NITROGEN

By Jim F. Lemons, Jr.

Nitrogen (N) is an essential element of life, a part of all plant and animal proteins. Crop plants cultivated for both human consumption and as animal feed require nitrogen for proper nutrition and maturation. Some crops such as alfalfa, soybeans, garden peas, and peanuts can convert atmospheric nitrogen into a usable form in a process called "fixation." However, most nitrogen available for crop production comes from decomposing animal and plant waste or from commercially produced fertilizers.

All commercial fertilizers contain their nitrogen in the ammonium and/or nitrate form or in a form that is quickly converted to these forms once the fertilizer is applied to the soil. Nitrates are produced from mineral resources principally in Bolivia and Chile. Commercial production of anhydrous ammonia is based on reacting nitrogen with hydrogen under high temperatures and pressures. The source of nitrogen is always air, which is almost 80% nitrogen. Hydrogen is derived from a variety of raw materials, including water, and crude oil, coal, or natural gas hydrocarbons. Other nitrogen fertilizers are produced from ammonia feedstocks through a variety of chemical processes.

In 1996, there were 25 ammonia producers with 41 plant locations in the United States. Many companies in the fertilizer industry were expanding their operations to include production of all three major plant nutrients—potassium, phosphorus, and nitrogen. Principal changes in the industry included the acquisition of nitrogen producer Arcadian Corp. by the Potash Corp. of Saskatchewan (PCS), and Mississippi Chemical Corp.'s acquisition of the plants of First Mississippi Fertilizer Inc.(Ampro) and of Triad Chemical Co.

Industry statistics for anhydrous ammonia and derivative products were developed by the Bureau of the Census, U.S. Department of Commerce. Summary of production of principal inorganic fertilizers by quarter is reported in the series MQ28B, and industrial gases (including nitrogen) are reported in the quarterly report MQ28C. The Bureau of the Census surveys approximately 250 producers of inorganic fertilizer materials. Final data are subsequently published in a companion annual report MA28B.

Legislation and Government Programs

Two court cases this year held significant interest for manufacturers of urea and ammonium nitrate. In May 1995, a suit filed by the relatives of people killed in the April 1995 Oklahoma City Federal Building bombing alleged that ICI Explosives USA had been negligent in allowing ammonium nitrate to be sold, knowing that it could be used in making explosives, without adding chemical desensitizers that might make the material less reactive. One technical question in this litigation is the feasibility of limiting explosive potential in large-scale volumes with the addition of monoammonium or diammonium phosphate or calcium ammonium nitrate. This lawsuit was followed by similar litigation against Arcadian, Norsk Hydro, and Dyno Nobel by the New York and New Jersey Port Authority for allegedly supplying nondesensitized fertilizers, which were ultimately used in the World Trade Center bombing of February 1993. By midyear, the Oklahoma bombing case against ICI Explosives had been dismissed by the Oklahoma District Court, which ruled that ICI had no obligation to anticipate and guard against the willful and criminal misuse of its products. The final impact of this dismissal on the second court case has yet to be determined (Nitrogen, 1996a, e, f).

The final Environmental Protection Agency (EPA) rule for preparing an Industry Risk Management Plan was signed May 24. The rule covers plants, terminals, and dealerships that handle more than the threshold limits of 4.5 tons of anhydrous ammonia, or 9 tons of aqua ammonia in 20% solution or 6.8 tons of nitric acid in concentrations of more than 80%. The rule requires these companies to perform a hazard assessment for each location, set up a release prevention program, and draft an emergency response plan. This combined Industry Risk Management Plan is to be submitted in 1999 (Green Markets, June 17, 1996)

Production

Production of anhydrous ammonia (82.2% N) increased 12% in 1996 to 14.6 million metric tons of contained nitrogen compared with that in 1995. Eighty-six percent of the production was for use as a fertilizer; the remaining 14% was used in other chemical and industrial sectors. (*See tables 1 and 2.*) Much of the increase in production was used domestically. Prices returned to values comparable with those of 1994 at $225 per short ton, f.o.b Gulf Coast spot prices.

The United States remained the worlds second largest producer and consumer of elemental and fixed types of nitrogen following China. Urea, ammonium phosphates, ammonium nitrate, ammonium sulfate, and nitric acid are the major downstream products produced from ammonia in the United States, in order of importance. Their combined production was 10.3 million tons of contained nitrogen with urea accounting for one-third of the production. (*See table 3.)*

Ammonia producers in the United States operated at or above design capacity. Nearly 59% of total U.S. ammonia production capacity was concentrated in the States of Louisiana

(39%), Oklahoma (14%), and Texas (6%), owing to large indigenous reserves of natural gas feedstock. Farmland Industries Inc.; Arcadian Corp.; Terra International, Inc.; CF Industries Inc.; Mississippi Chemical Corp., and Union Chemical Co., in order of importance, accounted for 68% of total U.S. ammonia capacity. (*See table 4.*)

Mississippi Chemical Corp. acquired the fertilizer operations of First Mississippi Corp. including the Ampro facility at Donaldsville, LA, which is expanding annual ammonia production capacity by 25% to more than 540,000 tons. This will be the first U.S. instillation to retrofit a plant utilizing the Kellogg Advanced Ammonia Process. (Nitrogen, 1996b) (Chemical Marketing Reporter, 1996e). The acquisition gave Mississippi Chemical full ownership of Triad Chemical with its anhydrous ammonia plant production capacity of 420,000 tons and a urea plant annual production of 500,000 tons.

