AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
BATCH #20

1. SUBJECT CLASSIFICATION
A. PRIMARY: Agriculture — AE10-0000-0000
B. SECONDARY: Agricultural economics

2. TITLE AND SUBTITLE
The expanding world fertilizer market

3. AUTHOR(S)
Parker,F.W.; Steward,D.D.; Peperzak,Paul

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1964	15p.	ARC 631.8,P239

7. REFERENCE ORGANIZATION NAME AND ADDRESS
USDA/ERS

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Presented at 12th annual Calif.Fertilizer Conf.,Fresno)

9. ABSTRACT

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-RAB-118	
12. DESCRIPTORS	**13. PROJECT NUMBER**
Fertilizers Innovations	**14. CONTRACT NUMBER** PASA RA-2-00 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

THE EXPANDING WORLD FERTILIZER MARKET

by

Frank W. Parker
Agency for International Development

Donald D. Steward
United States Department of Agriculture

Paul Peperzak
Tennessee Valley Authority

Prepared for delivery at the
Twelfth Annual California Fertilizer Conference
Fresno, California
January 20, 1964

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Frank W. Parker, Donald D. Steward and Paul Peperzak

The wide and increasing disparity in agricultural production and levels of nutrition among different countries and regions of the world was well documented at the World Food Congress. A more recent summary of the situation is given in the FAO report, State of Food and Agriculture, 1963 (8). 1/ The causes for the disparity are many and include cultural, institutional, economic and technological factors. We will consider one important technological factor, the use of fertilizer. Coleman (5) has recently estimated that world fertilizer consumption in 1970 will be 48.5 million tons of nutrients as compared to 27.1 million tons in 1959-60. Ewell (6) estimates additional world fertilizer requirements at 40 pounds of nutrients per capita and estimates the capital investment required to produce this would be $21 billion during the next ten years. These estimates suggest the possible magnitude of the expanding fertilizer market.

Governments, industry and others concerned with economic development and agricultural production in both underdeveloped and developed countries are giving increased attention to the role of fertilizers in the process. The question of concern to many is the probable rate of expansion of fertilizer consumption in different regions of the world in the next ten to twenty years. This paper is addressed to that question and will consider a number of factors that will certainly influence the rate of increase in fertilizer use. Consideration will be given to both the developing and developed countries. 2/

We will first consider past trends in consumption, for they have some significance as a guide to the future. World fertilizer consumption increased from 7.5 million tons in 1945 to 28.5 million tons in 1960/61 as shown in Figure 1. The increase of 21 million tons of nutrient was divided between the developed and underdeveloped countries on an approximately 10:1 ratio. Adams (1) reports that in the 1950-60 period, world fertilizer consumption increased at the rate of 7.08 percent per year, 6.70 percent for the developed and 11.18 percent for the less developed countries. The data

