many fruit trees appeared to be suffering from water stress. The average cost of irrigation well development was found to be YRls 41,775 per ha [p. 209],

thus illustrating the importance of finance in expanding irrigation farming.

In a more recent set of economic studies conducted at Dhamar, economist Michael Brown calculated the budgets for a number of improved and traditional input packages, including the cost of inorganic fertilizers and manure. A sample of these is shown in Table 2-1, which gives fertilizer and manure costs as a percent of total cash outlays. In this type of analysis, no cost is assigned to unpaid family labor.

Table 2-1 indicates that fertilizer outlays can represent a relatively high proportion of the total cash costs associated with crop production. In irrigated maize, for example, 200 kg/ha of ammonium phosphate would have cost YRls 1200 (Rls 300/bag) in Dhamar in 1987, accounting for 17 percent of a total cash budget of YRls 6,910 per ha for "traditional" maize production. In an "improved" package, a total of 500 kg of ammonium nitrate would have accounted for 31 percent of a total cash outlay of YRls 9375. The relatively high cost of animal manure is also evident in Table 2-1.

The Dhamar cost studies indicate that the cost of fertilizer can represent a very significant portion of the total cost of production. This is especially true since Yemen is a country in which agriculture is still not highly monetized and in which purchased inputs often do not play an important role in the production process.

2.2 Background and Organization of the 1987 Survey

The 1987 Yemen Fertilizer Use Survey was designed to expand the base of information about farmers' fertilizer use and related practices. The questionnaire (see Appendix C) included sections about general household and farm characteristics, market access, equipment ownership, contact with government agencies, sources of information about fertilizer, and use of credit. Each farmer interviewed provided information about all crops cultivated in 1987, with details on fertilizer use. The farmer was also asked to recall details of his fertilizer use in prior years.

The sample of 400 farmers was drawn from 16 districts in seven provinces, representing five different agro-climatic zones of the country. This five-region classification followed similar divisions by Sharif [7, p.22] and Ronco [5, pp.34-36].

Since a comprehensive list of farms is not available in Yemen, it was not possible to identify a complete population for sampling or to utilize fully random or stratified random sampling procedures. In order

Table 2-1. Fertilizer and Manure Costs as A Percent of Cash Outlays for Wheat, Maize and Deciduous Fruits in the Dhamar Area, 1987.

	Cost as a Percent of Total Cash Outlays
Winter Wheat, irrigated:	
Traditional variety and practice:	
Fertilizer	0
Improved variety:	
Fertilizer	22
Maize, irrigated:	
Traditional variety:	
Fertilizer	17
Manure	35
Improved variety:	
Fertilizer	31
Manure	25
Deciduous Fruit, irrigated:	
First year establishment costs:	
Fertilizer	8
Manure	20
Normal production, non-labor cost:	
Fertilizer	45
Manure	0

Source: [20]

to insure that the sample would be representative of a wide variety of conditions and management practices, it was drawn from districts and regions throughout the country. At the same time, however, some districts were purposely chosen from better farming areas in order to insure that a significant level of fertilizer use would be encountered. Thus, the statistical results are not expected to be exactly proportional to Yemen as a whole.

Once a district was chosen, government officials there were asked to provide a list of 100 "typical" farmers from the area, composed of one third each small, medium and larger sized farmers. From this list, the MAF Statistics Department survey team chose 25 farmers at random,

one third from each size category. The final sample distribution was as follows:

Region	Province	Number of Districts	Number of Farmers
Coast	Hodeidah	3	74
North	Hajjah	1	26
	Saadah	2	50
Central Highlands	Sana'a	4	100
Southern Uplands	Taiz	2	50
	Ibb	2	50
Eastern Desert	Marib	2	50
	TOTALS	16	400

Names of the individual districts in each province are provided in Appendix Table B-1.

2.3 Results of the Fertilizer Survey

2.3.1 Household and Farm Characteristics. Families and farms in the fertilizer survey are larger than those reported for the nation as a whole. The average family size of 12.2 persons in the survey is much higher than the 5.8 average reported for Yemen in the 1983 Agricultural Census [11]. The large size encountered in the survey was similar to the average household sizes of about 11 members reported for the Dhamar farm surveys [14, 15]. In the fertilizer survey, families as large as 56 members were reported. It seems that the extended family is being enumerated, whereas the agricultural census may be counting only the nuclear family.

Workers abroad accounted for an average 0.11 persons per household in the fertilizer survey. This was considerably fewer than the 0.26 persons per family listed as being "temporarily abroad" in the 1983 agricultural census. However, 13 percent of the household heads in the fertilizer survey reported that they had worked in a foreign country at some time in the past. It is likely that the number of people working abroad has declined since 1983; this would be consistent with Yemen's recent decline in foreign remittances. The implication is that farm families may have less cash to invest in irrigation wells and machinery now than they did several years ago. This would also mean that they have less money to buy fertilizer.

In addition to workers abroad, survey farms reported an average of 0.16 persons per family with off-farm work in Yemen. This could be an important source of cash for many families, in addition to what might come from abroad.

Only 48 percent of the household heads surveyed indicated that they are literate. At the same time, an average of 2.5 literate adults were reported per household, indicating that other adult family members are often available to help in situations where literacy is important, such as in reading technical information about farming.

The average holding size in the fertilizer survey was 11.1 ha, compared to only 2.3 ha reported in the 1983 census. While it is clear that the average farm in the survey was larger than the national average, some of the difference may be due to the apparent confusion between the extended and the nuclear family, noted above.

In terms of area cropped, the survey average was 5.19 ha, compared to 1.74 ha found in the census. In the survey the average irrigable area reported by farmers was 5.3 ha, whereas the crop area they actually irrigated in 1987 was only 2.62 ha. Thus, 51 percent of the area cropped by survey farms in 1987 was irrigated. According to the Census of Agriculture, only 22 percent of the national area cropped was irrigated.

The cropping pattern reported by farmers in the fertilizer survey appears to reflect their relatively high use of irrigation. They were found to have a greater proportion of their land in vegetables than Yemeni farmers as a whole, judging by comparison to the national cropping pattern in 1986 (see Table 2-2). Conversely, survey farmers had a smaller proportion of their land in cereals and legumes than the national average.

Since survey farms are larger than average Yemeni farms, use irrigation to a greater extent, and have a much higher proportion of their cropping pattern in vegetables, care must be used in drawing general conclusions from the survey.

2.3.2 Market Access and Availability of Fertilizer. Most farmers contacted in the survey had reasonably good access to roads and markets. The average distance to the nearest main road was 3.1 km, while the maximum was 20 km. The distance to the nearest market averaged 5.5 km, with a maximum of 25 km. A high proportion interviewed (81 percent) indicated that the nearest market was in a town or city whereas only 19 percent said there was a market in their own or a nearby village. Evidently, local markets offer only limited capabilities. Only 12 percent of the farmers interviewed said they could market crops in their own or a nearby village, while the remainder said they would have to go to a city or town.

Survey farmers were asked about the availability of food commoditites and farm inputs. Results are shown in Table 2-3. Whereas most farmers (88 percent) said they could get flour in a city or town, only 44 percent said that fertilizer could be obtained there, and far fewer thought that pesticides or high yielding seeds were available from a city or town. While MAF offices or projects were a relatively minor source of fertilizer, they were somewhat more important as a source of pesticides and high-yielding seeds.

Table 2-2. Cropping Pattern of Survey Farms Compared to Yemen's Average National Crop Area Allocation.

Crop	Percent of Total Area Cropped: Survey 1987	National 1986
Sorghum and millet	60	66
Wheat and barley	9	11
Maize	5	4
Legumes	1	4
Potatoes and tomatoes	5	1
Other vegetables	5	2
Industrial crops	6	2
Fruits and tree crops	9	10
TOTALS	100 %	100 %

Table 2-3. Availability of Food Commodities and Farm Inputs.

Available from:	Percent of Farms Reporting Available: Wheat Flour	Chemical Fertilizer	Pesti-cides	High Yielding Seeds
Own or nearby village	9.3	3.5	0.5	1.5
City or town	88.3	43.5	13.3	4.3
MAF office or project	-	5.5	10.8	20.0
Other sources	1.3	2.5	5.5	0.5
Doesn't know if available	-	-	1.5	1.0
Not available	1.3	15.0	15.8	25.0
No response/didn't use	-	30.0	52.8	47.8

In general, these results show that fertilizers are not as readily available as is a basic food commodity such as flour, but they are much more available than pesticides and high-yielding seed varieties.

2.3.3 Availability of Vehicles and Farm Equipment. Results of questions about the availability of equipment are shown in Table 2-4. Overall, 46 percent reported owning a car or a truck. The proportion of

respondents owning a vehicle was much higher in the Eastern Desert Region (96 percent) and lower on the Coast (16 percent). The high overall availability of cars and trucks would be expected to facilitate market access and transportation for the group surveyed.

Table 2-4. Ownership of Vehicles and Equipment.

	Percent of Survey Farmers Who:			
	Own Car or Truck	Own Pump	Share Pump	Own or Share Tractor
Survey average	46	46	25	13
Coastal Region	14	63	7	16
Southern Uplands	29	8	36	5
Central Highlands	60	36	52	10
Northern Region	49	56	5	10
Eastern Desert	94	98	0	28

Ownership of pumps was reported by 46 percent of survey farmers overall, while almost all farms in the Eastern Desert (Marib) area surveyed had a pump. In general, tractor ownership was relatively low. While 28 percent of farmers in the Marib area reported ownership of tractors, only 10 percent of the full sample owned a tractor.

Availability of vehicles and equipment would be expected to be lower among the national farm population than reported above for the survey, due to the smaller average farm size for the nation as a whole.

2.3.4 Fertilizer Use. Of the 400 farmers interviewed, 181 (45 percent) reported using fertilizer in 1987. In addition, 34 farmers who did not use fertilizer in 1987 had used it in prior years, bringing the total with fertilizer use experience up to 215 farmers, or 54 percent of the sample. Table 2-5 shows how use varied by region in 1987 and prior years.

Table 2-5. Use of Fertilizer Among Sample Farmers in 1987 and in Prior Years.

	Percent Who Used:	
	In 1987	In Prior Years
Survey Average	45	48
Coastal Region	5	33
Southern Uplands	71	55
Central Highlands	65	82
Northern Region	36	33
Eastern Desert	28	28

In general, fertilizer use was found to be highest in the Southern Uplands and the Central Highlands. Use was lower in the Coast than in

other areas. Furthermore, Table 2-5 indicates that fertilizer use has increased in some areas while it may have declined in others. While only five percent of the sample farmers in the coastal region were found to apply fertilizer in 1987, 33 percent indicated that they had used it in the past. In contrast, in the southern region 71 percent of farmers reported fertilizer use in 1987, whereas only 55 percent had used it there in the past.

Farmers were asked when they had begun to use inorganic fertilizer. Twenty-eight (7 percent) used it for the first time in 1987, 15 percent reported first use in 1984 or 1985, 22 percent first used it in 1981-84, and 56 percent reported first use in 1980 or before. Three farmers had used fertilizer before 1972.

Survey farmers were also asked to indicate the source of the fertilizer used in 1987. Results are shown in Table 2-6. Almost 80 percent of those responding indicated that they had obtained their fertilizer from a merchant. Sixteen percent of these were merchants in the farmer's own or a nearby village, whereas 84 percent were merchants in a town or city. MAF offices and government agricultural projects were of secondary importance as a source of fertilizer, with only 16 percent of those responding indicating this source.

Table 2-6. Source of Fertilizer Used in 1987.

	Percent of Respondents
Merchant in own or nearby village	13
Merchant in town or city	67
MAF Office or agricultural project	16
Other source	4

Of a total of 1,982 bags (50 kg each) of inorganic fertilizers applied in 1987 by the farmers surveyed, 84 percent were identified as urea, 3 percent as triple superphosphate (TSP) and 13 percent as "compounds". Levels of fertilizer application varied widely from crop to crop, as shown in Table 2-7.

The overall average level of nitrogen applied was just over 18 kg of N/ha. This is about three times the national average application for 1987 and is undoubtedly a reflection of the fact that the sample farms have a far higher level of irrigation than the national average.

The close association between irrigation and fertilizer use can be seen in Table 2-7. Among the grains, for example, the least irrigated (sorghum and millet) receive the lowest levels of inorganic fertilizer. Nevertheless, not all irrigated areas are receiving fertilizer. While 83 percent of the wheat area in the sample was irrigated, only 47 percent of the area received inorganic fertilizers.

Table 2-7. Levels of Fertilizer Application and Related Inputs for Crops Grown by Survey Farmers in 1987.

Crop	Average Percent of Crop Area: Irrigated	Organic Manure Applied	Chemical Fertilizer Applied	Nitrogen from Urea (kg/ha) Avg	Max	Percent of fields Receiving TSP or compound
Sorghum	31	23	13	10	939	1
Millet	3	1	0	0	0	5
Wheat	83	43	47	53	732	2
Maize	82	44	37	27	359	2
Potatoes	100	23	68	60	1136	2
Tomatoes	89	13	12	11	568	4
Alfalfa	100	17	0	0	0	0
Lentils	46	26	37	22	142	0
Tobacco	83	0	0	0	0	0
Papayas	73	1	94	107	345	2
Oranges	69	26	68	69	920	11
Grapes	86	50	22	44	340	10
AVERAGE for All Crops	51	23	19	18	6723	2

N. B. See Appendix Table B-2 for more details.

As was found in the surveys of Dhamar area farmers discussed earlier, the use of organic manure was found to be substantial. Both livestock and poultry manure is applied. While 23 percent of the overall crop area received manure, only 19 percent received inorganic fertilizers.

Farmers' overall pattern of fertilizer application seems to reflect sound technical and economic logic. As will be discussed in Chapter 3, research in Yemen has shown that wheat is more responsive to nitrogen (N) application than sorghum, and survey farmers are applying more N to wheat. Economics would dictate that more fertilizer be applied to irrigated crops and to higher valued crops. Indeed, farmers are seen to apply higher amounts of N to potatoes, papayas and oranges. Fruits and other tree crops have higher requirements for nutrients other than N, and such crops are receiving more of the "compound" fertilizers.

While there is an appreciable level of technical and economic sense to the pattern shown in Table 2-7, there is obvious room for improvement. It is not at all apparent, for example, why tomatoes should be receiving lower levels of nutrients than wheat or maize, or

that they should be receiving only one sixth the N that potatoes do. All of the alfalfa in the sample is irrigated, and research has shown that alfalfa in Yemen makes a substantial yield response to phosphates; yet no phosphates were applied to the alfalfa fields in the sample. Lentils, a legume, were found to receive an average of 22 kg of N per ha, even though legumes normally show relatively low response to N.

Another problem with the pattern of application reported by farmers is the fact that the maximum levels of N applied in some cases are well above levels that would give any response. While many of these high maximums result from spreading a single bag of fertilizer on a very small plot, in other cases these high levels of application indicate that farmers do not know the proper levels to apply.

The problems discussed above indicate that Yemeni farmers need more information about the correct levels of fertilizer to apply and the appropriate nutrients for different crops.

2.3.5 Regional Differences in Fertilizer Application, Irrigation and Crop Yields. There were significant regional differences in fertilizer applications for some crops. Separate data tabulations were made for seven different crops, and these are shown in Appendix Tables B-3 through B-9. Some of the important observations and conclusions to be drawn from this analysis are discussed in the following paragraphs.

Farmers in the central region (the four Sana'a districts surveyed) applied an average of more than 44 kg/ha of nitrogen to their sorghum, which was five to twenty times higher than the rates which were applied in the other three regions where sorghum is grown (see Appendix Table B-3).

In the southern, central and northern regions, sorghum yields were reported to be much higher where fertilizer was applied. In the coastal region, however, sorghum yields reported by farmers were quite low, and fertilizer appeared to give no response. Since the coastal area is an important sorghum production zone, it appears that priority should be given to identifying higher yielding and more responsive sorghum varieties for that area. Sorghum yields reported in the North were quite low, but response to fertilizer appeared to be good.

Relatively high levels of N were applied to wheat in the South, Center and North, but none was applied to the 32 fields encountered in the eastern zone. Response was found to be quite high in the Center, but there was no measurable response in the North (Appendix Table B-4).

Relatively small amounts of fertilizer were applied to maize in the coastal region, even though almost all maize fields in that area were irrigated (Appendix Table B-5). Yields in the Coast were also low, compared to the southern and central zones. In both the South and the Coast, farmers who used fertilizer reported yields that were about double the yields indicated without fertilizer.

Most of the potatoes grown by survey farmers were in the southern region, where all farmers used inorganic fertilizer and where the average yields of almost 24 tons/ha were quite high (Appendix Table B-6). Nitrogen application was much lower in the Center and in the North, and potato yields were also much lower in these two regions.

In the coastal region where most of the tomato fields in the survey were found, relatively little fertilizer was used compared to other regions (Appendix Table B-7). Nevertheless, tomato yields in the Coast were about 30 percent higher than in other regions. It appears that farmers have not yet learned to use fertilizer to an advantage on this crop.

Regional data on fertilizer use and response for the different crops, such as that found in Appendix Tables B-3 through B-9 can be used to guide varietal development, fertilizer response studies, and extension programs.

2.3.6 Farmers' Perceptions of Problems with Fertilizer. Few if any of the farmers interviewed felt that they needed additional information about how to use fertilizers or which fertilizers to use. Of the 217 who responded to the question on fertilizer problems, 50 percent said that the main problem is that fertilizer is too expensive. Thirty-five percent said that the problem is that fertilizer is not available. Twelve percent said that there is a problem in using fertilizer due to drought or a shortage of irrigation water. In addition to these, a small number of miscellaneous problems were reported.

2.3.7 Application Methods. The methods used in applying fertilizer can be important in insuring that it is made available to the plant and is not wasted. For example, if urea is broadcast on the surface of damp, high pH soils in hot weather, much of the nitrogen may be lost through volatilization. It is preferable to apply urea with a seed drill or to till it into the soil immediately after broadcasting; irrigation immediately upon application can also be helpful. Phosphates should be banded into the soil below the seed, rather than broadcast on the surface, or they cannot be efficiently used.

When survey farmers were asked how they apply their fertilizers, only two persons reported using machinery, whereas the rest reported applying fertilizer by hand. Only 36 percent of those interviewed said they tilled the fertilizer into the soil immediately after application. However, 83 percent of the respondents indicated that they do irrigate on the same day that they apply fertilizer. Thus, there appears to be an awareness of the need to incorporate urea into the soil, although tillage would be preferable to irrigation.

2.3.8 Sources of Technical Information. Survey farmers reported several different sources of information about fertilizers (Table 2-8). The most frequently cited source was the Ministry of Agriculture and

Fisheries (45 percent), although neighbors or relatives were also an important source (35 percent). Other sources included merchants and radio programs, which accounted for 5 to 7 percent of the sources cited in each case. Only a few farmers mentioned television, and the newspaper and the Agricultural Credit Bank were cited by one farmer each.