In addition to these acquisitions, Mississippi Chemical Corp. announced expansion of its nitrogen fertilizer manufacturing facilities at Yazoo City, MS. Plans include a new 450-ton-per-day ammonia plant based on the ICI Katalco's Leading Concept for Ammonia process and modification of the ammonium nitrate plant from 680,000 to 860,000 tons per year. The expansion is expected to be fully operational by early 1998 (Mississippi Chemical Corporation, 1996; Nitrogen, 1996d).

PCS acquired Arcadian Corp., the largest producer of nitrogen fertilizer in the Western Hemisphere (Fertilizer Markets, 1996a). Arcadian Corp. had been in the process of expanding ammonia capacity at its plant in Augusta GA, from 1,500 to 1,700 tons per day (Fertilizer Focus, 1996). It is also expanding granular urea capacity at its plant in Lima, OH, by 140,000 tons per year and raising ammonia plant capacity to 635,000 tons per year, an increase of 9% (European Chemical News, 1996a). These expansions were expected to be completed by 1998.

The Dakota Gasification Co. (DGC) started up a 136,000-ton- per-year ammonium sulfate line at its Beulah, ND, plant. This process utilizes a forced oxidation technology developed by General Electric that reacts sulfur dioxide with ammonia and air in a two-stage recycling process. The process utilizes the sulfur dioxide waste from the unique DGC coal gasification plant and recirculating waste heat to reduce costs to competitive levels (Nitrogen, 1996c).

The Port Neal, IA, ammonia production plant of Terra International Inc. commenced ammonia production in December 1995. The 300,000-ton-per-year plant had been severely damaged in an explosion in December 1994 (Fertilizer Focus, 1996). Its nitrogen solutions plant came on-line in May 1996 (C&EN, 1997). Terra is also expanding production of nitric acid, which will allow for the upgrade of ammonia production to urea-ammonium nitrate (UAN) increasing UAN capacity from 470,000 to 735,000 tons per year.

Agrium Inc. (US) and Viridian Inc. (Canada) announced in October their agreement to merge, which will create one of the largest fully integrated fertilizer production and marketing corporations in North America. The corporation will be known as Agrium Inc. (Chemical Marketing Reporter, 1996).

Environment

Both the ammonium and nitrate forms of N are highly soluble in water and are readily available for crop plant uptake. Ammonium is held by soil particles therefore not subject to movement down through the soil during periods of rainfall or irrigation. Nitrates, however, do move downward with soil water. This leaching process can lead to nitrate accumulation in ground water. As soils are warmed during the growing season, the ammonium form of nitrogen is subject to conversion to nitrate in a process called "nitrification." Most of the ammonium not used by the crop is eventually converted to nitrate. Nitrogen stabilizers and nitrification inhibitors can slow the conversion of soil ammonium to nitrate. Best management practices to increase nitrogen use efficiency and reduce nitrate leaching include application of fertilizer as close to the time of actual crop use, multiple applications, terracing, grass waterways, and strip cropping.

A study released in April provides the first detailed analysis of the Chesapeake Bay air shed. The work concentrates on nitrogen as one of two major pollutants affecting the bay, causing algae blooms and oxygen "dead spots" that harm marine life. Although most of the nitrogen in the bay comes from land sources, which include sewage effluent, chemical runoff from farmlands, and suburban development, this study indicated that 20% to 35% of the total nitrogen pollution may come from air pollution. The study seems to indicate that a significant portion of this pollution is from Midwestern powerplants and other smokestack industries, some as far as 650 kilometers from the bay. Further analysis of these results and possible techniques to overcome the problems is an ongoing field of research and discussion (Shields, 1996).

A survey reported annually to the EPA and commissioned by the Fertilizer Institute indicates that releases of ammonia and other chemicals from nitrogen fertilizer facilities decreased 3.6% during 1994 as compared to the previous year and down 5.6% as a ratio to tons produced. Since Toxic Release Inventory (TRI) reporting began in 1987, the nitrogen fertilizer industry has reduced emissions 74.6% as a ratio of pounds released per pound produced. This reduction has been due to the installation of new scrubbers, neutralizer concentrators that capture fumes from the process of mixing ammonia and nitric acid, and heat saturators that reduce a plant's steam requirements by recycling condensate. (Chemical Marketing Reporter, 1996d).

Consumption

Apparent consumption returned to values comparable with 1994, at 16.6 million tons of N; an increase of 8% over 1995 values. *(See table 1.)* Apparent consumption is calculated as the production plus imports minus exports, adjusted to reflect any changes in stocks.

Consumption of nitrogen fertilizers in the United States for the 1996 crop year (ending June 30, 1996) is reported in table 5. Consumption increased 4% from 1995 values to 11.1 million

tons of nitrogen. Anhydrous ammonia is the principal fertilizer product representing 32% of fertilizer consumption.

Urea and UAN solutions together constitute 38% of fertilizer consumption during the 1996 crop season. Urea is typically 45.9% N, and UAN solutions are typically 29.8% to 29.9% N. In the industrial sector, urea is used extensively as a protein supplement in ruminant animal feeds, for the production of urea-formaldehyde adhesives, and for the synthesis of plastics and resins.

Ammonium nitrate was used primarily in solid and liquid fertilizers, in industrial explosives, and as blasting agents. Total production of ammonium nitrate was 2.6 million tons of contained nitrogen. (*See table 3.*) After World War II, ammonium nitrate became the leading solid nitrogen fertilizer in the United States and worldwide, and remained such until about 1975, when its use was surpassed by synthetic urea. In 1996, approximately 25% of ammonium nitrate production was used in fertilizer consumption. Ammonium nitrate containing 33.9% N constituted 6% of 1996 fertilizer consumption.

