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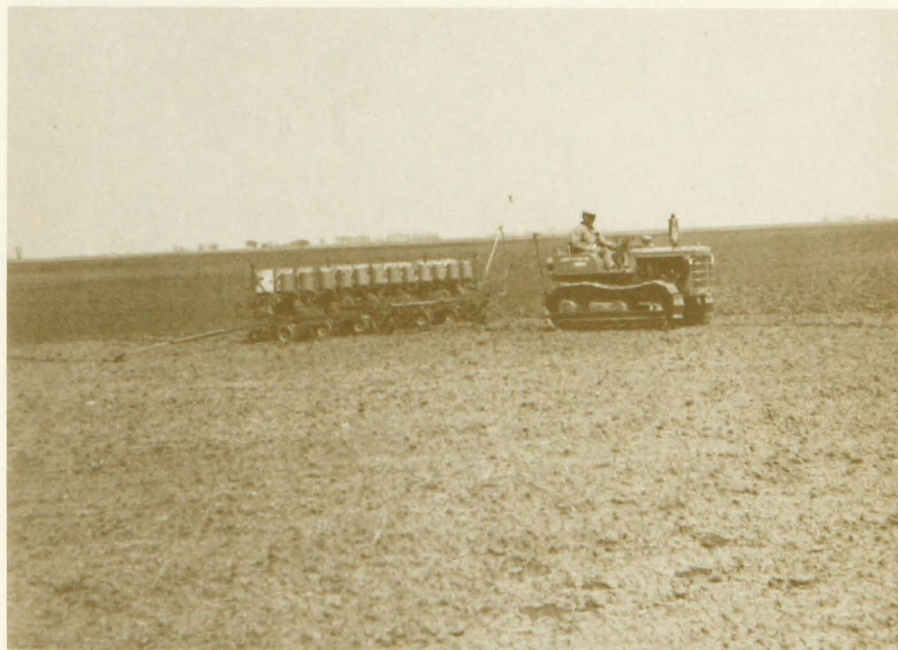
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The Fertilizer Problem . . . Situation And Outlook

Farmers throughout the nation reviewed their fertilizer practices this year as prices skyrocketed and many farmers could not even obtain fertilizer. Together with the energy crisis, the fertilizer situation seemed all the more agonizing during a year of record farm prices. The reasons for the fertilizer shortage and for the high fertilizer prices are many and complex, and it is important that farmers and agribusinessmen understand them. This issue of *Minnesota Agricultural Economist* tells the why's of the fertilizer situation and lets us know what to expect in the future.



Use of fertilizer mixtures and materials in Minnesota is still in the midst of an upward trend which began in 1940. In the year ended June 30, 1973, Minnesota farmers used a record high of 1.8 million tons.

By Dale C. Dahl and
Winston W. Grant

Introduction

Many Minnesota farmers used less fertilizer per acre this year. This was partially because of higher prices. But in some areas, it was also because of a fertilizer shortage. Will sufficient fertilizer be available in 1975 and beyond? Will the prices continue to rise? The answers depend upon several factors. These include availability and prices of fossil fuels, crop acreages, crop prices, prices of other agricultural inputs, farm income, farm size, weather, transportation, and other considerations.

This issue of *Minnesota Agricultural Economist* reviews recent fertilizer demand and supply relationships in Minnesota, the United States, and throughout the world. It projects supply and demand factors that will shape future fertilizer prices and availability. It also discusses the impacts of current and future fertilizer developments.

Preliminary considerations

Fertilizers contain a wide range of chemicals that nourish plants. The most fundamental nutrients are nitrogen, phosphorus, and potassium. Sulphur, another plant nutrient, is also important for the production of some nitrogen and

phosphate materials. These plant nutrients are all produced commercially and used in various ratios in different forms and combinations (table 1).¹

The relationships between fertilizer use and crop production are widely documented. As the amount of cropland increases, more fertilizer is required. Also, crop yield per acre increases with more fertilizer (up to a limit of decreasing returns). Farmers will, in general, expand acreage or try to increase yields when crop prices rise.

Fertilizer supply is restrained by the availability of "feedstocks" (fossil fuels and mineral deposits), fertilizer production processes, and existing manufacturing capacities. Current nitrogen production is largely a process of combining atmospheric nitrogen with hydrogen from natural gas or other carbonaceous materials to form anhydrous ammonia (NH_3). Natural gas is now the predominant input for NH_3 synthesis. In choosing a location for an ammonia plant, a source of cheap feedstock and the potential market are major considerations.²

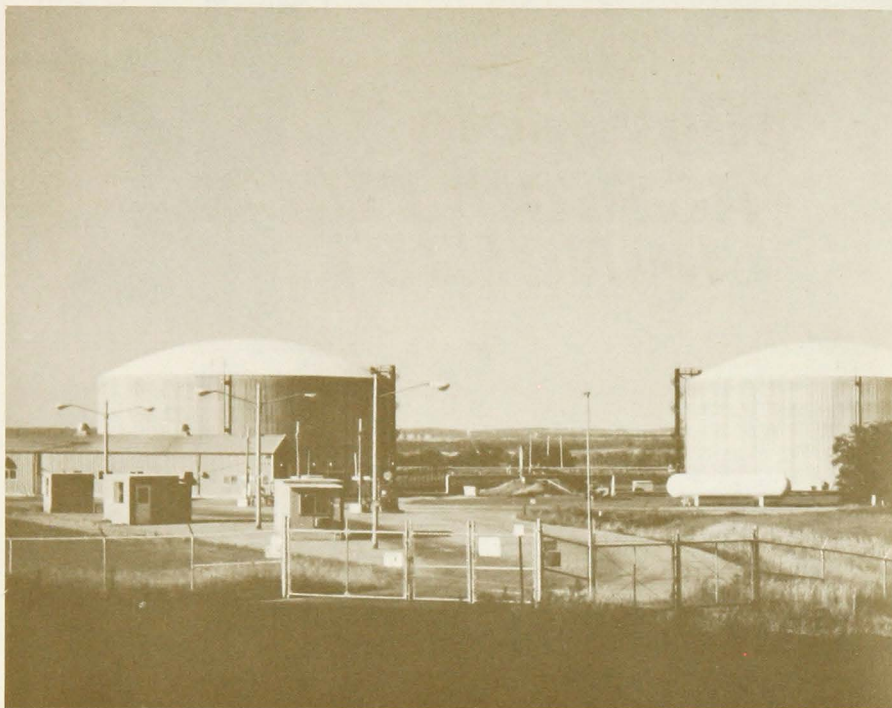
Phosphate rock is the basic source of phosphate fertilizer. The primary mining area is Florida, although deposits exist in Tennessee, North Carolina, and the western states. Normal and concentrated forms of "superphosphate" fertilizers are made with sulphuric or phosphoric acid. The di-ammonium phosphates used extensively in blending and mixing are a product of phosphoric acid and ammonia.³

New Mexico was the major domestic source of potassium fertilizer. Utah and California are other important sources. However during 1973-74, Canada supplied

¹The nutritional value of manure and compost is significant, but not discussed in this article. Estimates for Minnesota farms for 1969 show that manure could provide about 20 percent of croplands' needs that year.

²"The Nitrogen Picture, 1957 Model," *Journal of Agricultural and Food Chemicals*, August 1957 (a staff report), p. 574.

