Exhibit I-1

USITC Dataweb Imports of Phosphates

HTSUS 3103.11.0000, 3103.19.0000, 3105.20.0000, 3105.30.0000, 3105.40.0010, 3105.40.0050, 3105.51.0000, and 3105.59.0000

Country	UNIT	2017	2018	2019	Jan-Apr 2019	Jan-Apr 2020
Morocco	metric tons	1,378,096	1,827,488	2,049,155	839,168	673,843
Morocco	short tons	1,519,089	2,014,458	2,258,804	925,023	742,784
Morocco	LDPV US	$493,787,715	$788,881,314	$751,026,133	$358,070,130	$198,149,061
Morocco	AUV	$325	$392	$332	$387	$267
Russia	metric tons	523,660	936,277	767,432	596,973	279,313
Russia	short tons	577,236	1,032,067	845,948	658,049	307,890
Russia	LDPV US	$189,769,637	$400,251,972	$314,956,404	$255,731,493	$82,671,173
Russia	AUV	$329	$388	$372	$389	$269
Subject Imports	metric tons	1,901,756	2,763,765	2,816,587	1,436,141	953,156
Subject Imports	short tons	2,096,325	3,046,526	3,104,752	1,583,073	1,050,673
Subject Imports	LDPV US	$683,557,352	$1,189,133,286	$1,065,982,537	$613,801,623	$280,820,234
Subject Imports	AUV	$326	$390	$343	$388	$267
All Other	metric tons	634,569	848,514	795,872	342,600	282,130
All Other	short tons	699,492	935,325	877,298	377,651	310,995
All Other	LDPV US	$253,222,295	$394,527,389	$354,926,173	$163,352,845	104,643,264
All Other	AUV	$362	$422	$405	$433	$336
World Total	metric tons	2,536,325	3,612,279	3,612,459	1,778,741	1,235,286
World Total	short tons	2,795,816	3,981,851	3,982,050	1,960,724	1,361,668
World Total	LDPV US	$936,779,647	$1,583,660,675	$1,420,908,710	$777,154,468	$385,463,498
World Total	AUV	$335	$398	$357	$396	$283

Source: USITC DataWeb

USITC Dataweb Imports of Phosphates

HTSUS 3103.11.0000, 3103.19.0000, 3105.20.0000, 3105.30.0000, 3105.40.0010, 3105.40.0050, 3105.51.0000, and 3105.59.0000

HTS Number	Country	UNIT*	2017	2018	2019	Jan-Apr 2019	Jan-Apr 2020
MAP - AMMONIUM DIHYDROGENORTHOPHOSPHATE (MONOAMMONIUM PHOSPHATE)							
3105.40.0010	Morocco	short tons	711,731	873,738	1,158,420	363,407	425,073
3105.40.0010	Russia	short tons	358,203	698,308	481,953	365,777	146,543
3105.40.0010	All Other	short tons	71,282	237,529	308,575	150,331	53,546
DAP - DIAMMONIUM HYDROGENORTHOPHOSPHATE (DIAMMONIUM PHOSPHATE)							
3105.30.0000	Morocco	short tons	515,934	728,260	767,413	345,951	207,199
3105.30.0000	Russia	short tons	180,623	312,430	331,286	280,039	144,282
3105.30.0000	All Other	short tons	190,414	198,695	177,687	73,297	65,862
OTHER MINERAL OR CHEMICAL FERTILIZERS CONTAINING THE TWO FERTILIZING ELEMENTS NITROGEN AND							
3105.59.0000	Morocco	short tons	127,128	178,756	119,160	83,700	43,216
3105.59.0000	Russia	short tons	37,442	21,330	26,043	12,194	16,817
3105.59.0000	All Other	short tons	13,466	13,813	32,796	13,164	32,675
TSP - SUPERPHOSPHATES CONTAINING BY WEIGHT 35% OR MORE OF PHOSPHORUS PENTOXIDE P205							
3103.11.0000	Morocco	short tons	164,296	181,934	100,035	66,690	67,296
3103.11.0000	Russia	short tons	0	0	0	0	0
3103.11.0000	All Other	short tons	172,224	273,728	141,838	47,344	88,065
All Other Phosphate Fertilizers (HS3103.19.0000, 3105.20.0000, 3105.51.0000. 3105.59.0000)							
	Morocco	short tons	0	51,770	113,777	65,275	0
	Russia	short tons	967	0	6,666	40	247
	Other	short tons	29,724	211,561	216,402	93,516	70,848

* Converted from metric tons to short tons by multiplying by 1.10231.

Source: Census import data downloaded from USITC Dataweb.

Imports by Port of Entry and Source

First Unit of Quantity (Converted to Short Tons from Metric Tons)
HS Commodities: 310520, 310551, 310559, 310319, 310311, 310530, 310540
Source: https://dataweb.usitc.gov/

	2017	2018	2019	2019 Jan-Apr	2020 Jan-Apr
Morocco Total	**1,519,089**	**2,014,458**	**2,258,804**	**925,023**	**742,784**
New Orleans, LA	1,518,841	1,838,590	2,014,155	859,748	742,784
Share of Total	*100.0%*	*91.3%*	*89.2%*	*92.9%*	*100.0%*
Houston-Galveston, TX	0	167,703	243,669	65,275	0
Mobile, AL	0	7,528	0	0	0
Pembina, ND	248	637	980	0	0
Russia Total	**577,236**	**1,032,067**	**845,948**	**658,049**	**307,890**
New Orleans, LA	545,804	995,366	713,977	601,434	261,433
Share of Total	*94.6%*	*96.4%*	*84.4%*	*91.4%*	*84.9%*
Houston-Galveston, TX	276	0	16,357	44	28,922
Mobile, AL	0	39	0	0	0
Pembina, ND	0	0	333	0	0
Philadelphia, PA	0	18,739	30,644	18,519	11,023
Charlotte, NC	0	0	22,614	12,984	0
All Other Ports	31,156	17,924	62,023	25,069	6,511
Subject Imports Total	2,096,325	3,046,526	3,104,752	1,583,073	1,050,673
New Orleans, LA	2,064,645	2,833,956	2,728,132	1,461,181	1,004,217
Share of Total	*98.5%*	*93.0%*	*87.9%*	*92.3%*	*95.6%*
Houston-Galveston, TX	276	167,703	260,026	65,320	28,922
Mobile, AL	0	7,566	0	0	0
All Other	31,404	37,300	116,594	56,572	17,534
All Other Countries	**699,492**	**935,325**	**877,298**	**377,651**	**310,995**
New Orleans, LA	335,311	604,010	589,533	250,374	207,593
Share of Total	*47.9%*	*64.6%*	*67.2%*	*66.3%*	*66.8%*
Houston-Galveston, TX	4,007	6,453	2,793	1,380	4,518
Mobile, AL	4,648	5,056	5,030	2,424	10,959
Pembina, ND	19,255	14,804	9,690	5,661	4,255
Philadelphia, PA	314	11,990	40	0	2
Charlotte, NC	10,500	130	10,078	10	191
All Other Ports	325,457	292,883	260,133	117,802	83,477
Total All Countries	**2,795,816**	**3,981,851**	**3,982,050**	**1,960,724**	**1,361,668**
New Orleans, LA	2,399,956	3,437,966	3,317,665	1,711,556	1,211,809
Share of Total	*85.8%*	*86.3%*	*83.3%*	*87.3%*	*89.0%*
Houston-Galveston, TX	4,282	174,156	262,819	66,700	33,441
Mobile, AL	4,648	12,623	5,030	2,424	10,959
Pembina, ND	19,503	15,441	11,003	5,661	4,255
Philadelphia, PA	314	30,729	30,684	18,519	11,025
Charlotte, NC	10,500	130	32,692	12,994	191
All Other Ports	356,613	310,806	322,156	142,870	89,988

Source: U.S. Census data from USITC Dataweb.

Exhibit I-2

The Ledger

Mosaic will permanently close idle Plant City facility

By Kevin Bouffard
Posted Jun 18, 2019 at 6:33 PM
Updated Jun 19, 2019 at 10:53 AM

The Mosaic Co. has announced it will permanently shut down its mothballed fertilizer manufacturing facility in Plant City, which has been idle since late 2017.

An earlier version of this story said that Mosaic has fertilizer plants in Fort Meade and near Mulberry in Polk County. The Polk plants are actually located in Bartow and near Mulberry. This article has been updated.

PLANT CITY — The Mosaic Co. on Tuesday announced it would permanently shut down its mothballed fertilizer manufacturing facility in Plant City, which has been idle since late 2017.

Mosaic officials said at the time it was closing the Plant City facility because it was the highest-cost manufacturing plant in Florida. About 430 people worked there at the time.

“Our decision to close the Plant City phosphate facility reaffirms our commitment to low-cost operation,” President and CEO Joc O’Rourke said in a company statement. “We will continue to meet global demand for high-quality phosphate fertilizers with production from our low-cost facilities in Florida, Louisiana, Brazil and Peru, and through our joint venture in Saudi Arabia."

Mosaic has two fertilizer plants in Polk County — Bartow and the New Wales facility near Mulberry — and the Riverview plant near Tampa.

Among the Plant City workers, approximately 200 people got jobs at other Mosaic locations and roughly 130 workers took an early retirement, spokesman Ben Pratt told The Ledger on Tuesday. Approximately 100 workers accepted severance packages.

A small team of Mosaic employees currently responsible for care and maintenance activities will remain at the facility to manage closure and compliance responsibilities over the next several years, the company statement said.

The move was not unexpected.

O'Rourke told analysts in May during a conference call on Mosaic's first quarter financial report that the company had to make a final decision about the Plant City facility by June 30, the end of the second quarter.

Mosaic has been dealing for the past several quarters with slow growth in its phosphate fertilizer division, which is centered in and around Polk. In the first quarter report, it lowered projections for phosphate and potash fertilizer production because of high inventories and expected delays in North American fertilizer sales.

Since then, Midwestern farmers, among the biggest users of phosphate fertilizers, have faced flooding and continued heavy rains that made it impossible to plant corn and other crops in soggy ground. That likely depressed fertilized demand even further than projected earlier.

Mosaic is scheduled to release its second quarter financial report Aug. 5.

Such news is never welcome, said Jake Austin, president and CEO of the Plant City Economic Development Corp., but the local economy is booming and can better weather the shutdown.

“We don’t like to see a plant like that with high wages leave the community,” he said. “At the same time, there are coming into Plant City more companies than there are workers. There is no shortage of opportunities If it’s going to happen, it happened at a decent time.″

More significant that closing the Plant City facility was Mosaic’s decision last year to move its corporate headquarters from the Minneapolis area to the Tampa area this year, Austin said.

“Anytime you lose jobs, it’s going to have an economic impact, but it’s been offset by Mosaic’s decision to relocate its headquarters to Hillsborough,” he said.

It’s only the second Fortune 500 company based in Hillsborough in addition to insurance company WellCare Health Plans Inc. of Tampa. The Tampa Bay area has six other Fortune 500 companies, including Publix Super Markets Inc. in Lakeland.

Two local economic observers did not see Mosaic’s decision as having a major impact on the Polk economy.

“I would not expect significant impacts on other sectors, particularly because this plant was already idle,” said Jim Farrell, assistant professor of finance and economics at Florida Southern College who tracks the Polk economy. “The bulk of the impacts would have been felt when they idled the plant in 2017. Phosphate mining continues to shift further south, and we should see the remaining activity in our area idle then close in the coming years as it too becomes too costly. Any impacts of the closures can be mitigated by the repurposing the land and facilities for other uses.”

By making Mosaic a stronger company financially, the move would benefit its Polk facilities, said Sean Malott, president and chief executive officer of the Central Florida Development Council in Lakeland.

“The phosphate industry is and will continue to be a strong driver of the Polk economy,” he said. “Technological advances have improved manufacturing efficiency in recent years. By streamlining their facilities, Mosaic will be able to focus their resources on their other Florida facilities, two of which are based in Polk, and continue to be an important employer providing hundreds if not thousands of jobs locally.”

Mosaic obtained the Plant City facility in 2014, when it purchased the Central Florida phosphate operations of CF Industries for $1.4 billion. CF reported the plant had a production capacity of 1.7 million tons of phosphate fertilizer.

Before it was idled in December 2017, the Plant City facility produced approximately 1.4 million tons, the company statement said.

Mosaic expects to non-cash charge of up to $390 million for the permanent closure, including asset write-offs and an increase of the asset retirement obligation liability, in the second quarter, the statement said.

The 2017 shutdown was prompted by an oversupply of phosphate fertilizer products on the global market, the company said at the time.

China, which used to import up to 5 million metric tons of phosphate fertilizers annually, had become a fertilizer exporter. Morocco, which has the world's largest phosphate ore reserves, had also ramped up its production.

Wall Street investors reacted positively to the news. Mosaic's stock gained 78 cents in value, up 3.3%, to close Tuesday at $24.06 on the New York Stock Exchange.

Kevin Bouffard can be reached at kevin.bouffard@theledger.com or at 863-802-7591.

Exhibit I-3

New Life For Mosaic’s Plant City Fertilizer Factory

By BRADLEY GEORGE (/PEOPLE/BRADLEY-GEORGE) • SEP 25, 2019

(//wusfnews.wusf.usf.edu/sites/wusf/files/styles/x_large/public/201909/anuvia_zellwood_factory.png)

Anuvia's fertilizer processing plant in Zellwood, Orange County. ANUVIA

A Central Florida company says it will take over part of Mosaic's fertilizer factory in Plant City.

Anuvia Plant Nutrients, based in Zellwood, has announced it will hire 135 people to produce its own fertilizer, which is made mostly with recycled waste from food scraps and septic tanks.

"What we do is really different," CEO Amy Yoder **told the Orlando Sentinel in 2017. (https://www.orlandosentinel.com/business/os-bz-anuvia-disney-fertilizer-20170825-story.html)** "Most fertilizer companies just dry waste solids into a pellet and maybe coat it with a chemical. We break it down chemically, then build new product, which reduces runoff and leaching."

At its peak, 4,400 Mosaic employees turned phosphate into fertilizer in Plant City. The company temporally shut down the plant in 2017, citing high production costs and a worldwide glut of phosphate fertilizer. In June, Mosaic announced the plant would remain shuttered and it would write off $390 million in closure costs.

RELATED: Mosaic Closes Plant City Factory For Good (https://wusfnews.wusf.usf.edu/post/mosaic-closes-plant-city-fertilizer-factory-good)

Yoder says Anuvia has seen growing demand for its products since its Zellwood plant opened three years ago. The company currently produces 80,000 tons of fertilizer annually. That will increase to more than a million tons per year once the Plant City facility is online.

TAGS: MOSAIC COMPANY (/TERM/MOSAIC-COMPANY)

ANUVIA PLANT NUTRIENTS (/TERM/ANUVIA-PLANT-NUTRIENTS) PLANT CITY (/TERM/PLANT-CITY)

Exhibit I-4

Names and Contact Information for Domestic Producers of Phosphate Fertilizer

The Mosaic Company 3033 Campus Drive, Suite E490 Plymouth, MN 55441 Tel: (763) 577-2700 Website: www.mosaicco.com Email: Mark.isaacson@mosaicco.com
Nutrien Ltd. 3005 Rocky Mountain Avenue Loveland, CO 80538 Tel: (970) 685-3300 Website: www.nutrien.com Email: info@nutrien.com
J.R. Simplot Company P.O. Box 27 Boise, ID 83707 Tel: (208) 336-2110 Website: www.simplot.com Email:jrs_info@simplot.com
Itafos/Agrium 3010 Conda Rd Soda Springs, ID 83276 Tel: (713) 242-8444 Website: www.itafos.com Email: administration@itafos.com
Meherrin Ag & Chemical 413 Main St Severn, NC 27877 Tel: (800) 775-0333 Website: meherrinag.com Email: meherrininfo@meherrinag.com

Exhibit I-5

PROPRIETARY INFORMATION DELETED
CONTAINS RANGED DATA

U.S. Production and Petitioner Standing

1,000 st of product

					Jan.-Mar.			
Domestic Industry		**2017**	**2018**	**2019**	**2019**	**2020**		**Source**
DAP	[	5,179					]	TFI
MAP	[						]	TFI
TSP	[					14	]	Mosaic estimate of Simplot production
MicroEssentials/NPS	[			3,174			]	Mosaic estimate of Simplot production and actual Mosaic production
NPK	[				70		]	Mosaic estimate of Nutrien and Meherrin production
Total	[						]	

					Jan.-Mar.		
Mosaic Production		**2017**	**2018**	**2019**	**2019**	**2020**	
DAP	[						]
MAP	[		3,011				]
TSP	[						]
MicroEssentials/NPS	[	2,648		3,025			]
NPK	[						]
Total	[						]

					Jan.-Mar		
Mosaic % of Production		**2017**	**2018**	**2019**	**2019**	**2020**	
DAP	[						]
MAP	[						]
TSP	[						]
MicroEssentials/NPS	[						]
NPK	[						]
Total	[						]

Exhibit I-6

PROPRIETARY INFORMATION DELETED
CONTAINS RANGED DATA

U.S. Producers' Phosphate Capacity

U.S. DAP/MAP/MES/NPs Capacity
Unit: 1000 Tonnes P_2O_5

Company	Location		2017	2018	2019	
Itafos/Agrium	Conda	[	174			]
Mosaic	Bartow	[				]
Mosaic	Uncle Sam/Faustina	[				]
Mosaic	New Wales	[				]
Mosaic/CF Industries	Plant City	[		941		]
Mosaic	Riverview	[				]
Nutrien/PotashCorp	White Springs	[			412	]
Nutrien/PotashCorp	Aurora	[				]
Simplot	Pocatello	[				]
Simplot	Rock Springs	[				]
Total		[				]
	Total 1000 ST of product	[				]

converted to 1,000 short tons products using 48% P2O5 content

U.S. TSP Capacity
Unit: 1000 Tonnes P_2O_5

Company	Location		2017	2018	2019	
Simplot	Pocatello	[	55			]
Total		[				]
	Total 1000 ST of product	[				]

converted to 1,000 short tons product using 46% P2O5 content

Source: IFA Detailed Processed Phosphate Capacities 2019

U.S. NPK Capacity
Unit: 1000 Short Tons

Company	Location		2017	2018	2019	
Nutrien	Americus	[				]
Nutrien	Florence	[		107		]
Meherrin	Winston Weaver	[				]
Total		[				]

Source: Mosaic Estimates

Total Domestic Production Capacity 2019 by Company
Unit: 1000 Short Tons

Company	Location		2019	
Itafos/Agrium	Conda	[		]
Mosaic	Bartow	[		]
Mosaic	Uncle Sam/Faustina	[		]
Mosaic	New Wales	[		]
Mosaic/CF Industries	Plant City	[		]
Mosaic	Riverview	[		]
Nutrien/PotashCorp	White Springs	[	984	]
Nutrien/PotashCorp	Aurora	[		]
Nutrien	Americus	[		]
Nutrien	Florence	[		]
Simplot	Pocatello	[		]
Simplot	Rock Springs	[		]
Meherrin	Winston Weaver	[		]
Total		[		]

Exhibit I-7

DECLARATION OF [ ]

I, [ ], pursuant to 28 U.S.C. § 1746, hereby declare as follows:

1. I am over 18 years of age and competent to make this declaration.

2. My name is [ ], and I am currently employed as a [ ] at the Mosaic Company. I have been with the Mosaic Company for [ ] years, and I have been in my current role for the past [ ].

3. As [ ], I am responsible for researching phosphate fertilizer markets, both in the United States and globally, and gathering information from industry sources such as The Fertilizer Institute ("TFI") and the International Fertilizer Association ("IFA"). I have first-hand knowledge regarding the universe of phosphate fertilizer producers both in the United States and in foreign countries such as Morocco and Russia. Based on my personal knowledge and experience, there are five phosphate fertilizer companies currently operating in the United States: The Mosaic Company ("Mosaic"); Nutrien Ltd. ("Nutrien"); J.R. Simplot Company ("Simplot"); Itafos (formerly Agrium); and Meherrin Ag & Chemical ("Meherrin").

4. The U.S. production data presented in Exhibit I-5 are sourced from TFI reports and my own personal knowledge and experience in the industry. TFI is an industry association that collects data from U.S. phosphate fertilizer producers. TFI's Market Intelligence report includes production data for MAP and DAP reported by U.S. producers Mosaic, Nutrien, Simplot, and Itafos. Because TFI does not report production data for other types of phosphate fertilizers—including TSP, NPS, and NPK, which are produced by Mosaic, Nutrien, Simplot, and Meherrin—I prepared estimates of total U.S. production for these types of phosphate fertilizers based on my own personal knowledge and experience.

5. The production capacities presented in Exhibit I-6 are sourced from IFA reports and my own personal knowledge and experience in the industry. IFA conducts a worldwide survey of current and future producers of phosphate fertilizers. IFA compiles the results of this survey in a "World Processed Phosphates Capacities" report, which details production capacity by plant and country for all responding phosphate fertilizer producers. IFA reports production capacities for phosphate fertilizer plants in terms of P_2O_5 capacity in metric tonnes, which can be converted to short tons using the standard conversion factor for metric tonnes to short tons (1 metric tonne = 1.102 short tons) and the appropriate percentage of P_2O_5 for a particular type of phosphate fertilizer, as shown in Exhibit I-6.

6. The IFA production capacity data included in Exhibit I-6 cover phosphate fertilizer plants producing MAP, DAP, TSP, and NPS fertilizers of U.S. producers Itafos, Simplot, Mosaic, and Nutrien (formerly PotashCorp). However, IFA does not publish production capacity data for plants that produce NPK fertilizers, which include plants operated by U.S. producers Nutrien and Meherrin. Because IFA's reports do not include this data, I prepared estimates of production capacity for the two U.S. producers that manufacture NPK fertilizers, Nutrien and Meherrin, based on my own personal knowledge and experience in the industry.