Ammonium sulfate was used mostly as a fertilizer material, valued for its nitrogen content (21.2% N) and for its readily available sulfur content (24.3% sulfur). It is commonly produced as a byproduct of caprolactam production, an intermediate in nylon manufacture. Since the introduction of ammonium nitrate and urea, the relative importance of ammonium sulfate worldwide has steadily decreased. In the 1996 crop year, fertilizer consumption of ammonium sulfate based on nitrogen content was 2% of the market. Nonfertilizer uses constitute approximately 40% of the total ammonium sulfate market (on a contained nitrogen basis), including food processing, fire control, tanning, and cattle feed.

Nitric acid production is shown in table 3. Nitric acid is used in salt formation reactions to produce metal nitrates and in metal degreasing, treating and pickling for graphic and galvanic industries. Nitration reactions with benzene, phenol, and toluene produce dyestuffs, pharmaceutical products, trinitrotoluene (TNT) explosives, and disinfectants. Esterification reactions with glycol, glycerol, and cellulose produce nitroglycerine explosives (dynamite), celluloid, and nitrocellulose lacquers. Oxidation reactions with toluene, p-xylene, and cyclohexanone produce polyurethanes and polyester fibers (nylon), respectively.

Acrylonitrile was used in the production of acrylic fibers, high impact acrylonitrile-butadiene-styrene (ABS) plastics, nitrile elastomers, and nylon fibers, resins, and plastics. (*See table 3.)*

Other uses of ammonia are for the production of amines, cyanides, and methyl methacrylate polymers (plexiglass); liquid home and industrial cleaners; pulp and paper products; industrial refrigeration; metallurgy; and as a propellant in vehicular air bags.

Elemental nitrogen is used extensively by the electronics, metals, food, and aerospace industries because of its unique inert and cryogenic properties. Nitrogen can be used to prevent fires and explosions as a purging agent for cleaning and processing equipment, and as a controlling atmosphere for annealing and heat treating and other metal preparation processes where oxygenation is a concern.

Stocks

At yearend 1996, stocks totaled 1.5 million tons N, comparable with 1995 stocks of 1.6 million tons N. (*See table 6.*)

Transportation

Ammonia was transported by refrigerated barge, rail, pipeline, and truck. Three companies serve 11 States with pipelines 4,900 kilometers (km) in length, with 4,800 km of river barge transport, and by rail and truck used primarily for interstate or local delivery.

Koch Industries operated the Gulf Central ammonia pipeline from the Gulf of Mexico (Louisiana) to the Midwest as far north as Iowa, covering 3,065 km, and to the east to Huntington, OH. The annual capacity of this pipeline was about 2 million tons, with a storage capacity of more than 1 million tons.

Mapco Ammonia Pipeline Inc. operated its own pipeline and its subsidiary, Mid-America Pipeline System, that extended from Borger in northern Texas to Mankato in southern Minnesota, covering 1,700 km. The Mapco pipeline had an annual capacity of more than 1 million tons and about 500,000 tons of ammonia storage capacity.

CF Industries Inc. and Cargill Fertilizer, Inc. jointly operated the Tampa Bay Pipeline (TBP) system with a 135-km route. TBP moved nitrogen compound and ammonium phosphate for fertilizer producers in Hillsborough and Polk Counties, FL.

Capacities for trucks and rail cars are usually 20 and 100 tons, respectively. Depending on the product loaded and the volume of the container, barges can accommodate from 400 to 2,000 tons.

Ammonium nitrate is transported by rail, road, and water, but its transportation on U.S. navigable waterways is restricted. Urea is shipped either in bulk or as bagged material.

Prices

Anhydrous ammonia prices increased 11 to 15% in 1996 in relation to 1995 prices as quoted f.o.b. barge Gulf Coast and Corn Belt. (*See table 7.*) Ammonium nitrate prices f.o.b. Corn Belt remained steady at prices ranging from $160 to $170 per short ton. Urea prices however decreased about 10% to 17% over that same time period as reported f.o.b. Corn Belt (prilled) and Gulf Coast (granular and prilled). Diammonium phosphate prices also decreased approximately 16%-17% from 1995 quotes f.o.b. central Florida.

Foreign Trade

Anhydrous ammonia exports were up by 37% compared to those of 1995. Almost 75% was imported by the Republic of Korea. U.S. anhydrous ammonia imports dropped 6.5% in 1996. Trinidad and Tobago and Canada supplied 89% of total

U.S. ammonia import tonnage. (*See tables 8 and 9.)*

Trade of other nitrogen materials is shown in tables 10 and 11. Exports of Urea increased 67% in 1996 compared with those of 1995. Export markets also increased for monoammonium phosphate and mixed chemical fertilizers. Imports of other U.S. nitrogen compounds in 1996 remained similar to 1995 tonnages.

World Review

Anhydrous ammonia and other nitrogen materials were produced in more than 80 countries. Global ammonia production in 1996 increased slightly relative to 1995 levels. Total ammonia production was nearly 100 million tons contained nitrogen in 1996, based on data reported by the U.S. Geological Survey. About 24% of global ammonia production originated in China; Asia contributed 39% of world total ammonia production. The United States and Canada represented 19% of the global total, with the United States accounting for 79% of the region. Countries in the former U.S.S.R. were 12% of the total; Western Europe, 9%; Middle East, 6%; Latin America, 6%; and Eastern Europe, Africa, and Oceania contributed the rest. (*See table 12.)*

World ammonia exports in 1996 increased slightly compared with those of 1995, to 10.9 million tons of contained nitrogen. Russia, Trinidad and Tobago, Ukraine, and Canada accounted for 58% of the world total, in order of importance. Western Europe imported 35% of global ammonia trade, followed by the United States (30%) and Asia (16%) (International Fertilizer Industry Association, 1996).