³Douglas, John R., Jr., et. al., *Fertilizer Trends, 1964, including TVA's Activities*, National Fertilizer Development Center, TVA, Muscle Shoals, Alabama, pp. 5-6.



Liquid nitrogen fertilizer is held under pressure in large storage tanks in Minnesota. Barges bring the fertilizer from the Mississippi Delta where it is manufactured.

Table 1. U.S. fertilizer application rates, selected years.

	Application rate ¹		
	1968	1973	1974 ²
	-----Pounds per acre-----		
Nitrogen:			
Corn	96	106	110
Wheat	20	30	32
Cotton	58	54	55
Soybeans	3	3	3
Average—all harvested crops	47	52	55
Phosphate: (P_2O_5):			
Corn	57	55	59
Wheat	14	17	17
Cotton	32	29	30
Soybeans	10	13	13
Average—all harvested crops	31	31	32
Potash: (K_2O):			
Corn	55	57	59
Wheat	6	6	6
Cotton	25	24	25
Soybeans	12	18	18
Average—all harvested crops	26	27	28

¹Pounds per acre of crops harvested.

²Estimated.

SOURCE: *United States and World Fertilizer Outlook—1974 and 1980*, U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 257, May 1974, p. 29.

more than 76 percent of the potash used in the United States.⁴

Some historical developments

From 1940 to 1970, nitrogen fertilizer usage increased more than 17 times. Phosphate consumption increased about five times, and 1970 potassium use was more than nine times the quantity used in 1940. Similar changes have taken place in world consumption, although the relative increases have not been nearly as great. World nitrogen consumption about tripled from 1960 to 1970, while both phosphate and potassium use doubled.⁵

Fertilizer supply has undergone similar changes, especially in the structure of the industry. Only seven firms were manufacturing anhydrous ammonia in the United States before 1940. Eighty-seven percent of those plants' production came from the two largest firms. In 1969, over 85 firms were producing anhydrous

ammonia. The four largest firms represented only about 18 percent of production.⁶

Technological changes and expanding market prospects were primarily responsible for this. In the late 50's, the cost of producing nitrogen was greatly reduced by the centrifugal compressor. The result was several nitrogen-producing plants were built during the 60's. There was a phenomenal increase in U. S. nitrogen consumption. Fertilizer producers believed the demand would continue so farmers could meet domestic food requirements and produce grains for less developed countries (LDC's). The LDC's "Green Revolution" was expected to indefinitely stimulate the strong demand for fertilizer products through the export market.

However in the mid-to-late 60's, the anticipated increase in world fertilizer consumption took a sharp turn. By 1968, the capability of the U. S. fertilizer industry to produce and distribute its products far exceeded consumption. The problem was compounded as developing countries expanded their own fertilizer production capacities.

By 1970, the retail price of anhydrous ammonia was one-half its earlier highest level. Phosphate and potash prices were reduced by about 12 percent. The U. S. industry tried to adjust. Obsolete plants were shut down, many plants were sold, construction was postponed, and expansion was cancelled.

By the early 1970's, world fertilizer supply and demand had begun to balance much faster than the industry in developed countries anticipated. Continued growth in LDC's fertilizer use was prompted by their governments and by development organizations. Record fertilizer imports were also stimulated by adverse weather conditions in many parts of the world in 1971 and 1972. Moreover, production abilities of the developed nations were challenged as these countries tried to increase food and fiber production to satisfy domestic requirements and to supply food for the stricken countries.

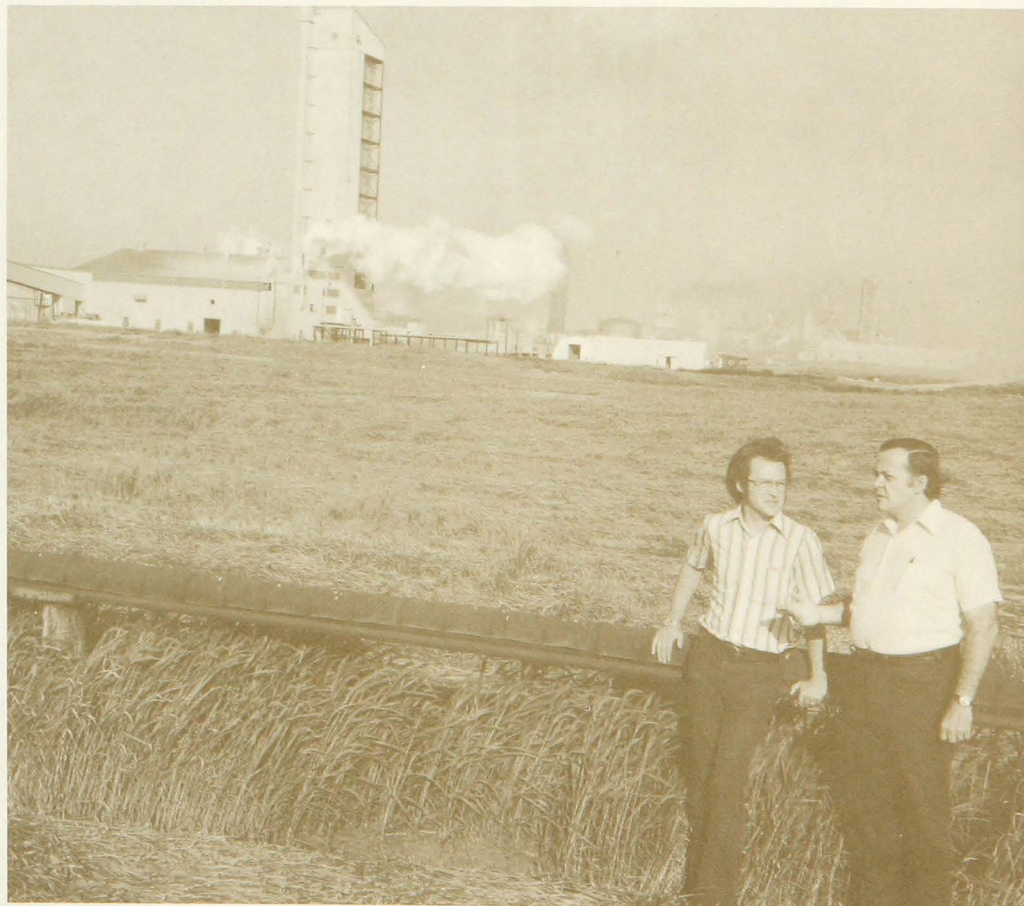
The harsh lesson fertilizer producers learned in the 60's made them cautious about rapidly expanding again. Natural gas shortages and environmental problems also

⁴Derived from information reported in *United States and World Fertilizer Outlook—1974 and 1980*, U.S. Department of Agriculture, Economic Research Service, AER No. 257, May 1974, p. 9.

⁵*Op. Cit.*, p. 1.

⁶*Op. Cit.*, p. 3.

Dale C. Dahl (right) is professor in the Department of Agricultural and Applied Economics, University of Minnesota. Winston W. Grant is a research specialist in the department. In the background of this photo is the only ammonia plant in Minnesota. It's located southeast of the Twin Cities. No nitrogen fertilizer is manufactured in the state.