Table 2-8. Source of Information About Inorganic Fertilizers

	Percent of Sources Cited
Extension agent, MAF official or agricultural project	44.5
Neighbor, friend or relative	34.2
Merchant or businessman	6.8
Radio	5.1
Television	1.7
While working in a foreign country	1.4
Agricultural Bank	0.3
Newspaper	0.3
Other sources	5.5

Table 2-9. Frequency of Contact With Agricultural Officials and Offices

	Extension agent or MAF official has visited farm	Farmer has visited agricultural office or experiment station
Often	16	8
Occasionally	22	25
Once	7	16
Never	55	51

Farmers were also asked about the frequency of their contacts with MAF officials and projects. Almost half have had such contacts, as shown in Table 2-9. The fact that such a high proportion (16 percent) report frequent visits to their farm by an extension agent or MAF

official again suggests that the sample is not representative of Yemen's overall farm population.

2.3.9 Prices Paid for Fertilizer. Table 2-10 shows the average and range of prices per 50 kg bag of fertilizer reported by survey farmers for 1987. At YRls 286 per bag, the average paid for urea was higher than that paid for TSP (YRls 253) or for compounds (YRls 261).

Table 2-10. Fertilizer Prices Reported by Survey Farmers for the 1987 Crop Year.

	Urea	Triple Super-phosphate	Compound fertilizers
Purchase reported	181	5	14
Price: (YRls/bag)			
Average	286	253	261
Maximum	390	300	350
Minimum	140	180	200

The high price for urea is clearly a reflection of strong demand and a relatively limited supply. The cost of urea delivered to the warehouse in Hodeidah, with all import costs, tariffs, and handling charges paid, cannot have exceeded YRls 100 per bag in 1987. Internal transportation and storage cannot have exceeded YRls 30, and a "normal" retail mark-up should not exceed YRls 15 per bag. The MAF sold its supplies of urea to farmers and merchants for YRls 175 per bag in 1987. The average YRls 286 per bag reported by farmers is obviously much higher than either the import cost or the MAF price, plus normal transport, storage and handling costs. Thus, the supply is so limited relative to the demand that the price is bid up until the market is balanced.

Import costs of TSP and compounds would have been at least $20 to $30 per ton (YRls 10 to 30 per bag) higher than the cost of urea. The MAF sold these other fertilizers to farmers and merchants at the same YRls 175 per bag as urea. Yet, the fact that these fertilizers are selling at a lower price than urea, despite their much more limited supply, is an indication of the weaker demand for the other fertilizers.

The fact that phosphate has the lowest price, even though its supply is the most limited, shows that farmers have not yet recognized its value. Since experiments show that phosphates do give a significant response for many crops, it appears that the MAF must work harder to demonstrate the value of phosphates to farmers.

When information and understanding about fertilizers other than urea becomes more widely spread, and when farmers have seen sufficient evidence about the value of the other fertilizers, the relative weakness

Table 2-11. Current and Past Prices Paid for Fertilizers as Reported by Survey Farmers, with Comparison to Rural Grain Prices.

Fertilizer Prices:	1981	1982	1983	1984	1985	1986	1987
Urea, YR1/50 kg bag	72	164	125	80	145	231	288
Number of farmers reporting	9	22	40	19	31	30	181
Triple Superphosphate, YR1/bag	N/A	87	110	80	135	200	253
Number of farmers reporting		3	3	1	2	2	5
Rural Market Price for Basic Grains							
White sorghum, YR1/kg		2.26	4.02	5.92	6.33	6.13	6.41
Yellow sorghum, YR1/kg		2.00	3.94	6.09	6.39	5.98	6.66
Maize, YR1/kg		2.09	3.33	6.15	6.65	5.67	6.01
Wheat, YR1/kg		3.29	3.62	4.85	6.84	6.69	6.01
Average		2.41	3.73	5.75	6.55	6.12	6.27
Ratio of Grain to Nitrogen Prices [*]		.34	.69	1.65	1.04	.61	.50

Source: Fertilizer prices from 1987 Fertilizer Survey; crop prices from MAF Statistics Project.

[*] - Ratio derived by dividing average grain price by price per kg of N obtained from urea (46% N), where urea prices are as indicated above.

in demand should change. In the meantime, private traders cannot be expected to import much larger quantities of the other fertilizers since they are obviously less profitable to handle than urea.

In the survey, farmers were asked about their fertilizer use in prior years, including information about the prices paid. Many farmers were able to recall past prices paid for urea and triple superphosphate. In Table 2-11, historical price series for urea and TSP are shown, based on what farmers reported for 1981-87. To provide a basis for comparison, historical prices of grain crops were obtained from the MAF Statistics Department, and these are also included in Table 2-11.

It is seen that urea and TSP prices have followed similar trends. Grain prices rose relative to fertilizer prices in 1983 and 1984, undoubtedly in response to the drought and reduced crop yields which Yemen experienced in those years. Beginning in 1985, grain prices declined, and by 1987 the grain-to-nitrogen price ratio was close to that of 1982. While fertilizer prices in Yemen are high, so are crop prices. As the discussion of Yemen's crop and fertilizer price structure in 1986 will show (see section 3.6 in Chapter 3), Yemen's grain-to-fertilizer price ratio is more favorable than those of many other countries. Thus, high crop prices tend to offset high fertilizer prices, and fertilizer prices in Yemen probably do not serve to discourage fertilizer use more than in other countries.

Table 2-12. Sources of Credit for Farm Equipment and Fertilizer.

	Farm Equipment (%)	Fertilizer (%)
Percent of farmers who have used credit to purchase:	16.3	3.8
Source of credit:		
Friends or neighbors	17	29
Relatives	22	29
Money lenders	1.5	0
Merchant or trader	9.2	35
Agricultural Credit Bank	51	5.9

NB. Two of the 15 farmers who used credit for fertilizer reported more than one credit source.

2.3.10 Credit. Even though Yemen's relative fertilizer prices may not seem high by international comparison, the cost of fertilizer does represent a high portion of farmer production costs, as was demonstrated in section 2.1. Furthermore, farmers surveyed indicate that high prices are their single biggest problem with fertilizers. One

way to help farmers overcome the cash requirements obstacle, as has been demonstrated in other countries such as Egypt, is through the use of farm credit.

Survey farmers were questioned about the availability and sources of credit. While 65 (16.3 percent) of the 400 farmers interviewed reported having used credit to purchase a tractor, pump or other piece of farm equipment, only 15 (3.8 percent) said that they had used credit in the purchase of fertilizer. The sources of credit varied, as shown in Table 2-12.

Whereas farmers had to rely on neighbors, relatives and merchants to obtain credit for fertilizer, more than half of those who had used credit for farm equipment (33 of 65) were able to obtain it from the Agricultural Credit Bank. Only one of the farmers who used credit for fertilizer dealt with the bank. The absence of a credit program for fertilizer at the Agricultural Credit Bank appears to have a significant adverse effect on farmers' ability to obtain credit for this purpose.

2.4 Analysis of Factors Which Promote Fertilizer Use

The preceding discussion covers a fairly wide range of factors related to fertilizer use, but it considers most of these factors one at a time without attempting to say which are most important. In the statistical analysis of survey results the study team was also interested in determining whether some factors are more important than others in leading to or facilitating the use of fertilizers. To address this issue, statistical regression analysis was employed.

The dependent variable chosen in the regression analysis was kilograms of urea applied per hectare of cropped area for the farm. Since only 45 percent of the survey farmers used fertilizer in 1987, this meant that the dependent variable had a value of zero in over half of the cases. The question being asked with the regression may be stated as follows: "Why do some farmers use fertilizer (urea), and why do some use more than others?"

In the analysis, separate regressions were run for each region except the coast, in order to examine whether the factors which determine fertilizer use might vary from region to region. Regressions were also performed on the entire data set, with the use of control (dummy) variables for regions. A summary of final results of the "best" regression for each region and the best full data set regression are shown in Table 2-13. The coeficients shown in the table are "beta" coeficients for the independent or "explanatory" variables. They indicate the additional kg/ha of urea associated with a unit change in the explanatory variable. The following discussion summarizes the main findings of the regression analysis.

While ability to read and write does not seem to explain higher fertilizer use, farmers who have more years of education do appear to

use more fertilizer in the southern and the central regions. This suggests that education has a positive impact on fertilizer use.

Surprisingly, where fertilizer was said to be available from local merchants, farmers were found to use less fertilizer. This appears to indicate that farmers who normally obtain their fertilizer from a city or town are likely to use more fertilizer than those who rely on local village merchants for their supplies.
Table 2-13.

As expected, vehicle and equipment ownership is associated with higher fertilizer use. For the full data set, farmers who owned a car or truck were estimated to use 33.8 kg/ha more urea than those without a vehicle, and tractor owners used an estimated 46.9 kg/ha more. Pump ownership seemed to help explain higher fertilizer use in the south but was not statistically significant in other areas. As the use of pumps and the availability of vehicles and tractors increases, farmers can be expected to use more fertilizer.

The practice of tilling or irrigating fields after nitrogen application was a significant explanatory factor in three out of four regions and for the regression as a whole. This is interpreted to mean that farmers who have gained a relatively high amount of knowledge about fertilizer use are likely to use fertilizer and to use it in larger quantities.

"Source of urea" was a zero/one variable with a value of one for those farmers who obtained their urea from an MAF office or a government project, while zero signified purchase from the market. While relatively few of the survey farmers reported obtaining fertilizer from the MAF or an agricultural project, this evidently had a positive impact on fertilizer use among those who did.

Finally, the negative signs for the "hectares cropped" coefficients indicate that larger farms (those with more total cropped area) use relatively less fertilizer per hectare. Conversely, smaller farms use fertilizer more intensively. A logical conclusion from this is that fertilizer does benefit smaller farmers and that it probably serves as a substitute for land.

2.5 Concluding Remarks

The 1987 Yemen Fertilizer Survey suggests that a significant number of Yemeni farmers do have experience with inorganic fertilizers, although more than half of the farm population has probably never used them.

The survey indicates that farmers have a good general sense about where and how to use fertilizers. They normally use them more on responsive crops in irrigated areas, and on higher valued crops.

Table 2-13.

Coefficients in the "Best" Equation for 4 of 5 Regions and all Regions Using All Survey Respondents

	Region				
	South	East	North	Central	All
Dependent Variable					
Kilograms of Urea per Hectare					
Intercept	-2.2	-1596.8	448.3	-33.2	-23.2
Independent Variables					
Ability to Read and Write		-51.4*			
Years of Education	2.9*			14.8**	
Percent of Land Irrigated	1.2**				
Percent of Land Owned					
Distance to Nearest Market					
Fertilizer Available Locally	-34.2**			-95.4	-70.4*
Own a Car or Truck	7.7			35.9	33.8**
Own a Pump	31.2**	100.9		-46.8	
Own a Tractor		59.4*	205.2**	69.1*	46.9**
Extension Agent Visited Farm	21.1**				
Farmer Visited Ag. Office				-42.2*	
Covers or Irrigates after Application		186.5**	246.1**	77.1**	137.3**
Borrowed Money to Buy Fertilizer					
Borrowed Money to Buy Equipment		77.9	177.5*		
Kilograms of Natural Fertilizer	0.004				-0.006*
Price of Urea		5.6**	-1.5**	0.3	
Source of Urea		621.2**	350.9**		73.2**
Hectares Cropped	-6.9**	-11.4**	-2.2*	-3.5	-3.0**
Southern Region Dummy Variable					
Eastern Region Dummy Variable					43.3*
Northern Region Dummy Variable					109.2**
Central Region Dummy Variable					
Number of Observations	100	50	75	100	400
R^2	0.78	0.83	0.68	0.27	0.36
Number of Variables	8	8	6	9	9

**Prob. < .01 - Probability that true parameter equals zero.
*Prob. < .1 - Probability that true parameter equals zero.

The Ministry of Agriculture and related extension programs and projects are recognized by farmers as the single most important source of information about fertilzers. About half of the farmers surveyed have made contact with extension agents, MAF officials and related projects.

The survey suggests that additional educational and information programs about fertilizers are required. Farmers are not applying fertilizer at adequate levels to all of the crops that need it. Application methods, such as the need to incorporate urea into the soil through tillage and the need to band phosphates, must be emphasized. The value of phosphates must be demonstrated to farmers.

Farmers indicate that the cost of fertilizers does pose a significant problem for them. The availability of credit for fertilizers is currently quite limited. The Agricultural Credit Bank's role in fertilizer credit has almost ceased to exist in recent years. To help alleviate the burden imposed by the cost of fertilizers, expanded availability of credit is required.

3. THE ESTIMATION OF YEMEN'S FERTILIZER NEEDS

3.1 Soil Characteristics

Soil surveys [2] show that most of the agricultural soils of Yemen have properties that are characteristic of arid region soils in many other countries. It can be stated at the outset that experience elsewhere indicates that significant crop yield increases are possible from the use of fertilizers on these soils.

The soil characteristics significant for fertilizer needs, for management of fertilizers, and for crop response to fertilizer are:

- Most of Yemen's soils are calcareous, meaning that they contain lime (calcium carbonate).

- These soils tend to be alkaline, with pH above 7.0 in many cases.

- In soil analyses for available soil phosphorus, conducted by the Cornell Soil survey team [2], approximately 75 percent of the samples tested were in the low to medium range for plant available phosphorus.

- Analyses have also shown that most of the soils have a high level of exchangeable potassium, which is essentially the same as "available" potassium.

- Analysis shows that there is a low level of organic matter, which means that the soils have very low capacity for providing available nitrogen for a crop.

- Every indication is that Yemeni soils contain those types of clay minerals which have great shrink-swell properties on drying and wetting. Consequently, they have high holding capacities for potassium and other nutrient cations. However, such soils have limitations when irrigated with saline water, particularly if the water has a high sodium absorption ratio (SAR).

3.2 Implication of Soil Characteristics for Fertilizer Needs and Fertilizer Management

Nitrogen: Nitrogen is the nutrient element most often required for increasing crop yields, and except for leguminous crops it is the one needed in largest quantity. It is almost universally true that soils which have been farmed for a long period of time will not produce as much available nitrogen as the crop could use. In making this statement it is assumed that crop varieties are used which have a capacity to utilize high levels of soil fertility.

Well adapted modern varieties of crops have the capability of converting large inputs of nitrogen and moisture to high yields, when

grown on desert soils such as those found in Yemen. The yield response to supplemental nitrogen inputs is greater in higher rainfall areas, but the need for supplemental nitrogen will hold even at low levels of rainfall [34]. When desert lands which are low in organic nitrogen are irrigated, the amount of nitrogen fertilizer needed can be very high.

While nitrogen and moisture are each essential inputs for crop production, the yield response to additional nitrogen input is also related to the availability of other nutrients, especially phosphorous. If sufficient phosphorous is not available, the added N will not have its full effect. When a responsive plant variety is being used and when phosphorous and moisture are adequate, nitrogen needs are directly related to the production potential of the variety. In cereal production, a rough approximation is that for every kilogram of N added there should be an increase in grain output of about 20 kg [for example, see 36]; that is, 15 kg of N should increase grain output by 300 kg.

In dryland farming with limited rainfall, the addition of N may pose a hazard if seasonal rainfall is less than expected. In such cases the addition of N could result in "burning" the plants, and yields would be lower than in comparable unfertilized areas. The risk of this occurring is higher in areas where the average annual rainfall is less than 450 mm. To minimize this risk, reduced levels of N application are recommended for the lower rainfall zones.

Since essentially all of the readily available nitrogen fertilizers are of the ammonium type and since most of the cropland in YAR is calcareous, special care must be exercised so as not to waste nitrogen fertilizers. There is a potential for a considerable loss of nitrogen by the process of volatilization if nitrogen fertilizers are broadcast on the surface of moist or damp soil. Ammonium type fertilizers such as urea or ammonium nitrate, when in contact with moist calcareous soil, react and chemically release ammonia which escapes into the air. Losses by this means can be great.

The remedy for volatilization loss is to incorporate the fertilizer into the soil by tillage immediately after application. When urea is used, irrigation directly after application can also prevent loss, since the urea is soluble. Without timely incorporation accomplished by tillage or irrigation, the efficiency of nitrogen fertilizer utilization is greatly reduced.

Various measures are required to improve nitrogen application methods and thus to increase the efficiency of nitrogen use. These may include educating farmers about appropriate techniques, improving the implements which are available for tillage and for applying fertilizer, and improving irrigation systems so that irrigation water is available when it is needed for use in conjunction with fertilizer application. The survey results discussed in Chapter 2 indicate that farmer knowledge and practices need much improvement. The increasing use of irrigation and the growing availability of pump irrigation systems in the past decade have probably helped to augment nitrogen use efficiency.

Phosphates: While nitrogen needs are quite directly related to yield potential, phosphorus needs are first and foremost related to soil chemical, physical and mineralogical properties. Thus, the amount of phosphorus required depends more on soil characteristics than on the plant yield potential. While recommended N applications increase rather markedly with increasing soil moisture availability and yield potential, recommended phosphorus fertilizer applications increase less dramatically.

Often, phosphorous deficiencies do not begin to show up until levels of nitrogen fertilizer become substantial. Thus, Yemeni farmers are not unique in placing a strong initial emphasis on nitrogen and in showing much lower interest in phosphates. For many crops, however, as nitrogen use increases to higher levels the increased production of plant material will require more phosphorous than is naturally available in the soil. At this point, further yield increases from nitrogen will be limited unless phosphates are added.

When phosphate fertilizer is applied to soil that is low in available phosphate, it is normally necessary to apply it at high levels for two or more years in order to "quench" the soil's ability to reduce the availability of added phosphate. Once this is accomplished, however, lower long term maintenance applications can be made on an annual or every second year basis.

When phosphate fertilizer is broadcast onto calcareous soil and tilled in, the phosphate fertilizer undergoes a chemical reaction with the soil which reduces the fertilizer availability. To reduce this process, growers must learn to place the phosphate fertilizer in a "band" below or below and to the side of the seed. Band placement can reduce the need for phosphate fertilizer by 50 percent when compared to the amount needed when phosphate is broadcast on the surface and tilled in. The 1987 survey showed that most Yemeni farmers still broadcast fertilizer by hand, which suggests that phosphate use efficiency is currently quite low and that improved application methods are needed.

Potassium: Desert soils like Yemen's are generally high in potassium. Indeed, most soils have about the same levels of potassium. However, differences in associated minerals cause the release of potassium to vary quite a bit from soil to soil. Some crops have high potassium requirements, exceeding the amounts normally released by the soil, and these need to receive regular potash applications. Grapes, bananas and certain other tree crops are known to require extra potash, as does alfalfa. Potatoes, tomatoes and some other vegetables are also heavy potassium users.

Soil Alkalinity and Micronutrients: Availability of nutrients for plant uptake is influenced to a large extent by soil pH. The pH that allows for the greatest availability of most nutrients is 6.0 to 6.5. Availability is still reasonably good at a pH of 7.5, but lime, which is almost always a component of higher pH soils, limits the availability of phosphorus and several micro-nutrients [35].

When alkaline soils are irrigated, iron deficiency is common, especially in tree crops, grapes, and some field crops, one of which is sorghum. Even though iron may be present at relatively high levels, plants are not able to take it up, and they suffer from iron chlorosis. Varietal selection can play a role in reducing the severity of iron chlorosis, as can the addition of kelated iron fertilizers.