World urea production increased 4% to 43 million tons contained nitrogen in 1996. China and India accounted for 37% of 1996 world production. The United States and Canada produced about 12% of the total. Global urea exports remained steady at 11.2 million tons N in 1995 and 1996. Russia and Ukraine accounted for 26% of total exports; Middle East, 19%; Eastern Europe, 12%; Canada and the United States, 15%; Asia, 9%; Western Europe, 8%; Latin America, 8%; and Africa and Oceania shipped minor tonnages (International Fertilizer Industry Association, 1996). Asia accounted for 53% of global urea imports; Latin America accounted for 12%, North America accounted for 11%, and Western Europe accounted for 11%.

Brazil.—During July, Brazilian producer Petrobras revamped its ammonia and urea plants at Laranjeiras, in Sergipe State, increasing ammonia capacity from 1,000 to 1,250 tons per day and increasing urea capacity from 1,450 to 1,600 tons per day (Fertilizer Week, 1996).

Canada.—In 1996, Canada produced 3.8 million tons of contained nitrogen as anhydrous ammonia. Exports increased 10% to 926,000 tons. Urea production was 1.5 million tons N, and exports increased 25% to 963,000 tons N.

Continental Nitrogen and Resources Corp. is building a 136,000-ton-per-year industrial-grade ammonium nitrate plant at Brandon, Manitoba. This plant will be the first in North America to use a prilling tower recirculating air loop (Chemical Marketing Reporter, 1996).

Chile.—The only commercially exploited mineral to be used as a fertilizer in Chile is nitrate. It occurs as an impure sodium nitrate, known as caliche. Sociedad Quimica y Minera de Chile SA (SQMC), the only producer of natural nitrates, exports to Latin America, China, North America, and Western Europe. The principal product is sodium nitrate with 16% nitrogen content, known as Chilean nitrate or Chilean saltpeter. Farmers often refer to it simply as soda. SQMC produces about 840,000 tons per year of nitrate, 400,000 tons of sodium sulfate, and 5,000 tons of iodine.

The Minera Yolda Mine in northern Chile had planned to start operations in September or October 1996, with plant operations to produce either 272,000 tons per year of sodium nitrate or 323,000 tons per year of potassium nitrate. The project was delayed in 1996 when the contractor experienced financial difficulties (Phosphorus & Potassium, 1996).

China.—China's production of urea in 1996 increased 12% to 9 million tons contained nitrogen. Imports were at 2.9 million tons N, approximately 27% of world trade.

China had forecast lower urea imports, in part because five large new urea plants came into production in 1996. Plants on Hainan Island and at Huehato in Inner Mongolia started trial production towards the yearend (Chemical Marketing Reporter 1996). In July, a new ammonia/urea complex came on-stream in Sichuan Province.

Italy.—Norsk Hydro, one of Europe's largest producers of fertilizers, has strengthened its position in the Southern European fertilizers market with the acquisition of the fertilizer production units of EniChem in Ferrara and Ravenna. The Ferrara plant includes a 500,000-ton-per-year ammonia plant and a urea plant of similar capacity. The Ravenna plant has a 360,000-ton-per-year compounded nitrogen-phosphate-potassium fertilizer operation and a 500,000-ton-per-year calcium ammonium nitrate plant. (Chemical Engineering News, 1996b). In addition, Norsk Hydro has acquired Terni Industrie Chimiche, a nitrogen fertilizer unit of EniChem. This purchase involves plants with annual capacities of 110,000 tons of ammonia, 120,000 tons of urea, and 120,000 tons of calcium nitrate and speciality fertilizers (Chemical Engineering News, 1996a)

Mexico.—Production of ammonia increased 3.1% to 2.1 million tons contained nitrogen. Exports, however, dropped 35% to 167,000 tons N. An explosion of the country's largest gas complex in Cactus, Chiapas, on July 26 cut the nation's natural gas supply by one third and interrupted the supply of ammonia for export which has typically been about 25,000 tons per month of ammonia (European Chemical News, 1996b).

Russia.—A new 2.3-million-ton-per-year terminal was officially opened in March at Murmansk in the Koal Inlet of the Barents Sea, in the extreme northeast of Russia. The terminal was designed to accommodate exports of urea, potash, and phosphate fertilizers. Ammonia storage tanks capable of handling 907,000 tons per year and handling equipment were also being installed. Principal stakeholders are Murmansk Commercial Port, Agrochimexport, and Perm Minudobreniya (Fertilizer Focus, 1996).

Saudi Arabia.—Safco planned to double its existing capacity at Jubail with the completion of a new ammonia/urea complex in 1999. The plant will consist of a 453,000-ton-per-year ammonia and 544,000-ton-per-year granular urea plant. The plant will use Stamicarbon technology for the urea process, Brown & Root process for ammonia, and Hydro Agri's granulation technology (Fertilizer Week, 1997). Saudi Arabia is the predominant fertilizer producer in the Arab Gulf, and the country has three fully or partially state-owned fertilizer companies that come under the auspices of Saudi Arabian Basic Industries Co.

Trinidad and Tobago.—In 1996, Trinidad and Tobago produced 1.8 million tons of contained nitrogen as ammonia an increase of 6% compared with that of 1995. Exports increased 5% to 1.6 million tons N in ammonia.

Mississippi Chemical Corp. began construction of a 1,800-ton-per-day ammonia plant that will be the largest single-train ammonia production facility in the world. The plant will incorporate the Kellogg Advanced Ammonia Process. It is expected to be operational by early 1998 (Mining Engineering, 1996). Arcadian's 255,000-ton-per-year ammonia plant at Point Lisas initiated production in April (Fertilizer Markets, 1996).