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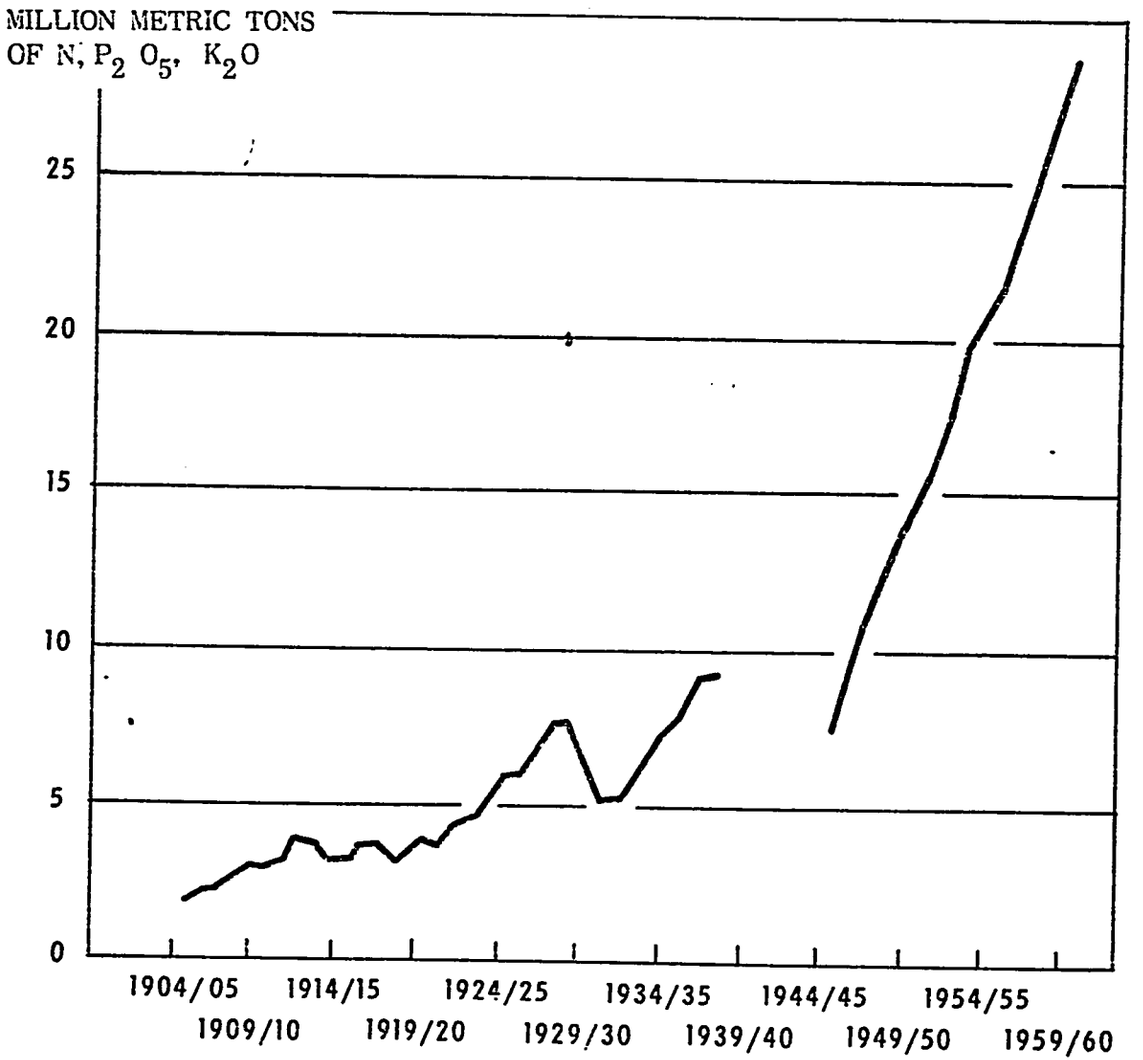
The views expressed in this paper are those of the authors, and not necessarily those of the agencies they represent.

1/ Underscored numbers in parentheses refer to items in the Literature Cited, page 14.

2/ The developed countries include the United States, Canada, Europe, U.S.S.R., Japan and Oceania. All other countries, including Mainland China are considered developing countries.

Fig. 1

WORLD FERTILIZER CONSUMPTION, 1905-06—1960-61



SOURCE: FERTILIZERS: AN ANNUAL REVIEW OF WORLD PRODUCTION, CONSUMPTION AND TRADE. FAO, ROME. 1961.

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are summarized in Table 1. We are familiar with the increase in the developed regions, North America, Europe, and Oceania. In the developing countries, the

Table 1.- World consumption of fertilizer nutrients and compound rate of increase, 1950-60 (consumption in million metric tons)

Area	Consumption		Rate of increase
	1949-1950	1959-1960	
			Percent
More developed area 1/----	11.59	22.16	6.70
Less developed area-------	.90	2.59	11.18
Africa----------	.30	.59	7.04
Asia----------	.37	1.15	12.01
Latin America--------	.23	.85	14.07
WORLD TOTAL 2/----------	12.49	24.75	7.08

1/ Includes North America, Europe, Oceania, Japan, and Ryukyu Islands
2/ Excludes Russia, Mainland China and their satellites.
Source: Adams, J. Richard, Fertilizer Use in the Less Developed Countries, U.S. Department of Agriculture. Paper prepared for presentation at International Fertilizer Conference, Bombay, India, December 1963.

rapid increase was limited to a few countries in some regions, and in some it seemed to be associated with the increased production of cash and export crops. Nevertheless, there has been a substantial increase in the use of fertilizers on cereals and other food crops, but in many of the developing countries, progress has been slow. Everything considered, however, the last ten to fifteen years has seen a most remarkable increase in fertilizer consumption throughout the world. How long will it continue? Before estimating fertilizer consumption in 1970 and 1980, we will consider an estimate of food and fertilizer requirements in 1980.