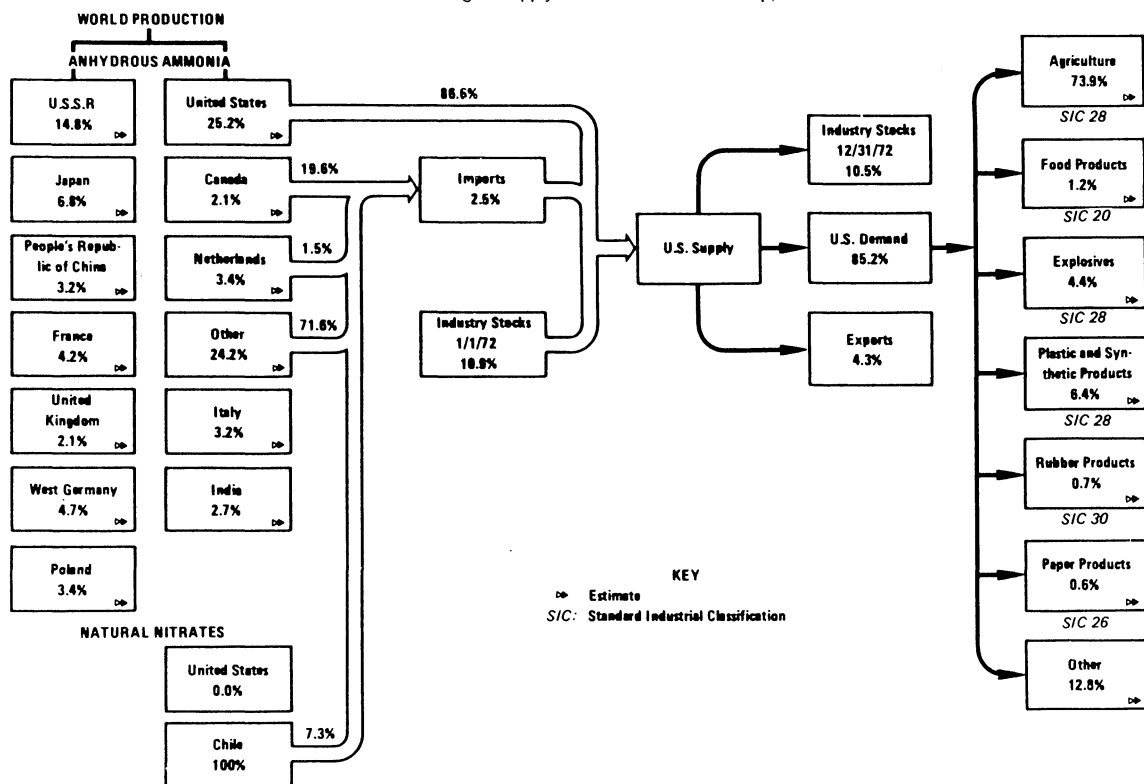


Figure 1. The United States depends upon other countries, in varying degrees, for nitrogen, phosphorus, and potassium. The users of these supplies include many industries other than agriculture. These diagrams indicate the flow of these chemical nutrients from sources to industrial user. (From *United States and World Fertilizer Outlook—1974 and 1980*, U.S. Department of Agriculture, Economic Research Service, AER No. 257, May 1974.)

frustrated expansion efforts. Although expansion is now underway, 2 to 4 years is required to get new plants in full operation in the United States, and 4 to 6 years are required in LDC's.

Not only is the fertilizer industry faced with reduced capacity and inventories of nitrogen, phosphates, and the feedstocks from which they are produced, but it also has an inadequate supply of railroad cars. Last fall, according to Edward Wheeler, president of the Fertilizer Institute, fertilizer producers were receiving less than three-fourths of the cars they needed to distribute available fertilizer.⁷

Minnesota's situation is similar to that of the remainder of the world and especially to that of the rest of the United States. During the 60's, fertilizer consumption showed the combined effects of improved

farm production techniques and the development of new fertilizer distribution and marketing channels. Minnesota fertilizer consumption climbed from a 1962 level of 560,000 tons to approximately 1,780,000 tons in 1973.⁸

In Minnesota, nutrient mining (taking nutrients out of soil without replacing them) took place until about the mid-50's because of the rich nutrient content of the soils. By the mid-60's, programs were in effect to maintain and improve the soils' nutrient balance, to improve the marketing system, and to generally promote the use of fertilizer through user-education programs. The results were significant. From 1955 to 1973, fertilizer use increased nearly fivefold. That compares to an increased use in the

United States during that time of slightly less than 1.9 times. Increased use of primary nutrients (nitrogen (N), phosphates (P_2O_5) and potash (K_2O)) were also dramatic during that time. From 1955 to 1973, nitrogen use increased 12 times, phosphates increased nearly four times, and potash increased more than six times.⁹

At the end of the 1960's, however, Minnesota began to feel the effects of industry recovery from excess capacity, tightened supplies of feedstocks, and bottlenecks in distribution. From 1967 to 1973, the number of dry blending plants licensed to sell fertilizer in Minnesota decreased more than 8 percent—from 491 to 450.¹⁰ And a southern Minnesota coop said that, by the end of the late 1960's, its

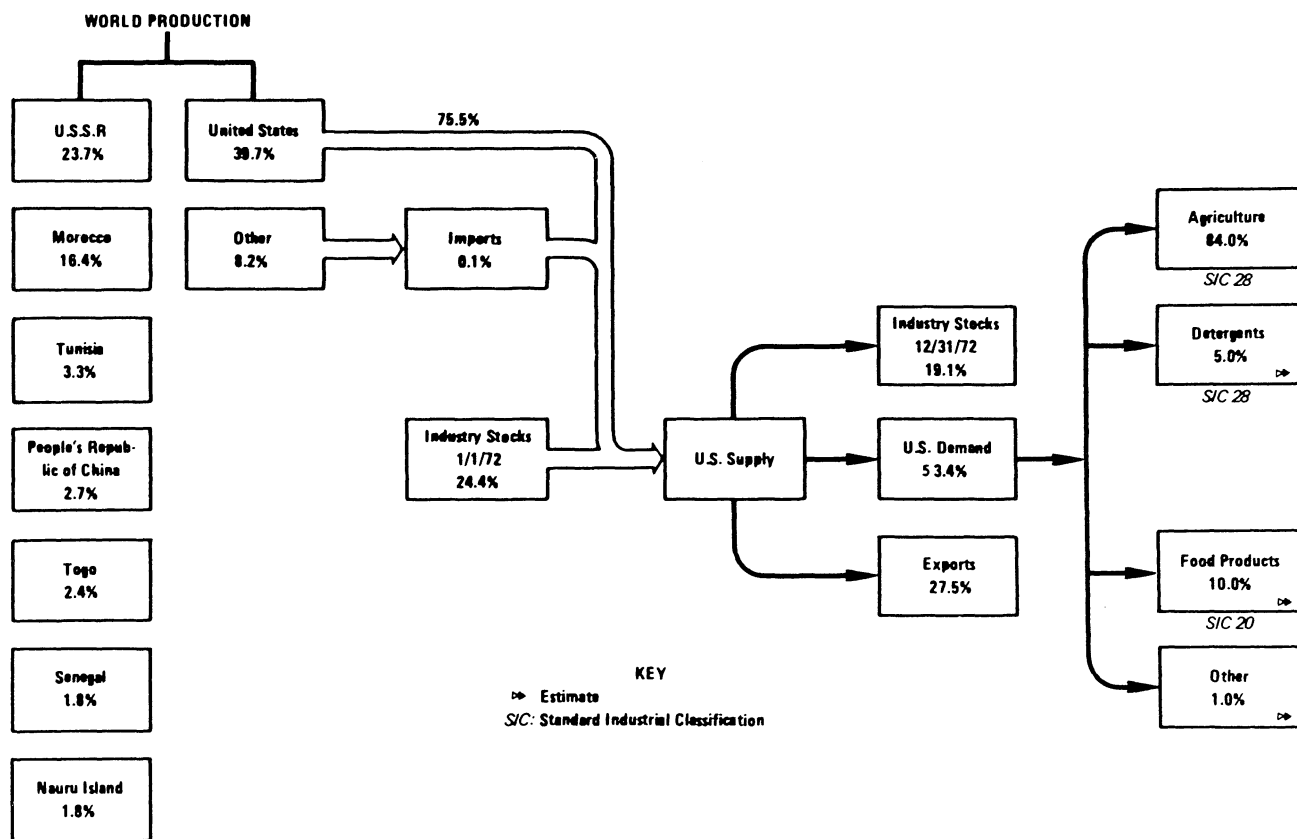
⁷"Fertilizer Institute Cautions Congress on Critical Shortages," *Chemical Marketing Reporter*, Oct. 15, 1973, 5.