Current Research and Technology

Researchers at the Tokai University in Kanagawa, Japan, have discovered that using urea as the gaseous nitrogen source in the heavy doping of a diamond cathode can provide the source for a new generation of high-performance miniaturized vacuum tubes. These tubes can be powered from a single commercial 1.5-volt battery and will find application in microelectronics and displays (Chemical and Engineering News, 1996c).

Outlook

One of the current global trends is the regionalization of markets, particularly in ammonia where freight costs are higher to cover refrigeration. Thus, markets for the former U.S.S.R. tend to be Europe and North Africa, while the Middle East tends to dominate as a supply source for south and east Asia.

The use of nitrogen containing fertilizers is expected to increase during the next few years in response to expected increases in crop planting and fertilizer use. The estimated amount of that growth, however, covers a wide range. The Washington, DC, based Fertilizer Institute predicts moderate growth of 1% to 3%, while stock analysts have predicted growth of up to 7% within the United states. These growth predictions are based in part on the expected continued demand from South America and south and east Asia (Chemical and Engineering News, 1997; Nitrogen, 1996d).

Urea production is expected to increase by 12% by the end of the century. Asia has become the main destination of urea, with China and India being the two largest consumers. New global capacity is expected as most of the debottlenecking and upgrading of older urea plants has been completed. New construction is expected in China, India, and the Middle East.

Another of the major changes is the continuing increase in market share for granular urea which has a more consistent size than prilled urea. Also, granular urea has a release and yield that is more constant (Nitrogen, 1996d).

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[1]Prior to January 1996, published by the U.S. Bureau of Mines.

TABLE 1
SALIENT AMMONIA STATISTICS 1/ 2/

(Thousand metric tons of contained nitrogen unless otherwise specified)

	1992	1993	1994	1995	1996 p/
United States:					
Production	13,400	12,600	13,400	13,000 r/	14,600
Exports	354	378	215	319	435
Imports for consumption	2,690	2,660	3,450	2,630	2,460
Consumption, apparent 3/	15,600	15,100	16,500	15,300 r/	16,600
Stocks, Dec. 31; producers'	1,060	852	956	959 r/	953
Average annual price per ton product, f.o.b. gulf coast 4/	$106	$121	$211	$191	$225
Net import reliance 5/ as a percent of apparent consumption	14	17	19	15	12
Natural gas price; wellhead 6/	$1.74	$2.04 r/	$1.85 r/	$1.55 r/	$2.25
World:					
Production	93,400 r/	91,700 r/	92,200 r/	96,100 r/	97,500 e/
Trade 7/	9,270	9,060	10,000	10,800	11,000

e/ Estimated. p/ Preliminary. r/ Revised.
1/ Data are rounded to three significant digits, except prices.
2/ Synthetic anhydrous ammonia, calendar year data, Bureau of the Census; excludes coke oven byproduct.
3/ Calculated from production, plus imports minus exports, and industry stock changes.
4/ Green Markets, Fertilizer Market Intelligence Weekly, Pike & Fischer, Inc.
5/ Defined as imports minus exports, adjusted for industry stock changes.
6/ Monthly Energy Review, U.S. Department of Energy. Average annual cost at wellhead in dollars per thousand cubic feet.
7/ International Fertilizer Industry Association Statistics World Anhydrous Ammonia Trade.

TABLE 2
FIXED NITROGEN PRODUCTION IN THE UNITED STATES 1/

(Thousand metric tons of contained nitrogen)

	1995	1996 p/
Anhydrous ammonia, synthetic: 2/		
Fertilizer	11,600	12,600
Nonfertilizer	1,410 r/	1,930
Total	13,000 r/	14,600

p/ Preliminary. r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Current Industrial Reports, MA28B, M28B, and MQ28B, Bureau of the Census.

TABLE 3
MAJOR DOWNSTREAM NITROGEN COMPOUNDS
PRODUCED IN THE UNITED STATES 1/ 2/

(Thousand metric tons)

Compound	1995	1996 p/
Urea:		
Gross weight	7,370 r/	7,370
Nitrogen content	3,440 r/	3,440
Ammonium phosphates: 3/		
Gross weight	16,500 r/	16,900
Nitrogen content	2,850 r/	2,810
Ammonium nitrate:		
Gross weight	7,700 r/	7,550
Nitrogen content	2,700 r/	2,640
Ammonium sulfate: 4/		
Gross weight	2,400 r/	2,420
Nitrogen content	509 r/	514
Nitric acid, direct use: 5/		
Gross weight	1,770 r/	1,740
Nitrogen content	407 r/	400
Acrylonitrile:		
Gross weight	1,450	1,380 6/
Nitrogen content	390	370 6/
Caprolactam:		
Gross weight	714	725 6/
Nitrogen content	93	94 6/
Total:		
Gross weight	37,900 r/	38,100
Nitrogen content	10,400 r/	10,300

p/ Preliminary. r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Ranked in relative order of importance by nitrogen content.
3/ Diammonium phosphate (DAP), monoammonium phosphate (MAP), and other ammonium phosphates.
4/ Excludes coke plant ammonium sulfate.
5/ Gross nitric acid production netted for use in production of ammonium nitrate.
6/ Data based on first two quarters of 1996, doubled for total year. Reporting by ITC was discontinued after the second quarter.

Sources: Bureau of the Census and International Trade Commission.