Food and Fertilizer Requirements

Effective future demand for food in the world will be determined by two factors: Population growth and rate of economic development. The influence of the growth of population is evident; if world population increases 50 percent by 1980, food requirements would obviously increase 50 percent unless per capita consumption changed. It does change, however, because diets improve with economic development. Great changes have occurred in the U.S. diet in the last twenty-five years. Similar changes have taken place in Western Europe and Japan since 1950 and the change is continuing. There has been little change in most of the developing countries. If economic development proceeds at a satisfactory rate, per capita food consumption will increase substantially in the next twenty years. Cochrane et al (4), for example, estimate the demand for food in the developing countries will increase at an average annual rate of 3.48 percent compounded per year during 1960-75. About 40 percent of this increase will be due to greater per capita consumption associated with an increase in national income at an assumed rate of four to five percent per year. The balance, 60 percent, will be due to the increase in population.

Sukhatme (11) estimated future world food production that would be required to meet the needs of the growing population, assuming some improvement in nutrition in developing countries. He concluded that the world's food supply would have to be doubled by 1980 if reasonably adequate levels of nutrition are to be met. The economic assessment of effective demand for food and the nutritional approaches to food requirements lead to substantially the same conclusion, depending on the assumptions regarding the rate of economic development or improvement in nutrition.

In a recent USDA publication, Brown (2) states that if the population of the less developed regions of the world expands by the expected 3 billion persons by the end of this century, these regions will need to develop an additional food production capacity equal to current world capacity. He added that the "extended use of fertilizer is strategically important, for, in areas of adequate moisture, it is the primary means of achieving higher yields and greater overall food production."