Zinc availability is reduced at higher pH levels and in the presence of calcareous soils. Crops like maize, sorghum, potatoes, and tree fruits can be severely affected by zinc deficiencies.

Boron availability is also reduced by high pH. Adequate boron is vital for maximum growth of alfalfa and for many of the cruciferous vegetables, and boron influences the quality of these crops. Tree fruit crops often show boron deficiency on these soils.

In the study team's discussions with research and extension officials, trace element deficiencies were often identified as a problem in horticultural crops. The deficiencies most often identified were iron, zinc and manganese. The limitations posed by such deficiencies can be serious, but they are not universal and therefore must be identified and dealt with by region. While it is essential that imports of micronutrient fertilizers be permitted to remedy these problems, it is not possible with existing information to estimate the quantities of such materials that will be required.

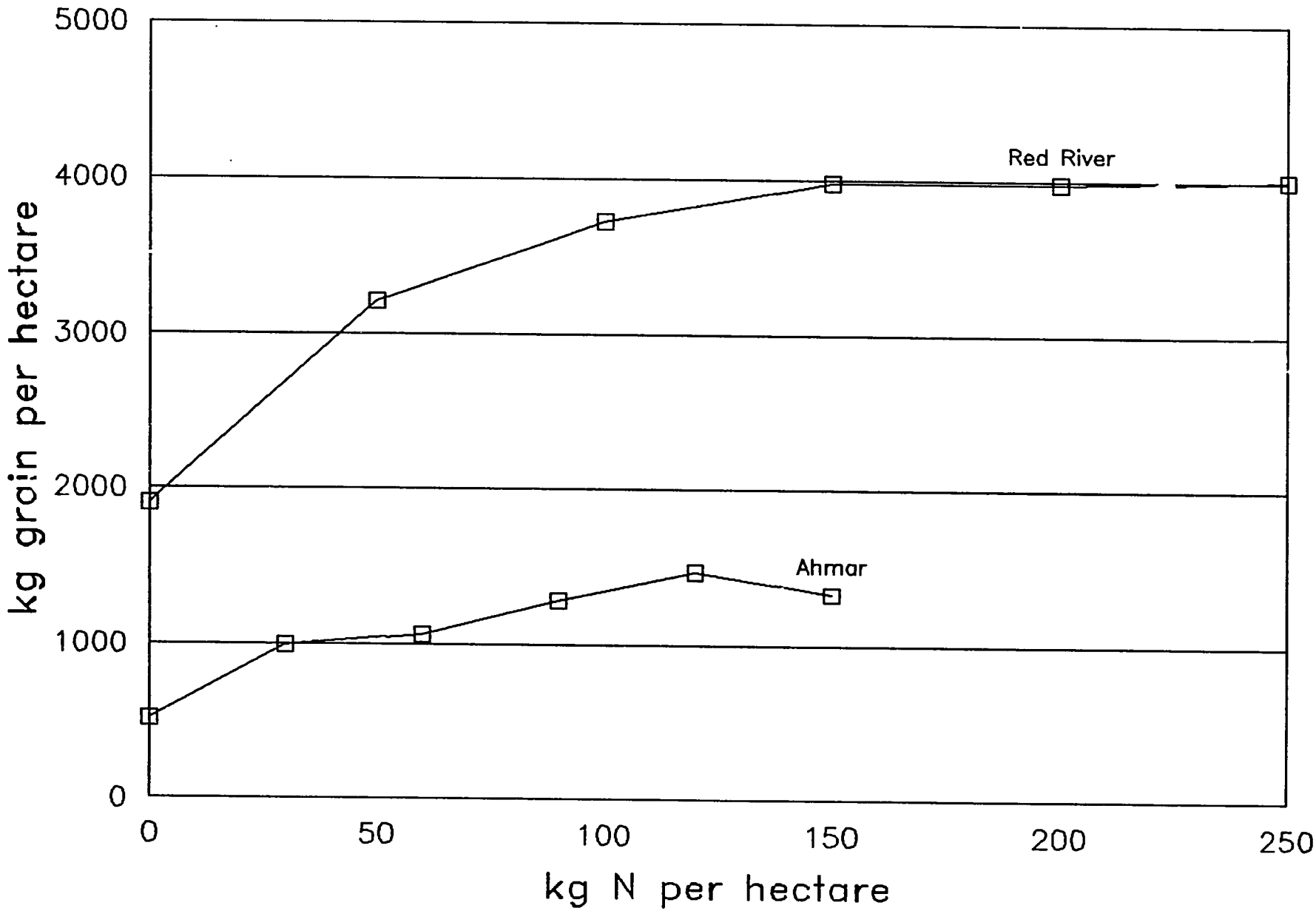
In contrast to those nutrients that have reduced availability under alkaline conditions, the availability of molybdenum is increased. In some cases (depending on the soil) the availability of this nutrient can be so high that levels can accumulate in leguminous forages to the point that they become toxic for ruminant animals.

3.3 Basis Used for Arriving at Estimates of Nutrient Needs

Crop Response to Fertilizer: The preferred method of estimating fertilizer needs is to base them on yield response functions developed from the results of field experiments. In such experiments it is normal to ensure that all nutrients and required inputs other than the one being studied are provided at adequate levels.

As an example, two response functions are shown in Figure 3-1, based on 1981 experiments at the Dhamar Agricultural Improvement Centre. The yield of 'Ahmar' wheat increased from 513 to 1467 kg/ha when 120 kg/ha of N was added. This was an average of 7.95 kg of grain per kg of N, which is substantially lower than the 20:1 norm cited earlier. Nitrogen application beyond 120 kg/ha even resulted in decreased yields. Results of a parallel experiment with the the 'Red River' wheat variety indicated a much higher yield of 1900 kg/ha with no fertilizer. Also, the response to N application was much higher, averaging 18 kg of yield per kg of N over the range from 0 to 100 kg/ha.

Figure 3-1. Response of Wheat to N at Dhamar Trials.



A yield response function of the above type needs to be obtained for:

- each crop;
- each nutrient;
- each rainfall zone (available moisture level); and
- each distinctly different soil region.

There are experimental data which would permit deriving response functions of this nature for some crops in some regions of Yemen [24,25,26]. In 1985, FAO soil scientist S. A. Amer made a valuable survey of the fertilizer response work which has been done in Yemen [1]. Most of the response trials to date have been concentrated in a few regions, especially in the southern uplands and in the central highlands near Dhamar. For some crops, response studies have been limited to just one or two nutrients. In other cases, it is not certain that trials have been run on the latest crop varieties. Where trials have been run, results are often not reported in enough detail or with enough observation points to permit the derivation of a complete response function.

In general, not enough of these studies have been conducted to permit estimation of nutrient response functions for all crops throughout the entire country. This will only be possible after experiments are conducted on a wider variety of crops, with more nutrient combinations and levels, and for more regions and levels of available soil moisture.

While results of fertilizer experiments were used where available, to estimate Yemen's fertilizer needs the study team found it necessary to consult a variety of other sources of information. These included discussions with research and extension personnel, scientists at the Sana'a University Faculty of Agriculture, members of the HITS program, personnel in the Ministry of Agriculture and Fisheries, various regional development centers, fertilizer dealers and the manager of a large commercial farm. Published sources were also utilized [2,3,4], as were experiences in other areas of the world with conditions similar to those that exist in the YAR.

Extension personnel at the Central Highlands Regional Development Project in Dhamar and at the Southern Uplands Regional Development Project in Taiz supplied information on their current fertilizer recommendations. While such recommendations were extremely useful in helping to develop the requirements used here, they could not be used to make complete estimates for the nation or even for the regions involved. The development project recommendations at times do not distinguish between requirements for irrigated or rainfed areas; furthermore, these projects were designed to work initially in higher productivity areas where there is more potential for increasing output. In general, the extension recommendations are somewhat higher than the requirements estimated here.

Principles that govern soil-plant-climate interactions were also relied upon in developing the fertilizer requirements estimated by the

study team. Generally, elements of two alternative approaches were combined. In part, the requirements were based on the nutrients that would be needed to eliminate soil deficiencies--that is, the nutrients that would be required to bring nutrients up to levels which have generally been found to be sufficient for high levels of crop production. However, this "soil sufficiency approach" was also supplemented by the "nutrient removal" approach -- that is, consideration was given to experimentally derived information from a number of international sources as to the amounts of nutrients removed by the principal products (e.g. grain) and associated plant materials (e.g. straw).

3.4 Long Run Estimates of Nutrient Requirements

For estimating purposes, crops grown in Yemen were classified into four broad categories, each containing crops which are expected to demonstrate similar responses to nutrient application or to have similar nutrient requirements. These categories are: cereals; fruits, nuts and other tree crops; vegetables and industrial crops; and legumes. To make the estimates as accurate as possible, the study team also classified the needs for major crop groups according to six levels of available moisture: two for irrigated production and four for rainfed.

3.4.1 Requirements per hectare. As a first step in the process of estimating total fertilizer requirements, the study team developed per hectare requirements for each crop class under each level of available moisture. These estimates are shown in Table 3-1. The requirements in Table 3-1 were derived primarily from an agronomic point of view, assuming relatively favorable conditions. Such favorable agronomic conditions are currently not widespread in Yemen, but it is assumed that they will gradually be established with the passage of time. Only then will the levels of fertilizer indicate in Table 3-1 be fully required. For this reason, they are referred to as long run requirements.

The agronomic assumptions on which Table 3-1 is based are the following:

- Production is geared toward optimum yield of the main component of that crop. Cereals are produced for grain and not necessarily for forage. More emphasis on straw production would tend to increase nitrogen requirements above those indicated.

- Nutrient rates suggested in Table 3-1 refer to nutrients from mineral fertilizers. Where livestock are part of the farming system with accompanying forage legume production, inorganic nitrogen needs would probably be reduced somewhat. An accounting of nutrients available from manure was beyond the scope of this study. However, it is clear that Yemen's production of livestock manure is

insufficient to provide a very large proportion of the nutrients required by high-yielding plant varieties.

- Crop production management is at good levels and adapted varieties capable of utilizing high fertility levels are used; furthermore, all other factors affecting crop yields are at or near optimum.

- For all the area indicated as "pump irrigated", it is assumed that sufficient water is available so that moisture does not become a yield limiting factor. This may not be true for irrigated land in this class but there is no way of accounting for any lesser degree of moisture availability.

The study team observed that high nutrient application in the Yemeni experiments often did not result in yields as high as could be expected. Also, the experimental results in YAR indicate a lower maximum productive N application beyond which there is no indication of yield increase with more N applied. There are three likely explanations for this lack of response: (1) varieties with limited genetic capability for transforming N into yields, (2) chemical conditions in either soil or water that hinder growth(*), or (3) other environmental conditions or management practices that inhibit yield response to fertilizer.

(*) The study team found cases in which yields from experimental plots where irrigation water was used showed very little response to nitrogen fertilizer. In most field trials, no mention is made of the quality of the water used for the experiment. In one case, however, it was reported that the irrigation water contained almost 1 Meq./l. of nitrate [1, p.106]. Using this water for irrigation adds substantial nitrates to the soil (approximately 140 kg N/ha per 100 cm of water added). This point aside, the total yield was not as high as one would expect, perhaps because the water was also quite salty (4 mmhos/cm). In view of uncertainties in several cases regarding interpretation of data and low yields the team took a conservative route in suggesting nutrient rates.

As the route to higher yields is discovered, then higher rates of nutrients may be suggested. Yields of irrigated wheat of 5-6 metric tons/ha should be quite routine in Yemen, and yields of 6-8 metric tons/ha of irrigated maize grain should be easily attained. Yields of well adapted varieties of sorghum (with high Yield Potential) should produce grain yields that are in the same range as maize yields. Currently, however, such cereals yield less than 1 ton/ha for the country as a whole, although irrigated yields undoubtedly average higher than this.

There may be a question why the same rate of nitrogen fertilizer is not suggested for the high rainfall areas as for irrigated areas. The reason is that even though total rainfall may be equal to the amount of moisture applied under irrigation, the control of timing and

Table 3-1. Long Range Fertilizer Requirements Per Hectare, by Type of Crop and Moisture Regime.

	Kg of Nutrients Per Hectare					
	Nitrogen		Phosphate		Potash	
	Range	Assumed Average	Range	Assumed Average	Range	Assumed Average
Cereals:						
Pump Irrigation	110-250	145	50-100	65		
Spring & Runoff Irr	80-175	100	40- 80	50		
Rain > 600mm	60-150	85	35- 70	45		
Rain 450-600 mm	45-100	55	25- 60	40		
Rain 250-450 mm	20- 60	25	15- 40	25		
Rain < 250 mm	0- 30	10	0- 20	5		
Fruits, Nuts, Other Tree Crops:						
Pump Irrigation	150-300	200	80-200	100	60- 90	75
Spring & Runoff Irr	100-260	170	50-180	90	50- 80	65
Rain > 600mm	70-250	140	50-150	85	45- 75	60
Rain 450-600 mm						
Rain 250-450 mm						
Rain < 250 mm						
Vegetables and Industrial Crops:						
Pump Irrigation	110-250	165	80-200	100	60- 90	75(a)
Spring & Runoff Irr	80-220	125	50-180	90	50- 80	65(a)
Rain > 600mm	80-200	95	50-150	85	45- 75	60(a)
Rain 450-600 mm						
Rain 250-450 mm						
Rain < 250 mm						
Legumes:						
Pump Irrigation			70-120	80	70-120	85(b)
Spring & Runoff Irr			60-100	70	60-100	75(b)
Rain > 600mm			50-100	60	50-100	70(b)
Rain 450-600 mm			40- 60	45		
Rain 250-450 mm			20- 45	30		
Rain < 250 mm			5- 30	10		

(a) Applies to vegetables such as potatoes and tomatoes but not to industrial crops such as tobacco, cotton and sesame.
(b) Applies to alfalfa but not dry legumes.

rate of application under irrigation is superior to what occurs under rainfed situations.

The nutrient rates suggested in this report represent only a general guide. Soil test results from each region must be consulted in order to derive estimates of nutrient requirements which are appropriate for the soils there. Even then, soil fertility will vary from farm to farm because of differences in past fertilizer practices (either of mineral fertilizers or of manure) and cropping patterns.

It must be stressed that the per hectare quantities indicated in Table 3-1 (and the full national requirements subsequently estimated in Tables 3-3 and 3-4) are only expected to be needed in the long run. As our subsequent projections will indicate, it will be at least 10 years and more likely 20 years before these levels are attained.

Furthermore, it must be stressed that the fertilizer "requirements" and total tonnage estimated in this section of the report are derived mainly from an agronomic of view and they do not necessarily represent what current market demands might or should be. Economic demands and the projected rates of growth of future fertilizer use or demand are subjects to be addressed later in this chapter. From an agronomic point of view, however, it should be noted that future advances in varieties, cultural practices, and water management could lead to the capability for using even more fertilizer than estimated here.

3.4.2 Land Area by Crop, Region and Moisture Level. As a second step in the estimation process, it was necessary to determine the areas in each crop and for each level of available moisture. Furthermore, the national land areas by crop and moisture level were distributed among regions in order to make the projections more useful for regional planning by the Ministry of Agriculture and Fisheries (MAF). Since detailed information by crop class and moisture level was not available at the regional level, estimating procedures were required.

Crop areas at the national and regional level were taken primarily from the MAF Statistical Yearbook for 1986, with supplementary information from the World Bank's Country Economic Memorandum for 1986 and a few other incidental sources. The 1983 Agricultural Census did provide information at the national level for crops grown under two different irrigation types -- for pump and runoff ("spate") -- and for three rainfall levels. The census also listed the total area for three different types of irrigation (pump, spate and spring) and rainfed for each province, but it did not delineate the rainfed area by level of rainfall or the crop areas by water source at the province level.

The distribution of areas shown in Table 3-2 was derived by the study team through a process of interpolation. That is, values on the right hand border of the table were known at the national level from the 1983 Census and from 1986 statistics, and values at the bottom of the table (pump irrigation, springfed and rainfed) were available at the regional level from the Census. The individual cells for each crop and

for each water source in each region were then estimated to be in direct proportion to the border values.

Instead of utilizing an irrigation source and rainfall level delineation, as shown in Tables 3-1 and 3-2, it must be recognized that it would be preferable to delineate according to available moisture. Classification by available moisture takes timing of rainfall and management of irrigation into account. However, studies that would permit classification by available moisture have not been done in Yemen. They are badly needed for many purposes, and they would help to improve upon the types of estimates made herein.

In the absence of moisture availability studies, it has been assumed that pump irrigated areas are managed well enough and that water is sufficiently available at the pumping source to insure adequate soil moisture throughout the growing season. Similarly, it is assumed that the rainfall in the over 600 mm zone is normally timed and managed so as to provide a relatively good level of soil moisure during the growing period.

Even with the assumption that rainfall level is a reasonably accurate reflection of available moisture, the study team felt that the under-450 mm rainfall class used in the Census was too broad for good estimates of fertilizer requirements. Therefore, the team made its own division of the under-450 mm rainfall zone into two sub-classes, dividing at the 250 mm level. This was thought to be useful since there is generally a sharp delineation in fertilizer requirements for areas less than 250 mm of rainfall.

3.4.3 The Aggregate Estimates shown in Tables 3-3 and 3-4 were derived by multiplying the per-acre requirements of Table 3-1 by the areas indicated in Table 3-2. Again, it must be stressed that these are long run projections and that several years of steady increase will need to occur before these levels are achieved.

Table 3-3 gives aggregate estimates at the regional and national level for each of the three main nutrients, by crop class. Table 3-3 indicates:

* cereals (sorghum, millet, wheat and maize), which occupy 81 percent of the crop area, will require only 62 percent of the nitrogen, 62 percent of the projected phosphate, and none of the potash.

* Fruits, nuts and other tree crops (the latter being composed of coffee and qat), occupying only 11 percent of the area, will require 28 percent of the N, 23 percent of the P, and 75 percent of the projected K needs.

* Vegetables and industrial crops (the latter being cotton, tobacco and sesame), with 5 percent of the land, will require 10 percent of the N, 11 percent of the P, and 18 percent of the K.

Table 3-2. Agricultural Area by Type of Crop, Irrigation or Rainfall Level, and Region.

