Fertilizer

Can Its Appropriate Use Solve the World Food Crisis?

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Abstract

Fertilizer, particularly nitrogen and phosphate, currently is in short supply and high priced. As a result, world food production is being held back. Construction of new plants worldwide, however, ensures that fertilizer supplies will be sufficient to meet demand and needs by the late 1970s. Whether or not fertilizer production can keep pace with food needs of the exploding populations in the years beyond 1980 seems highly problematical. Shortages of basic raw materials for fertilizer production do not appear to be a problem.

If we are to avoid widespread famine in the developing countries, fertilizer must be used — and in vast amounts. The addition of fertilizer is essential to maintain or increase food production. Estimates generally indicate that 30 to 40 percent of the increased production during recent years in developed countries is directly attributable to increased use of fertilizer. In developing countries, where soils are less fertile, possibly half or more of any increases in production will depend on fertilizers.

Increased use of fertilizers, however, will not do the job alone. It has been amply demonstrated in developing countries, especially by the so-called "green revolution," that fertilizers will increase production only modestly unless used in combination with other good cultural practices. These include improved crop varieties, weed and disease control, irrigation and proper water control where needed, adequate plant populations, and proper tillage. As all professional agriculturists know, much of the success of U.S. farmers in food production, as well as those of other developed countries, depends on use of a balanced package rather than on a single input.

The fact remains, however, that fertilizer is a key input; without it there can be no green revolution. In fact, the high-yielding crop strains are high in yield because they respond so well to fertilizer application.

Selling the concept of a balanced package of inputs to uneducated and often unmotivated farmers in developing countries, however, is a major problem. Most developing countries have a very low ratio of extension people to farmers. The Food and Agriculture Organization (FAO) of the United Nations, for example, has a general objective of one full-time field-level extension worker per 1,000 farm families. Yet, the present average is one per 8,000 families. As a result, relatively few farmers receive professional guidance on fertilizer use or farming practices in general (1). On the other hand, Taiwan, which has been highly successful in increasing its agricultural production, reportedly has one extension worker per 300 farm families.

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World Fertilizer Consumption

World fertilizer consumption has grown tremendously in recent years. But most of the fertilizer is used in the developed countries. Only 14 percent of the world's fertilizer eventually ends in the developing countries—and these countries contain 61 percent of the world's population.

World consumption of plant nutrients (Nitrogen and phosphorus and potassium oxides—(N, P_2O_5, and K_2O) totaled 77.4 million metric tons in 1973 (2). This represents and average increase of about 8 percent per year since 1962. Nitrogen accounted for 36.2 million tons — almost half of the total and three times the 11.9 million tons used in 1962. Phosphate consumption exceeded 22 million tons of P_2O_5, up from 10.5 million in 1962. Potash use totaled 18.7 million tons of K_2O, up from 8.8 million in 1962.

The rate of growth of fertilizer consumption is higher in developing than in the developed countries — about 13 percent, compared to 7 percent per year. But the developing countries have the highest percentage only because their base is much smaller; the developed regions still account for the largest increases in actual tonnage of fertilizer nutrients.

The Tennessee Valley Authority's forecast for total world fertilizer consumption in 1980 is between 105 and 123 million metric tons, or an increase of between 4.8 and 6.9 percent per year from 1972 to 1980 (3). Using the midpoint of the range, 114 million tons, this amounts to 57 million tons of N,31 million tons of P_2O_5, and 26 million tons of K_2O. Seventy-four percent of the 1980 consumption is expected to be in the developed regions. As at present, while the developing countries will continue to lead in terms of relative rates of growth, the developed regions will account for the largest tonnage increases. Developed regions are expected to expand consumption by more than 27 million tons of plant nutrients and the developing regions by more than 14 million. This amounts to an average annual growth rate between 1972 and 1980 of 4 percent for the developed countries and 7 percent for the developing.

Demand for fertilizers, particularly nitrogen and phosphate, recently has been exceeding supply, both on the international market and in most countries. The world fertilizer industry has followed a cyclical pattern in

recent decades — a period of rapid building that leads to excess production capacity followed by a near halt in new plant construction until demand catches up with or exceeds supply. The situation now is one of undercapacity for both nitrogen and phosphate, with world food production hampered by fertilizer shortages. The FAO, for example, estimates that the current shortfall in 100 developing countries totals about 2 million tons of fertilizer — which they say is enough to raise about 16 million tons of grains, the normal consumption of about 100-million people (4).