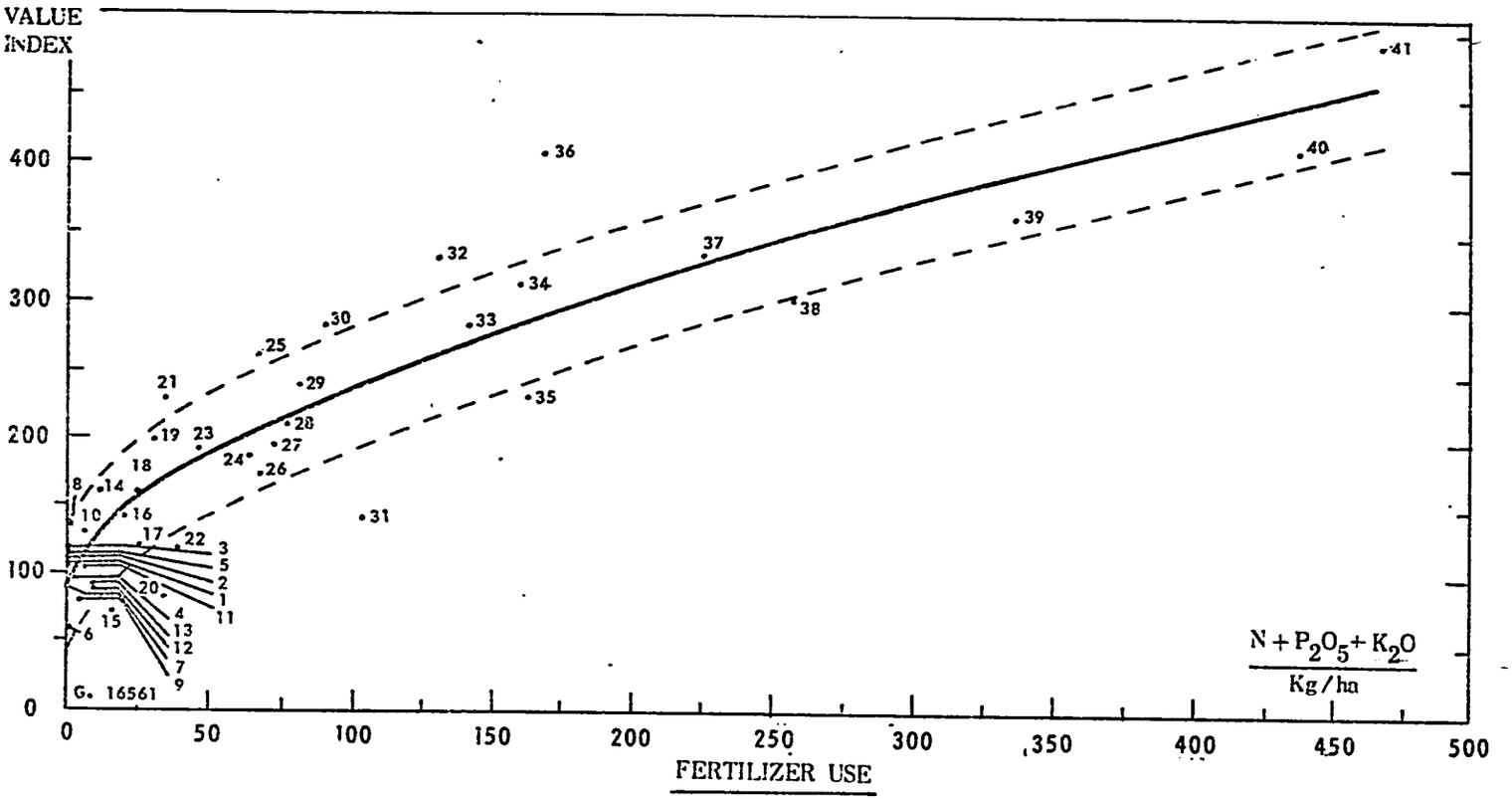
Farmers, agronomists, fertilizer manufacturers and others understand the relation between crop yields and the use of fertilizers. The industry is based on that relationship and it has been examined by agronomists and economists in many field experiments and farm management studies. Williams and Couston (12), however, carried such studies further when they developed the relationship between the national average yield of all crops and the use of fertilizer for forty-one countries. The relationship is shown in Figure 2, and its interpretation and significance is fully discussed in their paper. Their data provide a useful basis for estimating the amount of fertilizer any country may need in order to attain a desired level of productivity per unit of arable land. Parker (10) used this method and estimated the 1980 fertilizer requirements. He assumed that seventy-five percent of the increased food and agricultural production required in 1980 will come from increased yields and estimated requirements from the above curve. He calculated that the four less developed regions of the world should be using 30.0 million tons of plant nutrients in 1980. This was combined with an estimate of 40 million tons for the more developed countries to give a world total of 70 million tons.

Estimated Consumption, 1970 and 1980

If the required level of fertilizer consumption in 1980 were to be attained, world consumption would have to increase at an average rate of 4.7 percent per year. This is only two-thirds of the rate of increase for 1950-60. It, therefore, seems possible that the estimated requirements may be used. Before reaching such a conclusion, however, we should consider the several factors that will affect the rate of increase. These will be considered separately for (a) United States, Canada, Western Europe, Japan and Oceania, (b) Eastern Europe and USSR, and (c) the developing countries. The western countries are technoligically advanced in agriculture; Eastern Europe and Russia are less advanced, and most of the developing countries are only recently introducing modern technoligy in agriculture.