	Hodeidah Mahweet	Taiz Ibb	Dhamar Sana'a	Saadah Hajjah	Al-Gawf Mareb Al-Bayda	
	Coastal Region 1	Southern Upland Region 2	Central Highland Region 3	Northern Highland Region 4	Eastern Desert Region 5	Yemen Total
Cereals:						
Pump Irrigation	10,450	3,483	11,083	950	12,033	38,000
Spring & Runoff Irr	29,639	3,983	5,395	12,420	17,564	69,000
Rain > 600mm	27,066	28,946	43,381	18,194	5,413	123,000
Rain 450-600 mm	50,171	53,655	80,413	33,726	10,034	228,000
Rain 250-450 mm	62,934	67,304	100,869	42,306	12,587	285,000
Rain < 250 mm	22,005	23,533	35,269	14,792	4,401	100,000
Total Cereals:	202,265	180,905	276,410	122,388	62,032	844,000
Fruits, Nuts, Other Tree Crops:						
Pump Irrigation	16,500	5,500	17,500	1,500	19,000	60,000
Spring & Runoff Irr	6,443	866	1,173	2,700	3,818	15,000
Rain > 600mm	7,702	8,237	12,344	5,177	1,540	35,000
Rain 450-600 mm	0	0	0	0	0	0
Rain 250-450 mm	0	0	0	0	0	0
Rain < 250 mm	0	0	0	0	0	0
Total Fruits, Nuts:	30,645	14,602	31,017	9,377	24,359	110,000
Vegetables and Industrial Crops:						
Pump Irrigation	4,400	1,467	4,667	400	5,067	16,000
Spring & Runoff Irr	9,880	1,328	1,798	4,140	5,855	23,000
Rain > 600mm	3,521	3,765	5,643	2,367	704	16,000
Rain 450-600 mm	0	0	0	0	0	0
Rain 250-450 mm	0	0	0	0	0	0
Rain < 250 mm	0	0	0	0	0	0
Total Vegetables:	17,800	6,560	12,108	6,907	11,625	55,000
Legumes:						
Pump Irrigation	1,650	550	1,750	150	1,900	6,000
Spring & Runoff Irr	1,289	173	235	540	764	3,000
Rain > 600mm	2,421	2,589	3,880	1,627	484	11,000
Rain 450-600 mm	1,650	1,765	2,645	1,109	330	7,500
Rain 250-450 mm	1,760	1,883	2,822	1,183	352	8,000
Rain < 250 mm	770	824	1,234	518	154	3,500
Total Legumes:	9,540	7,783	12,565	5,128	3,984	39,000
All Crops:						
Pump Irrigation	33,000	11,000	35,000	3,000	38,000	120,000
Spring & Runoff Irr	47,250	6,350	8,600	19,800	28,000	110,000
Rain > 600mm	40,709	43,536	65,248	27,366	8,142	185,000
Rain 450-600 mm	51,822	55,420	83,058	34,836	10,364	235,500
Rain 250-450 mm	64,694	69,187	103,691	43,489	12,939	294,000
Rain < 250 mm	22,775	24,357	36,503	15,310	4,555	103,500
Total All Crops:	260,250	209,850	332,100	143,800	102,000	1,048,000
Pump Irrigation	33,000	11,000	35,000	3,000	38,000	120,000
Spring Irrigation	1,250	6,350	8,600	4,800	3,000	24,000
Runoff Irrigation	46,000	0	0	15,000	25,000	86,000
Rainfed	180,000	192,500	288,500	121,000	36,000	818,000
Total Irr. & Rain	260,250	209,850	332,100	143,800	102,000	1,048,000
Total Agriculture	359,000	225,000	452,000	175,000	140,000	1,351,000
Cultivated	255,000	204,000	324,000	137,000	100,000	1,020,000
Uncultivated	104,000	21,000	128,000	38,000	40,000	331,000

Table 3-3. Total Long Range Fertilizer Requirements, by Type of Crop and Region.

	Metric Tons of Nutrient					
	Coastal Region 1	Southern Upland Region 2	Central Highland Region 3	Northern Highland Region 4	Eastern Desert Region 5	Yemen Total
Nitrogen						
Cereals	11,333	8,233	13,131	5,987	4,872	43,555
Fruits, Nuts, Other Tree Crops	5,474	2,400	5,428	1,484	4,665	19,450
Vegetables and Industrial Crops	2,295	766	1,531	808	1,635	7,035
Legumes	0	0	0	0	0	0
TOTAL	19,102	11,399	20,089	8,279	11,171	70,040
Phosphate						
Cereals	7,069	5,675	8,857	3,982	2,642	28,225
Fruits, Nuts, Other Tree Crops	2,885	1,328	2,905	833	2,375	10,325
Vegetables and Industrial Crops	1,628	586	1,108	614	1,093	5,030
Legumes	502	356	605	238	261	1,963
TOTAL	12,085	7,944	13,475	5,667	6,371	45,543
Potash						
Cereals	0	0	0	0	0	0
Fruits, Nuts, Other Tree Crops	2,118	963	2,129	599	1,766	7,575
Vegetables and Industrial Crops	592	211	403	221	401	1,828
Legumes	203	120	219	84	126	753
TOTAL	2,913	1,295	2,751	903	2,293	10,155
TOTAL NUTRIENT	34,099	20,638	36,316	14,849	19,836	125,738

Table 3-4. Total Long Range Fertilizer Requirements, by Rainfall Regime and Region.

	Metric Tons of Nutrient					
	Coastal Region 1	Southern Upland Region 2	Central Highland Region 3	Northern Highland Region 4	Eastern Desert Region 5	Yemen Total
Nitrogen						
Irrigated	10,835	2,559	6,841	2,722	9,518	32,475
Rainfed >450mm	6,473	6,922	10,374	4,351	1,295	29,415
Rainfed <450mm	1,793	1,918	2,874	1,206	359	8,150
TOTAL	19,102	11,399	20,089	8,279	11,171	70,040
Phosphate						
Irrigated	5,942	1,376	3,631	1,538	5,143	17,630
Rainfed >450mm	4,398	4,704	7,049	2,957	880	19,988
Rainfed <450mm	1,744	1,865	2,795	1,172	349	7,925
TOTAL	12,085	7,944	13,475	5,667	6,371	45,543
Potash						
Irrigated	2,261	597	1,705	464	2,163	7,190
Rainfed >450mm	652	698	1,046	439	130	2,965
Rainfed <450mm	0	0	0	0	0	0
TOTAL	2,913	1,295	2,751	903	2,293	10,155
Total Nutrients						
Irrigated	19,039	4,531	12,177	4,725	16,824	57,295
Rainfed >450mm	11,523	12,324	18,469	7,746	2,305	52,368
Rainfed <450mm	3,537	3,783	5,669	2,378	707	16,075
TOTAL	34,099	20,638	36,316	14,849	19,836	125,738

* Legumes, including alfalfa and berseem forage plus beans and other grain legumes, while constituting 4 percent of the land area, will require no nitrogen, 4 percent of the phosphate, and 7 percent of the potassium.

Table 3-4 divides aggregate nutrient requirements according to water source rather than crop. This indicates:

* Irrigated areas, which account for only 22 percent of the cropped area, will require 46 percent of the total nutrients.

* Higher rainfall areas (above 450 mm), while accounting for 40 percent of the crop area, require 42 percent of total nutrients.

* Lower rainfall (under 450 mm) zones, which account for 38 percent of the area currently cropped, will require only 13 percent of the projected nutrient needs.

On a regional basis, it is seen that:

* Region 1, the coastal zone, which contains 25 percent of the crop area, will require 27 percent of the nutrients.

* Region 2, the Southern Upland Region containing 20 percent of the crop area, will require only 16 percent of the nutrients.

* Region 3, the Central Highlands Region with 32 percent of the area, accounts for 29 percent of the nutrient needs.

* Region 4, Northern Highlands, which contains only 14 percent of the crop area, will require only 12 percent of the nutrients.

* Region 5, the Eastern Desert, while containing only 10 percent of the total cropped area, accounts for 16 percent of nutrients.

In general, it can be seen that irrigated areas will require a high proportion of the fertilizer, as will zones that specialize in the production of fruits and vegetables. However, all regions will eventually require significant quantities of fertilizer.

How High Are the Projected Requirements? The total nutrient requirements shown in Table 3-4 are 125,738 nutrient tons. This is equivalent to 120 kg of nutrients per cropped hectare. As was discussed in Chapter 1, Yemen's fertilizer applications increased from 0.1 kg/ha in 1970 to 12.7 kg/ha in 1983. Due to import restrictions, average application levels have declined to about half that level since then. Even assuming that import restrictions were to be entirely eliminated,

it is unlikely that Yemen can increase its fertilizer use from 12.7 to 120 kg/ha as quickly as it went from 0.1 to 12.7. The following section examines the likely rate and timing of increased use.

3.5 Projecting the Future Timing of Fertilizer Requirements

To get a better sense of what is possible, it is instructive to compare Yemen's current situation to what has happened in other countries. Table 3-5 shows the experience of three near-by countries with similarities to Yemen. Morocco, which was utilizing 13.0 kg/ha in 1970, was able to raise fertilizer use to 29.3 kg/ha by 1983, which was equivalent to an annual growth rate of 6.5 percent. Jordan went from 2.0 to 39.4 during the same period, for an annual growth rate of 25.8 percent.

Table 3-5. Increases in Levels of Fertilizer (Nutrient) Use in Near-by Countries with Desert Soils.

	Total Nutrient Use (kg per ha)		Annual rate of
Country	1970	1983	growth
Morocco	13.0	29.3	6.5 %
Jordan	2.0	39.4	25.8 %
Saudi Arabia	4.4	177.7	32.9 %

Source: World Bank, World Development Report, 1986

Saudi Arabia increased from 4.4 to 177.7 kg/ha, an average annual growth of 32.9 percent. Of course, Saudi Arabia became a significant nitrogen fertilizer producer during this period, and fertilizer is readily available at low cost to farmers there. At the same time, the Saudi government, with its substantial economic power, saw fit to support high prices for certain basic commodities such as wheat, for which Saudi farmers were paid more than five times the international price. These conditions, which are not likely to be duplicated in Yemen, served to stimulate the phenominally high growth in fertilizer use by the Saudis.

At an annual growth rate of 25 percent, it would take more than 10 years for Yemen to bring its levels of fertilizer use up from 12.7 to 120 kg/ha of nutrient application. At a 10 percent growth rate, this would require 22 years. These two rates and time periods would seem to delimit Yemen's realm of possibilities, judging by the recent experience of other countries.

Another way to look at the timing issue is to estimate how much fertilizer would be required to bring about the increase in crop yields envisioned in Yemen's current development plans. The current 1986-1991 five year plan for agriculture calls for an average 3.5 percent rate of growth in production during the plan period (MAF, Directorate of Planning and Statistics, 1986, p. 101).

The study team made a rough calculation of the fertilizer required to sustain a 3.5 percent rate of growth in crop production through 1991 and beyond. It was first assumed that the rate of growth in total national fertilizer requirements is the same as the growth in fertilizer requirements for cereals, which currently occupy 81 percent of the total crop area. Projections of fertilizer requirements were then made by calculating the nitrogen content of the increased plant matter (grain plus straw) required to produce the projected 3.5 percent increase in grain output. An average nitrogen use efficiency of 50 percent was assumed. Following this approach, and assuming that annual nitrogen use is initially 12,000 tons (the approximate 1982-84 levels), it was determined that it would take Yemen 22 years before it utilizes the full 70,000 tons of nitrogen requirements which have been projected (Table 3-6E and Figure 3-2).

As an alternative to the preceding, it was assumed that Yemen crop production will grow at 8 percent annually, thus duplicating China's recent high rate of growth. At this rate, it would take 10 years before the full 70,000 tons of N is required to support the additional plant growth.

To summarize the above, it would appear that two different approaches to projecting fertilizer use come up with about the same answers. It will take Yemen somewhere between 10 and 22 years before the long range fertilizer requirements (Tables 3-3 and 3-4) will be fully utilized.

Table 3-6 also provides estimates of the amounts of phosphorous (P_2O_5) and potassium (K_2O) that would be needed each year in order to utilize the projected requirements of these nutrients within the same time periods projected for nitrogen -- i.e. within 10 or 22 years. In each case, a constant annual rate of growth is assumed.

3.6 The Economics of Fertilizer Demand

The estimate of fertilizer requirements in the preceding sections is based primarily on an agronomic apporach and does not take into account the economic conditions which are necessary for expanded input use. The projections assume that Yemeni farmers will ultimately demand the projected quantities of fertilizer. This assumption merits serious examination. Unless farmers demand the fertilizer -- that is, unless they are willing to pay the cost of using higher and higher quantities -- the projections will not be realized.

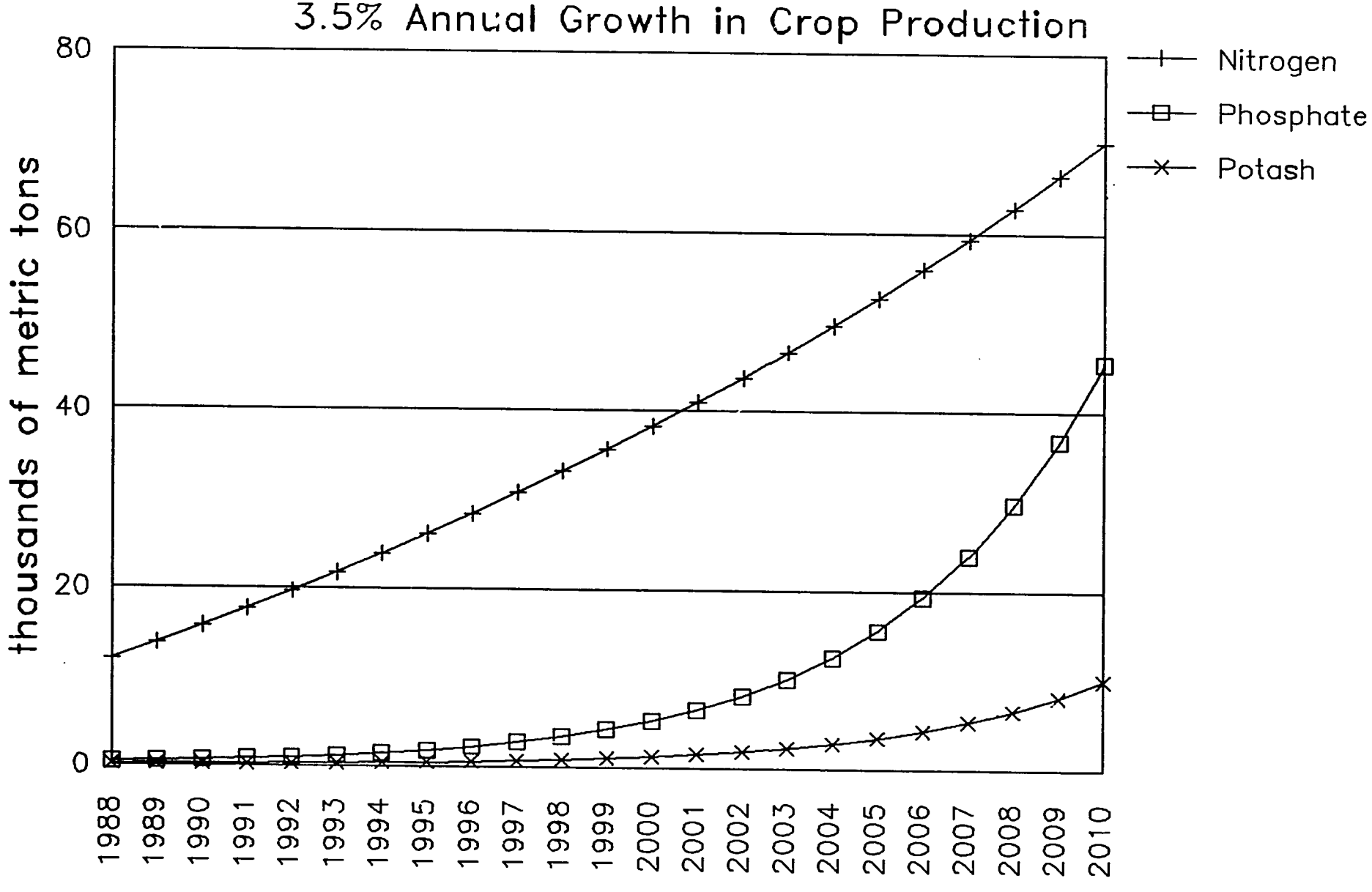
What causes farmers to demand ever higher quantities of fertilizer? Economists have shown that if the benefits from increased use of an input -- i.e. added production or reduced costs -- are greater than the increased cost of the input, then farmers will demand and use more of the input. Numerous factors influence the benefits and costs associated with input use and thus influence demand for an input such as fertilizer. These factors are addressed in the following discussion.

Table 3-6. Projected Increase in Fertilizer Use Under Different Growth Scenarios.

Assumed 3.5% Annual Growth in Crop Production:	Assumed Level for 1988	1989	1990	1994	1998	2002	2006	2010
	thousands of metric tons							
Cereals production	660	683	707	811	931	1068	1226	1407
Increment		23	24	27	31	36	41	48
Implied N increment		1.1	1.2	1.3	1.5	1.8	2.0	2.3
N increment, all crops		1.8	1.9	2.1	2.5	2.8	3.2	3.7
Total N, all crops	12.0	13.8	15.7	23.8	33.1	43.8	56.0	70.1
P increment, all crops		.1	.1	.3	.7	1.6	3.7	8.8
Total P, all crops	.4	.5	.6	1.5	3.4	8.1	19.3	45.5
K increment, all crops		.02	.03	.07	.15	.35	.82	1.89
Total K, all crops	.10	.12	.15	.35	.81	1.88	4.34	10.03

Assumed 8% Annual Growth in Crop Production:	1988	1989	1990	1994	1998	2002	2006	2010
Cereals production	660	713	770	1047	1425			
Increment		53	57	78	106			
Implied N increment		2.6	2.8	3.8	5.2			
N increment, all crops		4.1	4.4	6.0	8.2			
Total N, all crops	12.0	16.1	20.5	42.1	71.5			
P increment, all crops		.24	.39	2.56	16.9			
Total P, all crops	.40	.64	1.03	6.80	44.9			
K increment, all crops		.06	.09	.60	3.86			
Total K, all crops	.10	.16	.25	1.62	10.39			

Figure 3-2.Projected Increase in Fertilizer Use



Varieties. For expanded fertilizer use to be beneficial, improved seed varieties are extremely important. Traditional varieties are often not very responsive to increased fertilizer application. The increased yields derived from adding fertilizer to traditional varieties often will not pay for much added fertilizer. Currently, for example, there are improved wheat and potato varieties available in Yemen that have far greater response to fertilizer application than do the traditional varieties of these crops. However, it would appear that responsive new varieties of sorghum, millet, maize and many other crops may not yet be available.

Irrigation. Another factor in determining response to fertilizer is irrigation methods and management of available moisture. If irrigation pumps and water delivery systems are not available where needed, or if farmers lack basic knowledge about water management, then the moisture necessary to ensure high fertilizer response may not be available, and increased fertilizer use will not be beneficial. As was pointed out earlier, there is really very little information about the adequacy of available moisture in Yemen, and the same can be said about the adequacy of irrigation management practices.

Crop Management. Various management practices such as rate of seeding, the method of applying fertilizer, pest and disease control, tillage and so forth can affect yields and the efficiency of fertilizer use. High yielding varieties are often more sensitive to such management practices than are traditional varieties. Thus, it will be important to adjust and improve management as fertilizer use is increased.

Extension. Unless there is an effective system for disseminating technical knowledge about fertilizers, improved seed varieties, irrigation or other complementary inputs to farmers, it can be expected that demand for fertilizer will increase slowly.