I declare under penalty of perjury that the foregoing is true, correct, and accurately portrays my knowledge and experience.

Dated: 25 JUN 20 at 13:35 EST

[ ]

[ ]

Exhibit I-8

BUSINESS PROPRIETARY DOCUMENT
NOT SUSCEPTIBLE TO SUMMARIZATION

Exhibit I-9

CHAPTER 31

FERTILIZERS

Notes

1. This chapter does not cover:

    (a) Animal blood of heading 0511;

    (b) Separate chemically defined compounds (other than those answering to the descriptions in note 2(a), 3(a), 4(a) or 5, below); or

    (c) Cultured potassium chloride crystals (other than optical elements) weighing not less than 2.5 g each, of heading 3824; optical elements of potassium chloride (heading 9001).

2. Heading 3102 applies only to the following goods, provided that they are not put up in the forms or packages described in heading 3105:

    (a) Goods which answer to one or other of the descriptions given below:

        (i) Sodium nitrate, whether or not pure;

        (ii) Ammonium nitrate, whether or not pure;

        (iii) Double salts (whether or not pure) of ammonium sulfate and ammonium nitrate;

        (iv) Ammonium sulfate, whether or not pure;

        (v) Double salts (whether or not pure) or mixtures of calcium nitrate and ammonium nitrate;

        (vi) Double salts (whether or not pure) or mixtures of calcium nitrate and magnesium nitrate;

        (vii) Calcium cyanamide, whether or not pure or treated with oil;

        (viii) Urea, whether or not pure.

    (b) Fertilizers consisting of any of the goods described in (a) above mixed together.

    (c) Fertilizers consisting of ammonium chloride or of any of the goods described in (a) or (b) above mixed with chalk, gypsum or other inorganic nonfertilizing substances.

    (d) Liquid fertilizers consisting of the goods of subparagraph (a)(ii) or (a)(viii) above, or of mixtures of those goods, in an aqueous or ammoniacal solution.

3. Heading 3103 applies only to the following goods, provided that they are not put up in the forms or packages described in heading 3105:

    (a) Goods which answer to one or other of the descriptions given below:

        (i) Basic slag;

        (ii) Natural phosphates of heading 2510, calcined or further heat-treated than for the removal of impurities;

        (iii) Superphosphates (single, double or triple);

        (iv) Calcium hydrogenorthophosphate containing not less than 0.2 percent by weight of fluorine calculated on the dry anhydrous product.

    (b) Fertilizers consisting of any of the goods described in (a) above, mixed together, but with no account being taken of the fluorine content limit.

    (c) Fertilizers consisting of any of the goods described in (a) or (b) above, but with no account being taken of the fluorine content limit, mixed with chalk, gypsum or other inorganic nonfertilizing substances.

Notes (con.)

4. Heading 3104 applies only to the following goods, provided that they are not put up in the forms or packages described in heading 3105:

   (a) Goods which answer to one or other of the descriptions given below:

      (i) Crude natural potassium salts (for example, carnallite, kainite and sylvite);

      (ii) Potassium chloride, whether or not pure, except as provided in note 1(c) above;

      (iii) Potassium sulfate, whether or not pure;

      (iv) Magnesium potassium sulfate, whether or not pure.

   (b) Fertilizers consisting of any of the goods described in (a) above mixed together.

5. Ammonium dihydrogenorthophosphate (monoammonium phosphate) and diammonium hydrogenorthophosphate (diammonium phosphate), whether or not pure, and intermediates thereof, are to be classified in heading 3105.

6. For the purposes of heading 3105, the term "other fertilizers" applies only to products of a kind used as fertilizers and containing, as an essential constituent, at least one of the fertilizing elements nitrogen, phosphorus or potassium.

Heading/ Subheading	Stat. Suf- fix	Article Description	Unit of Quantity	Rates of Duty 1 General	Special	2
3101.00.00	00	Animal or vegetable fertilizers, whether or not mixed together or chemically treated; fertilizers produced by the mixing or chemical treatment of animal or vegetable products[1/]	t	Free[2/]		Free
3102		Mineral or chemical fertilizers, nitrogenous:				
3102.10.00		Urea, whether or not in aqueous solution		Free[2/]		Free
	10	Solid urea	t			
		Other:				
	30	Diesel exhaust fluid (DEF) of a kind meeting ISO 22241	t			
	50	Other	t			
		Ammonium sulfate; double salts and mixtures of ammonium sulfate and ammonium nitrate:				
3102.21.00	00	Ammonium sulfate	t	Free[2/]		Free
3102.29.00	00	Other	t	Free[2/]		Free
3102.30.00	00	Ammonium nitrate, whether or not in aqueous solution	t	Free[2/]		Free
3102.40.00	00	Mixtures of ammonium nitrate with calcium carbonate or other inorganic nonfertilizing substances	t	Free[2/]		Free
3102.50.00	00	Sodium nitrate	t	Free[2/]		Free
3102.60.00	00	Double salts and mixtures of calcium nitrate and ammonium nitrate	t	Free[2/]		Free
3102.80.00	00	Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution	t	Free[2/]		Free
3102.90.01	00	Other, including mixtures not specified in the foregoing subheadings	t	Free[2/]		Free
3103		Mineral or chemical fertilizers, phosphatic:				
		Superphosphates:				
3103.11.00	00	Containing by weight 35 percent or more of diphosphorous pentaoxide (P_2O_5)	t	Free[2/]		Free
3103.19.00	00	Other	t	Free[2/]		Free
3103.90.01	00	Other	t	Free[2/]		Free
3104		Mineral or chemical fertilizers, potassic:				
3104.20.00	00	Potassium chloride	t	Free[2/]		Free
3104.30.00	00	Potassium sulfate	t	Free[2/]		Free
3104.90.01	00	Other	t	Free[2/]		Free

Heading/ Subheading	Stat. Suf- fix	Article Description	Unit of Quantity	Rates of Duty 1 General	Rates of Duty 1 Special	Rates of Duty 2
3105		Mineral or chemical fertilizers containing two or three of the fertilizing elements nitrogen, phosphorus and potassium; other fertilizers; goods of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg:				
3105.10.00	00	Products of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg	kg	Free[2/]		Free
3105.20.00	00	Mineral or chemical fertilizers containing the three fertilizing elements nitrogen, phosphorus and potassium	t	Free[2/]		Free
3105.30.00	00	Diammonium hydrogenorthophosphate (Diammonium phosphate)	t	Free[2/]		Free
3105.40.00		Ammonium dihydrogenorthophosphate (Monoammonium phosphate) and mixtures thereof with diammonium hydrogenorthophosphate (Diammonium phosphate)		Free[2/]		Free
	10	Ammonium dihydrogenorthophosphate (Monoammonium phosphate)	t			
	50	Other	t			
		Other mineral or chemical fertilizers containing the two fertilizing elements nitrogen and phosphorus:				
3105.51.00	00	Containing nitrates and phosphates	t	Free[2/]		Free
3105.59.00	00	Other	t	Free[2/]		Free
3105.60.00	00	Mineral or chemical fertilizers containing the two fertilizing elements phosphorus and potassium	t	Free[2/]		Free
3105.90.00		Other		Free[2/]		Free
	10	Potassium nitrate-sodium nitrate mixtures	t			
	50	Other	t			

1/ See 9903.88.38.
2/ See 9903.88.03.

Exhibit I-10

CHAPTER 31

FERTILIZERS

Notes

1. This chapter does not cover:

   (a) Animal blood of heading 0511;

   (b) Separate chemically defined compounds (other than those answering to the descriptions in note 2(a), 3(a), 4(a) or 5, below); or

   (c) Cultured potassium chloride crystals (other than optical elements) weighing not less than 2.5 g each, of heading 3824; optical elements of potassium chloride (heading 9001).

2. Heading 3102 applies only to the following goods, provided that they are not put up in the forms or packages described in heading 3105:

   (a) Goods which answer to one or other of the descriptions given below:

      (i) Sodium nitrate, whether or not pure;

      (ii) Ammonium nitrate, whether or not pure;

      (iii) Double salts (whether or not pure) of ammonium sulfate and ammonium nitrate;

      (iv) Ammonium sulfate, whether or not pure;

      (v) Double salts (whether or not pure) or mixtures of calcium nitrate and ammonium nitrate;

      (vi) Double salts (whether or not pure) or mixtures of calcium nitrate and magnesium nitrate;

      (vii) Calcium cyanamide, whether or not pure or treated with oil;

      (viii) Urea, whether or not pure.

   (b) Fertilizers consisting of any of the goods described in (a) above mixed together.

   (c) Fertilizers consisting of ammonium chloride or of any of the goods described in (a) or (b) above mixed with chalk, gypsum or other inorganic nonfertilizing substances.

   (d) Liquid fertilizers consisting of the goods of subparagraph (a)(ii) or (a)(viii) above, or of mixtures of those goods, in an aqueous or ammoniacal solution.

3. Heading 3103 applies only to the following goods, provided that they are not put up in the forms or packages described in heading 3105:

   (a) Goods which answer to one or other of the descriptions given below:

      (i) Basic slag;

      (ii) Natural phosphates of heading 2510, calcined or further heat-treated than for the removal of impurities;

      (iii) Superphosphates (single, double or triple);

      (iv) Calcium hydrogenorthophosphate containing not less than 0.2 percent by weight of fluorine calculated on the dry anhydrous product.

   (b) Fertilizers consisting of any of the goods described in (a) above, mixed together, but with no account being taken of the fluorine content limit.

   (c) Fertilizers consisting of any of the goods described in (a) or (b) above, but with no account being taken of the fluorine content limit, mixed with chalk, gypsum or other inorganic nonfertilizing substances.

Notes (con.)

4. Heading 3104 applies only to the following goods, provided that they are not put up in the forms or packages described in heading 3105:

   (a) Goods which answer to one or other of the descriptions given below:

      (i) Crude natural potassium salts (for example, carnallite, kainite and sylvite);

      (ii) Potassium chloride, whether or not pure, except as provided in note 1(c) above;

      (iii) Potassium sulfate, whether or not pure;

      (iv) Magnesium potassium sulfate, whether or not pure.

   (b) Fertilizers consisting of any of the goods described in (a) above mixed together.

5. Ammonium dihydrogenorthophosphate (monoammonium phosphate) and diammonium hydrogenorthophosphate (diammonium phosphate), whether or not pure, and intermediates thereof, are to be classified in heading 3105.

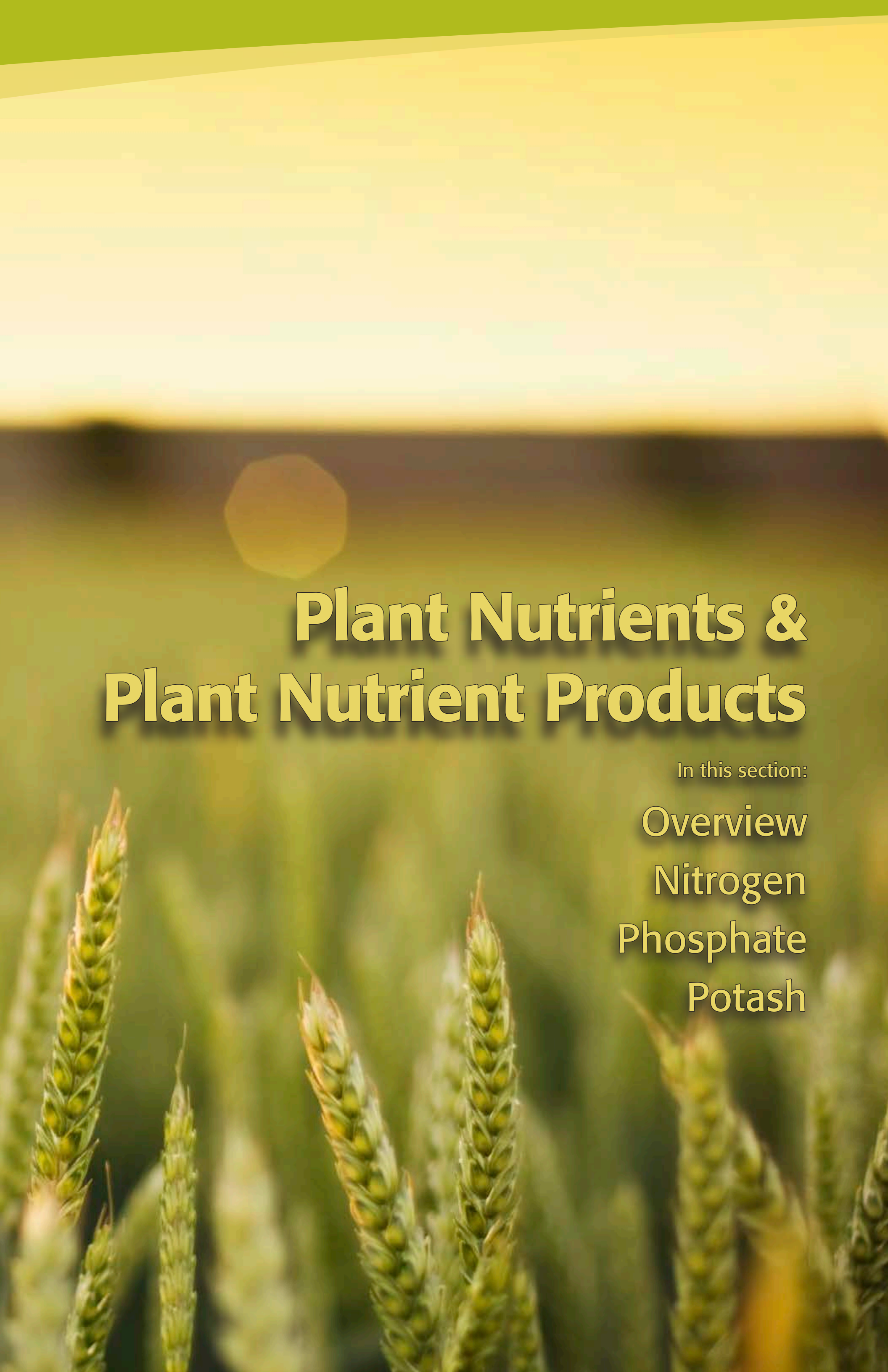
6. For the purposes of heading 3105, the term "other fertilizers" applies only to products of a kind used as fertilizers and containing, as an essential constituent, at least one of the fertilizing elements nitrogen, phosphorus or potassium.

Heading/ Subheading	Stat. Suf-fix	Article Description	Unit of Quantity	Rates of Duty 1 General	1 Special	2
3101.00.00	00	Animal or vegetable fertilizers, whether or not mixed together or chemically treated; fertilizers produced by the mixing or chemical treatment of animal or vegetable products	t	Free		Free
3102		Mineral or chemical fertilizers, nitrogenous:				
3102.10.00		Urea, whether or not in aqueous solution		Free		Free
	10	Solid urea	t			
		Other:				
	30	Diesel exhaust fluid (DEF) of a kind meeting ISO 22241	t			
	50	Other	t			
		Ammonium sulfate; double salts and mixtures of ammonium sulfate and ammonium nitrate:				
3102.21.00	00	Ammonium sulfate	t	Free		Free
3102.29.00	00	Other	t	Free		Free
3102.30.00	00	Ammonium nitrate, whether or not in aqueous solution	t	Free		Free
3102.40.00	00	Mixtures of ammonium nitrate with calcium carbonate or other inorganic nonfertilizing substances	t	Free		Free
3102.50.00	00	Sodium nitrate	t	Free		Free
3102.60.00	00	Double salts and mixtures of calcium nitrate and ammonium nitrate	t	Free		Free
3102.80.00	00	Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution	t	Free		Free
3102.90.01	00	Other, including mixtures not specified in the foregoing subheadings	t	Free		Free
3103		Mineral or chemical fertilizers, phosphatic:				
3103.10.00		Superphosphates		Free		Free
	10	Normal and enriched superphosphates, less than 40 percent available phosphorus pentoxide (P_2O_5) equivalent	t			
	20	Concentrated superphosphates, 40 percent or more available phosphorus pentoxide (P_2O_5) equivalent	t			
3103.90.01	00	Other	t	Free		Free
3104		Mineral or chemical fertilizers, potassic:				
3104.20.00	00	Potassium chloride	t	Free		Free
3104.30.00	00	Potassium sulfate	t	Free		Free
3104.90.01	00	Other	t	Free		Free

Heading/ Subheading	Stat. Suf-fix	Article Description	Unit of Quantity	Rates of Duty 1 General	Rates of Duty 1 Special	Rates of Duty 2
3105		Mineral or chemical fertilizers containing two or three of the fertilizing elements nitrogen, phosphorus and potassium; other fertilizers; goods of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg:				
3105.10.00	00	Products of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg	kg	Free		Free
3105.20.00	00	Mineral or chemical fertilizers containing the three fertilizing elements nitrogen, phosphorus and potassium	t	Free		Free
3105.30.00	00	Diammonium hydrogenorthophosphate (Diammonium phosphate)	t	Free		Free
3105.40.00		Ammonium dihydrogenorthophosphate (Monoammonium phosphate) and mixtures thereof with diammonium hydrogenorthophosphate (Diammonium phosphate)		Free		Free
	10	Ammonium dihydrogenorthophosphate (Monoammonium phosphate)	t			
	50	Other	t			
		Other mineral or chemical fertilizers containing the two fertilizing elements nitrogen and phosphorus:				
3105.51.00	00	Containing nitrates and phosphates	t	Free 1/		Free
3105.59.00	00	Other	t	Free		Free
3105.60.00	00	Mineral or chemical fertilizers containing the two fertilizing elements phosphorus and potassium	t	Free		Free
3105.90.00		Other		Free		Free
	10	Potassium nitrate-sodium nitrate mixtures	t			
	50	Other	t			

1/ See subheading 9903.27.05.

Exhibit I-11



Plant Nutrients & Plant Nutrient Products

In this section:

Overview
Nitrogen
Phosphate
Potash

Overview

The 17 Elements Required for Plant Growth

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Fl	115 Uup	116 Lv	117 Uus	118 Uuo
			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
			89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Non-Mineral Elements	Macronutrients		Micronutrients	
	Primary	Secondary		
C - Carbon H - Hydrogen O - Oxygen	K - Potassium N - Nitrogen P - Phosphate	Ca - Calcium Mg - Magnesium S - Sulphur	B - Boron Cl - Chlorine Cu - Copper Fe - Iron	Mn - Manganese Mo - Molybdenum Ni - Nickel Zn - Zinc

Plant nutrients simply are plant food. Just like feed provides the carbohydrates, protein, fat, vitamins and trace minerals required to nourish animals, plant nutrient products deliver the essential nutrients needed to nourish plants.

Plants require seventeen nutrients for optimum growth and development. Each of these nutrients is a chemical element found on the periodic table. Three of the seventeen elements – carbon, hydrogen and oxygen – are non-mineral elements that are available from the atmosphere or water. The other fourteen are classified as primary nutrients, secondary nutrients and micronutrients.

The three primary nutrients – nitrogen (N), phosphorus (P) and potassium (K) – are the carbohydrates, protein and fat of plant diets. Plants remove large amounts of the primary nutrients during the growing season and soils become depleted if these nutrients are not replenished after each harvest.

Calcium (Ca), magnesium (Mg) and sulphur (S) are classified as secondary nutrients while the eight micronutrients include boron (B), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), molybdenum (Mo), nickel (Ni), and chlorine (Cl). A deficiency of any one of the 17 nutrients will limit plant growth

The Law of the Minimum

Justus von Liebig, the famous 19th century German chemist who is recognized as the father of plant nutrition, discovered that plants absorb nitrogen and several other elements through their roots. Liebig's Law – also known as The Law of the Minimum – establishes that a deficiency of any one of these nutrients will limit plant growth.

The Law of the Minimum often is illustrated by Liebig's Barrel. This graphic shows that the shortest stave determines the maximum volume of liquid in a barrel. Similarly, a deficiency of a single nutrient will limit plant development and result in suboptimum yields or crop quality. Primary nutrient deficiencies are the most common, but secondary nutrient and micronutrient deficiencies are on the rise.

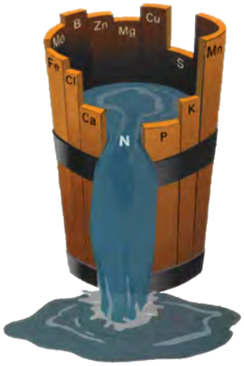
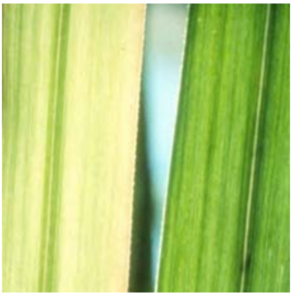


Image: TFI

The Growing Importance of Secondary and Micronutrients

Secondary nutrient and micronutrient deficiencies are occurring more frequently for several reasons. For example, sulphur deficiencies are occurring in many regions due to higher crop yields and thus greater plant uptake, lower sulphur dioxide emissions (acid rain deposited sulphur on soils), and a switch from low-analysis products that contain large amounts of sulphur (e.g. single superphosphate) to high-analysis products that contain little or no sulphur (e.g. diammonium phosphate).



Sulphur Deficiency (Left)

Zinc deficiencies also are occurring more frequently, especially in the developing world. Recent studies indicate that as many as one-fourth to one-third of the world's population is at risk of hypozincemia – a debilitating disease caused by insufficient amounts of zinc in the diet. One way to increase dietary zinc, particularly in the developing world, is to apply zinc to deficient soils in order to boost the amount of this nutrient in the edible portion of food crops such as wheat, rice and legumes

Maintaining Soil Fertility

Most of the 17 nutrients required for optimum plant growth are absorbed from the reservoir of nutrients in the soil or from what agronomists call the soil solution. Crops remove large amounts of nutrients over the course of a growing season. For example, corn that yields 200 bushels per acre removes 310 pounds of primary nutrients per acre just in the grain that is hauled from the field. Wheat that yields 80 bushels per acre removes 195 pounds of primary nutrients per acre in the grain taken off the field. Farmers at a minimum must replace these nutrients in order to keep the reservoir charged and maintain soil fertility.