Fig. 2

CURVE OF AVERAGE RELATIONSHIP BETWEEN FERTILIZER USE AND VALUE INDEX OF CROP PRODUCTION (Per Arable Hectare 41 Countries, 1956-58)



1. Burma
2. Argentina
3. Thailand
4. Pakistan
5. Turkey
6. India
7. Syria
8. Indonesia
9. Philippines
10. Canada
11. Colombia
12. Mexico
13. Brazil
14. Chile
15. South Africa
16. Yugoslavia
17. Spain
18. Greece
19. U. S. A.
20. Portugal
21. Ceylon
22. Australia
23. Italy
24. Peru
25. Egypt
26. Finland
27. Israel
28. Sweden
29. France
30. Austria
31. South Korea
32. Denmark
33. United Kingdom
34. Norway
35. Taiwan
36. Switzerland
37. West Germany
38. Japan
39. Belgium Luxembourg
40. Netherlands
41. New Zealand

SOURCE: M. S. WILLIAMS AND J. W. COUSTON. CROP PRODUCTION LEVELS AND FERTILIZER USE. FAO, ROME. 1962.

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Western Countries: During the 1950's, these countries increased total agricultural output at an average annual rate between 2.0 and 2.5 percent compounded. This meant a rise in per capita production of 1.0 and 1.5 percent per year. The greater agricultural output made possible improved nutrition and living standards in Western Europe and Japan and contributed to the large surpluses that exist in North America. How was this increased production attained? Can it be maintained? What was the role of fertilizers?

A basic cause for the increase was the rapid growth in demand during World War II and in the post-war years, providing economic incentives for farmers to expand production. This led to increased investments in agriculture and the rapid adoption of improved technology, including higher rates of fertilization (3). Government actions helped to strengthen and maintain favorable price-cost relationships. These actions took the form of price supports for agricultural commodities, a subsidy of means of production, or both in some countries. The incentives were accompanied by a good research and information service, ample and timely credit and a vigorous promotion and sales program of farm equipment and supplies by industry and better management by farmers. All combined to produce a revolution in agricultural technology and an increase in productivity of land, labor, and capital.

Technically, the rate of increase in productivity in the Western countries could doubtless be maintained during the 1960's. If it is, however, the increased production probably would result in an unmanageable surplus of agricultural products. This is one reason why the level of production, prices, price supports, and subsidies is an important problem for the U.S., the Common Market countries, and the entire Atlantic community. If tighter production controls are imposed, production incentives are reduced, and the rate of increase in fertilizer consumption would probably decline. On the other hand, increasing agricultural prices now visualized in several Common Market countries may tend to increase fertilizer usage in these countries.

Heady and Tweeten (9) have estimated that fertilizer consumption in the U.S. will increase 60 to 67 percent from 1960 to 1980 and that total agricultural output will increase 35 to 47 percent. Based on another estimating procedure, they suggest that fertilizer consumption might increase 100 percent, but that such an increase might well produce price depressing surpluses.

The influence of fertilizers on agricultural output in the Western nations is indicated by the USDA estimate that nearly one-half of the post-war increase in crop output per acre in this country was due to the greater use of fertilizers. Commercial fertilizers were credited as being the largest single factor in expanding total crop production (3).

No similar estimate has been made for Western Europe, Oceania and Japan, but there is no doubt that the rapid and sustained increase in the use of fertilizers has been a major factor in attaining the higher levels of productivity. Furthermore, greater investments in fertilizer are accompanied by larger investments in other elements of modern technology that substantially increase the efficiency of production.

There is no really satisfactory basis for estimating what fertilizer consumption in the Western countries will be in 1970 and 1980. However, considering the current high level of nutrition in most of these countries, the comparatively low rate of increase in population, and the limited opportunities for agricultural exports, an average annual increase in fertilizer consumption of 3.0 percent seems reasonable. It may exceed this in North America and Oceania where the rates of fertilization are moderate and it may be less than 3.0 percent in Western Europe and Japan where the rates are already rather high. An annual increase of 3.0 percent would result in the use of 26.9 and 36.1 million tons of nutrients in 1970 and 1980, respectively, as compared to 20.0 million in 1960 (see Table 4).

Eastern Europe and USSR: Agriculture is less technologically advanced in these countries than in the West, but it is in a position to advance rapidly if the governments provide the incentives and the essential inputs of capital and other resources. In many of these countries, agricultural production is so low that it tends to restrict general economic development and improved nutrition. There are good reasons, therefore, for the recent reevaluation of agricultural policy, which has resulted in giving more attention to increasing fertilizer consumption. Unlike the Western nations, Eastern Europe and the USSR can use the increased agricultural output that would result from increased technological inputs.