TABLE 4
DOMESTIC PRODUCERS OF ANHYDROUS AMMONIA IN 1996 1/

(Thousand metric tons per year of ammonia)

Company	Location	Capacity 2/
Agrium Inc.	Borger, TX	439
Air Products and Chemicals Inc.	Pace Junction, FL	46
Allied Signal Inc.	Hopewell, VA	409
Arcadian Corp.	Augusta, GA	576
Do.	Clinton, IA	237
Do.	Geismar, LA	501
Do.	LaPlatte, NE	182
Do.	Lima, OH	523
Do.	Woodstock, TN	356
Avondale Ammonia 3/	Fortier, LA	399
Borden Chemicals Inc.	Geismar, LA	364
CF Industries Inc.	Donaldsonville, LA	1,740
Coastal Chem, Inc.	Cheyenne, WY	172
Coastal St. Helens Chemical 4/	St. Helens, OR	85
Dakota Gasification Co.	Beulah, ND	91
E. I. du Pont de Nemours & Co. Inc.	Beaumont, TX	433
Farmland Industries Inc.	Beatrice, NE	255
Do.	Dodge City, KS	255
Do.	Enid, OK	919
Do.	Fort Dodge, IA	241
Do.	Lawrence, KS	409
Do.	Pollock, LA	459
Green Valley Chemical Corp.	Creston, IA	32
IMC-Agrico Co.	Faustina (Donaldsonville), LA	482
IMC Nitrogen Company 5/	East Dubuque, IL	269
J. R. Simplot Co.	Pocatello, ID	93
Koch Industries	Sterlington, LA	1,110
LaRoche Industries Inc.	Cherokee, AL	159
Mississippi Chemical Corp. 6/	Yazoo City, MS	455
Do.	Donaldsonville (Ampro), LA	500
Do.	Donaldsonville (Triad), LA	409
Monsanto Co.	Luling, LA	446
Nitromite Fertilizer	Dumas, TX	128
Shoreline Chemical	Gordon, GA	31
Terra International, Inc.	Blytheville, AR	364
Do.	Port Neal, IA	319
Do.	Verdigris, OK	955
Do.	Woodward, OK	446
Union Chemical Co. (Unocal)	Finley, WA	150
Do.	Kenai, AK	1,180
Wil-Grow Fertilizer Co.	Pryor, OK	86
Total		16,700

1/ Data are rounded to three significant digits; may not add to total shown.

2/ Engineering design capacity adjusted for 340 days per year of effective production capability.

3/ Joint venture between American Cyanamid and LaRoche Industries Inc. formed in 1994.

4/ Plant formally owned by Chevron Chemical Co.

5/ Plant formally owned by Phoenix Chemical Co.

6/ Plants formally owned by First Mississippi Fertilizer Inc. (Ampro) and Triad Chemical Co.

Sources: International Fertilizer Development Center (IFDC); North American Fertilizer Capacity, Ammonia, Apr. 1997. Blue, Johnson and Associates, North American NPK Plants and Capacities, Foster City, CA.

TABLE 5
U.S. NITROGEN FERTILIZER CONSUMPTION,
BY PRODUCT TYPE 1/ 2/

(Thousand metric tons nitrogen)

Fertilizer material 3/	1995	1996 p/
Single-nutrient:		
Anhydrous ammonia	3,240	3,590
Nitrogen solutions 4/	2,510 r/	2,570
Urea	1,680	1,630
Ammonium nitrate	581 r/	646
Ammonium sulfate	191 r/	200
Aqua ammonia	72	69
Other 5/	235 r/	251
Total	8,510 r/	8,960
Multiple-nutrient 6/	2,160 r/	2,170
Grand total	10,700 r/	11,100

p/ Preliminary. r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Fertilizer years ending June 30.
3/ Ranked in relative order of importance by product type.
4/ Principally urea-ammonium nitrate (UAN) solutions, %N 29.9.
5/ Includes other single-nutrient nitrogen materials, all natural organics, and statistical discrepencies.
6/ Various combinations of nitrogen (N), phosphate (P), and potassium (K): N-P-K, N-P, and N-K.

Source: Commercial Fertilizers. Prepared as a cooperative effort by The Fertilizer Institute, and the Association of American Plant Food Control Officials, Dec. 1996.

TABLE 6
U.S. PRODUCER STOCKS OF
FIXED NITROGEN COMPOUNDS
AT YEAREND 1/ 2/

(Thousand metric tons nitrogen)

Material 3/	1995 r/	1996 p/
Ammonia	959	953
Nitrogen solutions 4/	213	275
Urea	166	89
Ammonium phosphates 5/	118	87
Ammonium nitrate	62	65
Ammonium sulfate	60	42
Total	1,580	1,510

p/ Preliminary. r/ Revised.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Calendar year ending Dec. 31.
3/ Ranked in relative order of importance.
4/ Urea-ammonium nitrate and ammoniacal solutions.
5/ Diammonium, monoammonium, and other ammonium phosphates.

Source: Current Industrial Reports, MA28B and MQ28B, Bureau of the Census.

TABLE 7
PRICE QUOTATIONS FOR MAJOR NITROGEN COMPOUNDS
AT YEAREND

(Per short ton product)

Compound	1995	1996
Ammonium nitrate; f.o.b. Corn Belt 1/	$162-$170	$160-$170
Ammonium sulfate; f.o.b. Corn Belt 1/	124-136	119-130
Anhydrous ammonia:		
F.o.b. Corn Belt	205-220	233-245
F.o.b. Gulf Coast 2/	185-195	225
Diammonium phosphate; f.o.b. central Florida	212-215	177-180
Urea:		
F.o.b. Corn Belt, prilled	220-235	197-210
F.o.b. Gulf Coast, granular 2/	217-222	188-190
F.o.b. Gulf Coast, prilled 2/	217-220	181-184

1/ Illinois, Indiana, Iowa, Missouri, Nebraska, and Ohio.
2/ Barge, New Orleans.