Over the long pull, however, supply tends to average out with demand. There are some signs at this time that the supply-demand situation is starting to right itself. However, fertilizer prices are still unrealistically high. This has worked hardships on developing countries, most of which import large amounts of either finished products or raw materials, or both. There simply is not enough foreign exchange in most developing countries to pay the high prices to import the materials needed.

Phosphate supply-demand is expected to balance shortly, as the United States and much of the world industry are rapidly constructing new plants (5). Supply is expected to increase 27 percent between 1974 and 1978—bringing the total world production to over 30 million tons of P_2O_5. Demand is expected to increase 21 percent during the same period. All indications are that we will have significant surpluses by 1976 or 1977.

On the other hand, the world nitrogen supply situation may remain precarious until the late 1970s (6). Substantial additional capacity is under construction or planned — from 58 million tons of ammonia in 1972 to 77 million tons by 1978. Continued shortages and high prices of natural gas, naphtha, and fuel oil, which provide hydrocarbons for ammonia synthesis, may well limit production.

Need Versus Demand

The projections on fertilizer consumption by 1980 that have just been given are based on what is likely and feasible and are, of course, independent of actual needs for increases in food production in the developing countries.

We have attempted to arrive at a rough estimate of actual fertilizer needs by 1980 (J. I. Shields, unpublished data, Tennessee Valley Authority, 1975). To do this, certain assumptions have to be made. First, on the world basis, grain crops will be using three-fourths to over four-fifths of the total increase in fertilizer use. World grain production is projected to increase about 4 percent per year from 1,320 million metric tons in 1973 to about 1,737 million in 1980. About 25 percent of the grain will come from increased acreage and 75 percent from higher yields through greater use of inputs. Also, for each kilogram of plant nutrient (N, P_2O_5, K_2O) one may expect, on the average, about 10 kilograms of increased grain yield. Using these assumptions along with the increased fertilizer use projected earlier, it appears that sufficient fertilizer will be available in 1980 to meet the projected increase for grain needs and leave about 14 percent available for nongrain crops, which may be on the short side. If these assumptions are correct, fertilizer use in 1980 should be close to projected world needs.

Meeting the increased fertilizer production by 1980 will be costly. Capital outlay for new facilities between 1974 and 1980 is estimated to total at least $25 billion (J. T. Shields, unpublished data, 1975).

Whether fertilizer production can keep pace with needs in the decades following 1980 is problematical. The writer believes it is extremely doubtful that fertilizer production or, for that matter, agricultural productivity, can keep pace with the exploding population growth in developing nations. Annual population growth rate of the world is now about 2 percent, but runs as high as 3.5 percent in some developing countries. The human population, now at around 4 billion, seems to be headed toward 6 or 7 billion at the end of the century. Vast amounts of capital investment would be required to produce the fertilizers needed; and even if this capital could be obtained, developing countries have numerous constraints that hold back use of fertilizers and the *adoption* of technology.

Constraints Holding Back Use

As mentioned earlier, lack of field-level extension workers is one serious restraint to food production in developing countries. Lack of guidance in wise use of fertilizers is particularly significant. With fertilizers we are dealing with a high cost per acre input, much higher than costs of improved seeds, disease and insect control, and often higher than irrigation. This makes the farmer cautious in fertilizer use, and he may choose not to use any fertilizer.

Lack of adequate farmer incentive perhaps is the most important deterrent to rapid expansion of fertilizer use in developing countries. In most of these countries, particularly in Asia, the cost of fertilizer is high in relation to the prices farmers receive for their produce. As a result, the return on their fertilizer investment is simply too low to encourage adequate fertilizer use. One reason is that developing countries tend to support a cheap food policy so that their consumers can buy food within their limited incomes. Some countries, however, use subsidies to lower fertilizer prices, thereby improving the benefit-cost ratio and stimulating fertilizer use.