In the 1950's, Eastern Europe and the USSR increased fertilizer consumption from 2.4 to 5.0 million tons, at an average annual rate of 7.7 percent. In view of recently announced plans for expanding fertilizer production, particularly in the USSR, we expect the rate of increase in fertilizer consumption to be considerably higher over the next ten years. Inasmuch as the production targets very likely will not be reached, however, we estimate that the average annual fertilizer consumption may not be more than 12 percent from 1960 to 1970 and will be considerably lower, possibly 5 percent from 1970 to 1980. This would mean the use of 15.5 million tons in 1970 and 25.3 million tons in 1980.

Developing Countries: In the developing countries, the urgency to increase agricultural production is great. A recent survey by FAO (8) indicates most countries plan an annual increase in agricultural output of 4.0 to 6.0 percent per year in the current Plan period. An average of 4.0 percent per year is essential for reasonably satisfactory economic development. If that or a higher rate is maintained, fertilizers must be used in substantial quantities. It is not a question of need for fertilizer, but the ability to convert the need to effective demand and then of supplying the market. In the last ten years, many countries have greatly increased their capacity to operate industrial, agricultural, and rural development programs. Nevertheless, as indicated by a recent AID survey, serious obstacles still need to be overcome.

In 1963, the U.S. Agency for International Development made an operational survey of factors associated with increasing fertilizer consumption in developing countries. Forty-five AID Missions responded to a series of ten questions. While the results of this survey may be viewed with limitations from a research point of view, they nonetheless provide some useful information. The survey shows:

1. Forty of the forty-five country Missions reported a fair to very good crop response to moderate amounts of fertilizers. The percentage increase varied from 15 to more than 100 percent, with an overall percentage of 86. The increase in crop produce per pound of plant nutrients ranged from 1 to more than 40 pounds, with an average of 17 pounds for grains and 13 pounds for all crops.

2. The use of moderate rates of fertilizers is profitable on nearly all food crops in all countries at current prices for fertilizers and crops. The return per dollar invested in fertilizer was reported as generally ranging from 1 to 6 dollars. Most cereal crops fall in the lower part of this range, and cash crops in the higher part. There were very few reports where the crop increase did not pay for the fertilizers, but the return was usually lower than in the U.S. and Europe.

3. On the basis of the Mission's estimates, 1980 fertilizer requirements will be 23 percent higher than the estimate made from the FAO curve on crop yields and fertilizer use. This would indicate a requirement of about 37 million tons of nutrients in the developing countries in 1980.

4. Most governments are giving some attention to expanding the supply and use of fertilizers by one or more means. A summary of government actions are listed in Table 2. , More than half of the 45 countries are giving special

Table 2.- Government action in 45 countries to increase fertilizer consumption, as reported by AID Missions, 1963

Type of action	Number of countries
Extension and demonstration--	28
Credit & subsidy of fertilizer price----------	23
Construction of fertilizer plants and promotion thereof	22
Research----------	16
Increase import of fertilizer	8
Total or partial reduction of import duty on fertilizers--	5

attention to fertilizers in national planning per se. In addition, other actions such as soil surveys, especially prominent in Latin America, will also have an indirect effect on fertilizer use.

5. Fifteen missions indicate that fertilizer consumption is restricted by the availability of foreign exchange for imported fertilizers.

6. The USAID Mission's ranked listing of the main factors limiting the use of fertilizers are summarized in Table 3.

Table 3.- Prominence of five selected factors restricting fertilizer use in 45 countries, as reported by A.I.D. Missions, 1963

Ranking importance	Number of times reported				
	Land Tenure	Education	Credit	Price	Supply
1--------	1	26	4	5	2
2--------	5	10	12	9	3
3--------	3	1	10	10	6
4--------	4	4	5	8	2
5--------	4	3	2	1	8
Total------	17	44	32	33	21

Education of farmers, or rather the lack of it, was most frequently regarded as the major limiting factor. Of 44 times listed as a limiting factor, it was ranked first or second in importance 36 times. Credit limitations and the high price of fertilizers are next in order as limiting factors. Several Missions mentioned lack of suitable markets and transportation facilities for agricultural products as important limiting factors. Risk and uncertainty associated with weather, drought, flooding, etc., no doubt is another important factor restricting the use of fertilizer.