Source: Green Markets, Fertilizer Market Intelligence Weekly, Dec. 23, 1996 and Jan. 6, 1997.

TABLE 8
U.S. EXPORTS OF ANHYDROUS AMMONIA,
BY COUNTRY 1/

(Thousand metric tons ammonia)

Country	1995	1996 p/
Korea, Republic of	321	399
Morocco	--	28
Belgium	--	26
China	(2/)	18
Mexico	3	16
Canada	8	15
Costa Rica	11	10
Colombia	--	7
Senegal	--	7
Taiwan	14	1
Brazil	19	--
Other 3/	11 r/	3
Total 4/	387	530

p/ Preliminary. r/ Revised.
1/ Value data suppressed by Bureau of the Census. Ranked in relative order of importance by country and geographics.
2/ Less than 1/2 unit.
3/ 1995 includes 14 countries, 1996 includes 13 cpuntries.
4/ Data may not add to totals shown because of independent rounding.

Source: Bureau of the Census.

TABLE 9
U.S. IMPORTS OF ANHYDROUS AMMONIA,
BY COUNTRY AND REGION 1/

(Thousand metric tons ammonia and thousand dollars)

Country or region 2/	1995 Gross weight	1995 Value 3/	1996 p/ Gross weight	1996 p/ Value 3/
Trinidad and Tobago	1,520	331,000	1,470	298,000
Canada	1,150	181,000	1,210	206,000
Russia	NA	179,000	NA	84,000
Ukraine 4/	NA	70,700	NA	144,000
Mexico	252	53,000	176	34,600
Latvia	101	24,300	--	--
Venezuela	74	15,800	37	7,300
Middle East 5/	45 r/	10,500 r/	--	--
West Europe 6/ 7/	36	9,070	34	7,000
Far East 8/ 9/	2	151	32	6,670
Brazil	--	--	25	4,800
Total	3,200	877,000	2,990	793,000

p/ Preliminary. r/ Revised. NA Not available.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Ranked in relative order of importance by country and region.

3/ C.i.f. value.

4/ Independent republic of the former U.S.S.R., effective Jan. 1992.

5/ In 1995 includes Kuwait, Algeria, and Saudi Arabia, in order of importance.

6/ In 1995 includes the United Kingdom, the Netherlands, and Germany, in order of importance.

7/ In 1996 includes Germany and Greece.

8/ In 1995 value is for Japan.

9/ In 1996 includes Indonesia, Thailand, and Taiwan, in order of importance.

Sources: Bureau of the Census and U.S. Geological Survey.

TABLE 10
U.S. EXPORTS OF MAJOR NITROGEN COMPOUNDS IN 1996 1/

(Thousand metric tons)

Compound	1995 Gross weight	1995 Nitrogen content	1996 p/ Gross weight	1996 p/ Nitrogen content
Fertilizer materials:				
Ammonium nitrate 2/	90	30	62	21
Ammonium sulfate 2/	917	193	824	173
Anhydrous ammonia	387	319	530	435
Diammonium phosphate	10,100	2,140 r/	7,920	1,680
Monoammonium phosphate	1,200	145	1,510	183
Urea	881	406	1,470	675
Mixed chemical fertilizers 3/	295	47	417	66
Total	13,800	3,280 r/	12,700	3,230

p/ Preliminary. r/ Revised.

1/ Data are rounded to three significant digits; may not add to totals shown.

2/ Includes industrial chemical products.

3/ Harmonized codes 3105.10.0000 and 3105.20.0000.

Source: Bureau of the Census.

TABLE 11
U.S. IMPORTS OF MAJOR NITROGEN COMPOUNDS IN 1996 1/

(Thousand metric tons and thousand dollars)

Compound	1995 Gross weight	1995 Nitrogen content	1995 Value 2/	1996 p/ Gross weight	1996 p/ Nitrogen content	1996 p/ Value 2/
Fertilizer materials:						
Ammonium nitrate 3/	721	245	103,000	718	251	110,000
Ammonium nitrate-limestone mixtures	74	20	9,340	75	20	11,200
Ammonium sulfate 3/	434	91	40,700	373	79	38,300
Anhydrous ammonia 4/	3,200	2,630	877,000	2,990	2,460	793,000
Calcium nitrate	NA	NA	NA	(5/)	(5/)	10,200
Diammonium phosphate	21	4	6,010	77	16	18,300
Monoammonium phosphate	NA	NA	NA	181	22	52,400
Nitrogen solutions	628	189	83,000	877	264	119,000
Potassium nitrate	NA	NA	NA	30	4	9,990
Potassium nitrate-sodium nitrate mixtures	NA	NA	NA	22	3	3,930
Sodium nitrate	NA	NA	NA	99	16	20,000
Urea	2,940	1,350	487,000	2,520	1,170	447,000
Mixed chemical fertilizers 6/	NA	NA	NA	86	10	26,400
Other ammonium phosphates	NA	NA	NA	NA	NA	NA
Other nitrogenous fertilizers 7/	NA	NA	NA	125	37	17,400
Total	8,010	4,500 r/	1,610,000	8,170	4,400	1,680,000

p/ Preliminary. r/ Revised. NA Not available.
1/ Data are rounded to three significant digits; may not add to totals shown.
2/ Import values c.i.f.
3/ Includes industrial chemical products.
4/ Includes industrial ammonia.
5/ Less than 1/2 unit.
6/ Harmonized codes 3105.10.0000 and 3105.20.0000.
7/ Codes 3101.00.0000, 3102.29.0000, 3102.60.0000, 3102.90.0000, and 3105.90.0050.