⁸*Commercial Fertilizers—Consumption in the United States, Fiscal Year Ended June 30, 1960-1973* issues, U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, Sp. Cr. 7(10-60)-(10-73).

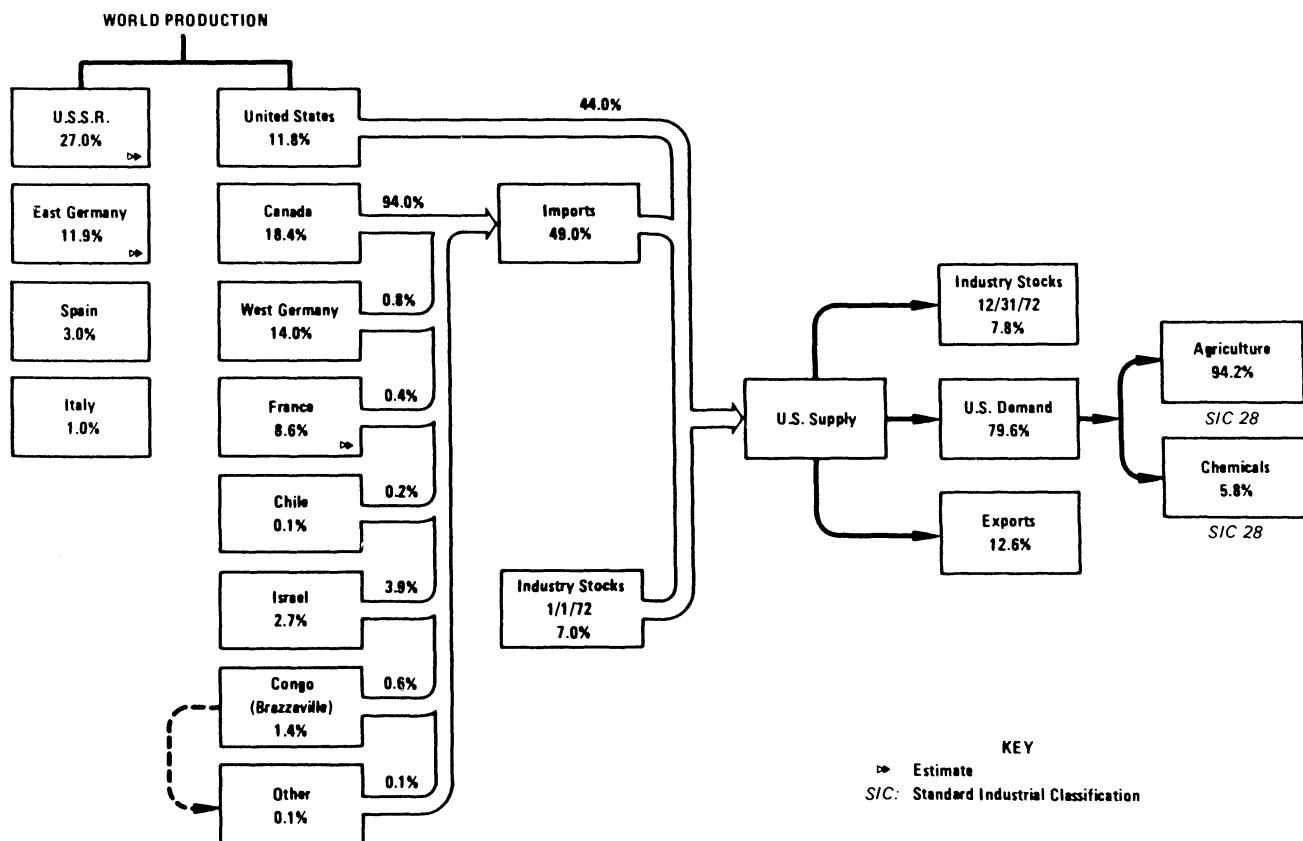
⁹Derived from data at fn. 8.

¹⁰From lists of fertilizer plants and manufacturers licensed for the 1967 and 1973 seasons, maintained by the Minnesota Department of Agriculture, Division of Agronomy Services.

Phosphorus supply and demand relationship, 1972



Potassium supply and demand relationship, 1972



trade area had 12 blending plants.¹¹ Coops were operating two of the plants in 1970. By 1974, one plant had closed, and all but three of the remaining plants are owned and operated by coops. Even the coops, operating at low operating margins and paying high prices for fertilizer, are hard-pressed and sometimes unable to find enough fertilizer for their own customers.

The present situation

World supply-demand balances

Throughout the world, production and consumption of nitrogen fertilizers increased about 300 percent during the 60's. World nitrogen production was estimated at 42.2 million tons in 1973, while 40.2 million tons were consumed.¹² Increases of 8.5 percent in production and 11.4 percent in consumption are estimated for 1974. This means that world nitrogen production and consumption will reach 45.8 and 44.8 million tons, respectively.¹³

Nitrogen surpluses are expected in each developed region. Regions expected to have shortages are the traditional nitrogen importers, i.e., the developing regions of Asia, Latin America, and Africa. This includes Red China, Taiwan, North Vietnam, North Korea, and Mongolia.

Even though a 2 percent nitrogen surplus is expected, the world supply-demand balance is so tight that market imperfections may cause some severe shortages. Regions depending heavily on imports will be most susceptible.

From 1960 to 1973, production and consumption of phosphate fertilizers increased about 150 per-

cent, half the increase for nitrogen. Approximately 26.1 million tons of phosphates were produced and 25.8 million tons consumed worldwide last year. World phosphate production in 1974 will likely be 28.8 million tons, an increase of nearly 10 percent over 1973. This compares to an estimated consumption of 27.7 million tons for 1974.

World phosphate supplies, though still tight, have actually improved from last year's 1 percent surplus. A 1974 surplus of 4.3 percent (1.18 million tons) is expected. World phosphate prices may decline somewhat, but they probably will remain strong.

Some North African countries, Eastern Europe, and the U.S.S.R. have increased phosphate production capacity. These increases have led to a significant surplus of phosphate fertilizer in developing Africa. Eastern Europe, the U.S.S.R., and the United States will likely provide most of the 1974 phosphate exports. The largest deficit regions will be Latin America and developing Asia.¹⁴

Production of potassium fertilizers has grown significantly faster than consumption since 1960, in sharp contrast to the nitrogen and phosphate situations. During the past 13 years, production increased 147 percent, and consumption increased 125 percent. In 1974, production is expected to increase to 24.1 million tons and consumption to 21.4 million tons—increases of 1.6 percent and 5.4 percent, respectively.