7. While most countries have some facilities for making soil analyses, only a few provide a moderately good soil testing service for farmers. Soil testing as such is highly inefficient and inadequate in at least 75 percent of the countries for want of equipment and trained staff. The Missions emphasize also the lack of correlation of soil analyses with field test data and soil surveys.

8. Twenty-five Missions gave summaries of soil testing data, usually indicating the percentage of soils that tested low, medium, or high in each of the three major plant nutrients. A high percentage of soils tested are low in nitrogen and phosphorus. Potash deficiency is also widespread but in this summary there are about an equal percentage of low and high potash soils.

9. Thirty-two of the forty-five Missions are providing some assistance in fertilizer programs. Most of the programs are devoted to research (18 Missions), extension (15), and soil testing (10). Thirty of the countries are also receiving assistance in fertilizer work from other foreign aid agencies, such as FAO (23 countries), the Rockefeller Foundation, the Ford Foundation, and from private industry.

10. Nearly all Missions emphasize that fertilizer use should be combined with the use of better cultural practices, good seed, pest control, and other improved soil, water, and crop management practices.

FAO has been giving technical assistance in fertilizers for nearly 20 years. Its work in this field has been substantially expanded since 1960 by the industry-financed Fertilizer Program under the Freedom from Hunger Campaign and U.N. special fund projects. Our study of available FAO data for about 20 countries substantially confirms the report of USAID Missions that in most countries there is a good and profitable response to the use of moderate quantities of fertilizers. The FAO studies also indicate that lack of information, incentives, credit, markets and timely supplies are limiting fertilizer consumption in country after country.

This summary of limiting factors may seem to present a preponderance of difficulties that restrict rapid change. A similar analysis in 1950, however, would have presented a much more discouraging situation. Nevertheless, fertilizer consumption increased at an average rate of 11 percent per year. In 1950, there was not the present wealth of information on crop response to fertilizers and the economic returns from their use. Many governments had little knowledge or concern about fertilizers and their place in agricultural development. The change from 1950 to 1963 is due in no small measure to the technical and economic assistance provided by the more developed countries as well as the efforts of the developing countries themselves. In some respects, the foreign aid programs of the developed countries and international agencies are a massive market development program. These programs will doubtless continue, increase in effectiveness, and materially help develop the market. Other favorable factors have developed more recently.

In the last five years, the petrochemical and fertilizer industry of the developed countries has become interested in making the investment required for the production and sale of fertilizers in developing countries. Substantial investments and commitments have already been made but recent announcements of mergers of oil and fertilizer companies indicate the industry is organizing to invest and operate in the expanding market. This is a highly favorable factor for industry can bring foreign capital to work with local capital, modern technology, managerial ability and improved methods of distribution and sales. The influence of this factor could be great. How great will depend on the policies and actions of the industry and the developing countries. Satisfactory arrangements should not be difficult to negotiate for the farmers, government and industry should all benefit.

The industry, a combination of foreign and domestic capital, must be efficient, produce high quality products, and sell them at or near world prices which are lower than in many of the countries today. The industry should fully recognize its responsibility to the public, to serve the farmer and to contribute to the economic growth of the nation. It must invest large amounts of capital, pay reasonable taxes and provide employment and training.

Governments should encourage industry to make the investment required and provide a climate for efficient operation. This will require changes in policy for some governments. It is already evident that the industry is developing mutually satisfactory terms with several governments. This trend of events should continue. If it does, a large and efficient fertilizer industry should develop without much direct financial assistance from governments of either the developing or developed countries.

The method of distributing and selling fertilizers may have great influence on the rate of increase in consumption. In many developing countries, industry is so small that it cannot perform this function and government is trying to do so but without much success. As a system of selling fertilizers is developed, two basic principles should be considered. First, the organization making the fertilizer should be responsible for its sale. This makes the producer more familiar with the problems and needs of farmers and will lead to product improvement and service to the man who uses it. Second, the salesman, dealer, or cooperative must profit from the sale as that is his incentive for trying to sell more. Just as the farmer must have an incentive for producing more, the salesman must have an incentive for selling more fertilizer. He, in turn, should realize that his product gives best results when used with good seed and cultural practices. He, therefore, must be a salesman, not only of fertilizer, but of better farming methods as well.