Another problem restricting fertilizer use is the very high interest rate that farmers in developing countries must pay for money they borrow. Institutional credit usually is not adequate to meet the farmer's needs, and he is forced to resort to private moneylenders or merchants who may charge interest rates ranging from 40 to 100 percent per year. The amount of money involved to provide adequate credit is enormous. FAO has estimated that credit requirements for fertilizers and pesticides together would amount to $4 billion per year.

Lack of foreign exchange either to build fertilizer plants or import fertilizers seriously restricts the amount of fertilizers available within a country for use by its far-

mers. Also, fertilizer plants in developing countries seldom are able to run at more than about 60 percent of their rated capacities due to interruptions of electrical supplies, poor maintenance, lack of spare parts, and related problems.

Still another constraint holding down fertilizer use is the problem of arranging for timely distribution and availability of fertilizers at readily accessible pickup points for farmers. Port and warehouse facilities usually are inadequate, transportation usually is by truck over poor roads, and storage facilities near point of use are inadequate or nonexistent. As a result, farmers often cannot get the fertilizers at the time, of the kind and quality, or in the amount they need.

In many developing countries, customary land tenure systems do not give the farmer incentive to make improvements to the land. This is true in much of Africa where rights to use agricultural land for cultivation are held by groups or tribes, and individuals do not own the land or possess land-use rights. In much of Latin America, on the other hand, a feudalistic system with large bodies of land controlled by a small, elite class is predominant.

There are many other constraints of varying importance. The significant point is that it is difficult to encourage sufficient and wise use of fertilizers to cope fully with the world food problem.

Availability of Raw Materials

There is deep and widespread concern about the availability of raw materials used in fertilizer manufacture. Four basic materials are needed. These are hydrogen, phosphate rock, potash, and sulfur. Hydrogen is needed for synthesis of ammonia, the basic ingredient of all nitrogen-containing fertilizers; it is obtained from natural gas, naphtha, fuel oil, coke oven gas, or coal. Phosphate rock and potash are the basic ingredients for phosphate- and potash-containing fertilizers. Sulfur is used primarily as sulfuric acid in the manufacture of most soluble phosphate fertilizers. A great many developing countries have no indigenous sources of any of these, or at best only one. As a result, if they attempt to manufacture their own fertilizers, these materials must be purchased on the world market, which again places a heavy burden upon their foreign exchange.

Recent shortages of natural gas, naphtha, and fuel oil — the major sources of hydrogen for ammonia synthesis — undoubtedly have held back new construction of some ammonia plants and contributed to the current fertilizer crisis, both in amounts of nitrogen available and price. Many countries, such as India and Japan, are dependent upon crude oil and naphtha from the Middle East, and the recent escalation in prices has badly upset their economies. It is ironic, too, that in view of the shortages, the oil-rich Persian Gulf countries, Nigeria, Venezuela, and others flare vast amounts of natural gas that is sorely needed in ammonia production.

Over the long pull, however, there is little concern that shortages of feedstocks will greatly inhibit nitrogen production. Although petroleum-based feedstocks may remain in short supply in many countries, coal is widespread and plentiful. Investment costs for coal as a source of hydrogen, however, are much higher than alternate sources of hydrogen because more complex facilities are required. Coal should be available in adequate quantities for centuries; and there is always the possibility that ample supplies of electrolytic hydrogen may become feasible as breeder reactors gain prominence, if controlled fusion becomes a reality, or as thermo-chemical processes are developed.

Deposits of mineable phosphate ores are currently mined at scattered locations throughout the world. While some of these deposits, such as those in Florida, will be exhausted within this century or shortly thereafter, other deposits, such as in the western United States, are very large. In addition, new deposits are being discovered throughout the world, particularly in developing countries where more diligent searches are being made to find fertilizer raw materials. Also, it seems probable that ways will be found to use lower-grade ores in fertilizer manufacture and to improve recovery rates during mining and beneficiation. At any rate, there should be no long-term shortages for the next several centuries.

Commercially suitable potash deposits, like phosphate, are limited to a relatively few countries. However, the known reserves of potash are immense, and there seems little likelihood of shortages developing for hundreds of years.