Credit. Normally, farmers must have money to purchase fertilizer and related inputs such as improved seed. This may pose a serious limitation for subsistence farmers who have only limited dealings in the cash economy. A workable credit system provides a way to overcome this obstacle. However, the farmer survey discussed in Chapter 2 indicated that there has been very little use or availability of credit for fertilizer in Yemen. Thus, the study team concludes that improved credit availability will be required in order for fertilizer use to expand to the levels projected above.

Prices. For commercial growers, the benefit of increased fertilizer use lies in the value of the increased crop output which the fertilizer produces. If crop prices are low, the benefit of fertilizer will be low and the incentive for additional fertilizer use will be reduced. The price of fertilizer, of course, determines the cost of fertilizer use. If fertilizer prices are high, the cost of fertilizer use will also be high, and this will serve to reduce fertilizer use.

The farmer's decision on whether to use more fertilizer depends on whether the benefits exceed the costs, which is insured if the following benefit-cost ratio exceeds one:

$$(1) \quad B/C = \frac{\text{(added output) x (crop price)}}{\text{(added fertilizer) x (fertilizer price)}} .$$

Some idea of the relative benefits of fertilizer application, and of the factors which influence these benefits, can be gained through analyzing experimental fertilizer response data. Table 3-7 summarizes some of Rees-Jones' analysis of experiments done in the Dhamar area during the 1979-1982 period. Results of four selected experiments are given, selected from about 20 experiments which Rees-Jones described [4].

The first two columns of Table 3-7 describe the response relationship. (A graph depicting the response relationships for 'Ahmar' wheat and 'Red River' wheat, based on two of the response trials shown in Table 3-7, was presented earlier in Figure 3-1.) The right-most column in the table gives the benefit-cost ratios for different levels of fertilizer application, based on 1982 prices in the Dhamar area.

The third column in Table 3-7 gives the marginal product of fertilizer application, which is calculated as follows for each incremental amount of fertilizer applied:

$$(2) \quad MP = \frac{\text{(added product)}}{\text{(added fertilizer)}} .$$

Note that as the level of fertilizer use increases, the marginal product declines. Ultimately, as indicated in the response of 'Ahmar' wheat to nitrogen, the marginal product may even become negative. The declining marginal product reflects the declining benefits of adding additional fertilizer at higher levels of use.

It follows from (1) and (2) above that the benefit-cost relationship can also be calculated as:

$$(3) \quad B/C = MP \times \frac{\text{crop price}}{\text{fertilizer price}} .$$

It is seen from the preceding that the higher the crop price the more favorable the benefit-cost relationship and the more incentive the farmer has to use fertilizer. Of course, a higher fertilizer price has the opposite effect, reducing the incentive.

In Yemen, both crop and fertilizer prices are high by international standards. Nevertheless, the relationship shown above (3) indicates that it is <u>the relative prices which are important</u> in determining whether the farmer has sufficient incentive to use fertilizer. Table 3-8 compares Yemen's grain/urea price ratios for

Table 3-7. Summary of Selected Response Trials at Dhamar Agricultural Improvement Centre, 1978-82.

Response of Irrigated 'Ahmar' Wheat to Nitrogen:

Level of N (kg/ha)	Grain Yield (kg/ha)	Marginal Product (kg/kg)	Benefit-Cost Ratio (1982 prices)
0	513		
30	994	16.0	12.1
60	1,062	2.3	1.7
90	1,281	7.3	5.5
120	1,467	6.2	4.7
150	1,329	-4.6	-3.5

Response of Irrigated 'Red River' Wheat to Nitrogen:

Level of N (kg/ha)	Grain Yield (kg/ha)	Marginal Product (kg/kg)	Benefit-Cost Ratio (1982 prices)
0	1,902		
50	3,213	26.2	19.8
100	3,725	10.2	7.7
150	3,980	5.1	3.9
200	3,980	.0	.0
250	4,003	.5	.4

Response of Irrigated 'Red River' Wheat to Phosphate:

Level of P2O5 (kg/ha)	Grain Yield (kg/ha)	Marginal Product (kg/kg)	Benefit-Cost Ratio (1982 prices)
0	4,725		
20	5,092	18.4	12.2
40	5,624	26.6	17.6
60	5,809	9.3	6.1
80	5,902	4.7	3.1
100	5,705	-9.9	-6.5

Response of Irrigated Alfalfa to Phosphate:

Level of P2O5 (kg/ha)	Total Green Matter (mt/ha)	Marginal Product (mt/kg)	Benefit-Cost Ratio (1982 prices)
0	78.8		
50	124.0	.90	43.3
100	160.1	.72	34.6
150	174.6	.29	13.9
200	186.9	.25	11.8

fertilizer. Table 3-8 compares Yemen's grain/urea price ratios for wheat and maize to the same ratios in other countries in 1986. The ratios in Yemen were relatively high, indicating that the incentives for nitrogen fertilizer use in Yemen were good. Yemen's grain/nitrogen price ratios were much higher than those in the United States, for example, and they were higher than in India, Pakistan and Turkey. They were slightly less favroable than in Egypt.

Table 3-8. Relative Prices of Crops to Urea Prices in Yemen and Other Countries, 1986

Country	Price Ratio of: Wheat to Urea	Price Ratio of: Maize to Urea
YEMEN ARAB REPUBLIC	1.48	1.22
Egypt	1.59	1.59
India	1.20	0.88
Japan	2.56	n.a.
Pakistan	0.90	n.a.
South Korea	1.39	1.56
Turkey	0.94	0.86
United States	0.46	0.40

Source: Based on reports by cooperators of the International Fertilizer Development Center, on USDA Agricultural Outlook, and on Yemen price information obtained from MAF and 1987 survey prices (see Table 2-11).

In the discussion of survey results in section 2.3.8 of Chapter 2, it was shown that Yemen's relative grain to nitrogen prices have declined over the past few years. This is partly a reflection of the return of grain production to more normal levels after the 1983-84 drought. However, it also shows the impact of grain imports on domestic grain prices. The government of Yemen and international donors must always be mindful that their programs to provide grain to consumers can have the impact of making domestic fertilizer use and grain production unattractive. Judging by Table 3-8, however, this was not the case in 1986.

Based on what the study team could learn from limited experimental data, it appears the response of available varieties to fertilizer use is more of a limiting factor to fertilizer use than are price incentives.

3.7 Summary and Future Research Needs

There is little doubt that the soils of the YAR need fertilizer and that substantial increases in production can ultimately be obtained through the application of additional amounts of fertilizer. Projections made in this chapter indicate that Yemen should ultimately require more than ten times the amount of fertilizer currently being applied. However, in order for such quantities of fertilizer to be profitably applied, a variety of other factors which influence crop yields must also be improved.

Additional fertilizer response trials are required, covering more crop varieties in more regions of the country, and on a broader range of available moisture conditions. The results of such research would help in making more accurate projections of fertilizer requirements as well as in developing more competent recommendations for farmers.

To develop better fertilizer recommendations it is essential to have soils information and maps available on a small enough scale to indicate soils characteristics at the local area level. The Cornell Soil Survey [2] is a good survey, but the scale of 1:500,000 does not give sufficient detail for local area or farm-level planning. In conducting new, more detailed soils classification and mapping studies, such as the UNDP soils mapping project which was recently approved by the MAF, it is important to follow the same soil taxonomy and classification system so that the information generated will be compatible with the results already available from the Cornell Study.

While experimental response studies such as those outlined in Table 3-7 are indispensible in judging fertilizer response potential, it is also important that farmers' field conditions and application practices be studied at greater length. The survey results discussed in Chapter 2 indicate that farmers' knowledge of appropriate application methods may be limited, or that physical circumstances may limit their capability to use better practices. The result may be very low efficiency in fertilizer application. A clearer understanding of farmers knowledge, practices and physical capabilities is needed. Conducting farm management or farming systems studies, such as those conducted at Dhamar, in other parts of the country would be useful in this regard.

It is also important to gain a better understanding of soil moisture management and moisture availability as they relate to fertilizer use. Farming systems studies can be useful in this regard, as can irrigation management studies such as those currently being explored by USAID.

Rainfall and rainfed agriculture will continue to be important components of Yemeni agriculture. The projections made in this chapter show that rainfed farming will account for more than half of Yemen's

fertilizer use in the long run. When making projections of rainfed production, however, there is a tendency to use those values that portray the yields obtained in higher rainfall years and to ignore drought conditions. It is essential to develop a better understanding of the influence of weather patterns on crop yields, and to take the likelihood of good years as well as bad years into account in developing fertilizer recommendations and in projecting fertilizer needs. Since a thorough study of long term weather records is not available in Yemen, the projections in this report have been somewhat handicapped. When in doubt, the study team tried to take a conservative approach to estimation.

4. INSTITUTIONAL AND MARKETING CONSIDERATIONS

4.1 Background

Yemen's imports and supplies of fertilizer have grown dramatically since 1970, but the increases have been sporadic. The supply has declined since 1983, and recent years have been characterized by fertilizer shortage.

The market and availability of fertilizer is affected by private merchants as well as government institutions. The private sector plays an important role in the importation and distribution of fertilizer. Public sector bodies such as the Ministry of Agriculture and Fisheries (MAF), the Ministry of Economy, Trade and Supply (MOETS), and the Central Bank influence the fertilizer supply and market, particularly through the control of foreign exchange and the import licensing system.

The Cooperative and Agricultural Credit Bank (CACB) was formerly engaged in the distribution and sale of fertilizers, as well as in the provision of credit for their use. Since 1982, however, the CACB's role has been diminished and at present the Bank does not sell fertilizer or make fertilizer loans.

Foreign government fertilizer donations have accounted for a large portion of available fertilizer supplies. Indeed, the CACB's entry into the fertilizer market was originally made possible by donations of urea by Saudi Arabia in 1975-76. Although total foreign donations have declined since Saudi Arabia quit making large annual gifts in 1985, recent contributions by Japan have constituted a significant share of the available supply. The way that donated fertilizers are distributed and priced by MAF also has important effects on the fertilizer market.

Agencies and projects affiliated with MAF also influence fertilizer use and markets. The Agricultural Research Authority (ARA) conducts research on fertilizer response and on the development of new seed varieties. As more results of this research reach the farmer, the demand for fertilizer will be further expanded.

The extension agents of the MAF and the promotional teams of regional development organizations (e.g. TDA, SURDP, CHRDP) advise farmers on the use of fertilizers and related farm inputs. These organizations have an increasing ability to use research information and to guide the farmer in the adoption and use of improved farm inputs such as seed varieties, pesticides, and fertilizers.

The objectives of this chapter are three-fold:

- to describe Yemen's current system for marketing and distribution of fertilizer,

- to indicate how this system is affected by the policies and programs of the government and various international agencies, and

- to provide suggestions for improved policies and programs.

4.2 The Fertilizer Market, Past and Present

There was little if any use of inorganic fertilizers in Yemen before 1970. In the mid-sixties, small quantities of fertilizers were introduced by international agencies. A project begun in about 1970 organized some fertilizer response trials and distributed free fertilizer samples to farmers near Sanaa and Ibb [21, p.14].

Since Yemen does not produce inorganic fertilizers, the entire supply must be imported. The study team developed a history of fertilizer imports since 1970 from several sources of information. A study conducted in 1983 by Louis Berger International [21] was very helpful for the 1971-81 period. A recent World Bank strategy paper provided data for the 1980-83 period [18, p.50], although this was not entirely consistent with the Berger information. The Agricultural Affairs Directorate of MAF furnished detailed information for 1982-87, although the figures were not always consistent with the World Bank series. A final compilation of results is shown in Table 4-1 (also see Chapter 1, Figure 1-1).

Table 4-1. Yemen Fertilizer Imports, 1971-87.

Year	Fertilizers	Estimated Total Nutrients
	...metric tons...	
1971	3,153	100
1972	4,046	300
1973	1,799	710
1974	4,256	1,015
1975	3,869	980
1976	7,932	5,072
1977	n.a.	2,123
1978	n.a.	2,739
1979	n.a.	9,900
1980	n.a.	13,300
1981	22,577	10,156
1982	31,005	12,400
1983	28,656	13,022
1984	1,416	744
1985	20,000	9,200
1986	1,404	471
1987	12,204	5,774

Sources: Louis Berger [21], World Bank [18] and MAF, Directorate of Agricultural Affairs.

Table 4-1 shows that Yemen's imports and supplies of fertilizer increased considerably from 1970 to 1983 but that the supply has been sporadic since then. Imports were very limited in 1984 and 1986, and recent years have been characterized by shortage.

4.2.1. The Opening of the Fertilizer Market, 1970-76. After the introduction of fertilizer by international agencies, private merchants entered the fertilizer trade. Initially, most fertilizer sold was handled by two large merchants, Hayel Saeed Anam and Company, and E. Soffary and Sons, who represented Kuwaiti urea producers [21, p.14].

Distribution initially posed no problem since both firms were large trading companies with established dealer networks and retail outlets in major cities. However, there were complaints that the companies had policies of setting high prices in order to "maximize short term profit" [21, p.15].

4.2.2 The Entry of the Agricultural Credit Bank. The Agricultural Credit Bank was founded in 1976. After reorganization in 1982, it became the Cooperative and Agricultural Credit Bank (CACB). During 1975-76, the World Bank was supporting agricultural development projects in the Tihama and Southern regions, and it began looking for a cheaper independent source of fertilizer supply to these projects. It suggested that the Credit Bank fill this role. At about the same time, Saudi Arabia offered its first donation of urea to Yemen. Thus, it was natural for the Agricultural Credit Bank to be the distributor for the donated urea, especially since this also served to keep "...public goods in the hands of public entities until its final delivery." [21, p.15].

The Bank's entry into the fertilizer market had the effect of driving the price down to about half the level which had been charged by private merchants. At this point, "...most of the private merchants got out of the fertilizer business altogether. Although the [Bank] supplied only urea, the market for the other fertilizers such as [ammonium nitrate], which was very small to begin with, collapsed" [21, p.16]. This marked the first instance of a problem that has been present in Yemen ever since: how can the government of Yemen price and distribute fertilizer which is donated by other governments so as to provide it at low cost to farmers without being unfair to private merchants?

Initially, the Credit Bank concentrated on selling to farmers who were associated with the regional agricultural projects near Ibb and Taiz and in the Tihama. In 1978 it began providing credit and farm inputs in non-project areas [21, p.16]. As sales expanded, the Credit Bank developed a network of retail agents to serve areas where it did not have a branch office. In 1981, the Bank's eight branches had a total of 66 private retail agents, including four producer cooperatives.

The Credit Bank experienced a number of problems in its operations. It was difficult to work out a mechanism for private agents to service Bank loans. Another problem was encountered in devising a commission

structure that provided adequate incentives for the agents to agressively promote sales. At times the Bank had trouble insuring that the agents would adhere to its official price when fertilizer supplies became scarce. The Bank also had trouble in securing distribution to remote areas.

Sometimes, fertilizer sales did not move fast enough, and stocks would "...sit around for months in substandard storage" [21, p.46]. Eventually, the Bank began to engage in the sale of phosphates and compound fertilizers other than urea. It was difficult to estimate the requirements for these, however, and some could not easily be sold. Stocks built up, and in some cases the Bank found it necessary to mark down the price drastically to facilitate sales, after stocks had not sold for several years.

Whether due to the difficulties noted above, or as a result of problems in collecting loans, the Agricultural Credit Bank's role in fertilizer sales and credit diminished rapidly after 1982. This is reflected in the volume of loan activity shown in the CACB's recent annual report. (see Table 4-2). After 1983 the MAF decided that the fertilizer donations received from the Saudis and from other governments would no longer be distributed by CACB.

Table 4-2. Fertilizer Loans Made by the Cooperative and Agricultural Credit Bank, 1982-1985.

	1982	1983	1984	1985
Number of fertilizer loans	279	34	38	5
Total value of loans ('000 YRls)	1,473	174	248	4

Source: [22, p.44]

4.2.3 The Current Era -- Dealing with Scarcity. The 1970's was an era of rapid expansion in Yemen's economy. As remittances flowed in from workers in Saudi Arabia, the economy expanded and demands for all sorts of goods, including agricultural equipment and farm inputs, increased. Many of these goods had to be imported. The economic boom was further stimulated by increases in foreign aid, some of it aid in-kind like the donated urea from Saudi Arabia.

As the 1970's ended, worker remittances began to fluctuate and level off, and they have declined in the 1980's. In terms of dollars, remittances were down 19 percent during 1983-85 compared to 1978-80 levels. Foreign aid has fluctuated; from 1982 to 1983 it dropped by 60

percent. Despite these limitations on receipts of foreign currency, there was continued pressure for imports to expand, and consequently by 1983 the country's foreign reserves had declined to critical levels [7, pp.16-18].

To cope with the increasing scarcity of foreign exchange, the government began to devalue the Rial. Whereas the currency had been pegged at YRl 4.56 to the dollar for 10 years (1973 until the final quarter of 1983), its official value was lowered until it reached YRls 11.86 to the dollar by early 1987 [7, p.18]. This represented a devaluation of more than 60 percent. At some points the Rial traded at rates as high as YRls 17 per dollar on the black market. The recent official rate stands at YRls 9.75 per dollar, which reflects some strengthening as a result of the commencement of oil exports in December 1987.

In addition to devaluation, the government instituted a system of import licensing, coupled with the establishment of strict control of foreign exchange conversion by the Central Bank. Under this system, MOETS issues import licenses for a list of priority goods which includes critical raw materials such as fertilizer. In practice, however, very little private importation of fertilizer was permitted after 1983.

Accurate statistics on private fertilizer imports are difficult to find. The study team has made estimates of private imports by subtracting the MAF's data on foreign fertilizer donations (Table 4-4) from its data on total fertilizer imports (Table 4-3). The result is shown in Table 4-5. The study team discussed these figures with several private importers, and the discussions confirmed the pattern shown in Table 4-5.

Table 4-3. Total Fertilizer Imports, 1982-87.

Year	Urea	Ammonium Sulphate 21-0-0	Di-ammonium Phosphate 18-46-0	Triple Super Phosphate	Various N-P-K Compounds	Total Imports
	.....metric tons.of fertilizer.....					
1982	22,000	2,400	-	595	6,000	31,005
1983	27,500	550	-	500	100	28,656
1984	-	-	700	698	18	1,416
1985	20,000	-	-	-	-	20,000
1986	7	699	-	699	-	1,404
1987	10,000	550	1,654	-	-	12,204

Source: MAF, Directorate of Agricultural Affairs

N.B. "Fertilizer" referts to total fertilizer material and not nutrients alone.

Table 4-4. Foreign Government Fertilizer Donations, 1982-87.

Year	Saudi Arabia Urea	Japan Ammonium Sulphate	Japan Di ammonium Phosphate	Japan Triple Super-phosphate	TOTAL DONATIONS
	.....metric tons.of fertilizer.....				
1982	20,000	2,400	-	595	22,995
1983	20,000	550	-	500	21,050
1984	-	-	700	699	1,399
1985	20,000	-	-	-	20,000
1986	-	699	-	699	1,398
1987	-	550	1,654	-	2,204

Source: MAF, Directorate of Agricultural Affairs

Table 4-5. Estimated Private Sector Imports, 1982-87.