Prices fell and profits disappeared in the late 1960's because of several years of capacity expansion. To protect the Canadian potash producers who were on the verge of bankruptcy in 1970, the Saskatchewan government established production controls. Announced capacity utilization rates climbed from less than 50 percent to an estimated 70 percent. Profits reappeared as consumption and production became realigned.

¹⁴*Op. Cit.*, p. 34. The above estimates are based on high consumption levels and rather conservative supply estimates. If production increases above the estimate, a substantial phosphate surplus could begin to appear. This would depress world prices.

World potash production is concentrated in only a few locations. Several regions show substantial surpluses, while others show large deficits. Therefore, there is considerable international trade. The substantial production surplus means that prices are not too high for most importing countries.

Recent U. S. consumption trends

Fertilizer material use in the United States was 42.5 million tons in the year ended June 30, 1973—up 1.3 million tons from the year before (table 2). This increase resulted primarily from increased crop acreage in 1973. Plant nutrient use also continued to grow. In the 1972 fertilizer year (1972-73), nitrogen and phosphate use each showed a 4 percent increase, while potash use was up about 2 percent.

According to U.S.D.A. estimates,¹⁵ (potential) 1974 nitrogen fertilizer consumption is expected to increase 12 percent—to 9.3 million tons. This is about 1 million tons more than was used in 1973. Most of the increased demand is for corn, wheat, and cotton production. Because of higher nitrogen prices, application rates used per acre for these crops are expected to be down.

Phosphate usage in 1974 is estimated to increase half a million tons—9 percent. This is mainly because of increased corn and wheat acreages. Desired phosphate application rates per acre for corn are expected to about equal 1972 rates which were somewhat higher than 1973 use. Planned wheat, cotton, and soybean application rates are expected to continue near 1973 levels.

For most crops, changes in potash consumption in recent years have been determined primarily by acreage changes. Application rates have remained constant. The average potash application rate estimated for all crops in 1974 is near the 1972-73 average. Total potash consumption is expected to exceed the 1973 level by about 7 percent.

¹¹U. S. Congress, Senate, Committee on Agriculture and Forestry, Subcommittee on Agricultural Credit and Rural Electrification, *Fertilizer Supply, Demand, and Prices*, Hearings, Part 1, 93rd Congress, 2nd Sess., Feb. 19, 1974 (Washington: Government Printing Office, 1974), pp. 166-167.

¹²Difference between production and consumption in the same year is explained by inventory holdover.

¹³*United States and World Fertilizer Outlook—1974 and 1980*, *Op. Cit.*, pp. 14-17.

¹⁵*U. S. and World Fertilizer Outlook*, a special report prepared for the Committee on Agriculture and Forestry, U. S. Senate, 93rd Congress, 2nd Sess., March 1974, pp. 5-11.

Table 2. Total material use and primary nutrient use, United States, 1960-73.¹

Year ending June 30	Total use (1,000 tons)	N (1,000 tons)	Available		Total (1,000 tons)	Index (1967 = 100)
			P ₂ O ₅ (1,000 tons)	K ₂ O (1,000 tons)		
1960.....	24,887	2,738.0	2,572.4	2,153.3	7,463.7	53.4
1965.....	31,836	4,638.5	3,512.2	2,834.5	10,985.3	78.6
1970.....	39,591	7,459.2	4,573.9	4,035.7	16,068.8	115.0
1973 ²	42,536	8,338.8	5,072.0	4,411.5	17,822.3	127.5

¹Includes Puerto Rico²Preliminary

Source: Years 1960-69 from "Consumption of Commercial Fertilizers and Primary Plant Nutrients" Stat. Bull. 472, Statis. Rptg. Serv., June 1971. Years 1970-73 from "Consumption of Commercial Fertilizer in the United States" SpCr 7 (10-73) Statis. Reptg. Serv., USDA, November 1973 and earlier issues.

In addition to higher prices and other factors affecting fertilizer application rates, acreages are important in determining the quantity of fertilizer farmers are expected to demand in 1974. According to their planting intentions expressed in January, farmers will harvest about 339 million acres in 1974. This represents an increase of 5 percent—17 million acres more than in 1973 and 46 million acres more than were harvested in 1972. Most of the 1974 acreage increase is expected in corn, wheat, and cotton. Soybean acreage may decline slightly.

Since Oct. 25, 1973, when fertilizer prices were exempted from ceilings, prices have risen rapidly. Nitrogen prices had increased 60 to 70 percent by mid-January; phosphate prices increased more than 40 percent; and potash prices rose nearly 30 percent. Under normal market conditions, higher fertilizer prices would tend to reduce application rates. However, 1974 crop prices are expected to be the highest ever, except maybe for 1973. The crop price/fertilizer price ratio must change to alter farmer application rate behavior.

Given current crop yield response to fertilizer application and high crop prices, farmers are expected to continue the use of fertilizer—at least up to recent rates if fertilizer is available. They should have little trouble financing increased fertilizer expenditures because of last year's record high net farm income.

U. S. production of fertilizer

Nitrogen is produced by 60 firms in the United States. These firms

operate 90 plants with an engineered annual capacity of 17 million tons of anhydrous ammonia—the basic nitrogen fertilizer. Due to high nitrogen prices, some producers are operating at about 94 percent of capacity. So far this year, reduction of natural gas supplies has not appeared to be a major constraint. Including other nitrogen sources, domestic production is expected to be 10.2 million tons in 1974, up from the 9.6 million tons in 1973.¹⁶

Phosphate is produced domestically by 25 companies in 30 plants. Estimated capacity is about 6.5 million tons P₂O₅. Phosphate production is expected to reach 5.9 million tons in 1974. Other phosphate sources will bring domestic supplies to 6.5 million tons, up slightly from 1973.

Domestic potash capacity is 2.9 million tons. The 11 companies producing it are located in the Southwest, mostly in New Mexico. Production is estimated at 2.5 million tons for 1974. Other domestic sources add another 430,000 tons for an expected 1974 supply of 2.93 million tons—up 300,000 tons from 1973.

The U. S. industry exported fertilizer to help recover from the chronic surpluses of the mid-60's. U. S. nitrogen exports exceeded imports for the first time in 1966. These exports continued to climb rapidly until 1969 when they peaked at 1.59 million tons. Net nitrogen

exports (exports minus imports) in 1974 are expected to total 444,000 tons.¹⁷

The United States provided over 30 percent of world phosphate exports in 1972. Except for 1969 and 1970, exports increased each year over the previous year. In 1974, exports are expected to reach 1.6 million tons, nearly 25 percent of domestic production and 13 percent more than 1973 exports.

Only a small portion of U. S. potash consumption is from domestic supplies. Canada supplies well over one-half the potash consumed in the U. S. In 1974, approximately 4 million tons of potash will be imported from Canada—up from 3.2 million tons in 1973.

Increased U. S. nitrogen and phosphate exports resulted from world prices that were higher than domestic prices. During the fertilizer surplus in the mid- to late 60's, U. S. prices exceeded world prices. Thus, only surplus U.S. fertilizers were exported. In the past few years, however, rising prices have made the export market attractive. To relieve export pressures, the Cost of Living Council removed fertilizer price controls on Oct. 25, 1973. Even though U. S. farmers could then bid for exportable fertilizer, world prices still provided a strong incentive to export.