Although sulfur currently is in tight supply, the long-term outlook is bright. Underground deposits suitable for Frasch mining (the most economic source) are limited primarily to the Gulf Coast areas of Mexico and the United States. Sour gas, containing hydrogen sulfide, is a major source, with producing fields currently located in Canada, France, and the United States. Sour gas deposits also are located in a number of gas-producing countries. Sulfur also is mined as pyrites in a number of countries. Recently, much interest has been shown in sulfur dioxide (SO_2) recovery from coal-fired steam plants as a pollution abatement measure. While this may not become an important source before the early 1980s, it should be a significant one as long as coal is mined, which should be several hundred years. Even if shortages should develop, both nitric and hydrochloric acids can be used as alternate methods to acidulate phosphate ores.

Summary

Fertilizer is one of the most important inputs in increasing world food production. Currently, fertilizers are in short supply. However, many new production facilities are being added and all indications are that supply and demand will be in balance by 1980 or earlier. Also, it appears that by 1980 need will be in reasonable balance with supply and demand.

Whether fertilizer production can keep pace with food needs of the exploding populations in the years beyond 1980 appears highly problematical. With the ex-

ploding population of the developing nations, vast amounts of capital for fertilizer production and distribution facilities would be required (around $25 billion is estimated as required between 1974 and 1980 to bring about the expected increases in production for that period). Besides, there are numerous constraints to increasing usage within the developing countries, such as lack of farmer educational programs, lack of farmer incentive, high interest rates, transportation and other distribution problems, and the existence of land tenure systems unfavorable to making improvements to the land.

Although insufficient amounts of low-cost hydrocarbon feedstocks for ammonia production are currently holding back production and use of nitrogen fertilizers, this is not expected to be a serious drawback to world nitrogen production in the decades ahead. Ammonia can be made from the vast amounts of natural gas being flared in the oil-rich countries, and over the longer pull, ammonia from coal gasification or from electrolytic hydrogen may become prominent. Phosphate ores and particularly potash are plentiful and should last for several centuries. Sulfur, although not absolutely essential to soluble phosphate production, is not expected to be in short supply for prolonged periods. Thus, raw materials for greatly expanded fertilizer production should not be a major concern for the foreseeable future.

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FOOD PRODUCTION: *Problems and Opportunities*

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Abstract

Underproduction of food is a worldwide problem affecting the economic, physical, and social well-being of all people, urban and rural, rich and poor, in developed and developing nations alike. The problem is compounded by lack of accurate information and analysis of factors that limit production and distribution in specific areas, notably in the developing nations of the world. As a first step in improving food crop production, the natural resources, biotic competition, and crop genetic resources should be assessed and coordinated with appropriate management practices for their fullest utilization. Information systems are needed to provide adequate statistics on population growth and trends, total arable land and area planted to various crops, energy resources, climate, natural resources, and other information related to crop and livestock production. Nutrition education is a necessary accompaniment to upgraded food production in many countries of the third world. A possible solution to these problems lies in sharing our research findings and improved technology with the developing nations by means of programs for advanced training and education such as those already being sponsored by various government agencies and private foundations.

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The need for more food in the world is being given much attention. The emphasis has been on the negative factors, such as drought and the rapidly increasing human population with its larger food requirement. Few critical analyses are available on the true nature of the food problem in subsistence agriculture areas in remote rural sections of many developing countries.

The Problem

The rapidly increasing urban areas around the world are also a big and distinct part of the problem of food shortages and total developmental needs. Because they depend almost completely on food production in rural areas, urban problems will not be considered at length in this article. Suffice it to say that urban areas are now growing rapidly and will continue to do so as long as urban dwellers can be fed and as long as life is less desirable in rural areas. Rural productivity of food and other necessary products is a key not only to the well-being of farmers; it is also critical to the well-being of people in the cities. Most cities now are overpopulated (or underbuilt) and adequate food is necessary to prevent further build-up of misery and acute need in the cities of the future. Thus the problem of low rural productivity is accentuated by the continued flow of people (especially those who gain in education) from the farm or village to the city and the capital that goes with them. Appropriate reinvestment of both educated people and capital in rural productivity, especially food production, is now a necessity around the world.

Need for Census Data

One problem common to most developing countries is a lack of accurate census information on rural population and food productivity. At present only crude estimates are available, without analytical treatment of the real nature of the problems of rural areas. The identi-