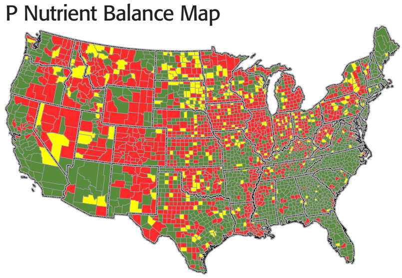
Nutrient Removal by Crop

lbs Acre	N	P_2O_5	K_2O	S
Corn - 200 Bu Acre Yield				
Grain	180	76	54	16
Stalks	90	32	220	14
Total	270	108	274	30
Soybeans - 70 Bu Acre Yield				
Grain	266	59	91	13
Stover	77	17	70	12
Total	343	76	161	25
Wheat - 80 Bu Acre Yield				
Grain	120	48	27	8
Straw	56	13	96	11
Total	176	61	123	19

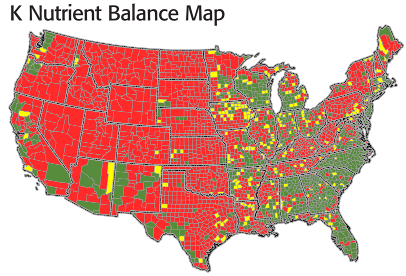
Source: IPNI

Steady yield increases mean that crops are removing more nutrients from soils each year. Yet many farmers continue to apply nutrients, especially phosphorus and potassium, at recommended rates that were developed years ago. A comprehensive analysis by the International Plant Nutrition Institute (IPNI) concludes that crops have removed more phosphorus and potassium than were applied to soils in the form of plant nutrient products and manure in many parts of the United States during the past several years. Nutrient management practices no doubt have improved over time due to advances such as the development of precision agriculture technologies, but this study indicates that U.S. farmers are mining phosphate and potash from their soils in many parts of the country.

P Nutrient Balance Map



K Nutrient Balance Map



Nutrient inputs for 2007

Nutrient removal average of 2006 - 2008

Source: IPNI and PAQ - NuGIS Project

Removal less than nutrient replacement

Removal approx. equal to replacement

Removal exceeds nutrient replacement

Safeguarding the Environment

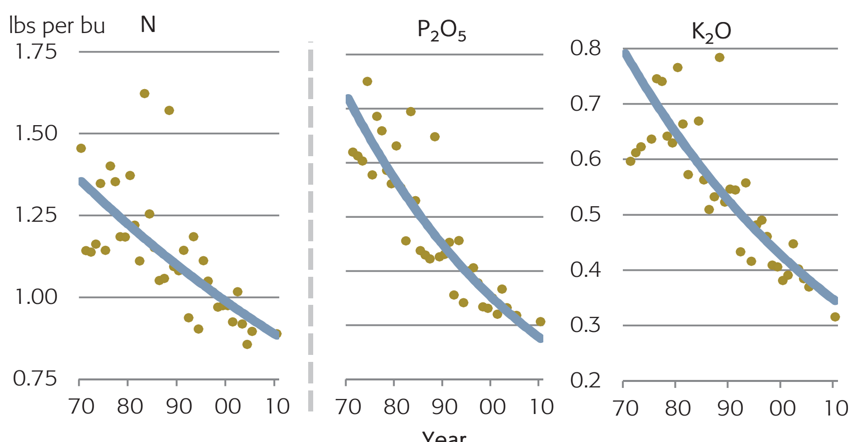
Managing nutrients in the soil solution is not an easy task thanks to the vagaries of Mother Nature. Farmers seek both to keep the soil solution charged with enough nutrients to optimize yields as well as to guard against losses of costly nutrients due to leaching and run-off – all without knowing what Mother Nature might deliver in terms of rainfall and other conditions that impact nutrient losses.

IPNI has developed a program to help farmers maintain soil fertilizer and safeguard the environment by ensuring that the soil solution is charged with nutrients from the *right source*, at the *right rate*, in the *right place* and at the *right time*. IPNI has labeled these the 4-Rs of nutrient stewardship. Execution of the 4-Rs includes best practices such as regular soil testing, accurate estimates of nutrients removed by crops, a full accounting of nutrients added by crop rotations or manure applications, balanced nutrient use, variable rate application, split applications and the use of nitrogen inhibitors or slow-release products.

The efficacy of plant nutrient use has increased significantly in the United States during the last few decades. For example, U.S. Department of Agriculture (USDA) data show that U.S. corn yields nearly doubled from 79 bushels per acre in 1970 to 157 bushels per acre in 2010. Yet primary nutrient application rates remained flat at 230 pounds per acre during the same period.

Nitrogen use per bushel of corn harvested has declined one-third from roughly 1.35 pounds in the first half of the 1970s to less than 0.9 pounds in 2010. Phosphorus and potash use per bushel of corn dropped nearly 60% from about 0.7 pounds to 0.3 pounds during the same period. The use of animal manure and other recycled materials has increased during this period, but U.S. farmers today are harvesting twice as much corn per acre using approximately the same amount of plant nutrients as in 1970.

U.S. Nutrient Use Efficiency on Corn

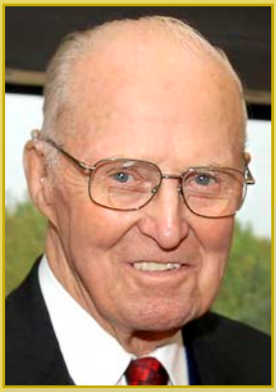


Source: USDA, AAPFCO, TFI

Vital Role of Plant Nutrients in Feeding the World

Modern plant nutrient products play a vital role in food production. In fact, agronomists estimate that plant nutrients account for 40% to 60% of crop yields. Plant nutrient products are a key component of a bundle of increasingly sophisticated inputs required to achieve the higher yields needed to feed the world.

No one understood this better or communicated it more effectively than Dr. Norman Borlaug. Borlaug, widely acclaimed as the Father of the Green Revolution, developed disease resistant and high yielding wheat varieties that are credited with saving hundreds of millions of people from starvation in the 1960s and 1970s. Beginning in 1944, Borlaug labored for 10 years breeding rust resistant cultivars at a research institute in Mexico. He then crossed these strains with a Japanese dwarf variety to produce hardy wheat varieties that, given sufficient water and plant nutrients, boosted yields almost three-fold.



Norman Borlaug
(1914 - 2009)

"Farmers can feed the world. Better seeds and fertilizer, not romantic myths, will let them do it."

Wall Street Journal
July 30, 2009

"This is a basic problem – to feed 6.6 billion people. Without chemical fertilizer, forget it. The game is over."

New York Times
April 30, 2008

Dr. Norman Borlaug
Nobel Peace Prize Laureate

The new varieties saved wheat production in Mexico and spawned the Green Revolution in Asia. India's wheat output doubled from 12 million tonnes in 1965 to 24 million tonnes in 1975. Wheat production in Pakistan also doubled during this period. Both countries had suffered deadly famines in the early 1960s and veterans of the Green Revolution joyfully recount how the countries frequently ran out of jute bags to store the bountiful harvests.

Borlaug, the strong farm boy (and accomplished wrestler) from Cresco, Iowa and a proud graduate of the University of Minnesota, won the Nobel Peace Prize in 1970 for the development of these new varieties as well as his tireless efforts to convince farmers to adopt this new technology. Time magazine named him one of the top 100 influential minds of the 20th century. Borlaug was driven by his strong conviction that it is impossible to build a peaceful world on empty stomachs.

Photo Source: Patrick O'Leary and University of Minnesota

Plant Nutrient Products

The three primary nutrients are contained in more than a dozen widely used commercial products just like carbohydrates, protein and fat are found in a variety of animal feeds. These commercial products contain one or more of the three primary nutrients. In fact, plant nutrient products are uniquely identified by three numbers that indicate the analysis or percentages of each primary nutrient in a unit of the product. For example, a bag of lawn fertilizer may show an analysis of 16-4-8 on its label. These numbers indicate that the product contains 16% nitrogen (N), 4% phosphorus expressed as available phosphorus pentoxide (P_2O_5) and 8% potassium expressed as soluble potassium oxide (K_2O).

So, this 50 lb. bag contains 8 pounds of N, 2 pounds of P_2O_5 and 4 pounds of K_2O. If a homeowner spreads the contents of this bag on a lawn that is one-tenth of an acre then the application rates are 80 pounds of N, 20 pounds of P_2O_5 and 40 pounds of K_2O per acre. By comparison, farmers in the Corn Belt apply roughly 150 pounds of N, 70 pounds of P_2O_5 and 60 pounds of K_2O on an acre of corn.

Some of the most widely used commercial plant nutrient products are anhydrous ammonia (82-0-0), urea (46-0-0), ammonium nitrate (34-0-0), urea-ammonium nitrate solution or UAN solution (28-0-0 to 32-0-0) ammonium sulphate (21-0-0), diammonium phosphate or DAP (18-46-0), monoammonium phosphate or MAP (11-52-0), ammonium polyphosphate solution or APS (10-34-0), single superphosphate or SSP (0-20-0), NPK compounds (numerous analyses such as 15-15-15) and muriate of potash or MOP (0-0-60).

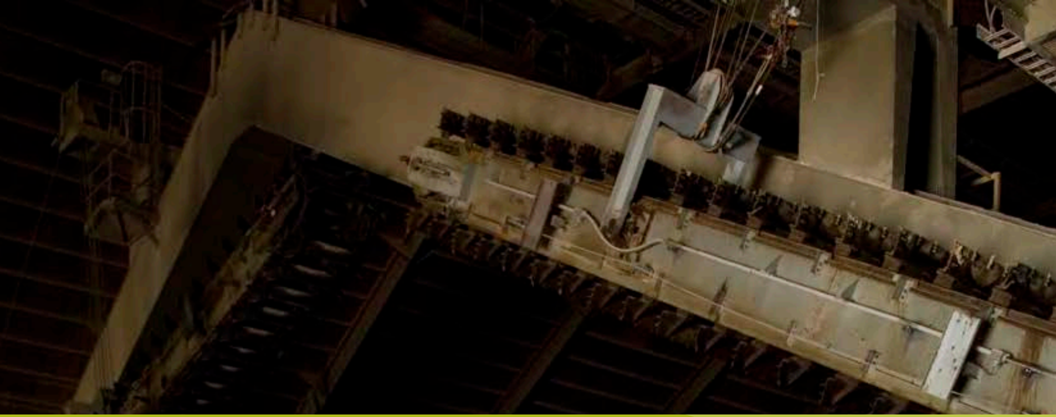
The physical characteristics of these products differ greatly. For example, anhydrous ammonia is a gas at normal temperatures and pressures. UAN solution and APS are liquids. Urea, ammonium nitrate, ammonium sulphate, DAP, MAP, SSP and MOP are solid granules. A few of these solid products likely were physically blended together to make the lawn fertilizer.

Distribution and Application

The distribution and application of plant nutrient products vary around the world. For example, in India, nearly all plant nutrient products are distributed in 50 kilogram polypropylene-lined bags. We estimate that Indian plant nutrient shipments totaled about 54 million tonnes in 2012/13, so that means almost 1.1 *billion* bags of plant nutrient products moved from domestic production and port facilities through tens of thousands of wholesale and retail distributors to Indian farmers.

A small-scale Indian farmer typically buys several bags of urea, DAP, MOP or NPK compounds and applies these products either by hand or with a small mechanical spreader. By contrast, a large-scale U.S. farmer typically buys several hundred tonnes of bulk products and hires the retail dealer to custom apply these materials with large and sophisticated application equipment.

The distribution and application of plant nutrient products generally evolves as the agricultural sector develops, land holdings consolidate and plant nutrient use increases. First, high-analysis products replace low-analysis products. This shift reduces the cost of storage, shipping and handling. For example, a high-analysis product such as MAP (11-52-0) contains three times more nutrients than SSP (0-20-0), so distributors can transport and store almost two-thirds less product and still deliver the same amount of primary nutrients (SSP contains significant amounts of sulphur, however). Second, large one-tonne bags and then bulk distribution typically replace 50 kilogram bags resulting in significant logistics and transportation cost savings. Third, custom application by retail crop input dealers using large scale and sophisticated equipment replaces application by the farm operator using small scale and less sophisticated equipment. Finally, variable rate replaces constant rate application. Brazil provides the best example of a country undergoing this transition today.



Phosphate

Phosphorus and Plant Nutrition

Phosphorus often is called The Energizer because it is a critical component of several "battery packs" that power plant growth and development. For example, phosphorus is an important compound in enzymes that control the production, transfer and storage of sugars throughout a plant. As a result, phosphorus is essential for the delivery of the large amounts of sugars required for early root development and seed formation. Phosphorus also is an important component of nucleic acids. These make up the DNA and RNA that direct complex processes such as cell division and protein synthesis.

Symptoms of phosphorus deficiency in plants include stunted growth, fewer or smaller leaves, overly green or purple leaves, delayed maturity and a lack of flowers or fruit. Purple leaves are a common symptom and indicate a build-up of sugars at the point of photosynthesis. There are no substitutes for phosphorus in a plant's diet.

Dragline Bucket

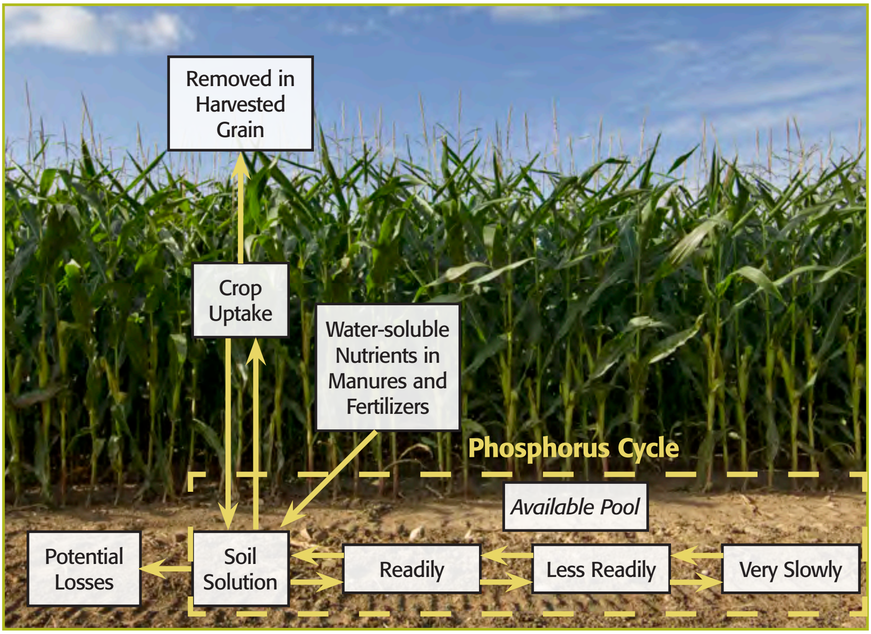
Granular DAP

Phosphorus Deficiency

The soil chemistry of phosphorus is more complex than that of nitrogen and other mineral elements. Plants absorb phosphorus from the soil solution in the form of orthophosphate ions, and dihydrogen phosphate ($H_2PO_4^-$) is the common form in most soils. Several reactions occur when phosphorus is applied to a soil. Water soluble phosphorus from plant nutrient products initially breaks down into orthophosphate ions in the soil solution and is readily available to plants.

Orthophosphate ions, however, differ from ammonium and nitrate ions in two important ways. First, orthophosphate ions typically are immobile in the soil solution. Once applied, phosphorus stays in the field as long as the soil remains there. As a result, phosphorus will carry over from one growing season to the next if not taken up by a plant. Most phosphorus losses occur as a result of soil erosion, so best management practices include the use of reduced or minimum tillage and buffer strips to reduce soil losses.

The Phosphorus Cycle



Second, orthophosphate ions are highly social creatures. While they may not move far in the soil, these ions bond quickly with other minerals such as aluminum, calcium and iron or with organic matter to form compounds that are less soluble and eventually less available to a plant. The chemical and physical characteristics of soil such as its pH, organic matter, moisture, temperature and compaction determine how much, how quickly and how tightly phosphorus will bond with other elements and become unavailable to a plant.

Fortunately, these bonds do not last forever, and the compounds eventually release phosphorus back into the soil solution as a result of other chemical reactions over time. This cycling of phosphorus from readily available to less available to unavailable and back occurs over several years.

Best management practices include frequent soil testing to measure available phosphorus, maintaining proper soil pH, building up soil organic matter and using sound tillage and application methods. Many farmers build available phosphorus to adequate levels in their soils and then simply replace the amount removed by the crop each year in order to keep the cycle intact. Skipping phosphorus application for a year or two may not greatly jeopardize yields if there is sufficient phosphorus that will become available from past applications. However, skipping an application or two breaks this cycle and will reduce available phosphorus in future years. As a result, larger applications may be required at that time in order to supply the amount of available phosphorus needed by a crop.

Phosphate Production - It Begins with Rock

Phosphorus is produced from phosphate rock, a mineral ore found in both marine sedimentary deposits as well as igneous formations. Large deposits of economically recoverable rock are found in a small number of regions such as North Africa, Western China, Central Florida and the Kola Peninsula of Russia.

Sedimentary ores are mostly horizontal deposits near the earth's surface. These deposits are mined with large draglines using traditional surface-mining methods. Igneous formations are mostly vertical deposits formed by ancient volcanic activity and are mined using conventional open-pit or underground mining techniques. Sedimentary deposits are more common and account for about 90% of global phosphate rock production today.

Cockpit of Dragline - South Fort Meade, FL

In Florida, the mining of sedimentary ore begins by removing 30 to 40 feet of overburden. Massive electric-powered draglines then scoop the soft ore and dump it into an earthen sump where it is blasted with water cannons to form a slurry. The slurry then is pumped through above ground pipelines to a beneficiation plant.

Sedimentary ores contain a mix of sand, clay and phosphate rock. The beneficiation process separates the sand and clay from the phosphate rock. For some ores, phosphate rock is separated by simple and low cost washing and screening processes. For most ores, however, in addition to washing and screening more complicated but widely used flotation processes are needed to separate fine clay and sand particles from the phosphate rock. The sand is pumped back to the mining area where it is put into the mine cut. The clay is pumped to a settling pond where it settles to the bottom over time. Beneficiated rock is then sent to chemical plants for processing into finished phosphate products.

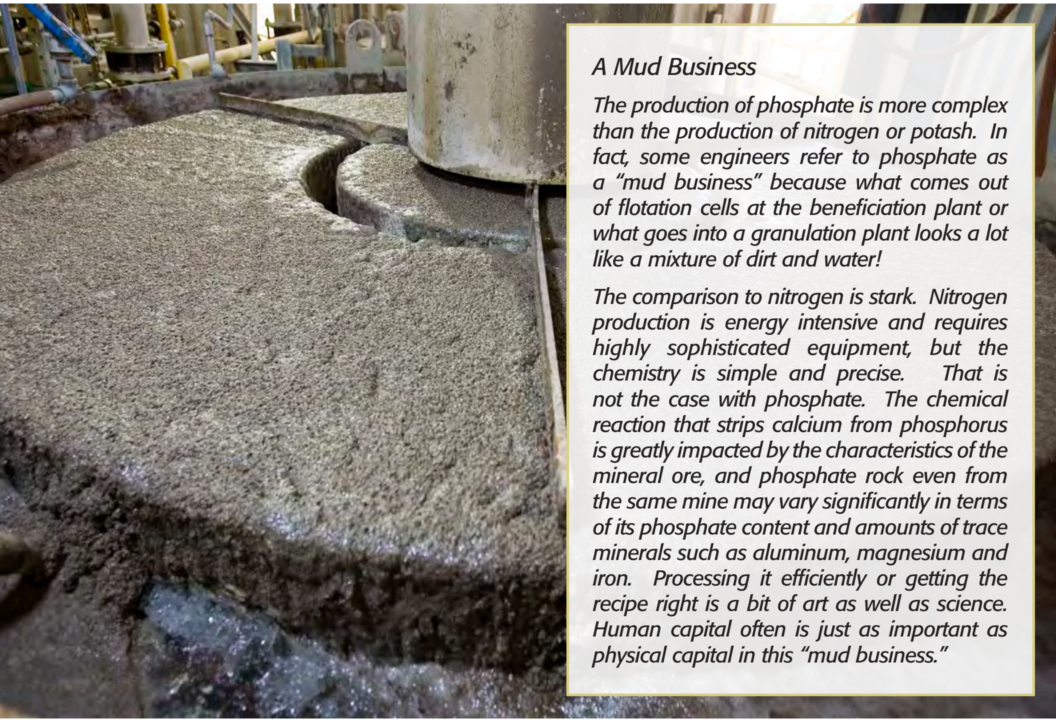
Before the First Bucket

The mining of surface ores with large draglines disturbs the land and creates unsightly landscapes. In the United States, long before the first bucket of ore is scooped out of the earth, a reclamation plan is in place that details how the mining company will restore the land to a state as good as or better than its original use.

The mining company works with regulatory authorities at local, state and federal levels to develop the reclamation plan. This plan documents land conditions prior to mining such as its topography, watershed, vegetative cover, wildlife populations and commercial uses and prescribes the programs and timeline to reclaim the land after it is mined.

The reclamation plan is one of the critical pieces required to obtain a mining permit and may take several years to complete. For example, vegetation may need to be documented or wildlife populations may need to be counted and tracked over multiple years.