Year	Total Imports	Foreign Donations	Estimated Private Imports
	...metric tons of fertilizer..		
1982	31,005	22,995	8,010
1983	28,656	21,050	7,606
1984	1,416	1,399	17
1985	20,000	20,000	0
1986	1,404	1,398	7
1987	12,204	2,204	10,000

Source: Estimates of the study team, based on Tables 4-3 and 4-4.

The data indicate that private imports and foreign donations were both reduced after 1983. The result was that total imports in the 1984-86 period averaged 7,600 tons of fertilizer material per year, which was only 25 percent of the 29,800 tons per year which had been imported in 1982-83. As a result of this shortage, fertilizer smuggling from Saudi Arabia reportedly occurred. While there is no way to determine how much material has entered the black market in this way, it is believed that the main impact on supplies has been felt in the northern and eastern provinces, which are adjacent to Saudi Arabia and that there has been limited impact on the central and southern regions.

The supply situation did not improve until 1987, when the government permitted 10,000 tons of urea to be imported by private traders. Nevertheless, the total supply in 1987 was still only 40 percent of the 1982-83 average.

The result of the restriction in imports has been an unstable market and increased prices for fertilizers. It is difficult to determine the exact amount of price increase since no official statistics are available for fertilizer prices paid by farmers. Furthermore, care must be taken in making price comparisons over a period of time without taking inflation or changes in the prices of related commodities into account. Thus, the study team first examined changes in fertilzer prices and then interpreted these in relationship to price changes for the grains.

The 1987 fertilizer survey indicated that farmers paid an average of YRls 286 per bag for urea in 1987 (see Chapter 2, section 2.6), which is more than four times the YRls 70 per bag farm price reported in the Louis Berger study [21] for early 1983. However, it is only slightly more than double the YRls 125 per bag which the farmers who were surveyed in 1987 recalled paying in 1983. From 1983 to 1987 the exchange rate for the Yemen Rial was increased from 4.56 to 11.86 YRls per U. S. dollar. Thus, in real terms the cost of fertilizer may actually have been less in 1987 than in 1983. In any case, the real price of fertilizer has not increased nearly as much as the nominal price in current Rials would indicate.

Despite the obvious shortage of fertilizer, crop prices may have increased even more during 1983-87 than fertilizer prices (see Chapter 2, section 2.2.8). The grain-to-fertilizer price ratio seems to have been somewhat higher in 1987 than in 1983, judging by the prices that survey farmers recall paying for fertilizer. Since this has happened in the face of sharp reductions in fertilizer supply, it suggests there may have been a downward shift in fertilizer demand since 1983. One factor contributing to such a reduction in demand may have been the drought in 1983-84, which would have reduced farm incomes and cash to purchase inputs. The reduction in worker remittances has probably also contributed to reduction in demand.

4.3 Current Role and Capabilities of the Private Sector

Conversations with merchants and importers indicate that the private sector feels that it has been pushed and shoved around in the fertilizer market. Private traders responded to initial farmer demand for fertilizer by importing urea from Kuwait in the early 1970's. When the Agricultural Credit Bank entered the fertilizer market to distribute donated urea from Saudi Arabia in the mid-1970's, the private market was disrupted. Some private importers abandoned the market entirely. Other traders continued to import a few phosphates and fertilizers other than urea.

Saudi donations of urea expanded in the early 1980's. After satisfying the CACB requirement and its own research and project needs, the MAF sold some of the Saudi urea directly to traders, retail merchants and large farmers. This put the CACB system and private merchants into face-to-face competition.

At times, the MAF sold to the Bank at a slightly lower price than merchants were charged. Merchants claim that, in addition to its cost advantage, the Bank could re-sell to farmers at a low price because, as a government entity, the Bank's price did not have to reflect the full cost of doing business. Some observers claim that the Bank was inefficient in its supply and distribution practices in that it did not send the right quantities to the right places and that it placed shipments to storage when they could have been distributed directly from the port.

The CACB has its own complaints about competing with the private sector. Bank officials say that private merchants would often hold their supplies off the market until the Bank had finished selling its supply, and then the merchants would sell their fertilizer at higher prices. They also claim that merchants would sometimes sell at lower prices than the Bank, making it impossible for the Bank to sell its supplies.

When the Ministry discontinued distribution through CACB, this would have left the market largely to the private trade again, except that by this time the licensing system had all but eliminated private imports, and the Ministry's supply of donated imports was declining.

The fluctuations in fertilizer supply after 1983 had very disruptive effects on the market. The MAF made its sales at relatively low prices, in the hope of holding the price down in the market. In 1987, for example, it sold (foreign donated) fertilizers to farmers and merchants for YRls 150-175 per bag. When MAF officials saw the high prices which merchants were getting for fertilizer on the open market -- an average of YRls 286 and highs of as much as YRls 390 per bag -- they naturally had the feeling that the private merchants were exploiting farmers. However, the MAF appeared to pay little attention to the fact that limited imports and the limited supply made it possible for the private sector to charge high prices.

Seven private trading companies were interviewed in the course of this study. All indicated their willingness to resume fertilizer imports, if permitted to do so -- indeed, three of these companies imported urea in 1987. Furthermore, the larger companies indicated that they have existing networks of distributors who can sell expanded fertilizer supplies in secondary towns, in addition to outlets in major cities.

There was agreement among these companies that, while there are some limitations in the handling facility at Hodeidah port, there are no significant limits in storage or transportation facilities to handle greatly increased volumes of fertilizer in Yemen. The availability of adequate transportation and storage was corroborated by interviews with the government's grain trading company, which handles a large volume of grain and flour imports.

Despite their apparent willingness and capacity to make additional imports, the private companies all expressed anxieties about related government import and pricing policies. They especially fear that the

Ministry or the CACB will undercut their prices in the market by selling donated fertilizers at less than the costs of commercial imports. They also expressed fear that the government will mistakenly allow more imports than farmers require, causing the price to collapse.

Private importers expressed their dismay at the way the system for import licensing and exchange control has been operated. They claim to have spent endless time and effort to obtain import licenses, only to be told that there is no foreign exchange available. They all point to more need for coordination among MAF, MOETS and the Central Bank in the management of the import system.

4.4 Current Organization and Management of the Import System

Three government bodies have primary control and set policy for fertilizer imports. These are the Ministry of Agriculture and Fisheries (MAF), the Ministry of Economy, Trade and Supply (MOETS), and the Central Bank. In addition to soliciting and receiving foreign donations of fertilizer, MAF requests and participates in allocating a part of Yemen's foreign exchange budget for importing fertilizer through the private sector.

In principle, the cornerstone of the exhange budgeting and import licensing system is the Economic High Committee on Foreign Trade Policy, in the Cabinet of Ministers. The Minister of Agriculture and Fisheries became a member of this committee in 1987. The High Committee estimates the total amount of foreign exchange that will be available for imports in a given year. It allocates this amount among the various ministries and issues guidelines to MOETS, which administers this budget. One part of the budget is for public sector imports, and another portion is for private sector imports, to cover such items as fertilizer.

Based on its total annual foreign exchange allocation from the High Committee, MAF prepares a detailed allocation budget for submission to MOETS. This contains categories for agricultural inputs such as fertilizer and pesticides. For these items, MAF's Directorate of Agricultural Affairs has first responsibility for estimating annual requirements. Normally, the Agricultural Affairs directorate consults with the Agricultural Research Authority in estimating needs.

Estimated needs for pesticides, fertilizers, and other inputs are forwarded to the MAF Directorate of Planning and Statistics, along with the estimated needs for other agricultural imports such as tractors. Planning and Statistics has the ultimate responsibility for prioritizing agriculture's needs and submitting the final foreign exchange budget for public and private imports to MOETS.

Expertise and experience for the budgeting process in MAF is limited. Budgeted fertilizer requirements appear to have been estimated mainly from some requirement figures stated in the current five year plan, reportedly 75,000 tons of fertilizer material in 1988. This would

be more than twice the highest annual amount ever consumed in Yemen (see Table 4-1).

To receive an import license for an agricultural input such as fertilizer, a trader must obtain initial approval from MAF. He first approaches the Directorate of Agricultural Affairs, which refers the request to the Agricultural Research Authority located in Taiz, for technical review. This step can be time consuming. While it may be useful if an unknown micro-nutrient or unusual compound fertilizer were involved, it seems unnecessary for urea or TSP.

Following approval by the Agricultural Affairs office, the importer must also obtain permission from MAF's Directorate of Planning and Statistics. In principle, this would involve review for availability of exchange budget. In practice, however, MAF recognizes that even when it approves a license, that does not always lead to final approval by MOETS. (For that matter, not all licenses approved by MOETS are matched with the necessary foreign exchange by the Central Bank.) Therefore, MAF approves licenses for more fertilizer than it has budgeted, in the hope that some will survive the procedures of MOETS and the Central Bank.

As described above, the whole exchange budgeting and import licensing procedure has tended to break down. Although the MAF Planning and Statistics office is supposed to be the main entity in charge of planning imports, this office finds it impossible to obtain timely information from MOETS and the Central Bank about the actual import picture. MAF only learns long after the fact what has happened, when it is too late to try to change the situation.

In addition to its role in planning fertilizer requirements and licensing private imports, MAF has also solicited fertilizer donations from foreign governments. With private imports so restricted during 1984-86, foreign donations constituted Yemen's supply of fertilizer. This being the case, a rational distribution of these imports was essential. It was undoubtedly for this reason that the MAF itself chose to distribute the donated fertilizer. After trying to satisfy the needs for research and for demonstration projects, MAF then sold fertilizers to merchants and large farmers.

While the Ministry's need to act as the fertilizer distributor in times of severe shortage is understandable, this has placed an added burden on the limited Ministry staff. Furthermore, the Ministry does not have adequate storage to handle the donated fertilizer imports -- for example, it is said that recent shipments have been stored in vacant chicken houses at government poultry farms. Also, now that private imports are again starting to flow, the Ministry is placed in a position of competing with private sector merchants.

Prospects for Imports in 1988. Although the Saudi grants dried up after 1985, Japanese fertilizer aid has continued. The Japanese Embassy

states that likely deliveries under its aid agreement will be about 2,500 tons of fertilizer in 1988. In late 1987, 6,400 tons of donated fertilizer were received from the Federal Republic of Germany.

In interviews conducted in March 1988, traders indicated that MOETS is now beginning to permit more importation of all commodities, including fertilizer. This appears to be resulting from increased availability of foreign exchange, now that Yemen has begun to export petroleum. Reportedly, if MOETS issues a license it is now automatic for the Central Bank to authorize the corresponding foreign exchange. Thus, the import procedure seems to have been simplified.

While MOETS has already approved licenses of some fertilizer for 1988, the total quantity of fertilizer involved is not known by MAF. If, as some rumors have it, there should be 40,000 tons of private imports, the year's supply may end up being four times as much as in 1987. This would probably be more of an increase than existing market channels could accomodate within a single year. The situation would thus turn from one of scarcity to one of glut. This could present as much of a problem as the recent fertilizer scarcity.

4.5 A Renewed Role for the Agricultural Credit Bank

While the CACB has not been active in fertilizer since 1984, it does not view itself as being permanently out of the fertilizer distribution business. The Chairman reported that CACB hopes to be able to sell fertilizer to farmers who participate in the new regional development projects in the northern and eastern regions. He reported that CACB now has appropriate legal status for importing its own fertilizer. Currently, however, the Bank may not have enough funds to finance fertilizer imports, and it appears to face the same import licensing obstacles as private traders.

Recently, about 70 percent of the Bank's loans have been related to farm machinery, land reclamation, and development of poultry, livestock and fisheries projects. A relatively small proportion of its loan activities have been related to farm inputs such as seed and chemicals. CACB currently does make loans for farm equipment sold by private dealers, but in the future it hopes to be able to import and sell such equipment on its own account.

The Bank is aware of the need for credit to support the use of fertilizer by smaller farmers. However, its current postion is that it will not make cash loans for farmers to purchase fertilizer at the "exorbitantly high prices" which are being charged by private merchants. The bank is only interested in making loans for fertilizer which it would itself sell at "fair, low prices".

CACB would presumably have to re-establish its network of retail agents for distribution to more remote areas, or it would have to rely on its 20 regional and branch offices. The regional offices in Taiz and Ibb each have new storerooms with about 10,000 tons capacity each, about half of which would be available for fertilizer storage.

The Credit Bank does offer a potential for reaching smaller and poorer farmers who are handicapped in obtaining fertilizer through the current marketing system. As a distributor, the Bank has certain advantages over direct distribution by MAF; it has better and more widely dispersed storage facilities, and it has a staff which is prepared to conduct commercial activities.

Current MAF and Yemen Government policy with respect to the Credit Bank appears to be uncertain. As a result, several issues are not clear. To what extent should the bank engage in commercial activities, selling farm equipment and inputs such as fertilizer in direct competition with the private sector? If it is permitted to conduct such activities, how should these goods be priced? Should the bank's loan programs be expanded to enable farmers to purchase inputs like seed and fertilizer? Should the bank be required to make loans which would cover purchases from the private sector? The MAF must take the lead in settling these issues.

4.6 Research and Extension

4.6.1 Agricultural Research Authority. The Agricultural Research Authority (ARA) is the semi-autonomous research arm of MAF. With main headquarters in Taiz and branch experiment stations located in other parts of the country, ARA has the capability for conducting fertilizer response studies in several representative agro-climatic regions. In addition to its budget from the government of Yemen, ARA is supported by the the U.N. Food and Agriculture Organization (FAO) and the World Bank, which adds strength in conducting its research program.

As a relatively new organization with origins dating back only to the early 1970's, it is natural that ARA should still face a broad range of research needs. In addition to unmet needs in fertility and related soils research, ARA still has much work to do in the identification and adaptation of improved, higher yielding crop varieties.

As was discussed in Chapter 3, experimental fertilizer response trials have already been made for many crops [see references 1, 4, 24, 25, and 26 for examples]. There is still a need to do complete response work for some of the main crops, and there is especially a need to conduct response work in more regions, under more varied soil and water conditions. As response work is expanded there will be a need to conduct more on-farm verification trials and to pay more attention to economic analysis of the technical findings.

In addition to fertilizer response work per se, there is a need for soil classification and mapping to be carried out at a finer scale -

- say, 1:40,000 or 1:50,000 -- which is suitable for use by local technical staff and extension agents. ARA does have a soils laboratory that is currently available for testing local soil samples, in conjunction with developing localized fertilizer recommendations.

Research on soil moisture availability in the different climatic and rainfall zones and under various irrigation management systems is badly needed so that better fertilizer recommendations can be developed at the local level.

Also, there is a need to pay continued attention to publication and documentation of findings, so that results of response trials for the newest varieties are available to researchers, extensionists, and planners alike.

4.6.2 Extension. Although MAF has a Directorate of Extension, the main thrust of extension activities is carried out through semi-autonomous development authorities and projects. The more established of these are the Tihama Development Authority (TDA), in the coastal region, and the Southern Uplands Rural Development Project (SURDP), both of which have their origins in the early 1970's. The Central Highlands Rural Development Project (CHRDP) was established more recently, and the RDP's for the northern and eastern regions are currently being organized. Like ARA, the regional organizations have the benefit of funding from multiple sources. For example, TDA currently receives support from the World Bank, the Kuwait Fund, the International Fund for Agricultural Development, and the Dutch Government, in addition to its YAR government budget.

According to SURDP officials, their strategy has been to place first emphasis on districts with greater potential for production increases. This has normally meant districts with irrigation or higher rainfall, and with better soils.

Extension activities follow the Training and Visit system which has been promoted by the World Bank. Under this system, extension agents work out of block offices located in the districts which they serve. An individual agent is responsible for 300 to 400 farmers. The extension officer at TDA reported that only five percent of his extension agents are secondary school graduates. Clearly, further training and education of extension agents would facilitate their work in fertilizer use and other farming practices.

Extension supervisors develop local area fertilizer recommendations from ARA research results, when possible. However, since there is often considerable variability in climate, rainfall, and available soil moisture in a region, it is difficult to find applicable response work in many cases. Furthermore, since existing soil surveys and maps [2] are at a relatively gross scale (1:500,000), it is not possible to use them very effectively in devising local fertilizer recommendations.

Local extension teams are responsible for organizing on-farm demonstrations. Generally speaking, such demonstrations are used to illustrate the benefits of a complete set of improved practices, including the recommended fertilizers, for a given crop. In TDA, for example, there were reported to be 140 such demonstrations in 1987. This does not appear to be a very large number, however, considering the number of farmers, the number of crops, and the differences in agro-climatic conditions.

Extensionists report that there is a strong interest in fertilizers among the farmers they contact. While extension agents know that phosphates and compound fertilizers do show response and are recommended for many crops, farmers continue to prefer urea in most cases. Evidently, little thought has been given to developing demonstrations which illustrate the benefits of phosphates more clearly.

The need for more and better demonstrations seems to have been a moot point for fertilizers in the past few years. Extension agents report that they find it ridiculous to promote fertilizer use and to make fertilizer demonstrations when farmers often cannot buy fertilizers on the local market. While the shortage has been a general one, it is particularly acute for specific products. For example, extension may have obtained di-ammonium phosphate from the MAF and used it in demonstrations, but the farmers find that only urea is available in local markets.

4.7 Foreign Governments and International Organizations

International bodies have a significant stake in supporting Yemen's research and extension organizations, as noted above. Some countries, notably Saudi Arabia, Japan and Germany, have helped to increase supplies by donating fertilizer materials to the Ministry of Agriculture and Fisheries. While the donations have undoubtedly been a worthwhile interim measure, they have also tended to postpone the day when Yemen will have to establish its own system to provide stable, expanding supplies of fertilizer.

Recently, two projects have been approved by the U.N. Food and Agriculture Organization (FAO) and by the U.N. Development Program (UNDP) which will have direct impacts on the fertilizer situation.

The FAO project, funded by the Danish government, will establish a Fertilizer Unit in MAF, Directorate of Planning and Statistics. This unit, to be initially headed by a foreign counterpart, will concentrate on planning fertilizer import requirements, on promoting and assembling information on fertilizer response trials, and supporting appropriate farm demonstrations. In addition to fertilizer, per se, the Unit will also direct some attention to pesticides and other related farm inputs.

The UNDP project [28] will conduct a detailed soil survey and land classification in the eastern and northern regions, in addition to providing needed institutional and financial support for the Soils

Department of ARA. This project will clearly develop needed soils classifications and maps which will be useful to extensionists and technicians at the local level in those regions. However, it is important to insure that this study follows the same classification system as Yemen's existing soils studies [2] so that the results will be compatible and non-duplicative, and so that personnel do not have to learn to use more than one system.

4.8 Recommended Improvements and Policies

4.8.1 Planning of Imports and Supply. Assuming that the current system of import licensing and exchange control continues, some obvious steps are required to make the system work. As a first step, MAF needs to develop more realistic estimates of total national requirements. The information and analysis contained in Chapters 2 and 3 of this report are intended to contribute to that process.