Table 3 shows spring 1974 prices for important fertilizer materials in the U. S. and the spring and fall prices for the previous 3 years. The effects of decontrol are obvious.

Although domestic supplies of potash are more than adequate,

¹⁶*Op. Cit.*, p. 8. Of the 13 million tons of nitrogen contained in the 16 million tons of ammonia produced, three-fourths, or 9.86 million, tons are available for fertilizer uses.

¹⁷*Op. Cit.*, pp. 6-11.

Table 3. Prices farmers paid per ton for selected fertilizer materials, United States, April, 1971-April 1974.

Fertilizer material	1971 April/Sept.	1972 April/Sept.	1973 April/Sept.	1974 April
	--dollars--			
Nitrate of soda	65.1/65.0	66.1/69.7	77.4/81.8	131
Sulphate of ammonia	51.7/51.2	52.1/53.0	55.2/59.5	110
Ammonium nitrate	63.3/63.8	64.7/65.4	71.4/77.3	139
Anhydrous ammonia	79.3/79.3	80.0/80.8	87.6/92.5	183
Urea	81.9/80.3	81.4/82.7	90.3/96.2	180
Super phosphate—20%	47.8/49	49.9/51.2	53.7/56.0	91.4
Super phosphate—46%	76.6/76	78.0/79.0	87.5/94.1	150
Phosphate rock	24.1/24.9	25.8/25.5	26.5/26.7	38.5
Muriate of potash 60% K ₂ O	58.2/57.7	58.8/58.7	61.5/63.6	81.3

Source: "Agricultural Prices," U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, April and September issues for the years cited.

Table 4. Fertilizer nutrient balance, United States, 1971/72-73/74

Item	1971/72	1972/73	1973/74
-----1,000 short tons-----			
Nitrogen:			
Domestic production ¹	9,097	9,560	10,232
Imports	843	881	946
Total available supply	9,940	10,441	11,178
Exports	1,032	1,350	1,390
Net supply	8,908	9,091	9,788
Demand	8,016	8,339	9,300
Unidentified demand ²	892	752	651-930
Total requirements			9,951-10,230
Deficit			150-450
Phosphate (P ₂ O ₅):			
Domestic production ¹	6,150	6,387	6,529
Imports	326	312	291
Total available supply	6,476	6,699	6,820
Exports	1,102	1,424	1,606
Net supply	5,374	5,275	5,214
Demand	4,873	5,072	5,500
Unidentified demand ²	501	203	385-550
Total requirements			5,885-6,050
Deficit			671-836
Potash (K ₂ O)			
Domestic production ¹	2,432	2,680	2,929
Imports	3,088	3,192	4,139
Total available supply	5,520	5,872	7,068
Exports	657	922	1,013
Net supply	4,863	4,950	6,055
Demand	4,332	4,412	4,700
Unidentified demand ²	531	538	540
Total requirements			5,240
Surplus			815

¹Adjusted for producer inventory changes.

²Unidentified demand is an amount of material produced and distributed that cannot be accounted for with the current data system. It may include product loss, changes in retail and farm inventories, and other undetermined items.

Source: USDA, ERS, *U.S. and World Outlook—1974 and 1980*, AER, No. 257, p. 12.

nitrogen and phosphate fall short of the quantities demanded (table 4). Increased production will not satisfy expected demand. The nitrogen deficit is estimated at 150 to 450 thousand tons—from 1.5 to 5 percent of demand. The phosphate deficit is more severe than the nitrogen deficit, ranging from 12 to 15 percent of demand.

The Minnesota situation

The current fertilizer situation in Minnesota reflects the situation in the remainder of the U. S. Fertilizer supplies are subject to the same constraints and limitations as are the supplies for the country as a whole. Beyond that, the Minnesota situation depends upon the ability of the distribution system to handle farmer's requirements. Alternate sources will be used to satisfy the demand left unfilled by the state's distributors. These alternate sources will probably sell at much higher prices.

Use of fertilizer mixtures and materials in Minnesota is still in the midst of an upward trend which began in 1940 when only 19 thousand tons were used. Since that time, use decreased from the previous year's use only twice, in 1970 and in 1972. Decreases in those years did not reflect any major changes in the trend, but rather indicated the effects of adverse weather at planting and application times. In the year ended June 30, 1973, use reached an alltime high of nearly 1.8 million tons—up from 1.6 million tons the previous year. This increase resulted primarily from the increase in cropland fertilized.

Figure 2 shows fertilizer use growth trends in Minnesota, the North Central States, and the United States. Those trends indicate that, until 1967, fertilizer use in Minnesota grew at about the same rate as in the region and country. Since then, it has grown at substantially greater rates. In 1973, fertilizer use in Minnesota was 223 percent of the 1965 usage; in the North Central States and the United States as a whole, it was 160 percent and 136 percent of 1965, respectively.

Plant nutrient use continued to grow in 1973. Nitrogen and phosphate use were each up more than 12 percent, while potash use increased about 8 percent.

Potential consumption of nitrogen in 1974 could increase 17 percent to 495.6 thousand tons. This is about 70 thousand tons more than was used in 1973. Most of the increased demand is for corn, wheat, oats, and barley.

Phosphate demand in 1974 could increase as much as 9 percent over 1973—26 thousand tons. Potash demand could increase 12 percent—33 thousand tons. The increased demand would be expected from corn, wheat, oats, and soybeans.

Since the ceilings were removed last fall, fertilizer price increases in Minnesota have paralleled those for the U. S. as a whole. Prices reported in April 1974 for principal grades and materials were in all cases as high in Minnesota as were those for the U. S. In several cases, they were nearly \$20 per ton greater.

Table 5 shows spring 1974 prices paid for principal grades of mixed fertilizers and for important fertilizer materials in Minnesota. Comparisons for spring and fall prices of the previous 3 years are also shown. As with U. S. prices, Minnesota prices show the obvious effects of tight supplies and no price control. April 1974 prices of the mixed fertilizers all show an increase of at least 50 percent from September 1973; the increases ranged from 54 percent to 83 percent. Prices of the fertilizer materials ranged from 37 percent more for muriate of potash to 110 percent more for anhydrous ammonia.

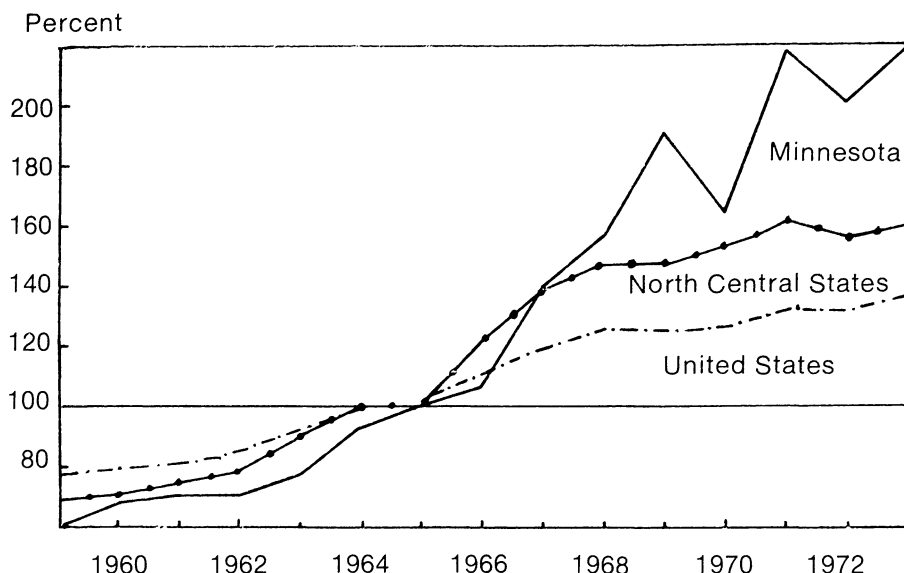
The outlook

The world fertilizer outlook

The world's nitrogen production capacity—including current capacity plus known planned additions—is expected to reach 63.7 million tons by 1978. If plants operate at 95 percent of capacity in developed regions and at 70 percent of capacity in LDC's, production will be 56.6 million tons. Demand is expected to reach 56 million tons by 1978. Thus, supply and demand will continue to be in tight balance.¹⁸

¹⁸United States and World Fertilizer Outlook—1974 and 1980, U. S. Department of Agriculture, Economic Research Service, AER No. 257, May 1974, pp. 34-41.