In Florida, phosphate companies have restored mined areas to a variety of uses such as wetlands, wildlife habitats, citrus groves, pastureland, pine tree plantations, parks, golf courses and housing developments. In some cases, reclamation has rectified environmental damage that occurred prior to mining through the restoration of wetlands or the elimination of invasive species.



A Mud Business

The production of phosphate is more complex than the production of nitrogen or potash. In fact, some engineers refer to phosphate as a "mud business" because what comes out of flotation cells at the beneficiation plant or what goes into a granulation plant looks a lot like a mixture of dirt and water!

The comparison to nitrogen is stark. Nitrogen production is energy intensive and requires highly sophisticated equipment, but the chemistry is simple and precise. That is not the case with phosphate. The chemical reaction that strips calcium from phosphorus is greatly impacted by the characteristics of the mineral ore, and phosphate rock even from the same mine may vary significantly in terms of its phosphate content and amounts of trace minerals such as aluminum, magnesium and iron. Processing it efficiently or getting the recipe right is a bit of art as well as science. Human capital often is just as important as physical capital in this "mud business."

Phosphate Production – Stripping the Calcium

Oil refineries "crack" the petroleum molecule. Soybean processors "crush" the oilseed. Phosphate chemical plants "strip" calcium from phosphate rock. That is because the phosphorus in the beneficiated ore is bonded tightly to calcium, making it water insoluble and therefore unavailable to plants. So, the simplest non-technical description of what takes place at these sprawling complexes is that the bond between calcium and phosphorus is broken in order to make plant nutrient products that contain water soluble phosphate.

The most widely used method of breaking this bond or stripping calcium from phosphorus is to grind the rock into a powder-like consistency and then attack it with either sulphuric or nitric acid. With the exception of a few plants mainly in Europe and Russia, most processes utilize sulphuric acid.

Sulphuric acid "strips" calcium from the phosphate rock. This reaction produces phosphoric acid, an intermediate product used to manufacture nearly all high-analysis phosphate products, and calcium sulphate. The calcium sulphate is an impure form of gypsum (called phosphogypsum) that has no economic value today and is stacked at production sites in the United States.

Phosphogypsum is considered a byproduct, but in reality the main chemical reaction is the crystallization of phosphogypsum during this process. So, the chemistry makes phosphoric acid look more like the byproduct of the crystallization of phosphogypsum!

High-analysis or concentrated phosphate products such as DAP, MAP, and TSP are manufactured by neutralizing phosphoric acid with anhydrous ammonia or additional high-grade phosphate rock. High-analysis products manufactured using this process account for approximately two-thirds of global phosphate production today.

The remaining one-third is made up mostly of SSP and NPK compounds. SSP also is produced by first attacking ground rock with sulphuric acid, but rather than removing the calcium sulphate, this slurry is granulated to make a lower analysis product that contains about one-third of the nutrients of a high-analysis product. As a result, SSP contains the calcium and sulphur that end up on a phosphogypsum stack when high-analysis products are made.

Most phosphate producers make sulphuric acid on-site by burning elemental sulphur. The production of sulphuric acid is exothermic and generates large amounts of heat that typically are captured to run plant processes as well as to generate electricity on site.

Wet vs. Thermal Process

The process for producing phosphoric acid described here is referred to as the wet process. Nearly all phosphoric acid operations utilize this method today. The thermal process is another method for producing phosphoric acid. This process roasts phosphate rock along with petroleum coke and silica in an electric arc furnace to produce elemental phosphorus. Elemental phosphorus then is burned to make a pure form of phosphoric acid that is used almost exclusively for food and industrial applications. The thermal process is energy intensive, and the combination of higher energy costs and technological advances in the purification of wet process acid during the last 20 years has resulted in the closure of nearly all thermal process facilities in the United States.

Phosphogypsum - Another Side of the Story

Phosphogypsum Stack #2 and Cooling Ponds - Riverview, FL

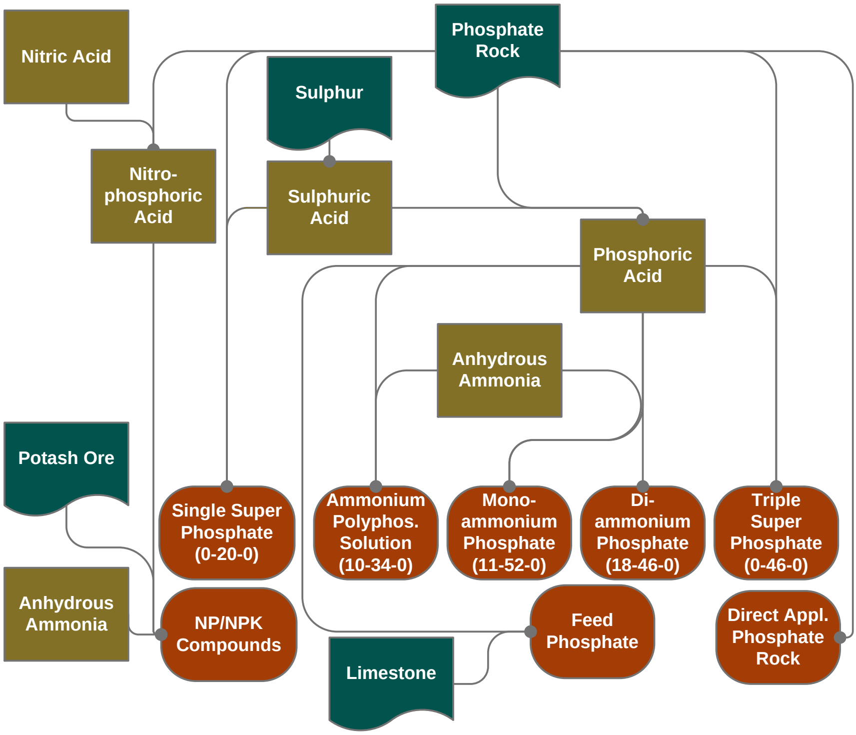
If you have ever driven through or flown over central Florida you can't help but notice the large phosphogypsum stacks that dot the landscape. The calcium sulphate byproduct produced at these facilities is an impure form of gypsum that has no economic use today and is stored at the plant site. These stacks are regulated and closely monitored in the United States.

Phosphogypsum storage is a costly part of the phosphate business, but there is another side of the story. Florida phosphate producers buy sulphur mainly from oil and gas refineries around the Gulf of Mexico. Refiners remove sulphur from oil and gas in order to comply with environmental standards for clean burning fuels. If refiners couldn't sell recovered sulphur to phosphate producers, they would have to store much of it at refineries because the phosphate industry uses about 50% of the sulphur recovered or mined in the world today.

Phosphate producers burn the sulphur to make sulphuric acid. This generates a large amount of heat and steam that is captured to run production processes as well as to generate "green" electricity at co-generation plants that are tied into the sulphuric acid units (there are no carbon emissions from this process). The sulphuric acid is used to make phosphate products that are vital to the world's food supply. The calcium sulphate byproduct then is pumped to a phosphogypsum stack where it is stored in compliance with strict environmental regulations and monitored on a regular basis.

That, we think, is a compelling story about the recycling and waste disposal of recovered sulphur.

Phosphate Production Process Flow



The phosphorus content of products is measured in units of phosphorus pentoxide (P_2O_5).

Diammonium Phosphate (18-46-0) Diammonium phosphate (DAP) is the most widely used high-analysis phosphate product worldwide. DAP is produced by first combining phosphoric acid with anhydrous ammonia in a reaction vessel. This initial reaction creates a slurry that is then pumped into a granulation plant where it is reacted with additional ammonia to produce DAP. DAP is a solid phosphate product that is applied directly or blended with other solid plant nutrient products such as urea and potassium chloride.

Monoammonium Phosphate (11-52-0) Monoammonium phosphate (MAP) is the second most widely used high-analysis phosphate product and the fastest growing phosphate product worldwide. MAP also is produced by first combining phosphoric acid with anhydrous ammonia in a reaction vessel. The resulting slurry is then pumped into the granulation plant where it is reacted with additional phosphoric acid to produce MAP. Some granulation plants can switch from DAP to MAP production simply by replacing the ammonia sparger with a phosphoric acid sparger. MAP also is a solid phosphate product that is applied directly or blended with other solid plant nutrient products.

Triple Superphosphate (0-46-0) Triple superphosphate (TSP) is the third most widely used high-analysis phosphate product. TSP contains only phosphate because it is produced by reacting phosphoric acid with additional high-grade phosphate rock. TSP also is a solid plant nutrient product, but it is hydroscopic or absorbs moisture and therefore cannot be blended with some products such as urea.

Superphosphoric Acid (0-72-0) & Ammonium Polyphosphate Solution (10-34-0) Superphosphoric acid (SPA) is produced by concentrating or removing additional water from phosphoric acid in order to boost its phosphate content to 68% to 72% P_2O_5. This gel-like product primarily is reacted with ammonia to produce ammonium polyphosphate solution (APS). APS is commonly referred to by its analysis – 10-34-0 solution. This liquid product is used as a direct application material and also as the base for several solution or suspension products. 10-34-0 solution often is mixed with other liquid products such as UAN solution to make products tailored to specific crops or phases of the growing season (e.g. starter fertilizers). Solid products, particularly potash, also are dissolved in to make suspension blends that deliver all three primary nutrients. 10-34-0 solution typically is produced in smaller regional plants by distributors who source SPA and ammonia and utilize cross-pipe reactor technology to manufacture the product on site.

Nitrophosphate & NPK Compounds (several analyses such as 17-17-17) Nitrophosphate compounds are produced by reacting phosphate rock with nitric acid rather than sulphuric acid. This process produces a variety of NP or NPK compounds containing different amounts of nitrogen, phosphorus and potassium (also added in the process). The process also produces calcium ammonium nitrate (CAN), an important nitrogen product in some regions such as Europe.

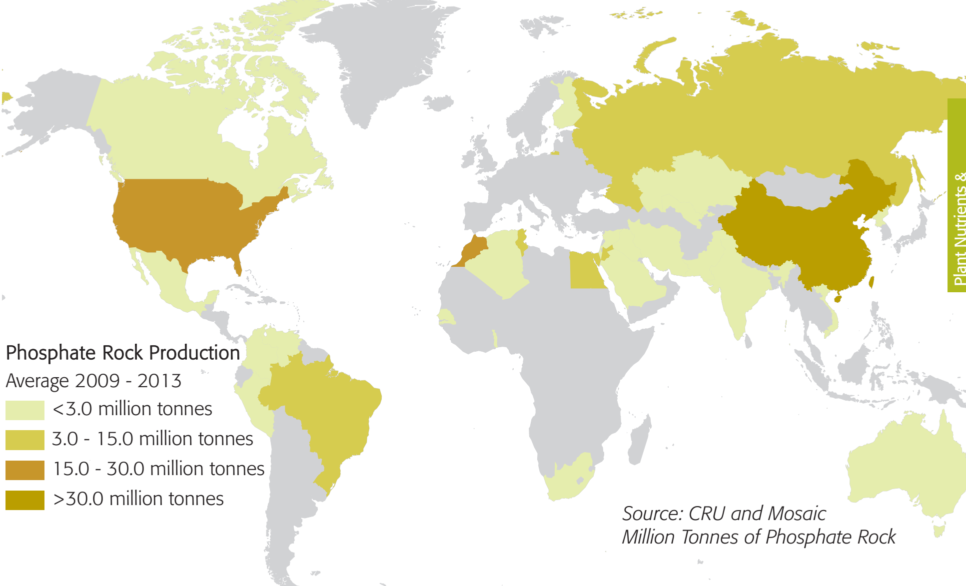
Single Superphosphate (0-20-0) Single superphosphate (SSP) is a low-analysis phosphate product that is produced by reacting ground rock with sulphuric acid. The resulting slurry is granulated into a solid that typically contains 18% to 22% P_2O_5. The phosphate content depends largely on rock quality. SSP contains the sulphur and calcium that are removed in the processes used to make high-analysis products.

Feed Phosphate Feed phosphate products are produced by neutralizing defluorinated phosphoric acid with limestone. The first step in the process is to reduce the fluorine-to-phosphorous ratio of the phosphoric acid to less than 1:100. That is achieved by adding diatomaceous earth (or activated silica) to phosphoric acid in order to "strip" fluorine from the acid. This defluorinated acid is neutralized with different quantities of limestone to produce the two most widely used feed phosphate products – dicalcium phosphate (Dical) and monocalcium phosphate (Monocal). Dical contains 18.5% P or 42.4% P_2O_5. Monocal is 21.0% P or 48.1% P_2O_5. In 2011, Mosaic launched Nexfos®, a granulated feed-grade monodicalcium phosphate that is a substitute for defluorinated phosphate rock. Nexfos contains 19.0% P or 43.5% P_2O_5.

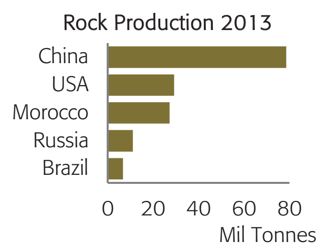
John Lawes: Father of the Plant Nutrient Industry

John Lawes is considered the father of the plant nutrient industry. Lawes was an agronomist who established the now legendary agricultural experiment farm at his family's estate in Rothamshed England in the 1840s. Among his many experiments and discoveries was the production of single superphosphate (SSP) from the reaction of sulphuric acid and phosphate rock. Lawes constructed the first simple production facility on the Rothamshed estate and patented the process in 1842. SSP became the first commercial plant nutrient product. It was wildly successful. In the UK alone, more than a dozen plants were operating within 10 years and about 80 facilities were producing SSP by 1870. SSP was the dominant phosphate product used by farmers worldwide for the next 100 years and is still a popular product in several countries such as Brazil, China and India.

Global Phosphate Rock Production



Phosphorus production begins with rock. Approximately 88% of global rock production is used to produce plant nutrients, and about 6% is used for the production of animal feed supplements. Industrial materials (mainly detergents and cleaning products) and food ingredients (largely purified acid for soft drinks) account for the remaining 6% of rock production.



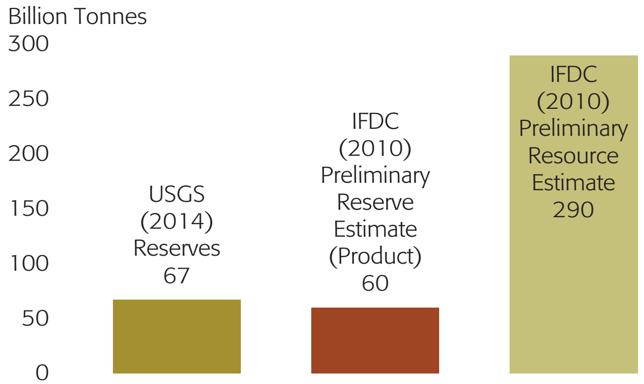
Source: CRU and Mosaic

Phosphate rock was mined in more than 30 countries, and global production reached 195 million tonnes in 2013, according to CRU statistics. However, only 14 countries mined more than two million tonnes of phosphate rock, and just six countries mined more than five million tonnes (the equivalent of one world scale mine). The top five countries accounted for over three-quarters of world production, and the top ten countries accounted for more than 85% of global output in 2013.

As with nitrogen, China ranks as the largest phosphate rock producer in the world by a significant margin. China mined more than 78 million tonnes of rock in 2013 or 40% of global output. This country alone has accounted for nearly all of the growth in global rock production so far this century, and the increase in Chinese production during the last decade exceeded the annual output of the next largest country. The United States (15%), Morocco (14%), Russia (6%) and Brazil (3%) rounded out the top five rock producing countries in 2013. Phosphate rock production outside of China has remained flat since 1995 with increases in some countries such as Morocco offset by decreases in other countries such as the United States.

Peak Phosphorus

Peak phosphorus is a hot research topic in academic circles today. Following the model of Hubbert's Peak Oil, a few recent studies have concluded that phosphate rock production will peak during the next 20 to 40 years and then decline sharply during the last half of this century. Proponents warn that depletion of phosphorus resources will imperil food supplies and concentrate economic and political power in countries such as Morocco that possess the largest remaining reserves. Researchers recommend more strict regulation of phosphorus production, use and recycling.

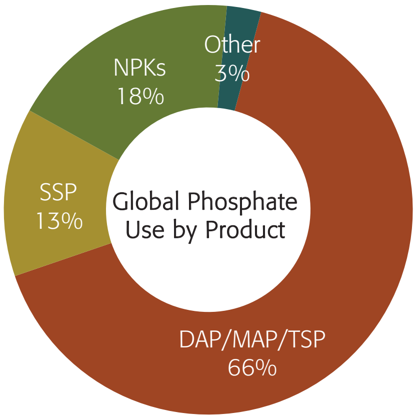


Source: USGS and IFDC

Critics of these studies acknowledge that phosphate rock is a finite and nonrenewable resource and support on-going efforts to further improve the efficacy of production, use and recycling. However, they contend that peak phosphorus studies utilize outdated estimates of rock reserves and fail to fully account for the impact of higher market prices and new technologies on resource estimates. They conclude that global phosphate rock reserves exceed estimates used in these studies by a wide margin and, as a consequence, see no threat of peak phosphorus production later this century.

That view is supported by recent estimates of global phosphate rock reserves and resources made by the U.S. Geological Survey (USGS) and the International Fertilizer Development Center (IFDC). *Reserves* are deposits that are economically recoverable based on expected market prices and current technology. *Resources* include reserves as well as deposits that likely will become economically viable as a result of higher market prices and likely advances in mining and beneficiation technologies. Based on a detailed review of global phosphate rock deposits, the IFDC and USGS estimate that reserves total 60 to 67 billion tonnes or roughly 310 to 340 years of production, and phosphate rock resources total 290 billion tonnes or more than 1,485 years of production at current rates.

The Leading Phosphate Products

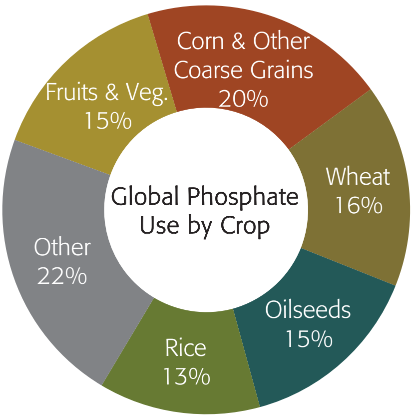


Source: CRU and Mosaic
Average 2009-2013

DAP, MAP and TSP are the most widely used phosphate products in the world, accounting for about two-thirds of global use from 2009 through 2013. These high-analysis products are used for direct application, blended with other solid nitrogen and potash products, or utilized in the production of some types of NP and NPK compounds. They also are the most widely traded phosphate products.

The next most commonly used phosphate products are NP/NPK compounds and SSP. The production and use of these products are concentrated in certain regions. For example, many producers in Europe and the former Soviet Union manufacture nitric acid based NP/NPK compounds, and large amounts of SSP are still produced and used in China, India and Brazil. SSP remains a popular product especially on sulphur deficient soils in these countries.

Phosphate Use by Crop



Source: IFA
Use in 2010/11

Like with nitrogen, corn and other coarse grains account for the largest share of global phosphate use (20%), according to the most recent estimates from the International Fertilizer Industry Association (IFA). Wheat consumes another 16% of the total. Nutrient intensive fruit and vegetable crops account for 15% of global phosphate use. Oilseed crops and rice account for another 15% and 13% of total use, respectively.

Use by crop differs significantly by country based on crop mix. For example, fruit and vegetable production claims 29% of total phosphate use in China or roughly 3.5 million tonnes P_2O_5. In fact, China's use of phosphate on just fruits and vegetables exceeds total phosphate consumption of all but two other countries today. In India, rice accounts for just under one-quarter of total phosphate use. Corn accounts for one-half of U.S. phosphate use, while soybeans consume nearly the same percentage in Brazil.

Exhibit I-12

Monoammonium Phosphate (MAP)

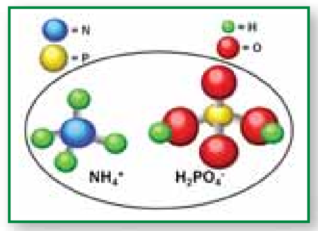
Monoammonium phosphate (MAP) is a widely used source of P and N. It is made of two constituents common in the fertilizer industry and has the highest P content of any common solid fertilizer.

Production

The process for manufacturing MAP is relatively simple. In a common method, a one to one ratio of ammonia (NH_3) and phosphoric acid (H_3PO_4) is reacted and the resulting slurry of MAP is solidified in a granulator. The second method is to introduce the two starting materials in a pipe-cross reactor where the reaction generates heat to evaporate water and solidify MAP. Variations of these methods are also in use for MAP production. An advantage of producing MAP is that lower quality H_3PO_4 can be used compared with other P fertilizers that often require a more pure grade of acid. The P_2O_5 equivalent content of MAP varies from 48 to 61%, depending on the amount of impurity in the acid. The most common fertilizer composition is 11-52-0.

Chemical Properties

Chemical formula:	$NH_4H_2PO_4$
P_2O_5 range:	48 to 61%
N range:	10 to 12%
Water solubility (20º)	370 g/L
Solution pH	4 to 4.5



Agricultural Use

MAP has been an important granular fertilizer for many years. It is water soluble and dissolves rapidly in soil if adequate moisture is present. Upon dissolution, the two basic components of the fertilizer separate again to release NH_4^+ and $H_2PO_4^-$. Both of these nutrients are important to sustain healthy plant growth. The pH of the solution surrounding the granule is moderately acidic, making MAP an especially desirable fertilizer in neutral and high pH soils. Agronomic studies show that there is no significant difference in P nutrition from various commercial P fertilizers under most conditions.