A plan needs to be developed for gradual import growth at a realistic rate. An immediate increase to the 75,000 tons of fertilizer material per year envisioned in the current five year plan is unrealistically high. If realized in the near future it would glut the market.

In order not to disrupt the market, MAF should recognize that supply should expand in an orderly fashion, with annual increases probably not exceeding more than 10 to 15 percent per year. As a starting place, it may be possible to return in 1988 to the 28,000 thousand ton per year range attained in the early 1980's, but in view of the much lower supplies of recent years, even this may involve some risk of creating distribution bottlenecks and unacceptably low prices.

MAF must develop better coordination with MOETS and the Central Bank so that it can obtain timely information on how many private imports have been approved and will be approved. It must learn to present solid justification of the need for fertilizer to these organizations.

The Minister of Agriculture and Fisheries, in his role on the High Committee on Foreign Trade Policy, should use his influence to promote better and more timely communication and coordination between MAF and the trade authorities in MOETS and the Central Bank.

MAF's statistics program should be expanded to include the annual collection of fertilizer prices from a representative sample of rural areas, so that the Ministry has the capability of judging whether supply is being expanded too quickly or not quickly enough.

In years when MAF sees that national needs will not be met by private traders, it should then proceed to seek and use donated fertilizer from other governments, as it presently does. Upon insuring that a stable supply of private imports is established, however, donated fertilizers could still logically be used to support MAF research and to

promote better fertilizer use through a larger number of demonstrations, conducted by the extension units of the regional development projects.

4.8.2 Marketing Policy. Yemen needs to have a clearer policy on how fertilizers are to be marketed. In the past the government permitted the Cooperative and Agricultural Credit Bank to sell fertilizer in direct competition with the private sector, but there were no safeguards to insure that the prices charged by the bank included the full cost of doing business. Furthermore, the bank was given preferred access to fertilizers which were donated by foreign governments, apparently at prices which were lower than those charged to private sector merchants for the same material. As a consequence, the bank may have charged low prices which constituted unfair competition to the private sector.

Although the credit bank's role in fertilizer distribution has been eliminated for the present, the MAF itself has continued to be the recipient of foreign fertilizer donations, a part of which it has sold to merchants while another part has been sold to larger farmers. Since it has often had full control of the very limited supplies of fertilizer which were available, this has placed the ministry in a powerful position while the private sector's role has often varied, and it has been unsure of how much fertilizer business it would be allowed to conduct.

In many developing countries it has been common practice for governments to take control of the marketing of fertilizers, to the exclusion of the private sector. One recent study [33] shows that fertilizer marketing and distribution costs tend to be higher in those countries where the government controls marketing. Table 4-6 shows how marketing costs vary between countries with and without government control of marketing. Government marketing was found to be common in

Table 4-6. Marketing and Distribution Costs for Fertilizer in Selected African and Asian Countries, 1983-85 (US dollars per ton)

Country	Transport & Storage	Interest	Distributor Margin	Other	Total
Kenya	44	20	31	38	133
Nigeria	90	-	21	26	137
Sudan	68	1	64	33	166
Zambia	85	15	15	34	149
Zimbabwe					
large farm	11	-	12	4	27
small farm	20	-	34	4	54
India	16	2	2	8	28
Indonesia	11	4	9	3	27
Thailand	12	2	15	34	63
Korea	23	43	10	1	77

Source: [33, p.147]

the African countries studied, "except for Zimbabwe, where two private firms were in competition." Costs in Zimbabwe and in Asian countries with private marketing were found to be much lower than in the African countries with government marketing. This evidence supports the contention that the private sector is more efficient at marketing fertilizer than the government.

In Yemen, the private sector has proven its ability to market fertilizer in the past. The MAF, on the other hand, has very limited capacity to market fertilizers. Distributing fertilizer places a burden on the Ministry's limited staff, which is thereby distracted from important duties in planning, regulating, and devising policies.

Considering all of the above, it is recommended that the MAF remove itself from the business of being a direct seller and distributor of fertilizers. By discontinuing its fertilizer sales and distribution activities, the Ministry would also avoid a conflict of interest in which it is in competition with the private merchants.

The Ministry may wish to consider turning over its fertilizer distribution activities -- i.e. those which relate to donated fertilizers -- to the credit bank. The bank has better facilities than the Ministry for conducting such business.

4.8.3 Price Policy. When the MAF and the CACB have sold fertilizer, the procedures they have used in determining how to price it have varied. Often, they have received donated fertilizers from abroad at zero cost, and they have naturally wanted to pass some or all of this benefit on to the farmer. They probably have not had a good accounting of their own local handling costs. Sometimes they have sold at prices which were much lower than private merchants could afford to sell imports for which they had paid the full international cost.

It is clear that private merchants often sell fertilizer at very high prices, particularly when they are able to take advantage of situations when the market is in short supply. In such circumstances governments are often tempted to institute price controls, to try to keep merchants from reaping windfall profits. Price controls are difficult and costly to enforce, and they often backfire. It appears that the government of Yemen has attempted to place price controls on fertilizer in some cases, but without much success.

Rather than attemt to control price by regulation, the most effective way to reduce fertilizer prices in Yemen will be to increase imports and supplies of fertilizer . As noted earlier, this will require that MAF educate and persuade the other government agencies which control the import process.

If the CACB should again become active in fertilizer marketing, it could exert a positive influence on the pricing situation by setting its price as if it were operating in a competitive market. This would mean starting with the full imported cost of the fertilizer, even if the fertilizer is donated by a foreign government. Local transport,

handling, and distribution costs should be added to this, plus a normal distributor's profit margin. In early 1988, such a procedure would have resulted in calculations similar to those shown in Table 4-7.

Table 4-7. Estimated Competitive Retail Price for Urea, 1988

			Yem. Rials per ton
Saudi Urea, cif Hodeida,			1,536
Customs agent	1%		
Earthquake tax	2%		
Bank fee, l.o.c.	3%		
Hodeidah port tax	2%		
Customs duty	10%		
Sub-total		18%	276
Peoples' assembly fee			14
Port fee			8
Handling at port and stacking in storage			46
Freight to Hodeidah storage			30
Inland freight			500
Storage			150
Distributor margin			250
Interest			50
TOTAL		Rls	2,810
Price per 50 kg bag		Rls 140.50	

Source: Port, handling, tranport, and storage costs from Yemen Corporation for Trade and Grain; import cost of urea from Hodeidah traders; dealer margin and interest costs estimated from Table 4-6; exchange rate of YRls 11 per U.S. dollar used to convert cif cost of urea.

4.8.4 Role of the CACB in Credit. The absence of ready sources of credit is an obstacle to fertilizer use, especially for smaller farmers. The MAF should encourage the Cooperative and Agricultural Credit Bank to develop new procedures for supplying credit to farmers who need it to purchase fertilizers. At the same time the MAF may wish to consider authorizing the CACB to engage again in marketing and selling fertilizers. However, in addition to providing credit for its own fertilizer sales, the Bank should be required to develop a mechanism for lending farmers the money to purchase fertilizer from private dealers.

4.8.5 Research and Extension. It is very wasteful to maintain costly extension organizations when fertilizer, one of the key inputs they are designed to promote, is not available. Thus, the first step required to improve the extension program is to ensure the availability of fertilizer on the local market.

There is a need for closer cooperation between the regional extension units and ARA in ensuring that the most useful response trials are being conducted extension recommendations are accurately reflecting research findings and local circumstances. The ARA has recently begun to hold a joint annual meeting with the regional development authorities to exchange ideas and information and promote improved research and extension programs for fertilizers. This program shows great promise, and it should be supported by the government of Yemen as well as international organizations.

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APPENDIX A

FERTILIZER SURVEY QUESTIONNAIRE - 1987

YEMEN ARAB REPUBLIC
MINISTRY of AGRICULTURE and FISHERIES
AGRICULTURAL STATISTICS DEPARTMENT

FERTILIZER SURVEY QUESTIONNAIRE - 1987

0000 GENERAL INFORMATION

0001 Farmer's name _____ Number: __ __ __

0002 Province _____ Code: __ __

0003 District _____ Code: __ __

0004 Village or town _____ Code: __ __

Name of enumerator _____

Name of supervisor _____

Name of coder ("exchanger") _____

Names of local measures: Land area _____

Crop production unit _____

CONTENTS

General Information..... Page 1

Family Characteristics and Farm Characteristics..... Page 2

Market Access, Equipment Ownership, Government Contact Page 3

Fertilizer Experience, Knowledge and Problems..... Page 4

Credit and Borrowing Experience..... Page 5

1987 Crop Production and Fertilizer Application..... Page 6

Fertilizer Use, Source of Purchase and Price..... Page 7

NOTES: _____

FERTILIZER SURVEY QUESTIONNAIRE - 1987

1000 FAMILY CHARACTERISTICS

1001 Total number of persons in farmer's family..... __ __

1002 Number of adults available for farm work..... __ __

1003 Number of family members from farm working in a foreign country..... __ __

1004 Number of family members with off-farm jobs in Yemen.. __ __

1005 Number of adults (>12 yrs) who can read and write..... __ __

1006 Age of household head (estimate if necessary)..... __ __

1007 Can household head read and write? (1=yes; 9=no)..... __

1008 Has household head ever lived in a foreign country?... __

1009 Total years education of household head..... __

2000 FARM CHARACTERISTICS

2001 Total number of parcels of land farmed..... __ __

FARM AREA AND AVAILABILITY OF IRRIGATION:	Local Measure	Square Meters
2002 Total area farmed	_____	_____
2003 How much of farm area is RAINFED only?.....	_____	_____
2004 How much is FLOOD irrigated?.....	_____	_____
2005 How much is irrigated from a SPRING ?.....	_____	_____
2006 How much is irrigated with a PUMP?.....	_____	_____
TENURE:		
2007 How much of farm area is OWNED?.....	_____	_____
2008 How much of area is LAND-SHARE CROPPED?.....	_____	_____
2009 How much is RENTED from others for cash?.....	_____	_____
2010 How much area is under OTHER ARRANGEMENTS?...	_____	_____
2011 TOTAL AREA CROPPED in 1987 (ha).....	_____	_____

Note: This data is taken from section 6000 1987 CROP PRODUCTION, page 6 below. It is the sum of all crop areas reported in field 6__02.

85

3000 MARKET ACCESS AND LOCATION

3001 Distance to nearest main road (kilometers)?..... __ __.__

3002 Distance to NEAREST market (km)?..... __ __.__

3003 Location of this market..... __
(1 = this village; 2 = nearby village; 3 = town/city)

3004 Distance to MARKET WHERE CROPS ARE NORMALLY SOLD?..... __ __.__

3005 Location of this market..... __
(1 = this village; 2 = nearby village; 3 = town; 4 = city)

AVAILABILITY OF FOODS AND FARM INPUTS:

Indicate the place where these items are NORMALLY AVAILABLE.

(1 = this village; 2 = nearby village; 3 = town/city
4 = MAF office or project; 5 = 'don't know';
6 = Agricultural Credit Bank
7 = other_____; 9 = not available)

3021 Wheat and other food grains..... __

3022 Flour..... __

3023 Chemical pesticides..... __

3024 Chemical fertilizers..... __

3025 Improved (high yielding) seeds..... __

EQUIPMENT OWNERSHIP/ACCESS: (1 = YES; 9 = NO)

3031 Do you own a car or truck?..... __

3032 Do you own a motor pump by yourself?..... __

3033 Are you part owner of a pump with another farmer?..... __

3034 Are you owner or part owner of a tractor?..... __

CONTACT WITH GOVERNMENT AGRICULTURAL OFFICIALS:
(9 = never; 1 = once; 2 = occasionally; 3 = often)

3041 How often has an extension agent or
or government agricultural officer visited your farm? __

3042 How often have you visited an agricultural
office or experimental farm?..... __

4000 KNOWLEDGE AND EXPERIENCE WITH FERTILIZER:

USE OF FERTILIZER:

4011 Did you use any chemical fertilizer during the 1987 crop year? (9 = no; 1 = yes) __

4012 Did you use any chemical fertilizer prior to 1987? __

IF ANSWER TO EITHER OF THE ABOVE TWO QUESTIONS WAS 'YES', THEN ANSWER:

4021 Approximately how many years ago was the FIRST TIME you used chemical fertilizers?..... __
(Example: 1987 would be 1, 1985 = 3, and so forth.)

WHERE DID YOU OBTAIN INFORMATION ABOUT CHEMICAL FERTILIZER? Code:

4022 _____ __

4023 _____ __

4024 _____ __

Codes to be filled in after the interview:
1 = neighbor, friend or relative;
2 = extension agent, ministry official or ministry project;
3 = Agricultural Bank; 4 = merchant or businessman;
5 = Newspaper; 6 = Radio; 7 = Television;
8 = While working in a foreign country;
9 = other_____

WHAT PROBLEMS DO YOU HAVE WITH CHEMICAL FERTILIZER? Code:

4031 _____ __

4032 _____ __

4033 _____ __

CHEMICAL FERTILIZER APPLICATION METHODS:
(answer only if chemical fertilizer used)

4041 How do you normally apply fertilizer?..... __
(1 = by hand; 2 = by machine, tractor, etc.)

4042 After the application, do you normally cover the fertilizer with soil or mix it with the soil? __
(1 = yes; 9 = no)

4043 After you apply the fertilizer, do you normally irrigate it directly or in the same day? __
(1 = right away or in the same day;
2 = within 2 or 3 days; 3 = 4 or more days;
9 = rainfed, no irrigation)

87

KNOWLEDGE AND EXPERIENCE WITH FERTILIZER (CONTINUED)

IN YOUR OPINION, WHICH ARE THE CROPS THAT BENEFIT MOST FROM CHEMICAL FERTILIZER? WHICH FERTILIZERS DO THEY NEED?

	-1		-2	-3
			Fertilizer needed by this crop:	
	Crop	(crop code)	Most important:	Also important:
405_	_____	(__ __)	__	__
406_	_____	(__ __)	__	__

Note: List the TWO CROPS which the farmer thinks would BENEFIT MOST from fertilizer. Fill in code later.

Fertilizer codes: 1 = urea or nitrogen fertilizers;
2 = phosphates; 3 = potash;
4 = compound fertilizers;
5 = doesn't know or is not sure of the kind.

5000 CREDIT AND BORROWING EXPERIENCE

5001 How often do you borrow (money) in order to obtain fertilizer or other inputs for farming? (9 = never; 1 = sometimes; 2 = normally or often) __

If answer is 'sometimes' or 'often', please state the TWO sources of borrowing used most of for fertilizer and other inputs: Code:

5002 _____ __

5003 _____ __

5011 Have you ever borrowed (money) in order to purchase a pump, a tractor or some other piece of farm equipment? (9 = no; 1 = yes) __

If answer is 'yes', please state the most important source of borrowing for purchase of such equipment:

5012 _____ __

Codes for
1 = from friends or neighbors;
2 = from family member or relative;
3 = from money lenders; 4 = from merchants or traders.
5 = from the Cooperative and Agricultural Credit Bank;
6 = other bank. 7 = Other source, specify_____

WHICH CROPS DID YOU GROW IN 1987? FILL OUT A FORM 6000 FOR EACH.

_____ _____ _____ _____

_____ _____ _____ _____

6000 1987 CROP PRODUCTION Report on up to four different crops:

6__00 Name of Crop.....	_____	_____	_____	_____
6__01 Code for crop.....	__ __	__ __	__ __	__ __
TOTAL AREA CULTIVATED IN THE CROP? (Summer + winter) Local measure:	_____	_____	_____	_____
6__02 Square meters:	_____	_____	_____	_____
TOTAL PRODUCTION OF THE CROP? (Summer + winter) Local measure:	_____	_____	_____	_____
6__03 Kilograms:	_____	_____	_____	_____
MARKETED PRODUCTION (Summer + Winter) Local measure:	_____	_____	_____	_____
6__04 Kilograms:	_____	_____	_____	_____
CROP AREA (Summer + Winter) WHICH RECEIVED:				
IRRIGATION: Local measure:	_____	_____	_____	_____
6__05 Square meters:	_____	_____	_____	_____
NATURAL FERT.: Local measure:	_____	_____	_____	_____
6__06 Square meters:	_____	_____	_____	_____
CHEM. FERTILIZER: Local meas.	_____	_____	_____	_____
6__07 Square meters:	_____	_____	_____	_____
NOTE: If none was applied, enter zero.				
FERTILIZERS APPLIED TO CROP IN 1987:				
CHEMICAL FERTILIZERS:	.....5 0 KG. B A G S.....			
6__08 Urea.....	_____.__	_____.__	_____.__	_____.__
6__09 Triple super-phosphate....	_____.__	_____.__	_____.__	_____.__
6__10 Compound N-P-K fertilizer	_____.__	_____.__	_____.__	_____.__
6__11 Other (name_____)	_____.__	_____.__	_____.__	_____.__
6__12 Other (name_____)	_____.__	_____.__	_____.__	_____.__
TOTAL CHEMICAL FERTILIZERS:	_____.__	_____.__	_____.__	_____.__
NATURAL FERTILIZERS:				
6__13 Livestock manure (grain bags)	_____	_____	_____	_____
6__14 Poultry manure (grain bags):	_____	_____	_____	_____

Note: If the farmer has more than four crops, add additional pages to report on the others. Report on all of his crops.

7000 FERTILIZER USE/PURCHASE SCHEDULE: Did you use any of the following fertilizers in 1987 or in previous years?	(-1) 1987 Crop Year	(-2) Previous High use Year
======UREA:======		
711- Total quantity used (BAGS of fertilizer).....	_____	_____
712- Price paid per bag (YRls).....	__.__ __	__.__ __
713- Purchased from (see code list below).....	__	__
714- Year of highest use.....	__ __ __ __	
======TRIPLE SUPER-PHOSPHATE:======		
721- Total quantity used (BAGS of fertilizer).....	_____	_____
722- Price paid per bag (YRls).....	__.__ __	__.__ __
723- Purchased from (see code list below).....	__	__
724- Year of highest use.....	__ __ __ __	
======COMPOUND FERTILIZERS:======		
731- Total quantity used (BAGS of fertilizer).....	_____	_____
732- Price paid per bag (YRls).....	__.__ __	__.__ __
733- Purchased from (see code list below).....	__	__
734- Year of highest use.....	__ __ __ __	
======OTHER TYPE (Give name):_____		
741- Total quantity used (BAGS of fertilizer).....	_____	_____
742- Price paid per bag (YRls).....	__.__ __	__.__ __
743- Purchased from (see code list below).....	__	__
745- Year of highest use.....	__ __ __ __	

7661 TOTAL FERTILIZER, all types, 1987.(BAGS)..... _____

Note: For the "previous high use year", ask the farmer about that year in the past when he used the most fertilizer. Ask him to remember the best that he can. Give the approximate year, if he can't remember exactly.

Codes for PURCHASED FROM: 1 = merchant in own or nearby village; 2 = merchant in large town; 3 = MAF office or project; 4 = Agricultural Credit Bank (CACB); 5 = other bank 6 = government agricultural project; 7 = neighbor, friend or relative.