The relative price of crops and fertilizers have a great influence on farmer demand and use of fertilizer. In the United States and most western countries, the increased use of fertilizers in the post-war period was favored by higher and relatively stable prices of crops and comparatively low and stable prices of fertilizers (3). In many developing countries, on the other hand, the farm price of crops is often low and unstable and the cost of fertilizer is high. These relationships will certainly change in the next ten to fifteen years. Fertilizer prices at the farm level will be lower and will more nearly reflect world prices than they do today. Such a change will certainly be an important factor in promoting the use of fertilizers.

The last factor we will consider is the supply of fertilizers from domestic production and imports. Both will require large amounts of foreign exchange. As previously indicated, it may be possible to secure most of the foreign exchange required for plant construction from the petrochemical and fertilizer industry. There is little probability, however, that domestic production will be adequate for the next ten to fifteen years. Continued large-scale imports will be needed and these can only be financed by the government itself or through the economic assistance programs of other countries and international agencies. The AID survey indicated that lack of foreign exchange for imports has been restricting fertilizer consumption in fifteen countries. They, like the USSR, may need to give greater priority to fertilizer in national development and when allocating foreign exchange. There is also an obvious need for the developed nations

to give greater attention to financing fertilizer imports as part of their economic assistance programs. The U.S. has been doing this on a massive scale for more than fifteen years. Other OECD countries and the International Development Association should give careful consideration to doing likewise. Unless appropriate action is taken in these matters, fertilizer consumption in many countries may be limited by the lack of foreign exchange.

An estimate of future fertilizer consumption in the developing countries must consider the various factors we have discussed and others. None is more important than the resolution of the people and governments of these countries to solve their economic problems. All things considered, we estimate that the average annual rate of increase in fertilizer consumption for 1960-1970 may be 15 percent and that it may decline to 10 percent during the following decade. This would mean consumption of 10.9 and 28.3 million tons of nutrients in 1970 and 1980 respectively.

Our estimates for the three groups of countries and the world are summarized in Table 4. It shows that world fertilizer consumption may reach 53 million tons by 1970 and approach 90 million tons by 1980. These estimates indicate that world consumption may be somewhat greater than the estimates of fertilizer requirements cited earlier in this paper. If the estimated level

Table 4.- Fertilizer consumption in 1960, and estimated consumption in 1970 and 1980, three selected areas of world
(nutrient consumption in million metric tons)

Area	1960 consumption 1/	Compounded rate of increase		Estimated consumption	
		1960-70	1970-80	1970	1980
		Percent			
Western countries 2/	20.0	3.0	3.0	26.9	36.1
Eastern Europe and U.S.S.R.	5.0	12.0	5.0	15.5	25.3
Developing countries 3/	2.7	15.0	10.0	10.9	28.3
World	27.7	6.8	5.3	53.3	89.7

1/ 1960 consumption averaged from consumption data for 1959-60 and 1960-61. Mainland China excluded.

2/ Includes United States, Canada, Western Europe, Oceania and Japan.

3/ Includes all countries of Latin America, Near East, Far East, and Africa, except Mainland China and Japan.

Source: Food and Agriculture Organization of the United Nations, State of Food and Agriculture, Rome 1963, pp. 218-223.

of fertilizer use is attained and accompanied with essential increases in other essential improved practices, the world will be better fed than at any period in history.

We have discussed the growth of the world market for fertilizer, considered factors that will influence the growth of the market, and presented estimates of the market in 1970 and 1980. In closing, we want to emphasize that the level of fertilizer consumption attained will depend in large measure on the policies and actions of the governments and industries of both the less developed and more developed nations. We believe the industry represented at this meeting appreciates the opportunities and responsibilities involved in helping to develop and supply the expanding market for plant nutrients that are so essential in meeting man's food needs and improving his well being.

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