Granular MAP is applied in concentrated bands beneath the soil surface in proximity of growing roots or in surface bands. It is also commonly applied by spreading across the field and mixing into the surface soil with tillage. In powdered form, it is an important component of suspension fertilizers. When MAP is made with especially pure H_3PO_4, it readily dissolves into a clear solution that can be used as a foliar spray or added to irrigation water. The P_2O_5 equivalent content of high-purity MAP is usually 61%.

Management Practices

There are no special precautions associated with the use of MAP. The slight acidity associated with this fertilizer reduces the potential for NH_3 loss to the air. MAP can be placed in close proximity to germinating seeds without concern for NH_3 damage. When MAP is used as a foliar spray or added to irrigation water, it should not be mixed with calcium or magnesium fertilizers. MAP has good storage and handling properties. Some of the chemical impurities (such as iron and aluminum) naturally serve as a conditioner to prevent caking. Highly pure MAP may have a conditioner added or may require special handling to prevent clumping and caking. As with all P fertilizers, appropriate management practices should be used to minimize any nutrient loss to surface or drainage water.

A high purity source of MAP is used as a feed ingredient for animals. The NH_4^+ is synthesized into protein and the $H_2PO_4^-$ is used in a variety of metabolic functions in animals.

Non Agricultural Uses

MAP is used in dry chemical fire extinguishers commonly found in offices, schools, and homes. The extinguisher spray disperses finely powdered MAP, which coats the fuel and rapidly smothers the flame.

Abbreviations and notes: N = nitrogen; P = phosphorus; NH_4^+ = ammonium; $H_2PO_4^-$ = phosphate. MAP is also known as ammonium phosphate monobasic, ammonium dihydrogen phosphate

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Nutrient Source Specifics is a series of brief, condensed fact sheets highlighting common fertilizers and nutrient sources in modern agriculture. These topics are written by scientific staff of the International Plant Nutrition Institute (IPNI) for educational use. Mention of a fertilizer source or product name does not imply endorsement or recommendation. This series is available as PDF files at this URL: >www.ipni.net/specifics<

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Exhibit I-13

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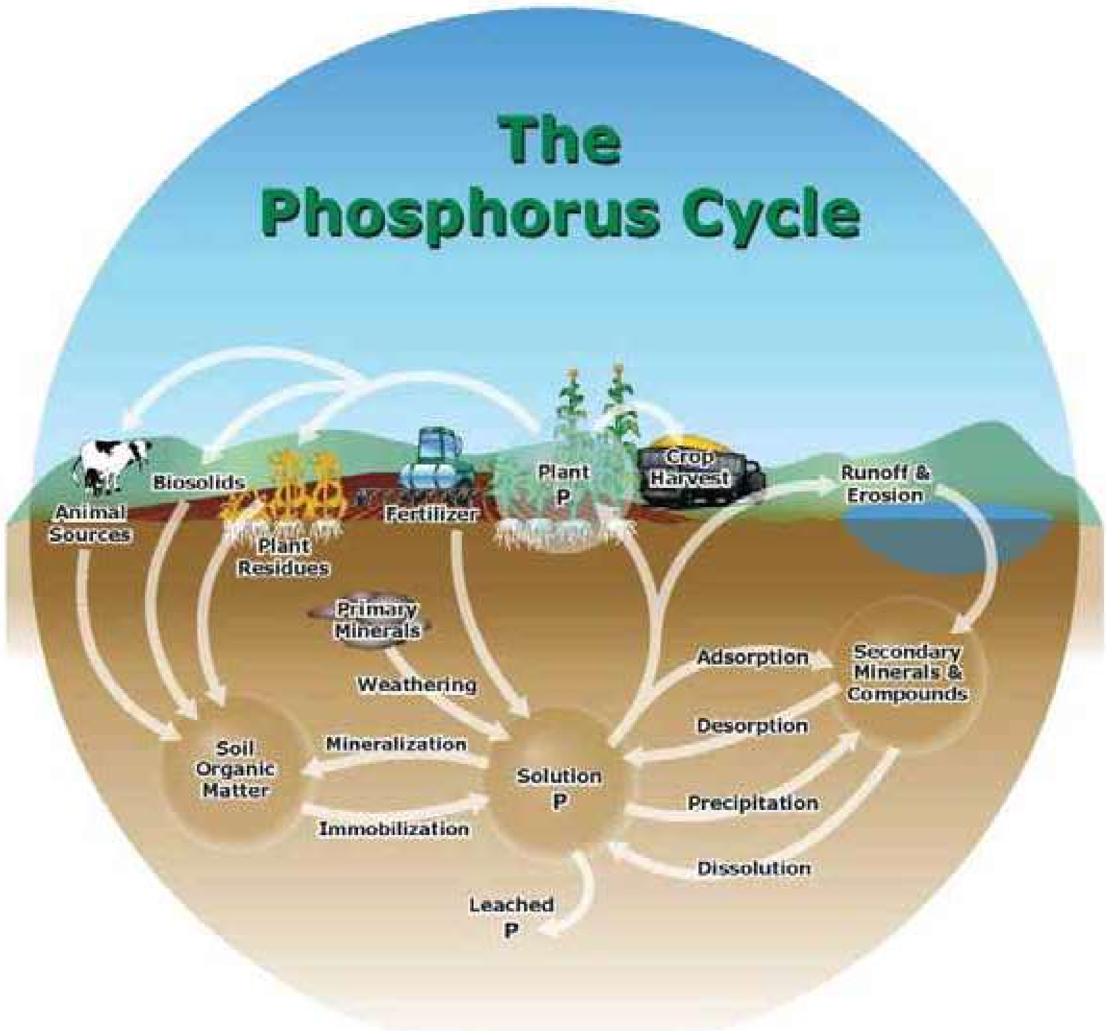
Phosphorus Fertilizer Production and Technology

Phosphorus (P) Cycling in Crop Production Systems



P is Essential for Plant Nutrition

- Taken up mostly as phosphate ($H_2PO_4^-$ and HPO_4^{2-})
- Involved in photosynthesis, energy transfer, cell division and enlargement
- Important in root formation and growth
- Improves the quality of fruit and vegetable crops
- Is vital to seed formation
- Improves water use
- Helps hasten maturity

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The Role of P as an Essential Nutrient for Animal Nutrition

- P is a major component of bones and teeth
- It is important for lactating animals
- P and calcium (Ca) are closely associated in animal nutrition
- It is essential for energy transfer and utilization

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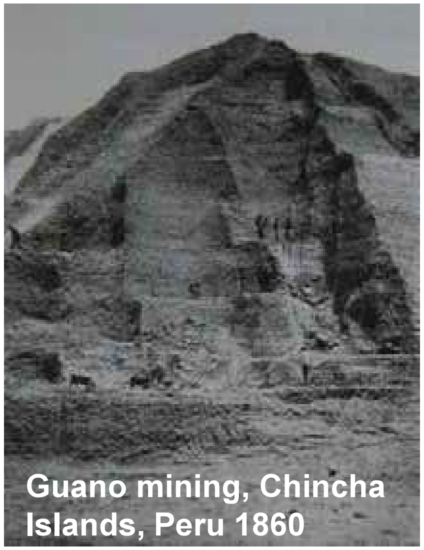
History of Phosphate Fertilizer

- Early sources were mostly animal based – bones, guano, manure
- Treatment of bones with acid to increase P solubility started early to mid 1800s
- Sulfuric acid treatment process of bones and P minerals (apatite) was patented in mid 1800s.
- Today most P fertilizer production is based on acidification of apatite from phosphate rock (PR)



Guano mining, Chincha Islands, Peru 1860

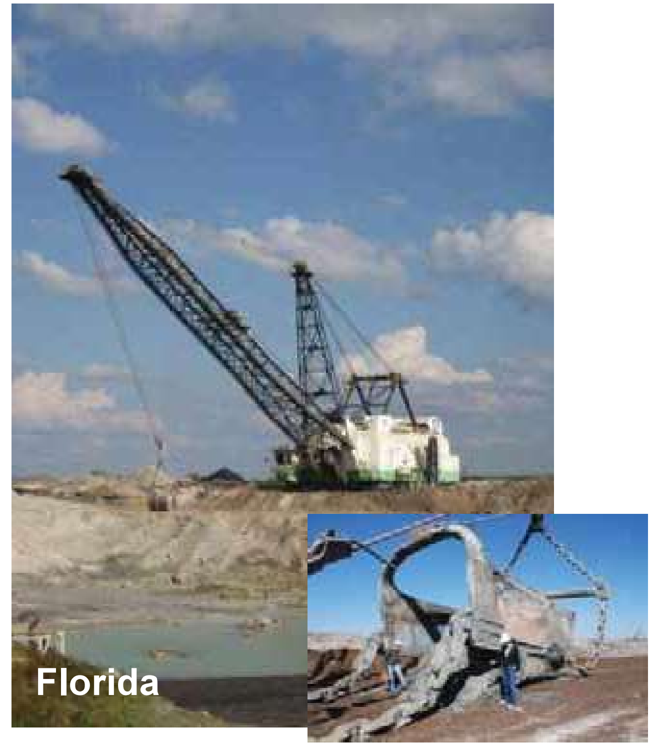
U.S. phosphate operation, late 1800s

Map of World P Resources

 Source: IFDC

PR Mining Techniques

- Most phosphate rock is extracted through open pit mining techniques such as
  - Draglines
  - Bucket wheel excavators
  - Front end loader removal



Phosphate Rock Utilization Factors

- Concentrated (beneficiated) PRs are usually about 27% to 37% P_2O_5 (may be as low as ~23%)
- Low free carbonate content to avoid excess consumption of acid in phosphoric acid production
- Low Fe_2O_3, Al_2O_3, and MgO contents (below ~5%) to avoid formation of intermediate products
- Low Cl^- content (<500 ppm) to prevent equipment corrosion

Ore Impurities and Beneficiation

- Initial removal of impurities from PR ore is called beneficiation
- Beneficiation of PR involves removal of materials such as sand, clay, carbonates, organics, and iron oxide
- Beneficiation may involve
  - Screening (wet or dry)
  - Washing
  - Hydrocyclones
  - Calcination
  - Flotation
  - Magnets


Aerial view of beneficiation

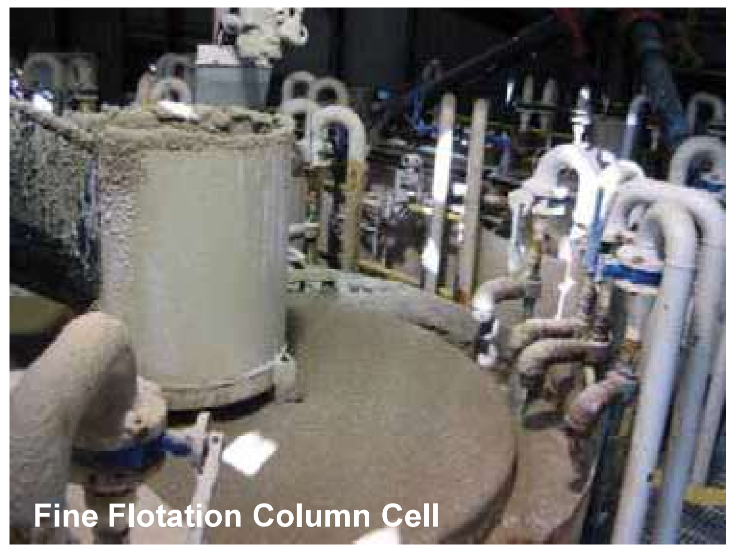
Ore Washing and Screening

- Separates oversize material (3 to 20 cm)
- Removes clays and other fines which result in a slurry of suspended waste called "slime"
- In areas without sufficient water, dry screening may be used

Ore Flotation

- Froth flotation requires deslimed feedstock
- The first step involves bubbling air through an anionic collector such as fatty acid
- Fine ore is passed though flotation cells, PR is attracted to the anionic collector, and rises with froth
- Floating apatite is thus separated from silica tailings by overflow or paddlewheels

Conventional Fine Flotation Circuits



Fine Flotation Column Cell

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Ore Calcination

- Is used at some locations to remove organic matter
- Organic matter is burned by passing ore through furnace
- Results in higher quality product
- Used where energy cost, especially natural gas, is low

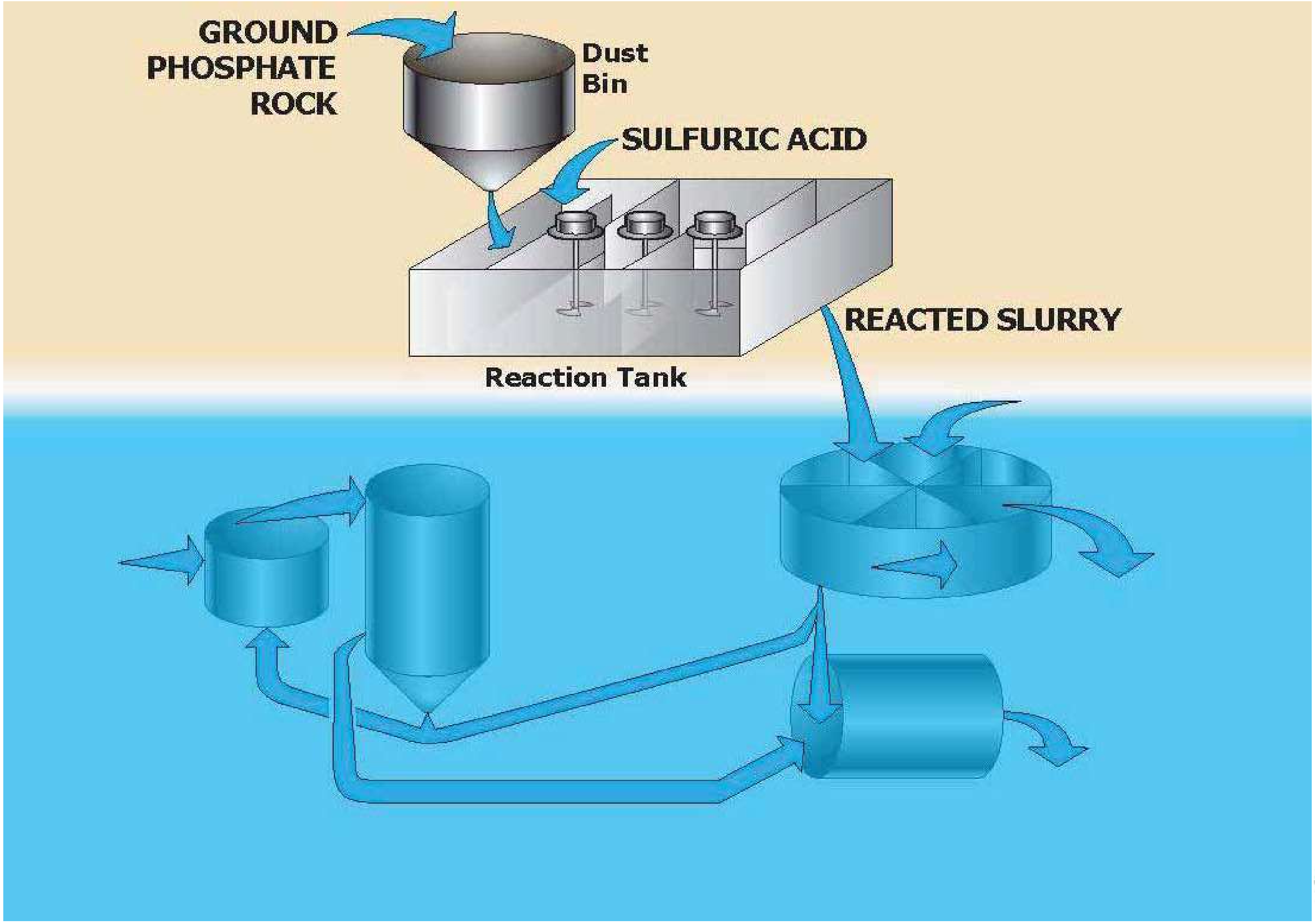
Non calcined PR, 67% BPL

Calcined PR, 72% BPL

Conversion of PR to Phosphoric Acid

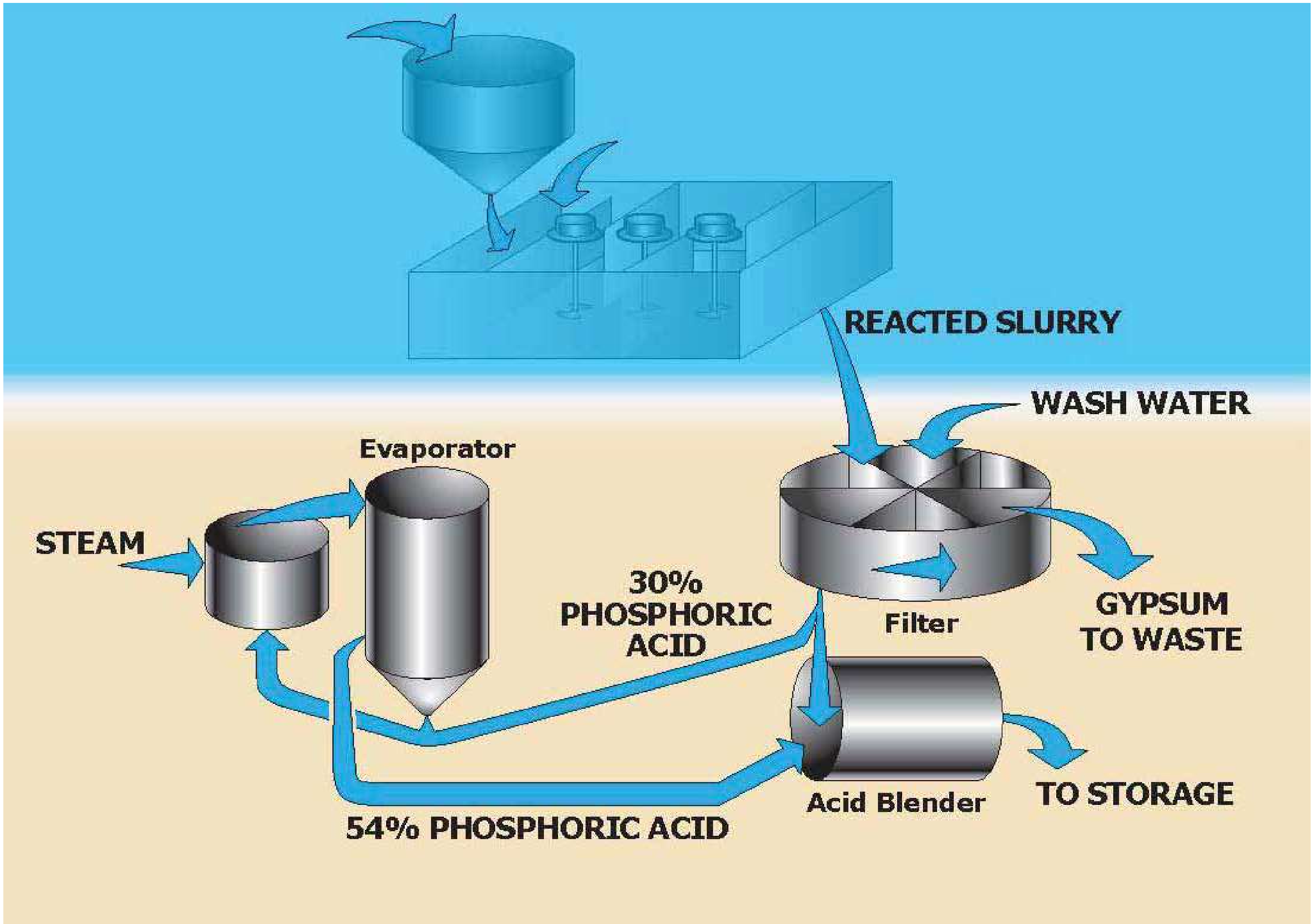
- After beneficiation, PR is converted to phosphoric acid
- Two processes of phosphoric acid production
  - Wet (chemical) process
  - Electric furnace (thermal) process
- The majority of P fertilizer is produced by wet process
  - Reaction of PR with acid
- The most common acid used on wet process is sulfuric (although others such as nitric acid are also used)
- The two major feedstocks in P fertilizer manufacturing are PR and elemental S

Wet Process Phosphoric Acid Production



(Cont.)

Wet Process Phosphoric Acid Production



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Tailing Disposal

- Two major tailings produced in P fertilizer manufacture
  - Slime
  - Phosphogypsum
- Slime is produced by the separation of clay and other "fines" from PR
- Slime may be
  - placed in settling ponds
  - disposed of in the sea
  - placed in mined-out areas for reclamation

Tailing Disposal (Continued)

- Phosphogypsum (PG) is produced in the reaction of sulfuric acid with PR
- Most PG is placed in stacks near the point of production
- In some countries it is disposed of in the sea
- Only a small percentage (~15%) of PG is reused in
  - agricultural applications
  - cement retardant
  - construction materials
  - plaster board
- Where nitric acid is used to produce P fertilizer there is no gypsum byproduct

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P Fertilizer Sources – Dry Granular

- Ordinary or normal superphosphate (OSP or SSP)
  - $Ca\ (H_2PO_4)_2 \cdot H_2O$
  - Low analysis (0-20-0-10S)
  - Simple to produce – results from reaction of PR with sulfuric acid
  - Oldest source – less popular than in the past
- Triple superphosphate (TSP)
  - First high analysis P fertilizer (0-46-0)
  - Results from reaction of PR with phosphoric acid
  - Production has declined since the 1980s in favor of ammoniated phosphates

P Fertilizer Sources – Dry Granular (Cont.)