Figure 2. Trends in fertilizer use, Minnesota, North Central States, and United States, 1960-1973. 1965 = 100 percent.



SOURCE: "Commercial Fertilizers, Consumption in the United States, Year Ended June 30," Issues 1960 to 1973, U.S. Department of Agriculture, Crop Reporting Board.

Table 5. Prices farmers paid per ton for selected commercial fertilizers, Minnesota, April 1971-April 1974.

Item	1971	1972	1973	1974
	April/Sept.	April/Sept.	April/Sept.	April
-----Dollars per ton-----				
Mixed fertilizers				
5-20-20	70/69	72/71	77/81	125
6-24-24	77/76	79/78	84/87	140
7-21-7	—/70	68/70	82/85	155
8-32-16	84/83	86/84	91/98	160
10-34-0	—/90	91/94	100/110	175
12-12-12	67/67	76/69	75/76	120
18-46-0	97/95	100/100	115/115	200
Fertilizer materials				
Sulphate of ammonia	45/56	57/58	64/65	125
Ammonium nitrate	65/63	66/66	72/77	150
Anhydrous ammonia	79/79	82/81	88/95	200
Urea	93/86	84/77	89/100	200
Superphosphate 20%	52/53	58/59	65/70	120
Superphosphate 46%	79/77	82/82	88/97	160
Phosphate rock	33/35	35/35	36/40	60
Muriate of potash	57/55	59/57	60/60	82

SOURCE: "Agricultural Prices," U.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, April and September issues for the years cited.

World demand for nitrogen is expected to range from 57 million tons to 64.6 million tons in 1980—an increase of 42 to 61 percent over 1973. Using the midpoint as the most likely demand in 1980, estimated 1980 capacity (based upon 1978 capacity forecasts) will not meet this demand. Assuming plants in developed regions will operate at 95 percent of capacity while those in LDC's operate at 70 percent, something less than 10 million tons of capacity will be required to satisfy demand and to allow for a safe margin.

Recent plant announcements not included in these estimates suggest a strong supply response to current high prices and the anticipated 1980 deficit. The largest expected deficit region includes Red China, Taiwan, North Vietnam, North Korea, and Mongolia, and primarily Red China. However, Red China is reportedly embarking on a major expansion of nitrogen capacity. At least 10 large plants have already been contracted, some of which have been announced since supply estimates were made. Since Red China has a good record of capacity utilization, results of the Chinese program could have a significant impact on the size of the 1980 supply deficit.

Another region showing a sizable deficit and for which few data are available is East Europe-U.S.S.R. A recently announced agreement has been made between the U.S.S.R. and a U.S. oil company for construction of several large ammonia plants in the U.S.S.R. These could significantly reduce the 1980 estimated fertilizer supply deficit. Details on the construction schedule have not been announced.

If production capacity is not expanded, developing Asia would also have a substantial supply deficit in 1980. Some of the Mideast oil-producing countries in developing Asia have begun to produce nitrogen fertilizer. Current nitrogen production technology is closely tied to natural gas or naphtha, a petroleum refinery product. Many Mideast countries have these materials in abundance at very low cost. It seems likely they will expand their nitrogen production, particularly for exports, since many have a very limited agricultural base.

The 1980 phosphate situation, however, is not as critical as the nitrogen situation. World demand by 1980 is expected to range from 31.2 to 37.6 million tons P_2O_5 —an increase of 21 to 46 percent over 1973. Using the midpoint as the most likely demand in 1980, current capacity plus planned additions should meet anticipated demand. Assuming plants will operate at 95 percent of capacity in developed countries and 70 percent in LDC's, a surplus of 3.4 million tons will result. This is nearly 10 percent of anticipated consumption. If production should reach only 85 and 60 percent of capacity, respectively, the surplus would be only one-half million tons—about 1.5 percent of consumption.

The principal deficit areas are developing Asia and Latin America. Developing Africa should have a substantial surplus from high levels of production in North Africa. In contrast to the nitrogen situation, North America (chiefly the U.S.) will likely remain the world's largest phosphate-exporting region and a principal source for deficit developing regions.

World demand for potash is expected to range from 25.9 million tons K_2O to 30.6 million tons by 1980—an increase of 27 to 50 percent over 1973. Using the midpoint as the most likely estimate of demand, current potash capacity will not satisfy demand in 1980. A deficit of nearly 1.7 million tons would result. Although no planned additions have been announced, Canadian producers have indicated they will expand to satisfy world demand. With virtually unlimited reserves, Canada will remain the dominant exporter.

The U.S. fertilizer situation in 1980

A USDA study—based on forecasted fertilizer application rates and acres necessary to satisfy domestic and export food and fiber needs—projects increases in nitrogen use from 8.3 million tons in 1973 to 10.4-10.8 million tons in 1980.¹⁹ An assumed 6 to 10 percent reduction in crop acreages offset part of the effect of an anticipated

24 percent increase in nitrogen application rates. Phosphate projections indicate consumption of 5.7 to 6 million tons by 1980. Potash consumption is expected to be 5.4 to 5.5 million tons in 1980.

Despite the apparent shortage of natural gas, ammonia capacity is expected to increase significantly by 1980. Several plants are now under construction or planned for completion by 1980. Therefore, domestic nitrogen production is expected to increase by at least 11.1 million tons.

The United States' wet process phosphoric acid capacity is 6.5 million tons annually. Plants under construction or anticipated would give the U.S. about 9 million tons of phosphate production capacity by 1977.

Domestic potash production capacity is 2.3 million tons K_2O per year. Although this is well below domestic consumption, domestic capacity is not expected to increase because of the large quantities of Canadian potash nearby.

Nitrogen will continue to be in tight balance through 1980 with an expected surplus of 3 to 6 percent. This is approximately the amount necessary to prevent distribution problems and spot shortages.

The U.S. should be able to import nitrogen to offset exports and to cover unexpected increased consumption. American firms are building ammonia plants in the West Indies for the U.S. market, and other plants are expected. Plants are also under construction or planned in Canada and Mexico. Although some of this nitrogen will be used in the producing countries, considerable quantities could be exported to the U.S. The Canadian and Mexican plants are being built under the assumption that they can capture some of the nearby U.S. market. Similarly, the U.S. will be able to outbid other potential buyers since transportation costs—which account for a large portion of delivered cost—will be considerably below those of competitors. With estimated imports of about 2 million tons, the U.S. nitrogen supply is expected to be approximately 13 million tons. Although nitrogen prices may fall below current levels, they will not decline to recent levels.