APPENDIX B

1987 FERTILIZER SURVEY:

SAMPLE DESCRIPTION

*

DETAILED TABLES .

Appendix Table B-1. Yemen Fertilizer Survey, Sample Size and Distribution by District, Province and Region.

District	No. in Sample	Province	No. in Sample	Region	No. in Sample
Bajel	24	Hodeidah		Coast	
Marawah	25	Hodeidah		Coast	
Hais	25	Hodeidah	74	Coast	74
Abs	26	Hajjah	26	North	
Taiz	25	Taiz		South	
Magbana	25	Taiz	50	South	
Al Sadah	25	Ibb		South	
Saiani	25	Ibb	50	South	100
B.Heshaish	25	Sana'a		Center	
Amran	25	Sana'a		Center	
Khowlan	25	Sana'a		Center	
Raida	25	Sana'a	100	Center	100
Saadah	25	Saadah		North	
Bagem	25	Saadah	50	North	76
Marib	25	Marib		East	
Harib	25	Harib	50	East	50
TOTALS	400		400		400

Appendix Table B-2. Summary of Key Fertilizer Use Data, 1987 Yemen Fertilizer Survey

Crop	Crop Code	No. of Parcels	Total Cropped Area (ha)	Avg Parcel Size (ha)	Irrigation: Number of Parcels	Irrigation: Avg Area (ha)	Irrigation: Percent area irrig	Manure Applied: Number of Parcels	Manure Applied: Avg Area (ha)	Chemical Fertilizer Applied: Number of Parcels	Chemical Fertilizer Applied: Avg Area (ha)	Chemical Fertilizer Applied: Percent area fertilized	Urea Applied: Number of Parcels	Urea Applied: Avg N Appl (kg/ha)	Urea Applied: Max N Appl (kg/ha)	TSP Number of Parcels	Compound Fert Number of Parcels	Avg Product (kg/ha)	Avg Mktd Product (kg/ha)
ALL		1127	2074.5	1.84	855	0.93	51%	536	0.43	393	0.35	19%	384	18.3	6273	17	17		
Sorghum	11	308	1071.4	3.48	166	1.09	31%	180	0.81	99	0.45	13%	99	10.1	939	2	1	448	182
Millet	12	21	82.8	3.94	4	0.22	6%	2	0.10	0	0.00	0%	1	0.6	43	1	0	84	19
Wheat	13	135	164.1	1.22	121	1.00	83%	71	0.53	60	0.58	47%	59	53.1	732	0	2	1229	248
Barley	14	30	15.7	0.52	21	0.47	90%	16	0.19	16	0.32	60%	17	51.2	284	0	0	1661	730
Maize	15	107	101.2	0.95	78	0.78	82%	91	0.42	65	0.35	37%	65	27.3	359	2	0	1028	372
Potatoes	21	56	24.4	0.44	56	0.44	100%	12	0.10	43	0.30	68%	45	60.3	1136	0	1	17931	17165
Tomatoes	25	70	72.4	1.03	64	0.92	89%	17	0.13	26	0.13	12%	24	10.5	568	1	2	16100	15379
Onions	26	17	7.8	0.46	17	0.46	100%	5	0.13	8	0.13	28%	8	26.4	326	2	0	12625	12267
Watermelon	27	31	49.2	1.59	30	1.53	96%	5	0.15	0	0.00	0%	0	0.0	0	0	0	20401	20205
Okra	28	1	1.8	1.80	1	1.80	100%	0	0.00	1	1.80	100%	1	63.9	64	1	0	3149	0
Canteloupe	29	13	22.0	1.69	12	1.55	92%	2	0.17	0	0.00	0%	0	0.0	0	0	0	15362	15271
Peppers	30	2	0.5	0.27	2	0.27	100%	0	0.00	0	0.00	0%	0	0.0	0	0	0	9300	9380
Other Vegetables	31	38	29.9	0.79	38	0.79	100%	6	0.03	15	0.11	14%	15	23.1	939	2	0	4712	4559
Misc.Home Garden	32	3	0.6	0.20	3	0.20	100%	2	0.19	2	0.17	88%	2	77.7	652	0	1	1392	0
Sorghum fodder	41	36	86.5	2.40	19	1.48	62%	6	0.21	1	0.08	3%	1	0.8	23	0	0	4927	3942
Alfalfa	42	15	1.7	0.12	15	0.12	100%	1	0.02	0	0.00	0%	0	0.0	0	0	0	22594	13590
Lentils	51	13	9.3	0.72	8	0.33	46%	8	0.19	5	0.26	37%	5	22.3	142	0	0	906	509
Peas	52	3	1.6	0.55	2	0.41	74%	2	0.17	0	0.00	0%	0	0.0	0	0	0	1429	1026
Beans	53	2	0.2	0.08	2	0.08	100%	0	0.00	0	0.00	0%	0	0.0	0	0	0	1241	1241
Other legume	54	10	6.0	0.60	3	0.06	10%	3	0.10	2	0.05	9%	2	7.6	142	0	0	288	158
Cotton	61	3	1.0	0.33	2	0.21	64%	1	0.09	1	0.09	27%	1	23.1	85	1	0	714	523
Sesame	62	9	56.0	6.23	3	0.33	5%	2	0.22	0	0.00	0%	0	0.0	0	0	0	446	198
Tobacco	63	14	75.9	5.42	12	4.52	83%	0	0.00	0	0.00	0%	0	0.0	0	0	0	1547	1497
Bananas	71	1	0.4	0.36	1	0.36	100%	1	0.36	0	0.00	0%	0	0.0	0	0	0	6944	0
Papaya	72	5	3.7	0.73	4	0.53	73%	1	0.01	3	0.69	94%	2	107.1	345	1	1	6613	6284
Oranges	73	46	83.5	1.81	45	1.25	69%	20	0.47	16	1.23	68%	14	68.9	920	2	3	4356	4303
Other citrus	74	7	5.2	0.74	7	0.74	100%	3	0.20	4	0.63	85%	4	142.5	460	0	0	3033	1909
Dates	75	2	1.5	0.77	2	0.77	100%	1	0.73	0	0.00	0%	0	0.0	0	0	0	928	0
Coffee	76	3	6.9	1.37	5	1.37	100%	5	1.37	0	0.00	0%	0	0.0	0	0	0	991	991
Qat	77	7	2.5	0.36	7	0.36	100%	4	0.24	0	0.00	0%	0	0.0	0	0	0	1100	1100
Grapes	78	64	51.9	0.81	58	0.70	86%	33	0.40	12	0.18	22%	10	44.3	340	1	2	3969	3850
Deciduous fruit	79	6	9.4	1.57	6	0.52	33%	5	0.23	1	0.17	11%	0	0.0	0	0	1	8	0
Other perm. crop	80	41	25.8	0.63	38	0.61	98%	29	0.27	13	0.28	44%	9	80.3	6273	1	3	2001	1571
Misc.Home Orchar	81	6	1.5	0.26	3	0.16	63%	2	0.04	0	0.00	0%	0	0.0	0	0	0	303	101

Appendix Table B-3. Analysis of Fertilizer Use in SORGHUM Production.

	Coast	South	Center	North
Number of Fields	61	97	90	60
Average Field Size (ha)	4.06	1.10	1.20	10.14
Percent of Fields Fertilized:				
With Chemical Fert.	3%	21%	63%	33%
With Natural Fert.	7%	100%	57%	47%
Percent of Fields Irrigated	64%	15%	84%	60%
Percent of Chemically Fertilized Fields Under Irrigation	100%	70%	91%	100%
Percent of Irrigated Fields with Chemical Fertilizer	5%	93%	68%	56%
Avg Nitrogen Application	·····kg of N per ha·····			
Fields With N Applied	24.5	18.1	66.3	101.3
All Sorghum Fields	2.1	5.8	44.2	8.0
* Small Farms	.0	5.2	46.4	222.7
Medium Farms	.0	6.4	46.4	56.5
Large Farms	2.5	5.6	41.8	4.8
Average Yield (kg/ha)	·····kg of grain per ha·····			
All Sorghum Fields	554.7	940.4	1202.7	183.2
With Chemical Fert	457.6	1039.1	1314.9	1048.3
Without Chemical Fert	564.0	893.7	979.1	108.5
With Irrigation	577.3	1031.8	1398.2	780.1
Without Irrigation	497.8	903.3	322.9	40.0

* - Small Fields: 0 to 1.5 ha;
Medium Fields: 1.5 to 5 ha;
Large Fields: ≥ 5 ha.

Appendix Table B-4. Analysis of Fertilizer Use in WHEAT Production.

	South	Center	North	East
Number of Fields	1	66	36	32
Average Field Size (ha)	.16	.89	1.75	1.32
Percent of Fields Fertilized:				
With Chemical Fert.	100%	56%	61%	0%
With Natural Fert.	100%	50%	58%	50%
Percent of Fields Irrigated	100%	79%	100%	100%
Percent of Chemically Fertilized Fields Under Irrigation	100%	89%	100%	N/A
Percent of Irrigated Fields with Chemical Fertilizer	100%	63%	61%	0%
Avg Nitrogen Application	·····kg of N per ha·····			
Fields With N Applied	284.0	92.2	113.3	N/A
All Wheat Fields	284.0	50.8	90.3	.0
* Small Farms	N/A	46.7	63.9	.0
Medium Farms	N/A	67.7	70.4	.0
Large Farms	284.0	40.4	103.2	.0
Average Yield (kg/ha)	·····kg of grain per ha·····			
All Wheat Fields	2370.4	1436.1	1069.9	1172.3
With Chemical Fert	2370.4	2014.6	986.2	N/A
Without Chemical Fert	N/A	727.7	1401.8	1172.3
With Irrigation	2370.4	1976.5	1069.9	1172.3
Without Irrigation	N/A	259.0	N/A	N/A

* - Small Fields: 0 to 1.5 ha;
Medium Fields: 1.5 to 5 ha;
Large Fields: ≥ 5 ha.

Appendix Table B-5. Analysis of Fertilizer Use in MAIZE Production.

	Coast	South	Center
Number of Fields	13	91	3
Average Field Size (ha)	4.25	.50	.18
Percent of Fields Fertilized:			
With Chemical Fert.	15%	67%	67%
With Natural Fert.	0%	99%	33%
Percent of Fields Irrigated	92%	70%	67%
Percent of Chemically Fertilized Fields Under Irrigation	100%	98%	100%
Percent of Irrigated Fields with Chemical Fertilizer	17%	94%	100%
Avg Nitrogen Application	•••••kg of N per ha•••••		
Fields With N Applied	72.4	67.8	156.5
All Maize Fields	7.1	50.6	128.0
* Small Farms	N/A	45.2	.0
Medium Farms	.0	53.1	156.5
Large Farms	7.5	55.2	156.5
Average Yield (kg/ha)	•••kg of grain per ha•••		
All Maize Fields	479.3	1676.8	2656.8
With Chemical Fert	996.3	1904.4	2521.5
Without Chemical Fert	423.3	1004.0	3265.3
With Irrigation	482.9	1901.1	2521.5
Without Irrigation	404.8	908.5	3265.3

* - Small Fields: 0 to 1.5 ha;
Medium Fields: 1.5 to 5 ha;
Large Fields: ≥ 5 ha.

Appendix Table B-6. Analysis of Fertilizer Use in POTATO Production.

	South	Center	North	East
Number of Fields	41	9	1	5
Average Field Size (ha)	.34	.39	.33	1.30
Percent of Fields Fertilized:				
With Chemical Fert.	100%	22%	0%	0%
With Natural Fert.	7%	78%	100%	20%
Percent of Fields Irrigated	100%	100%	100%	100%
Percent of Chemically Fertilized Fields Under Irrigation	100%	100%		N/A
Percent of Irrigated Fields with Chemical Fertilizer	100%	22%	0%	0%
Avg Nitrogen Application	·····kg of N per ha·····			
Fields With N Applied	90.0	98.6	N/A	N/A
All Potato Fields	90.0	58.5	.0	.0
* Small Farms	112.6	.0	.0	N/A
Medium Farms	79.9	110.5	N/A	.0
Large Farms	94.2	39.5	N/A	.0
Average Yield (kg/ha)	·····kg of grain per ha·····			
All Potato Fields	23793.5	10307.5	7575.8	9923.1
With Chemical Fert	23793.5	10105.7	N/A	N/A
Without Chemical Fert	N/A	10378.1	7575.8	9923.1
With Irrigation	23793.5	10307.5	7575.8	9923.1
Without Irrigation	N/A	N/A	N/A	N/A

* - Small Fields: 0 to 1.5 ha;
Medium Fields: 1.5 to 5 ha;
Large Fields: ≥ 5 ha.

Appendix Table B-7. Analysis of Fertilizer Use in TOMATO Production.

	Coast	South	Center	North	East
Number of Fields	39	18	11	1	1
Average Field Size (ha)	1.01	1.03	.31	.66	4.00
Percent of Fields Fertilized:					
With Chemical Fert.	5%	83%	73%	100%	0%
With Natural Fert.	10%	28%	64%	100%	0%
Percent of Fields Irrigated	85%	100%	100%	100%	100%
Percent of Chemically Fertilized Fields Under Irrigation	100%	100%	100%	100%	N/A
Percent of Irrigated Fields with Chemical Fertilizer	6%	83%	73%	100%	0%
Avg Nitrogen Application	....kg of N per ha....				
Fields With N Applied	74.3	123.4	75.9	N/A	N/A
All Tomato Fields	2.7	102.5	67.3	.0	.0
* Small Farms	.0	114.1	75.2	.0	N/A
Medium Farms	.0	113.2	125.3	N/A	.0
Large Farms	3.4	72.6	29.0	N/A	N/A
Average Yield (kg/ha)	....kg of fruit per ha....				
All Tomato Fields	16950.5	10522.4	10378.4	4545.5	15000.0
With Chemical Fert	13610.1	10285.1	10928.4	4545.5	N/A
Without Chemical Fert	17074.3	11687.2	4267.0	N/A	15000.0
With Irrigation	17570.9	10522.4	10378.4	4545.5	15000.0
Without Irrigation	12842.8	N/A	N/A	N/A	N/A

* - Small Fields: 0 to 1.5 ha;
Medium Fields: 1.5 to 5 ha;
Large Fields: ≥ 5 ha.

Appendix Table B-8. Analysis of Fertilizer Use in ORANGE Production.

	Center	North	East
Number of Fields	1	6	39
Average Field Size (ha)	.07	1.68	1.88
Percent of Fields Fertilized:			
With Chemical Fert.	0%	50%	33%
With Natural Fert.	100%	100%	33%
Percent of Fields Irrigated	100%	100%	97%
Percent of Chemically Fertilized Fields Under Irrigation	N/A	100%	92%
Percent of Irrigated Fields with Chemical Fertilizer	0%	50%	32%
Avg Nitrogen Application			
		....kg of N per ha	
Fields With N Applied		155.4	212.2
All Orange Fields		68.6	69.0
* Small Farms		.0	.0
Medium Farms		522.7	160.7
Large Farms		50.1	27.7
Average Yield (kg/ha)			
		....kg of fruit per ha	
All Orange Fields		4809.6	4297.5
With Chemical Fert		4978.8	1940.4
Without Chemical Fert		2237.6	8715.2
With Irrigation		4809.6	6386.2
Without Irrigation		N/A	.0

* - Small Fields: 0 to 1.5 ha;
Medium Fields: 1.5 to 5 ha;
Large Fields: ≥ 5 ha.

Appendix Table B-9. Analysis of Fertilizer Use in GRAPE Production.

	Center	North	East
Number of Fields	45	18	1
Average Field Size (ha)	.67	1.20	.20
Percent of Fields Fertilized:			
With Chemical Fert.	9%	44%	0%
With Natural Fert.	42%	78%	0%
Percent of Fields Irrigated	87%	100%	100%
Percent of Chemically Fertilized Fields Under Irrigation	100%	100%	N/A
Percent of Irrigated Fields with Chemical Fertilizer	10%	44%	0%
Avg Nitrogen Application			
	····kg of N per ha····		
Fields With N Applied	75.4	282.0	N/A
All Grape Fields	8.4	94.5	.0
* Small Farms	2.3	54.3	N/A
Medium Farms	16.6	132.7	.0
Large Farms	.0	.0	N/A
Average Yield (kg/ha)			
	···kg of fruit per ha···		
All Grape Fields	4476.9	3256.7	5000.0
With Chemical Fert	6763.0	2374.2	N/A
Without Chemical Fert	4189.2	3776.2	5000.0
With Irrigation	4688.9	3256.7	5000.0
Without Irrigation	3645.6	N/A	N/A

* - Small Fields: 0 to 1.5 ha;
Medium Fields: 1.5 to 5 ha;
Large Fields: ≥ 5 ha.

APPENDIX C

FERTILIZER TERMINOLOGY AND COMMON NUTRIENT FORMS

APPENDIX C. FERTILIZER TERMINOLOGY AND COMMON NUTRIENT FORMS

"Fertilizer" is a generic term which can have many meanings. As used in this study, the term normally refers to inorganic fertilizers which are at times called "chemical fertilizers" to distinguish them from natural or organic fertilizers such as livestock manure.

In order to be exact when referring to a quantity of fertilizer, it is important to distinguish between the nutrient weight and the product weight. One ton of the product urea contains only 460 kg of the nutrient nitrogen. In this case it can be said that one ton of urea is one ton of fertilizer material, but it is more exact to refer to the 460 kg of nutrient (or nitrogen) which it contains. Most soil scientists and agronomists prefer to quantify fertilizer by its nutrient weight.

Forms of Nutrients

Each plant nutrient comes in several different forms according to the type of mineral salt involved. The following is a list of some of the more common fertilizers, together with the nutrient content (percentage) of each.

Nitrogen (N) Fertilizers	% N
Urea	46
Ammonium Nitrate	34
Ammonium Sulfate	21

Phosphate (P_2O_5) Fertilizers	% P_2O_5
Triple superphosphate	46
Single superphosphate	18-22

Potash (K_2O) Fertilizers	% K_2O
Muriate of potash	60
Sulfate of potash	50

Compound Fertilizers	% N	% K_2O
Mono ammonium phosphate	11	48
Diammonium phosphate	16-18	46-48
Ammonium phosphate nitrate	27	12
Ammonium phosphate sulfate	16	20

Fertilizers may also be specially formulated to contain specified percentages of N-P-K. For example, a compound specified to be 10-20-30 would contain 10 percent N, 20 percent P_2O_5, and 30 percent K_2O. A ton of this fertilizer material would contain a total of 600 kg of nutrient. 200 kg of the nutrient would be phosphate.

Any or all of the above products could be a satisfactory fertilizer material, provided that it meets specific soil and crop needs. For example, an ammonium phosphate fertilizer would not be applied to a field of alfalfa because this crop produces its own nitrogen supply (through the action of a rhizobium in the root modules).

Where non-legumes are grown and the soil is such that both N and P_2O_5 are needed, ammonium phosphates are good materials to use, provided that the N and the P_2O_5 are needed in the ratio that exists in the material. Often the ammonium phosphates are lower in cost per unit of nutrient than if each nutrient were purchased separately.