- Diammonium phosphate (DAP)
  - Analysis, 18-46-0
  - Produced by reacting 2 moles ammonia with 1 mole of phosphoric acid
  - Worlds major dry P fertilizer
- Monoammonium phosphate (MAP)
  - Typical analysis, 11-52-0
  - Produced by reacting 1 mole ammonia with 1 mole of phosphoric acid
  - Lower quality PR can be used in production of MAP than DAP

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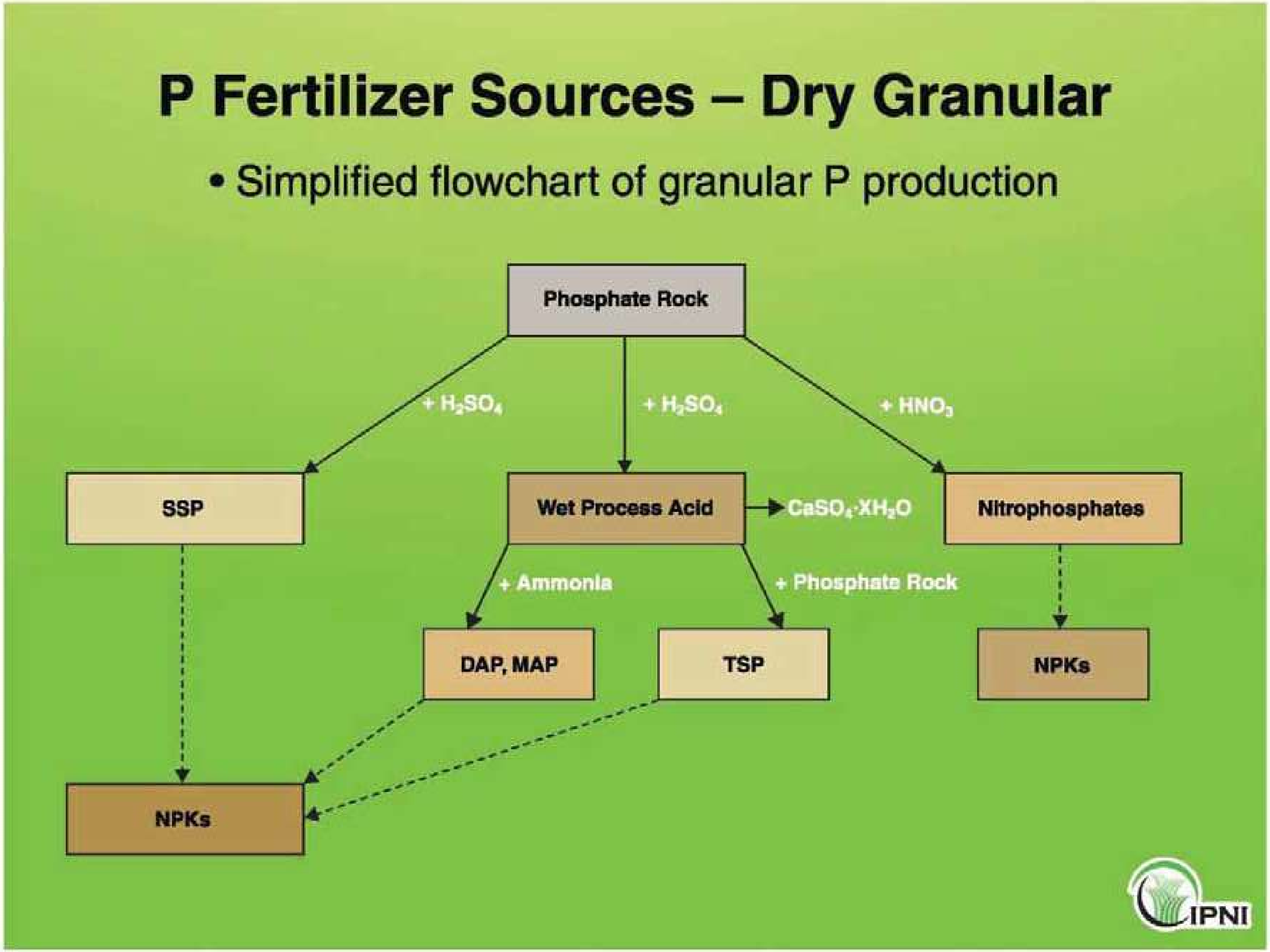
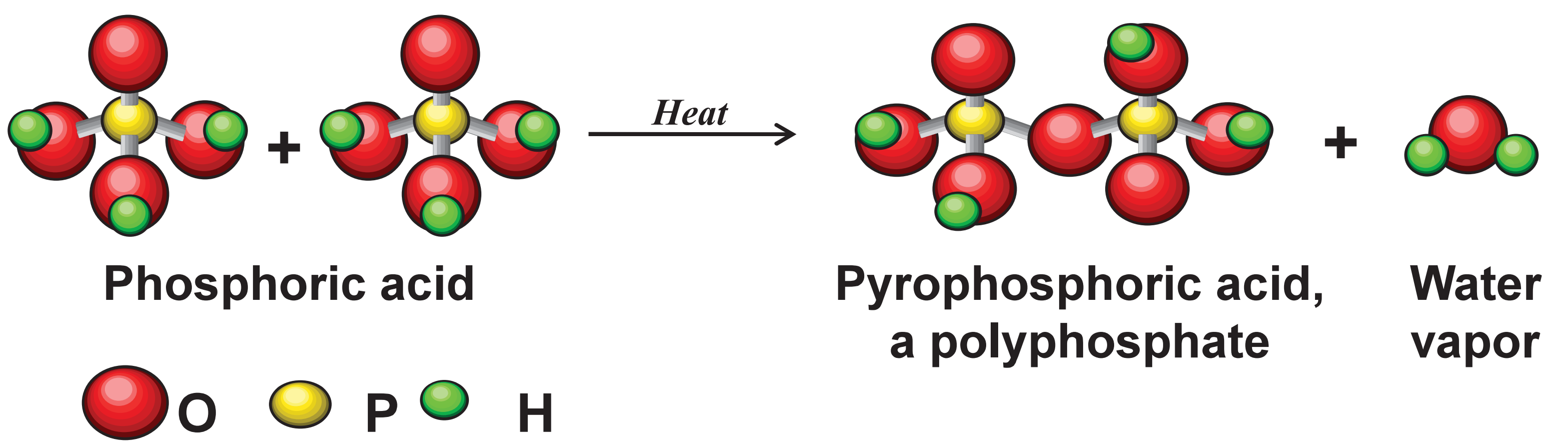


P Fertilizer Sources – Dry Granular
• Simplified flowchart of granular P production
Phosphate Rock
+ H_2SO_4
+ H_2SO_4
+ HNO_3
SSP
Wet Process Acid
$CaSO_4 \cdot XH_2O$
Nitrophosphates
+ Ammonia
+ Phosphate Rock
DAP, MAP
TSP
NPKs
NPKs
IPNI

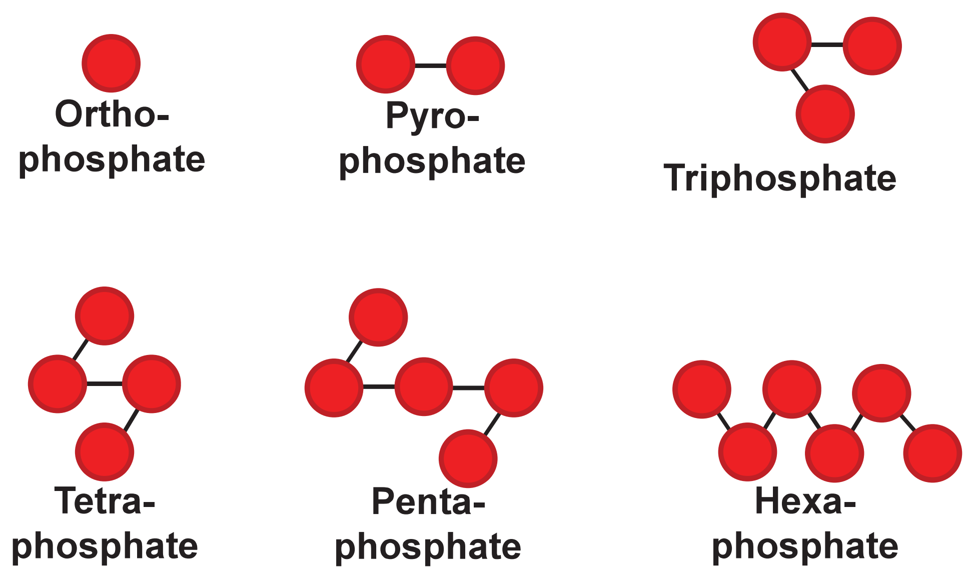
P Fertilizer Sources – Fluid

- Superphosphoric acid
  - Used as feedstock in the production of liquid polyphosphate fertilizers
  - Produced by dehydration of phosphoric acid
  - Contains 68 to 70% P_2O_5
  - Consists of mix of poly (20 to 35%) and orthophosphate



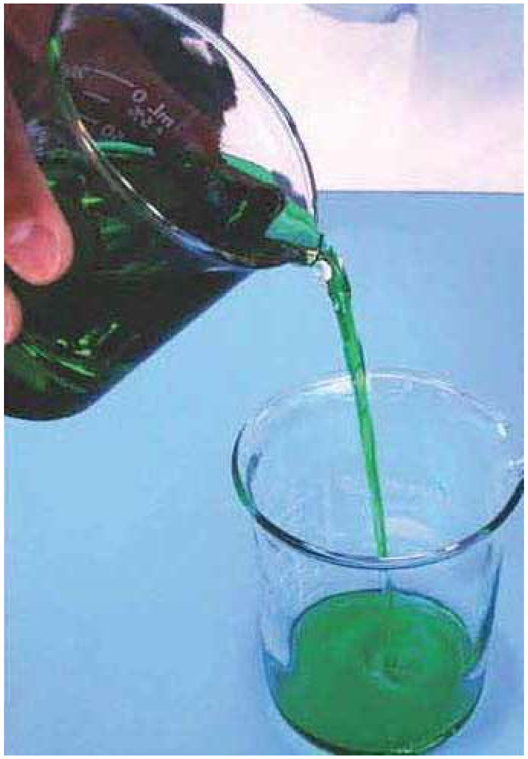
P Fertilizer Sources – Fluid (Cont.)

- Polyphosphates
  - Consist of a variety of polymers
  - Major polymer is pyrophosphate (two P molecules linked), but longer chained polyphosphates are also present



P Fertilizer Sources – Fluid (Cont.)

- Ammonium polyphosphate (APP)
  - Analysis 10-34-0 or 11-37-0
  - Major liquid P source
  - Mostly produced in TVA pipe reactor, introduced in 1972
  - Produced by reaction of superphosphoric acid, ammonia, and water
  - 70 to 75% of P is polyphosphate, the remainder is orthophosphate
  - Has good sequestering ability and storage characteristics



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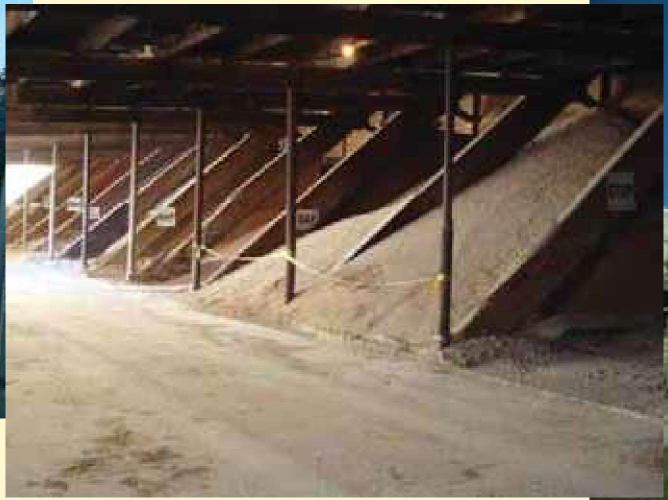
P Fertilizer Sources – Fluid (Cont.)

- Suspensions
  - First introduced in the 1960s
  - Consist of crystals suspended by gelled clay
  - Analysis intermediate between solutions (polyphosphate) and granular
  - Base materials commonly include anhydrous ammonia, MAP, water, attapulgite clay, and potash (KCl)
  - Distressed products can often be used to produce suspensions
  - Storage and application characteristics are poor relative to polyphosphates, thus they often require more management

Shipping and Storage



IPNI

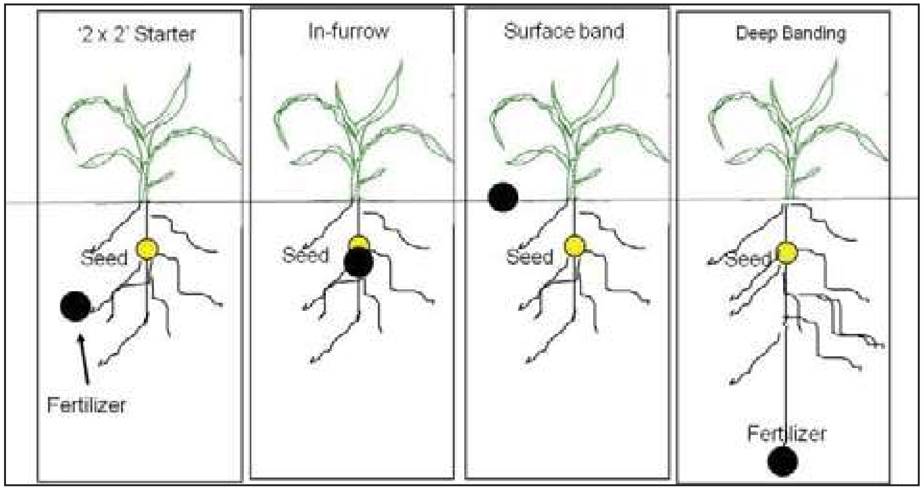
Phosphorus Fertilizer and the Soil

- Common commercial P fertilizers are highly (≥90%) water soluble
- Once dissolved in soils, orthophosphate is available for plant uptake
- Polyphosphates in APP must be converted to orthophosphate for plant uptake.
- Conversion or hydrolysis of poly to ortho in soils happens readily and does not affect nutritional value
- P chemistry in soils is complex – P may become sparingly available to plants in some soils due to formation of less soluble products

IPNI

Phosphorus Fertilizer Placement

- P fertilizer may be broadcast on the soil surface (liquid or dry) or it can be placed in a concentrated band
- There may be advantages to banding, including
  - Early crop growth enhancement
  - Concentration of P to minimize soil contact and reaction
  - Placement in the root zone



P Fertigation

- P fertilizer is sometimes applied with irrigation water, although not as commonly as N
- P fertigation requires special consideration of fertilizer properties and water chemistry
- It can cause system plugging and fouling by reacting with
  - Calcium
  - Magnesium
  - Ammonium
  - Iron
- Successful P fertigation requires careful planning!

High Yielding Crops Remove Large Amounts of P

Nutrients removed in crop harvest, including P, must eventually be replaced or production will suffer

Crop	Yield/A	Nutrient removal, lb P_2O_5/A	Yield, mt/ha	Nutrient removal, kg P_2O_5/ha
Maize	180 bu	80	11	90
Wheat	60 bu	30	4	34
Rice	70 cwt	45	7.8	50
Cotton	3 bales	35	1.6	39
Alfalfa	8 tons	120	18	134
Potato	500 cwt	75	56	84

Exhibit I-14

No. 17

Diammonium Phosphate

Diammonium phosphate (DAP) is the world's most widely used phosphorus (P) fertilizer. It is made from two common constituents in the fertilizer industry and it is popular because of its relatively high nutrient content and its excellent physical properties.

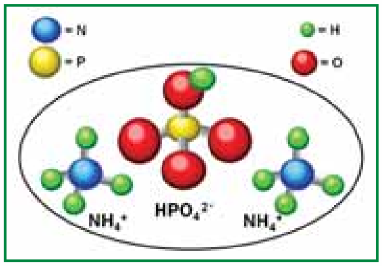
Production

Ammonium phosphate fertilizers first became available in the 1960s and DAP rapidly became the most popular in this class of products. It is formulated in a controlled reaction of phosphoric acid with ammonia, where the hot slurry is then cooled, granulated, and sieved. DAP has excellent handling and storage properties. The standard grade of DAP is 18-46-0 and fertilizer products with a lower nutrient content may not be labeled as DAP.

The inputs required to produce one ton of DAP fertilizer are approximately 1.5 to 2 tons of phosphate rock, 0.4 tons of sulfur (S), to dissolve the rock, and 0.2 tons of ammonia. Changes in the supply or price of any of these inputs will impact DAP prices and availability. The high nutrient content of DAP is helpful in reducing handling, freight, and application costs. DAP is produced in many locations in the world and is a widely traded fertilizer commodity.

Chemical Properties

Chemical formula:	$(NH_4)_2HPO_4$
Composition:	18% N
	46% P_2O_5 (20% P)
Water solubility (20 °C):	588 g/L
Solution pH:	7.5 to 8



Agricultural Use

DAP fertilizer is an excellent source of P and nitrogen (N) for plant nutrition. It is highly soluble and thus dissolves quickly in soil to release plant-available phosphate and ammonium. A notable property of DAP is the alkaline pH that develops around the dissolving granule.

As ammonium is released from dissolving DAP granules, volatile ammonia can be harmful to seedlings and plant roots in immediate proximity. This potential damage is more common when the soil pH is greater than 7, a condition that commonly exists around the dissolving DAP granule. To prevent the possibility of seedling damage, care should be taken to avoid placing high concentrations of DAP near germinating seeds.

The ammonium present in DAP is an excellent N source and will be gradually converted to nitrate by soil bacteria, resulting in a subsequent drop in pH. Therefore, the rise in soil pH surrounding DAP granules is a temporary effect. This initial rise in soil pH neighboring DAP can influence the micro-site reactions of phosphate and soil organic matter.

Management Practices

There are differences in the initial chemical reaction between various commercial P fertilizers in soil, but these dissimilarities become minor over time (within weeks or months) and are minimal as far as plant nutrition is concerned. Most field comparisons between DAP and monoammonium phosphate (MAP) show only minor or no differences in plant growth and yield due to P source with proper management.

Non Agricultural Uses

DAP is used in many applications as a fire retardant. For example, a mixture of DAP and other ingredients can be spread in advance of the fire to prevent a forest from burning. It then becomes a nutrient source after the danger of fire has passed. DAP is used in various industrial processes, such as metal finishing. It is commonly added to wine to sustain yeast fermentation and to cheese to support cheese cultures.

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Nutrient Source Specifics is a series of brief, condensed fact sheets highlighting common fertilizers and nutrient sources in modern agriculture. These topics are written by scientific staff of the International Plant Nutrition Institute (IPNI) for educational use. Mention of a fertilizer source or product name does not imply endorsement or recommendation. This series is available as PDF files at this URL: >www.ipni.net/specifics<

Ref. #17- 11040

Exhibit I-15

IPNI
Nutrient Source SPECIFICS

Single Superphosphate

No. 21

Single superphosphate (SSP) was the first commercial mineral fertilizer and it led to the development of the modern plant nutrient industry. This material was once the most commonly used fertilizer, but other phosphorus (P) fertilizers have largely replaced SSP because of its relatively low P content.

Production

The modern fertilizer industry was launched in the 1840s with discovery that the addition of sulfuric acid to naturally occurring phosphate produced an excellent soluble fertilizer, given the name superphosphate. Ground animal bones were first used in this reaction, but natural deposits of rock phosphate (apatite) soon replaced the limited supply of bones. Making SSP is similar to what naturally occurs with bones or apatite in acid soils. The basic technique has changed very little in the past century. Ground phosphate rock is reacted with sulfuric acid to form a semi-solid which cools for several hours in a den. The plastic-like material is then conveyed to a storage pile for several weeks of additional curing. The hardened material is then milled and screened to the appropriate particle size or granulated. The general chemical reaction is:

$Ca_3(PO_4)_2$ [rock phosphate] + 2 H_2SO_4 [sulfuric acid] → $Ca(H_2PO_4)_2$ [monocalcium phosphate] + 2 $CaSO_4$ [gypsum]

SSP can easily be produced on a small scale to meet regional needs. Since SSP contains both monocalcium phosphate (MCP, also called calcium dihydrogen phosphate) and gypsum, there are no issues with phosphogypsum by-product disposal as occurs with the manufacture of other common P fertilizers.

SSP is also known as ordinary superphosphate and normal superphosphate. It is sometimes confused with triple superphosphate (TSP) production, which is made by reacting rock phosphate with phosphoric acid.

Chemical Properties

Phosphorus content:	7 to 9% (16 to 20% P_2O_5)
Calcium (Ca) content:	18 to 21%
S content:	11 to 12%
pH:	< 2

Granular single superphosphate

Agricultural Use

SSP is an excellent source of three plant nutrients. The P component reacts in soil similarly to other soluble fertilizers. The presence of both P and sulfur (S) in SSP can be an agronomic advantage where both of these nutrients are deficient. In agronomic studies where SSP is demonstrated to be superior to other P fertilizers, it is usually due to the S and/or Ca that it contains. When locally available, SSP has found wide-spread use for fertilizing pastures where both P and S are needed. As a source of P alone, SSP often costs more than other more concentrated fertilizers, therefore it has declined in popularity.

Management Practices

No special agronomic or handling precautions are required for SSP. Its agronomic effectiveness is similar to other dry or liquid phosphate fertilizers.

The loss of P in surface runoff from fertilized fields can contribute to water quality problems. Farm practices that minimize this loss should be implemented.

Non Agricultural Uses

SSP is primarily used as a crop nutrient source. However MCP and gypsum (the two primary ingredients in SSP) are widely used in many products. For example MCP is commonly added to enrich animal feed. It is also routinely used as a leavening agent to cause baked goods to rise. Gypsum is widely used in the construction industry, as well as in the food and pharmaceuticals.

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Ref. #21 #11082

Exhibit I-16

Nutrient Source SPECIFICS

No. 14

Triple Superphosphate

Triple superphosphate (TSP) was one of the first high analysis P fertilizers that became widely used in the 20th century. Technically, it is known as calcium dihydrogen phosphate and as monocalcium phosphate, [$Ca(H_2PO_4)_2 \cdot H_2O$]. It is an excellent P source, but its use has declined as other P fertilizers have become more popular.