¹⁹*Op. Cit.*, pp. 25-33.

The tight phosphate situation will ease as the new plants begin producing. By 1975 or 1976, phosphate production should exceed demand substantially. Therefore, the U.S. should continue to be an important phosphate exporter. Prices should begin to decline at that time.

The U.S. will continue to be a potash importer. With the world's largest potash reserves in nearby Canada, the U.S. should have little difficulty obtaining needed supplies.

Future prospects for Minnesota

The average annual compound growth rate of fertilizer used in Minnesota from 1955 to 1973 was nearly 10 percent.²⁰ If this remarkable growth rate continues, fertilizer use in Minnesota would be 3,462,000 tons by 1980. The 1985 projection

would be 5,568,147 tons—nearly 4 million tons over 1973.

If every acre of producing cropland received the recommended fertilizer rate, an additional 702,790 tons would need to be applied now. On many Minnesota farms, there is a trend toward using even greater rates than those used to calculate aggregate recommendations. There is also a trend toward fertilizing an increasing share of producing cropland. If these trends continue, the fertility gap may be closed by 1980 and fertilizer use would be greatly expanded.

Minnesota fertilizer use patterns can also be projected from application rate trends and the percentage of cropland fertilized. By 1969, the fertilizer application rate had reached 241 pounds per acre. The projected rate would be about 357 pounds by 1980. A negative trend in harvested cropland is offsetting pressure against factors that tend to increase fertilizer consumption. A continuation of the combined effects of a negative trend in acres and a positive trend in fertilized cropland would result in 95.9 percent of all Minnesota

cropland being fertilized in 1980; by 1985, some fertilizer will be applied to all Minnesota cropland. When these projections are combined, the projected tonnage in Minnesota becomes 1,514,360 tons of fertilizer for 1975, 2,293,851 tons for 1980, and 2,665,913 tons for 1985.

Table 6 shows Minnesota's estimated fertilizer needs for 1980 based on two alternative programs. Model A considers present farm programs for feed grains, wheat, and cotton, along with trend level exports based on the past 15 years (1959-74) in 1980. Model B is more conservative; it includes acreage quotas on feed grains, wheat, and cotton with a low estimate for exports in 1980, i.e., no export subsidies. Materials needed range from 1,896,000 tons in Model B to 2,136,000 tons for Model A. Under Model B, nitrogen requirements will be less in 1980 than consumption was in 1973. Phosphate requirements under both models are less for 1980 than for 1973. However, potash requirements based on this estimating procedure are greater for 1980 in both instances than was actual use in 1973.

Table 7 summarizes fertilizer consumption projections for each of the four procedures. The estimate based on continuing the 10 percent compound consumption growth rate is much greater than any of the other estimates. The estimates based on crop acreage are considered most realistic and reliable. Farmers will not be able to maintain or increase yields if they do not apply at least maintenance rates. On the other hand, it makes little economic sense to apply fertilizer quantities in excess of withdrawal rates except to develop soil fertility to a basic level. Nitrogen levels cannot be built up by commercial fertilizer. Potash and phosphate levels can. However, agronomists indicate that basic phosphate fertility in some areas of Minnesota has been developed to adequate levels during the past decade. Some areas need to develop basic potash fertility, particularly in the more sandy soils.

Conclusions

Recent increases in fertilizer prices and shortages in Minnesota result from: several complex developments in world, national, and local markets for agricultural pro-

²⁰Based on tonnage reported in Fertilizer Summary Data, 1969 op. cit., and "Commercial Fertilizers—Consumption in the United States," (Washington, D.C.), U.S. Dept. of Agriculture, Statistical Reporting Service, Reports Sp Cr 7 (5-72), (5-73), (10-73).

Table 6. Estimated fertilizer maintenance needs for alternative farm program acreages, Minnesota, 1980.

Farm program	Tons N	Tons P ₂ O ₅	Tons K ₂ O	Tons total nutrients	Tons total materials
Model A	426,131	246,579	393,065	1,065,775	2,131,550
Model B	319,992	228,160	299,847	947,999	1,895,998

SOURCE: "An Economic Analysis of Fertilizer Retailing in Minnesota," unpublished Ph.D. thesis by Robert A. Rathjen, University of Minnesota, December 1970, p. 66.

Table 7. Various projections of fertilizer use, Minnesota, 1970-1985.

Method	1970	1975	1980	1985
-----thousand tons-----				
Continuing 10 percent compound growth rate	1,307	2,153	3,462	5,568
Considering projected rate of fertilizer use and increased cropland fertilized	998	1,514	2,294	2,666*
Alternative farm programs				
Model A			2,132	
Model B			1,896	

*Fertilizer containing 50 percent plant nutrients.

ducts and inputs; the energy crisis; government policies; and transportation problems.

The nitrogen and phosphate shortages are primarily from increased demand in the United States and throughout the world. Increased U.S. demand is stimulated by high crop prices, increased crop acreages, and 1973 record farm incomes. The U.S. shortages were also partly the result of high world prices compared to domestic prices. Therefore, U.S. fertilizer prices were decontrolled last fall, but world prices have remained competitive. The export incentive remains strong.

The U.S. demand for nitrogen fertilizers is expected to reach 9.3 million for July 1973 to July 1974—12 percent above the previous year's demand. Phosphate demand is expected to be up 9 percent to 5.5 million tons. The nitrogen supply may fall short of demand by as much as 5 percent, and the phosphate deficit could reach 15 percent. The potash situation is relatively good. The most serious problem for potash is transportation bottlenecks during crop shipping peaks.

Even though we are experiencing fertilizer shortages in nitrogen and

phosphates, 1974 use of both is greater than 1973 use. In addition, application in recent years has been well above maintenance levels. Therefore, reductions in applications should not significantly reduce crop yields.

Much of foreign countries' sudden increase in fertilizer demand can be attributed to their farmers' efforts to recover from severe and widespread drought in 1971 and 1972. This is another factor in the high 1973 crop prices. World demand for nitrogen is expected to reach 45 million tons this fertilizer year, while phosphate demand will be 28 million tons. These are increases of 11 and 7 percent, respectively. Potash consumption will be about 21 million tons—5 percent above last year.

By 1980, nitrogen and phosphate production will increase substantially in the U.S. and throughout the world. However, shortages or tight markets can be expected for several years because of 2-6 year lag times required to build new plants.

High prices probably will prevail for some time. Countries and regions that can pay the highest prices will have the advantage. Some poorer

countries, especially the less developed countries, could face serious shortages.

Problems faced by Minnesota farmers are similar to those for U.S. farmers in general. Minnesota is not a producer of primary plant nutrients. Therefore, the most serious problems will be high prices and distribution. Probably the number of small, independent farm input suppliers will decrease. In 1973, the number of Minnesota dry blending plants has already decreased.

Alternatives for easing the fertilizer situation may be to (1) modify energy allocations in favor of fertilizer production; (2) embargo exports; (3) allocate fertilizer; (4) encourage imports; (5) establish an improved information system; (6) improve scheduling in transportation. Certainly, some of these alternatives are more attractive than others, but some combination could provide short term relief.

In the long run, the most feasible alternatives are to increase feedstocks availability, increase production capacity, and improve use of effective capacity, especially in the less developed countries.

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