Source: Bureau of the Census.

TABLE 12
AMMONIA: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons of contained nitrogen)

Country	1992	1993	1994	1995	1996 e/
Afghanistan e/	40	30	30	30	30
Albania e/	15	15	15	15	15
Algeria	438	380	380	450 r/ e/	500
Argentina	72	72	73 r/	70 e/	70
Australia	392	398	413	433	433
Austria e/	410 r/	400	400	400	400
Bahrain	323	348	338	358	358
Bangladesh 3/	937	991	995 e/	975 e/	980
Belarus	916	619	500 e/	500 e/	500
Belgium	514	535	500 e/	500 e/	500
Bosnia and Herzegovina e/	5	2	1	1	1
Brazil e/	940	940	940	940	940
Bulgaria	905	885	800 e/	800 e/	800
Burma e/	110	110	130	130	130
Canada	3,104	3,410	3,470	3,773 r/	3,800
China e/	18,000	19,000	20,100 r/	22,600 r/	23,000
Colombia e/	86	99	90	90	90
Croatia	426 r/	345 r/	311 r/	295 r/	350
Cuba e/	135	135	130	130	130
Czech Republic e/ 4/	XX	149 5/	150	150	150
Czechoslovakia 6/	385 e/	XX	XX	XX	XX
Denmark e/	2	2 5/	2	2	2
Egypt	943	941	940 e/	940 e/	940
Estonia	115	45	45 e/	45 e/	50
Finland e/	10	10	12 r/ 5/	12 r/	12
France	1,848	1,871	1,480	1,470 r/	1,500

See footnotes at end of table.

TABLE 12--Continued
AMMONIA: WORLD PRODUCTION, BY COUNTRY 1/ 2/

(Thousand metric tons of contained nitrogen)

Country	1992	1993	1994	1995	1996 e/
Germany	2,113	2,100	2,170	1,470 r/	1,200
Georgia	96	58	35 e/	30 e/	30
Greece	140	57	55 e/	55 e/	60
Hungary	152	237	230 e/	230 e/	250
Iceland	9	9 e/	9	9 e/	9
India 7/	7,452	7,176	7,334	7,713	7,800
Indonesia	2,688	2,888	2,800 e/	2,850 e/	2,870
Iran	664	723	696	700 e/	700
Iraq e/	200	500	500	500	500
Ireland	384	367	380 e/	370 e/	370
Israel 3/	37	41	41 e/	41 e/	41
Italy	1,100 e/	729	504	500 r/ e/	500
Japan	1,545 r/	1,471 r/	1,483 r/	1,584 r/	1,560
Kazakstan	220	231	200 e/	200 e/	200
Korea, North e/	550	600	600	600	600
Korea, Republic of e/	442 5/	450	460	470	475
Kuwait	140	320	325 e/	325 e/	325
Libya e/	200	200	200	200	200
Lithuania	275	275 e/	277	442	130
Malaysia	331	334	334 e/	340 e/	340
Mexico	2,203	1,758	2,030	1,992 r/	2,150
Netherlands	2,588	2,472	2,500 e/	2,500 e/	2,500
New Zealand	68	78	78 e/	80 e/	80
Nigeria e/	337 5/	350	350	350	350
Norway	343	315	270	275 r/	275
Pakistan	1,144	1,446	1,450 e/	1,450 e/	1,450
Peru e/	90	90	90	90	90
Poland	1,222 r/	1,163 r/	1,230 r/	1,415 r/	1,400
Portugal	100	91	100 e/	100 e/	100
Qatar	622	628	640	650 e/	650
Romania	1,421	1,328	--	1,000 r/ e/	1,000
Russia	8,786	8,138	7,500 e/	7,500 e/	7,000
Saudi Arabia	904	1,097	1,900	2,000 e/	2,000
Serbia and Montenegro	148	100	159	135 r/	135
Slovakia e/ 4/	XX	263 5/	250	250	250
South Africa	541	607	600 e/	600 e/	600
Spain	479	354	360 e/	360 e/	360
Switzerland	31	28	30 e/	30 e/	30
Syria	81	67	67	67 e/	68
Taiwan	224	220	215	226	220
Tajikistan e/	50	40	30	25	20
Trinidad and Tobago	1,568	1,462	1,649	1,696	1,801 5/
Turkey	344	326	350 e/	350 e/	350
Turkmenistan e/	50 r/	50 r/	50 r/	52 r/	48
Ukraine	3,908	3,242	3,000 r/ e/	3,100 r/ e/	3,000
United Arab Emirates	275	288	243	250 e/	250
United Kingdom	869	873	1,006	1,000 e/	1,000
United States 8/	13,400	12,600	13,400	13,000 r/	14,600 5/
Uzbekistan	1,309	1,105	1,100 e/	1,100 e/	1,100
Venezuela	404	535	505	600	605 5/
Vietnam e/	45	52 5/	53	52	53
Zambia e/	7	10 5/	10	10	10
Zimbabwe e/	67	70	70	70	70
Total	93,400 r/	91,700 r/	92,200 r/	96,100 r/	97,500

e/ Estimated. r/ Revised. XX Not applicable.

1/ World totals, U.S. data and estimated data are rounded to three significant digits; may not add to totals shown.

2/ Table includes data available through June 18, 1997.

3/ May include nitrogen content of urea.

4/ Formerly part of Czechoslovakia; data were not reported separately until 1993.

5/ Reported figure.

6/ Dissolved Dec. 31, 1992.

7/ Data are for years beginning Apr. 1 of that stated.

8/ Synthetic anhydrous ammonia; excludes coke oven byproduct ammonia.