Production

The concept of TSP production is relatively simple. Non-granular TSP is commonly produced by reacting finely ground phosphate rock with liquid phosphoric acid in a cone-type mixer. Granular TSP is made similarly, but the resulting slurry is sprayed as a coating onto small particles to build granules of the desired size. The product from both production methods is allowed to cure for several weeks as the chemical reactions are slowly completed. The chemistry and process of the reaction will vary somewhat depending on the properties of the phosphate rock.

Chemical Properties

Chemical formula:	$Ca(H_2PO_4)_2 \cdot H_2O$
Fertilizer analysis:	45% P_2O_5 (0-45-0)
	15% Ca
Water-soluble P:	Generally >90%
Solution pH	1 to 3

Triple superphosphate is available in granular (shown) and non-granular forms.

Agricultural Use

TSP has several agronomic advantages that made it such a popular P source for many years. It has the highest P content of dry fertilizers that do not contain N. Over 90% of the total P in TSP is water soluble, so it becomes rapidly available for plant uptake. As soil moisture dissolves the granule, the concentrated soil solution becomes acidic. TSP also contains 15% calcium (Ca), providing an additional plant nutrient.

A major use of TSP is in situations where several solid fertilizers are blended together for broadcasting on the soil surface or for application in a concentrated band beneath the surface. It is also desirable for fertilization of leguminous crops, such as alfalfa or beans, where no additional N fertilization is needed to supplement biological N fixation.

Management Practices

The popularity of TSP has declined because the total nutrient content (N + P_2O_5) is lower than ammonium phosphate fertilizers such as monoammonium phosphate, which by comparison contains 11% N and 52% P_2O_5. Costs of producing TSP can be higher than ammonium phosphates, making the economics for TSP less favorable in some situations.

All P fertilizers should be managed to avoid losses in surface water runoff from fields. Phosphorus loss from agricultural land to adjacent surface water can contribute to undesired stimulation of algae growth. Appropriate nutrient management practices can minimize this risk.

Non Agricultural Uses

Monocalcium phosphate is an important ingredient in baking powder. The acidic monocalcium phosphate reacts with an alkaline component to produce carbon dioxide, the leavening for many baked products. Monocalcium phosphate is commonly added to animal diets as an important mineral supplement of both phosphate and Ca.

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Ref #14- 10074

Exhibit I-17

[Note: with the publication of the Fifth Edition of AP-42, the Chapter and Section number for Phosphate Fertilizers was changed to 8.5.]

BACKGROUND REPORT

AP-42 SECTION 6.10

PHOSPHATE FERTILIZERS

Prepared for

U.S. Environmental Protection Agency
OAQPS/TSD/EIB
Research Triangle Park, NC 27711

1-96

Pacific Environmental Services, Inc.
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Research Triangle Park, NC 27709
919/941-0333

1-96

AP-42 Background Report

TECHNICAL SUPPORT DIVISION

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

This report has been reviewed by the Technical Support Division of the Office of Air Quality Planning and Standards, EPA. Mention of trade names or commercial products is not intended to constitute endorsement or recommendation for use. Copies of this report are available through the Library Services Office (MD-35), U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

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1.0 INTRODUCTION

The document "Compilation of Air Pollutant Emission Factors" (AP-42) has been published by the U.S. Environmental Protection Agency (the EPA) since 1972. Supplements to AP-42 have been routinely published to add new emission source categories and to update existing emission factors. AP-42 is routinely updated by the EPA to respond to new emission factor needs of the EPA, State, and local air pollution control programs and industry.

An emission factor relates the quantity (weight) of pollutants emitted to a unit of activity of the source. The uses for the emission factors reported in AP-42 include:

1. Estimates of area-wide emissions;
2. Emission estimates for a specific facility; and
3. Evaluation of emissions relative to ambient air quality.

The purpose of this report is to provide background information from process information obtained from industry comment and 9 test reports to support revision of emission factors for sections 6.10.1, "Normal superphosphates," 6.10.2 "Triple Superphosphates," and 6.10.3, "Ammonium Phosphates."

Including the introduction (Chapter 1), this report contains four chapters. Chapter 2 gives descriptions of the normal superphosphates, triple superphosphates, and ammonium phosphates industries. It includes a characterization of the industry, an overview of the different process types, a description of emissions, and a description of the technology used to control emissions resulting from the production of normal superphosphates, triple superphosphates and ammonium phosphates productions, and a review of references.

Chapter 3 is a review of emissions data collection and analysis procedures. It describes the literature search, the screening of emission data reports, and the quality rating system for both emission data and emission factors. Chapter 4 includes the review of specific data sets, details criteria and noncriteria pollutant emission factor development, and contains the results of a data gap analysis. Appendix A presents AP-42 Sections 6.10.1, 6.10.2, and 6.10.3.

2.0 INDUSTRY DESCRIPTION

2.1 GENERAL

The phosphate fertilizer industry is divided into three segments: phosphoric acid and superphosphoric acid, normal and triple superphosphate, and granular ammonium phosphate. Only normal superphosphate, triple superphosphate, and ammonium phosphate are discussed in this background report.

Normal Superphosphates

Normal superphosphate refers to fertilizer material containing 15 to 21 percent phosphorous as phosphorous pentoxide (P_2O_5). As defined by the Census Bureau, normal superphosphate contains not more than 22 percent of available P_2O_5. There are currently about eight fertilizer facilities producing normal superphosphates in the U.S. with an estimated total production of about 273,000 megagrams (300,000 tons) per year.

Triple Superphosphates

Triple superphosphate, also known as double, treble, or concentrated superphosphate, is a fertilizer material with a phosphorus content of over 40 percent, measured as phosphorus pentoxide (P_2O_5). Triple superphosphate is produced in only six fertilizer facilities in the U.S. In 1989, there were an estimated 3.2 million megagrams (3.5 million tons) of triple superphosphate produced. Production rates from the various facilities range from 23 to 92 megagrams (25 to 100 tons) per hour.

Ammonium Phosphates

Ammonium phosphate ($NH_4H_2PO_4$) is produced by reacting phosphoric acid (H_3PO_4) with anhydrous ammonia (NH_3). Ammoniated superphosphates are produced by adding normal superphosphate or triple superphosphate to the mixture. The production of liquid ammonium phosphate and ammoniated superphosphates in fertilizer mixing plants is considered a separate process. Both solid and liquid ammonium phosphate fertilizers are produced in the U.S. and the most common ammonium phosphate fertilizer grades are monoammonium phosphate (MAP) and diammonium phosphate (DAP). This discussion covers only the granulation of phosphoric acid with anhydrous ammonia to produce granular fertilizer. Total ammonium phosphate production in the U.S. in 1992 was estimated to be 7.7 million megagrams (8.5 million tons).

2.2 PROCESS DESCRIPTION

Normal Superphosphates

Normal superphosphates are prepared by reacting ground phosphate rock with 65 to 75 percent sulfuric acid. An important factor in the production of normal superphosphates is the amount of iron and aluminum in the phosphate rock. Aluminum (as Al_2O_3) and iron (as Fe_2O_3) above five percent imparts an extreme stickiness to the superphosphate and makes it difficult to handle.

The two general types of sulfuric acid used in superphosphate manufacture are virgin and spent acid. Virgin acid is produced from elemental sulfur, pyrites, and industrial gases and is relatively pure. Spent acid is a recycled waste product from various industries that use large quantities of sulfuric acid. Problems encountered with using spent acid include unusual color, unfamiliar odor, and toxicity.

A generalized flow diagram of normal superphosphate production is shown in Figure 2.2-1. Ground phosphate rock and acid are mixed in a reaction vessel, held in an enclosed area for about 30 minutes until the reaction is partially completed, and then transferred, using an enclosed conveyer known as the den, to a storage pile for curing (the completion of the reaction). Following curing, the product is most often used as a high-phosphate additive in the production of granular fertilizers. It can also be granulated for sale as granulated superphosphate or granular mixed fertilizer. To produce granulated normal superphosphate, cured superphosphate is fed through a clod breaker and sent to a rotary drum granulator where steam, water, and acid may be added to aid in granulation. Material is processed through a rotary drum granulator, a rotary dryer, a rotary cooler, and is then screened to specification. Finally, it is stored in bagged or bulk form prior to being sold.

Triple Superphosphates

Two processes have been used to produce triple superphosphate: run-of-the-pile (ROP-TSP) and granular (GTSP). At this time, no facilities in the U.S. are currently producing ROP-TSP, but a process description is given.

The ROP-TSP material is essentially a pulverized mass of variable particle size produced in a manner similar to normal superphosphate. Wet-process phosphoric acid (50 to 55 percent P_2O_5) is reacted with ground phosphate rock in a cone mixer. The resultant slurry begins to solidify on a slow moving conveyer en route to the curing area. At the point of discharge from the den, the material passes through a rotary mechanical cutter that breaks up the solid mass. Coarse ROP-TSP product is sent to a storage pile and cured for three to five weeks. The product is then mined from the storage pile to be crushed, screened, and shipped in bulk.

Granular triple superphosphate yields larger, more uniform particles with improved storage and handling properties. Most of this material is made with the Dorr-Oliver slurry granulation process, illustrated in Figure 2.2-2.

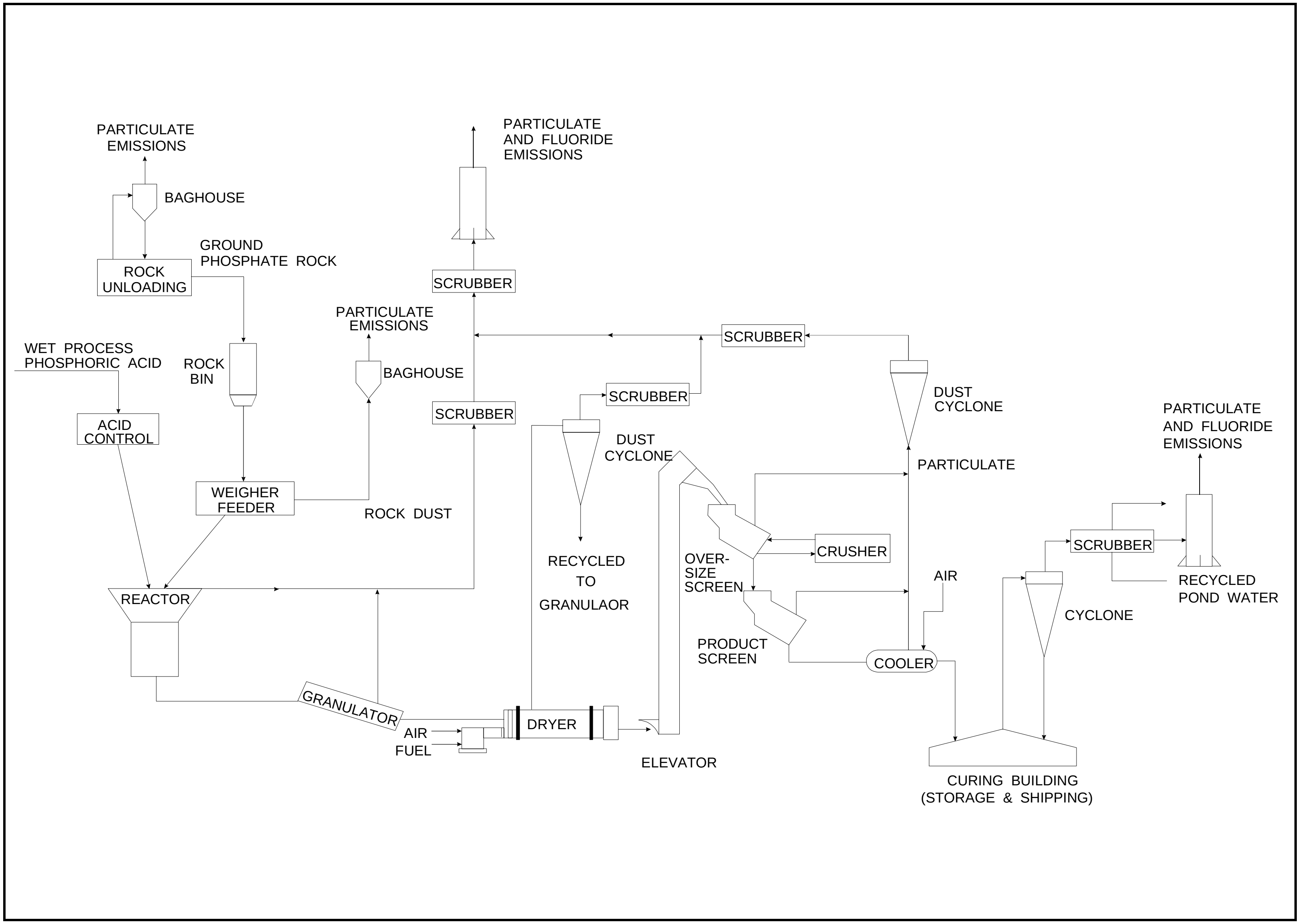

Figure 2.2-2 Dorr-Oliver process for granular triple superphosphate production[1]

In this process, ground phosphate rock or limestone is reacted with phosphoric acid in one or two reactors in series. The phosphoric acid used in this process is appreciably lower in concentration (40 percent P_2O_5) than that used to manufacture ROP-TSP product. The lower strength acid maintains the slurry in a fluid state during a mixing period of one to two hours. A small sidestream of slurry is continuously removed and distributed onto dried, recycled fines, where it coats the granule surfaces and builds up its size.

Pugmills and rotating drum granulators have been used in the granulation process. Only one pugmill is currently operating in the U.S. A pugmill is composed of a U-shaped trough carrying twin counter-rotating shafts, upon which are mounted strong blades or paddles. The blades agitate, shear, and knead the liquefied mix and transport the material along the trough. The basic rotary drum granulator consists of an open-ended, slightly inclined rotary cylinder, with retaining rings at each end and a scraper or cutter mounted inside the drum shell. A rolling bed of dry material is maintained in the unit while the slurry is introduced through distributor pipes set lengthwise in the drum under the bed. Slurry-wetted granules are then discharged onto a rotary dryer, where excess water is evaporated and the chemical reaction is accelerated to completion by the dryer heat. Dried granules are then sized on vibrating screens. Oversize particles are crushed and recirculated to the screen, and undersize particles are recycled to the granulator. Product-size granules are cooled in a countercurrent rotary drum, then sent to a storage pile for curing. After a curing period of three to five days, granules are removed from storage, screened, bagged and shipped.

Ammonium phosphates

Two basic mixer designs are used by ammoniation-granulation plants: the pugmill ammoniator and the rotary drum ammoniator. Approximately 95 percent of ammoniation-granulation plants in the United States use a rotary drum mixer developed and patented by the Tennessee Valley Authority (TVA). The basic rotary drum ammoniator-granulator consists of a slightly inclined open-end rotary cylinder with retaining rings at each end, and a scrapper or cutter mounted inside the drum shell. A rolling bed of recycled solids is maintained in the unit.

Ammonia-rich offgases pass through a wet scrubber before exhausting to the atmosphere. Primary scrubbers use raw materials mixed with acids (such as scrubbing liquor), and secondary scrubbers use gypsum pond water.

In the TVA process, phosphoric acid is mixed in an acid surge tank with 93 percent sulfuric acid (H_2SO_4), which is used for product analysis control, and with recycled acid from wet scrubbers. (A schematic diagram of the ammonium phosphate process flow diagram is shown in Figure 2.2-3.)

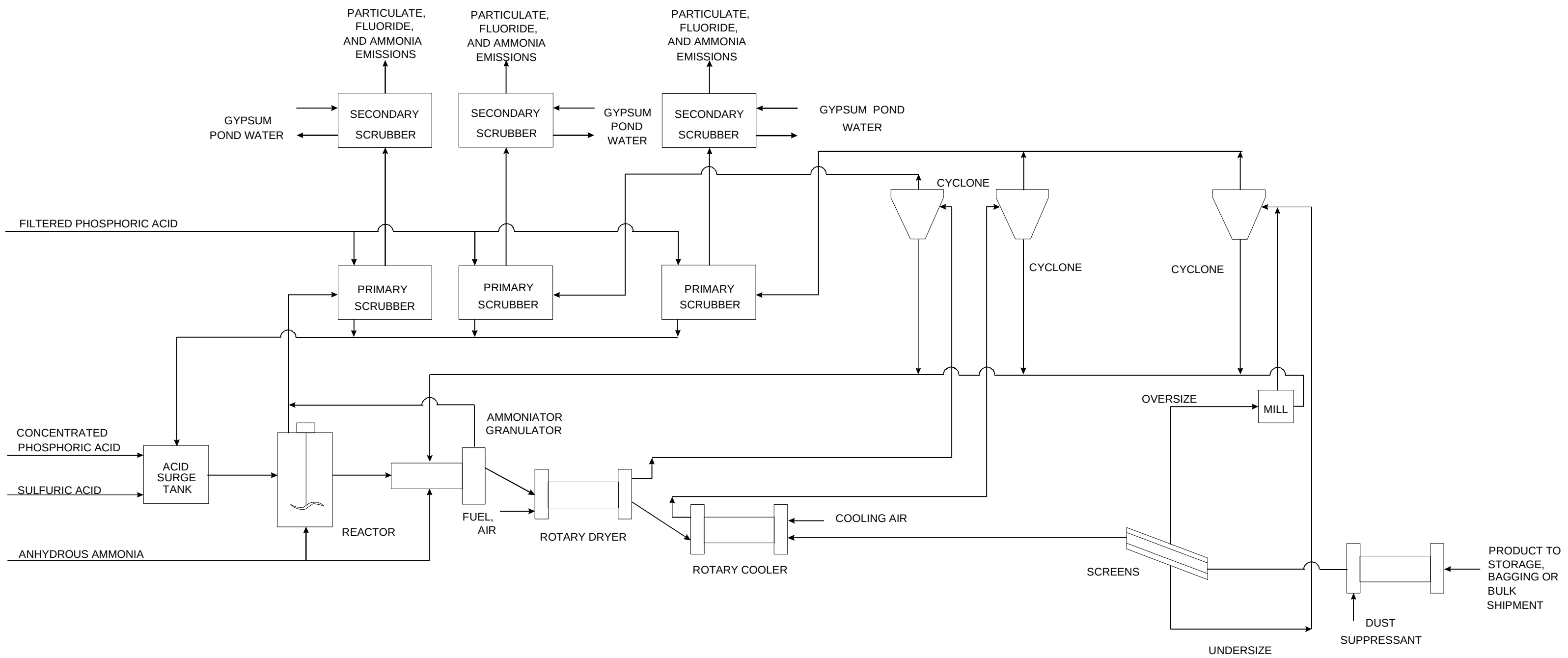

Figure 2.2-3 Ammonium phosphate process flow diagram

Mixed acids are then partially neutralized with liquid or gaseous anhydrous ammonia in a brick-lined acid reactor. All of the phosphoric acid and approximately 70 percent of the ammonia are introduced into this vessel. A slurry of ammonium phosphate and 22 percent water are produced and sent through steam-traced lines to the ammoniator-granulator. Slurry from the reactor is distributed on the bed, the remaining ammonia (approximately 30 percent) is sparged underneath. Granulation, by agglomeration and by coating particulate with slurry, takes place in the rotating drum and is completed in the dryer. Ammonia-rich offgases pass through a wet scrubber before exhausting to the atmosphere. Primary scrubbers use raw materials mixed with acid (such as scrubbing liquor), and secondary scrubbers use pond water.

Moist ammonium phosphate granules are transferred to a rotary concurrent dryer and then to a cooler. Before being exhausted to the atmosphere, these offgases pass through cyclones and wet scrubbers. Cooled granules pass to a double-deck screen, in which oversize and undersize particles are separated from product particles. The product ranges in granule size from 1 to 4 millimeters (mm). The oversized granules are crushed, mixed with the undersized, and recycled back to the ammoniator-granulator.

Exhibit I-18

PROPRIETARY INFORMATION DELETED

Importers of Phosphates from Morocco and Russia, 2019
Quantities in Short Tons

	Russia			Morocco				Mosaic
Importer Name	**DAP**	**MAP**	**NPK**	**DAP**	**MAP**	**NPK**	**TSP**	Top-10?
GAVILON FERTILIZER LLC	0	0	0	95,257	70,554	26,808		[ ]
CHS (CENEX HARVEST STATES)	15,701	0	0	145,686	48,480	0		[ ]
ADM FERTILIZER	0	0	0	23,771	52,272	23,485		[ ]
EUROCHEM TRADING USA CORP	24,251	48,502	1,293	0	26,235	0		[ ]
HELM	0	0	0	0	0	0	66,722	[ ]
AMEROPA NORTH AMERICA	8,047	0	0	0	10,816	0		[ ]
KOCH FERTILIZER	0	0	0	18,188	0	12,125		[ ]
BENTREI	12,125	0	0	0	0	0		[ ]
PURSELL AGRI-TECH LLC	0	0	303	0	0	0		[ ]
FLORIKAN ESA LLC	0	0	139	0	0	0		[ ]

Source: Ship manifest data from ImportGenius

Gavilon Fertlizer LLC
5 Skidway Village Walk, Suite 201
Savannah, GA 31411
Tel: (912) 598-8392
inquiries@gavilon.com

Ameropa North America
2502 North Rocky Point Drive
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Tampa, FL 33607
Tel: (813) 282 8228
info@ameropa.com

CHS (Cenex Harvest States)
5500 Cenex Drive
Inver Grove Heights, MN 55077
Tel: (651) 355-6000
info@chsinc.com;
chscontactus@chsinc.com

Koch Fertilizer
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North Wichita, KS 67220
Tel: (316) 828-3848
info@kochfertilizer.com

ADM Fertilizer
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Suite 1700
Minneapolis, MN 55402
Tel: (612) 340-5900
lneuman@adm.com

Ben-Trei Fertilizer Co LLC
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Tel: (918) 496-5115

EuroChem Trading USA Corp
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sales-NA@eurochemgroup.com

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Tel: (256) 510-0380
sales@fertilizer.com

Florikan Esa LLC
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Bowling Green, Florida 33834
Tel: (941) 379-4048
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Helm Fertilizer Corp
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Tampa, FL 33602
Tel: (813) 621-8846
mail@helmfert.com

Exhibit I-19

Names and Contact Information for Foreign Producers of Phosphate Fertilizer

OCP Group 2-4, Rue Al Abtal, Hay Erraha Casablanca, 20200 Morocco Tel: +212 5 22230025 Fax: +212 5 22221753 Website: www.ocpgroup.ma/en
EuroChem Trading RUS Dubininskaya Street, 53 115054 Moscow Russian Federation Tel: +7 (495) 545-39-69 Fax: +7 (495) 795-25-32 Website: www.eurochemgroup.com/
PhosAgro PJSC Bld 1, 55/1, Leninsky Prospekt 119333 Moscow Russian Federation Tel: +7 (495) 232-96-89 Fax: +7 (495) 956-19-02 Website: www.phosagro.com

Exhibit I-20

METHODOLOGY AND SPECIFICATIONS GUIDE

argus
argusmedia.com

ARGUS PHOSPHATES

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LAST UPDATED: APRIL 2020

The most up-to-date Argus Phosphates methodology is available on www.argusmedia.com

Methodology overview

Methodology rationale

Argus strives to construct methodologies that reflect the way the market trades. Argus aims to produce price assessments which are reliable indicators of commodity market values and are free from distortion. As a result, the specific currencies, volume units, locations and other particulars of an assessment are determined by industry conventions.

In the phosphates markets, Argus publishes prices as laid out in the specifications and methodology guide. Argus uses the trading period deemed by Argus to be most appropriate, in consultation with industry, to capture market liquidity.

In order to be included in the assessment process, deals must meet the minimum volume, delivery, timing and specification requirements in our methodology. In illiquid markets, Argus assesses the range within which product could have traded by applying a strict process outlined later in this methodology.

Survey process

Argus price assessments are informed by information received from a wide cross section of market participants, including producers, consumers and intermediaries. Argus reporters engage with the industry by proactively polling participants for market data. Argus will contact and accept market data from all credible market sources including front and back office of market participants and brokers. Argus will also receive market data from electronic trading platforms and directly from the back offices of market participants. Argus will accept market data by telephone, instant messenger, email or other means.

Argus encourages all sources of market data to submit all market data to which they are a party that falls within the Argus stated methodological criteria for the relevant assessment. Argus encourages all sources of market data to submit transaction data from back office functions.

Throughout all markets, Argus is constantly seeking to increase the number of companies willing to provide market data. Reporters are mentored and held accountable for expanding their pool of contacts. The number of entities providing market data can vary significantly from week to week based on market conditions.

For certain price assessments identified by local management, if more than 50pc of the market data involved in arriving at a price assessment is sourced from a single party the supervising editor will engage in an analysis of the market data with the primary reporter to ensure that the quality and integrity of the assessment has not been affected.

Market data usage

In each market, Argus uses the methodological approach deemed to be the most reliable and representative for that market. Argus will utilise various types of market data in its methodologies, to include:

- Transactions
- Bids and offers
- Other market information, to include spread values between grades, locations, timings, and many other data.

In many markets, the relevant methodology will assign a relatively higher importance to transactions over bids and offers, and a relatively higher importance to bids and offers over other market information. Certain markets however will exist for which such a hierarchy would produce unreliable and non-representative price assessments, and so the methodology must assign a different relative importance in order to ensure the quality and integrity of the price assessment. And even in markets for which the hierarchy normally applies, certain market situations will at times emerge for which the strict hierarchy would produce non-representative prices, requiring Argus to adapt in order to publish representative prices.

Verification of transaction data

Reporters carefully analyse all data submitted to the price assessment process. These data include transactions, bids, offers, volumes, counterparties, specifications and any other information that contributes materially to the determination of price. This high level of care described applies regardless of the methodology employed. Specific to transactions, bids, and offers, reporters seek to verify the price, the volume, the specifications, location basis, and counterparty. In some transactional average methodologies, reporters also examine the full array of transactions to match counterparties and arrive at a list of unique transactions. In some transactional average methodologies, full details of the transactions verified are published electronically and are accessible to subscribers. The deals are also published in the daily report.

Several tests are applied by reporters in all markets to transactional data to determine if it should be subjected to further scrutiny. If a transaction has been identified as failing such a test, it will receive further scrutiny. For assessments used to settle derivatives and for many other assessments, Argus has established internal procedures that involve escalation of inquiry within the source's company and escalating review within Argus management. Should this process determine that a transaction should be excluded from the price assessment process, the supervising editor will initiate approval and, if necessary, documentation procedures.

Primary tests applied by reporters

- Transactions not transacted at arm's length, including deals between related parties or affiliates.
- Transaction prices that deviate significantly from the mean of all transactions submitted for that week.
- Transaction prices that fall outside of the generally observed lows and highs that operated throughout the trading week.
- Transactions that are suspected to be a leg of another transaction or in some way contingent on an unknown transaction.
- Single deal volumes that significantly exceed the typical transaction volume for that market.
- Transaction details that are identified by other market participants as being for any reason potentially anomalous and perceived by Argus to be as such.

- Transaction details that are reported by one counterparty differently than the other counterparty.
- Any transaction details that appear to the reporter to be illogical or to stray from the norms of trading behaviour. This could include but is not limited to divergent specifications, unusual delivery location and counterparties not typically seen.
- Transactions that involve the same counterparties, the same price and delivery dates are checked to see that they are separate deals and not one deal duplicated in Argus records.

Secondary tests applied by editors for transactions identified for further scrutiny

Transaction tests
- The impact of linkage of the deal to possible other transactions such as contingent legs, exchanges, options, swaps, or other derivative instruments. This will include a review of transactions in markets that the reporter may not be covering.
- The nature of disagreement between counterparties on transactional details.
- The possibility that a deal is directly linked to an offsetting transaction that is not publicly known, for example a "wash trade" which has the purpose of influencing the published price.
- The impact of non-market factors on price or volume, including distressed delivery, credit issues, scheduling issues, demurrage, or containment.

Source tests
- The credibility of the explanation provided for the outlying nature of the transaction.
- The track record of the source. Sources will be deemed more credible if they
  - Regularly provide transaction data with few errors.
  - Provide data by Argus' established deadline.
  - Quickly respond to queries from Argus reporters.
  - Have staff designated to respond to such queries.
- How close the information receipt is to the deadline for information, and the impact of that proximity on the validation process.

Assessment guidelines
When insufficient, inadequate, or no transaction information exists, or when Argus concludes that a transaction based methodology will not produce representative prices, Argus reporters will make an assessment of market value by applying intelligent judgment based on a broad array of factual market information. Reporters must use a high degree of care in gathering and validating all market data used in determining price assessments, a degree of care equal to that applying to gathering and validating transactions. The information used to form an assessment could include deals done, bids, offers, tenders, spread trades, exchange trades, fundamental supply and demand information and other inputs.

The assessment process employing judgment is rigorous, replicable, and uses widely accepted valuation metrics. These valuation metrics mirror the process used by physical commodity traders to internally assess value prior to entering the market with a bid or offer. Applying these valuation metrics along with sound judgment significantly narrows the band within which a commodity can be assessed, and greatly increases the accuracy and consistency of the price series. The application of judgment is conducted jointly with the supervising editor, in order to be sure that guidelines below are being followed. Valuation metrics include the following:

Relative value transactions
Frequently transactions occur which instead of being an outright purchase or sale of a single commodity, are instead exchanges of commodities. Such transactions allow reporters to value less liquid markets against more liquid ones and establish a strong basis for the exercise of judgment.

- Exchange one commodity for a different commodity in the same market at a negotiated value.
- Exchange delivery dates for the same commodity at a negotiated value.
- Exchange a commodity in one location for the same commodity at another location at a negotiated value.

Bids and offers
If a sufficient number of bids and offers populate the market, then the highest bid and the lowest offer can be assumed to define the boundaries between which a deal could be transacted.

Comparative metrics
The relative values between compared commodities are readily discussed in the market and can be discovered through dialogue with market participants. These discussions are the precursor to negotiation and conclusion of transactions.

- Comparison to the same commodity in another market centre.
- Comparison to a more actively traded but slightly different specification commodity in the same market centre.
- Analysis of prices in forward markets for physically deliverable commodity that allow extrapolation of value into the prompt timing for the commodity assessed.
- Comparison to the commodity's primary feedstock or primary derived product(s).
- Comparison to trade in the same commodity but in a different modality (as in barge versus oceangoing vessel) or in a different total volume (as in full cargo load versus partial cargo load).

Volume minimums and transaction data thresholds
Because of the varying transportation infrastructure found in all commodity markets, Argus typically does not establish thresholds strictly on the basis of a count of transactions, as this could lead to unreliable and non-representative assessments. Instead, minimum volumes are typically established which may apply to each transaction accepted, to the aggregate of transactions, to transactions which set a low or high assessment or to other volumetrically relevant parameters.

For price assessments used to settle derivatives, Argus will seek to establish minimum transaction data thresholds and when no such threshold can be established Argus will explain the reasons. These thresholds will often reflect the minimum volumes necessary to produce a transaction-based methodology, but may also establish minimum deal parameters for use by a methodology that is based primarily on judgment.

Should no transaction threshold exist, or should submitted data fall below this methodology's stated transaction data threshold for any reason, Argus will follow the procedures outlined elsewhere in this document regarding the exercise of judgment in the price assessment process.

Minimum transaction thresholds

Assessment	Minimum trade volume for inclusion in assessment
fob bulk DAP/MAP Tampa	5,000t

Transparency

Argus values transparency in markets. As a result, we publish lists of deals in our reports that include price, basis, counterparty and volume information. The deal tables allow subscribers to cross check and verify the deals against the prices. Argus feels transparency and openness is vital to developing confidence in the price assessment process.

Swaps and forwards markets

Argus publishes forward assessments for numerous markets. These include forward market contracts that can allow physical delivery and swaps contracts that swap a fixed price for the average of a floating published price. Argus looks at forward swaps to inform physical assessments but places primary emphasis on the physical markets.

Publications and price data

Argus Phosphates prices are published in the Argus Phosphates report. Subsets of these prices appear in other Argus market reports and newsletters in various forms. The price data are available independent of the text-based report in electronic files that can feed into various databases. These price data are also supplied through various third-party data integrators. The Argus website also provides access to prices, reports and news with various web-based tools. All Argus prices are kept in a historical database and available for purchase. Contact your local Argus office for information.

Corrections to assessments

Argus will on occasion publish corrections to price assessments after the publication date. We will correct errors that arise from clerical mistakes, calculation errors, or a misapplication of our stated methodology. Argus will also correct errors that arise from mistakes made by market participants in reporting transactions. Argus will not retroactively assess markets based on new information learned after the assessments are published.

Ethics and compliance

Argus operates according to the best practices in the publishing field, and maintains thorough compliance procedures throughout the firm. We want to be seen as a preferred provider by our subscribers, who are held to equally high standards, while at the same time maintaining our editorial integrity and independence. Argus has a strict ethics policy that applies to all staff. The policy can be found on our website at www.argusmedia.com. Included in this policy are restrictions against staff trading in commodities or related stocks, and guidelines for accepting gifts. Argus also has strict policies regarding central archiving of email and instant messenger communication, maintenance and archiving of notes, and archiving of spreadsheets and deal lists used in the price assessment process. Argus publishes prices that report and reflect prevailing levels for open-market arms length transactions (please see the Argus Global Compliance Policy for a detailed definition of arms length).

Consistency in the assessment process

Argus recognises the need to have judgment consistently applied by reporters covering separate markets, and by reporters replacing existing reporters in the assessment process. In order to ensure this consistency, Argus has developed a programme of training and oversight of reporters. This programme includes:

- A global price reporting manual describing among other things the guidelines for the exercise of judgment.
- Cross-training of staff between markets to ensure proper holiday and sick leave backup. Editors that float between markets to monitor staff application of best practices.
- Experienced editors overseeing reporting teams are involved in daily mentoring and assisting in the application of judgment for illiquid markets.
- Editors are required to sign-off on all price assessments each week, thus ensuring the consistent application of judgment.

Review of methodology

The overriding objective of any methodology is to produce price assessments which are reliable indicators of commodity market values and are free from distortion. As a result, Argus editors and reporters are regularly examining our methodologies and are in regular dialogue with the industry in order to ensure that the methodologies are representative of the physical market being assessed. This process is integral with reporting on a given market. In addition to this ongoing review of methodology, Argus conducts reviews of all of its methodologies and methodology documents on at least an annual basis.

Argus market report editors and management will periodically and as merited initiate reviews of market coverage based on a qualitative analysis that includes measurements of liquidity, visibility of market data, consistency of market data, quality of market data and industry usage of the assessments. Report editors will review:

- Appropriateness of the methodology of existing assessments
- Termination of existing assessments
- Initiation of new assessments

The report editor will initiate an informal process to examine viability. This process includes:

- Informal discussions with market participants
- Informal discussions with other stakeholders
- Internal review of market data

Should changes, terminations, or initiations be merited, the report editor will submit an internal proposal to management for review and approval. Should changes or terminations of existing assessments be approved, then formal procedures for external consultation are begun.

Changes to methodology

Formal proposals to change methodologies typically emerge out of the ongoing process of internal and external review of the methodologies. Formal procedures for external consultation regarding material changes to existing methodologies will be initiated with an announcement of the proposed change published in the relevant Argus report. This announcement will include:

- Details on the proposed change and the rationale
- Method for submitting comments with a deadline for submissions
- For prices used in derivatives, notice that all formal comments will be published after the given consultation period unless submitter requests confidentiality

Argus will provide sufficient opportunity for stakeholders to analyse and comment on changes, but will not allow the time needed to follow these procedures to create a situation wherein unrepresentative or false prices are published, markets are disrupted, or market participants are put at unnecessary risk. Argus will engage with industry throughout this process in order to gain acceptance of proposed changes to methodology. Argus cannot however guarantee universal acceptance and will act for the good order of the market and ensure the continued integrity of its price assessments as an overriding objective.

Following the consultation period, Argus management will commence an internal review and decide on the methodology change. This will be followed by an announcement of the decision, which will be published in the relevant Argus report and include a date for implementation. For prices used in derivatives, publication of stakeholders' formal comments that are not subject to confidentiality and Argus' response to those comments will also take place.

Publication frequency

Argus publishes the Argus Phosphates report once a week on a Thursday evening in the UK. The report is published 51 weeks of the year. The Argus Phosphates report is not published for one week during the Christmas/New Year holidays in the UK, although the precise dates of non-publication are dependent on when holidays fall within the week. A full publication schedule is available at www.argusmedia.com.

General methodology

Argus surveys a wide variety of market participants during the course of the week including producers, trader, buyers, sellers and other market analysts. This survey seeks to confirm what trade has been done, by whom, as well as firm bids and offers. The goal is to cross-check market transactions from all participants wherever possible. The survey also seeks to ascertain fundamentals data, tender news and supply and demand information. Argus will contact and accept market data from all credible market sources including front and back office of market participants and brokers.

In assessing fob prices, Argus speaks with the key producers in the exporting regions — the US, Mexico, Russia, Morocco, Tunisia, Jordan, Saudi Arabia, China and Australia — and in assessing cfr prices, Argus speaks with the major importers in the main import markets — Argentina, Brazil, India, Pakistan and Europe. International and regional traders are also consulted and at all stages. Argus attempts to speak to all parties involved in a transaction. Argus also consults with freight brokers to ensure accurate netback calculations.

Assessing price ranges

Phosphate prices are assessed in various regions, countries and within countries on a free on board (fob) basis in the main export regions and on a cost and freight (cfr) basis in the main destination markets. Deals, bids and offers must be considered repeatable to be reflected in the assessments.

The report seeks to determine price ranges in which actual transactions are taking place or in which transactions could have taken place between a willing buyer and seller.

When there is sufficient liquidity and deals data are deemed reliable and representative, the price range will be defined on the low and the high end of confirmed deals concluded throughout the trading week. These deals must meet the minimum volumes and strict delivery timing, as well as specifications as laid down in this methodology.

Information on transactions, bids and offers that lie outside the specifications of timing, size, location and quality may be used in assessing price ranges, but deals that lie within these specifications are given most weight.

In markets that periodically lack liquidity, Argus may assess price ranges based on a range of other market information including netbacks to more liquid markets and market fundamentals.

The price guide reflects the last seven days of business Friday through to Thursday — market information will be collected up until 17:00 UK time on the Thursday of publication. However, while all information and trades are taken into account, in periods of high volatility, assessments are weighed towards trading activity later in the week or at the end of the Thursday of the assessment.

Spot, contract and formula pricing

Spot

Spot pricing refers to specific cargoes sold that are scheduled to load within 40 days of the sale being agreed. These prices are cash prices, i.e. net of any credit.

Contract

Contract pricing is split out from spot market assessments and refers to a significant sales volume spread over a minimum three-month shipping period. This is most relevant for Indian DAP, phosphate rock and phosphoric acid contract pricing.

Quarterly contract prices are updated when prices for the relevant quarter have been agreed, not necessarily or automatically at the beginning of that quarter.

Formula

Formula pricing is an arrangement where a buyer and seller agree in advance that the price to be paid for a product delivered in the future will be based on a pre-determined calculation, sometimes utilising published prices from Argus and/or other publications. Given that the exact nature of the calculation or the agreement between the parties is often private and confidential, and if the deal is considered a one-off (i.e not repeatable), then calculated netbacks are not used in formulation of a spot price range. However, if a buyer and seller use this method of pricing for multiple transactions on a specific trade route, then the editor may use the deal in formulating a spot price range using current known cfr levels, domestic prices in the destination country and indicative freight rates.

Terms

Some transactions are conducted on a sight/cash basis, but where credit terms apply, e.g. up to 180 days, these are taken into account and subtracted from the price so that the published price is net of credit or other terms.

One exception is the quarterly phosphoric acid price in India, which will usually include 30 days' credit and is quoted as such.

Units

All prices are assessed in US $/t, apart from US domestic references, which are priced in short tons (st). The report includes a price assessment for phosphoric acid that is expressed in $/t P2O5 (merchant grade phosphoric acid is shipped as a 54% P2O5 solution). The phosphate Price Guide includes an assessment for US molten sulphur quarterly contracts cfr Tampa, which is expressed in US long tons.

Lot and cargo sizes

For international trade, the minimum lot size used for consideration and inclusion in the relevant price range is 5,000t of a particular product (this includes part cargoes on larger vessels including other fertilizers and for which the freight rate may be more favourable, although this will be explained in the text). The exception is prices quoted in the US domestic market for which the price is indicative of one barge, assumed to be carrying a minimum of 1,500st, with no set maximum number of barges. There may be occasions when a barge is loaded with less quantity for reasons of low draught levels, but this will be explained fully in the text.

For the phosphates report, Argus considers cargoes as follows — typically short sea routes in Europe (for example from north Africa) employ vessels of 5,000-6,000t. Deepsea voyages employ handysize vessels and above:

- Minimum 5,000t (for example Mediterranean vessels from north Africa)
- Handysize 10,000-35,000t (the majority of deepsea phosphate trade)
- Handymax (35,000-59,000t)
- Panamax (60,000-85,000t plus)
- Post-panamax 85,000t and above (OCP began loading such vessels in Jorf Lasfar, Morocco, in early 2015)

In the US domestic phosphates market:

- A typical barge on Nola is 1,500st
- A central Florida railcar is minimum 100st

Products and specifications

Diammonium phosphate (DAP) is a dry, bulk fertilizer containing 18pc nitrogen and 46pc phosphate by weight. It is produced by combining ammonia with phosphoric acid and is widely used in granular form for direct application to land or as a feedstock for bulk blending for NPK manufacture. Prices are only assessed based on deals concluded in the agricultural sector. Sales to the industrial sector may be discussed in the text, but will not form part of the assessment.

Monammonium phosphate (MAP) is a dry bulk fertilizer containing typically 11-12pc nitrogen and 52pc phosphate by weight. It is also formulated by adding phosphoric acid to ammonia solution and can be used for direct application or for use as a raw material in bulk blending. Argus assesses the MAP price for product with minimum 52pc phosphate by weight. Typical grade includes Moroccan 11-52 and Russian 12-52 MAP. Other types of product, particularly 11-44 and 10-50 MAP from China, are mentioned in the text and prices reported.

Triple superphosphate (TSP) 46pc P2O5 (straight fertilizer — i.e. no N or K).

Single superphosphate (SSP) 21pc P2O5 (low analysis straight fertilizer) — is a low analysis fertilizer and international trade is thin as most product is manufactured and consumed locally, particularly in Brazil and India. Prices are quoted in specific country text sections as a guide, but Argus does not quote such prices in its price guide.

Phosphoric acid 100pc P2O5 (as merchant grade 54pc P2O5 solution) usually quoted in terms of tonne P2O5, i.e. 100pc P2O5 content, although it is actually shipped in a 54pc concentration, called merchant grade acid or phosphoric acid solution, for ease of handling and storage. Phosphoric acid is a liquid, is highly corrosive and dangerous and has to be shipped in stainless steel tankers.

Phosphate rock — phosphate fertilizers are made from phosphate rock (calcium phosphate). This is mined as an ore either by opencast (strip) or underground mining. Phosphate rock is present in many countries, but is only present in commercially viable quantities in a few (Morocco has 80pc of global reserves). The phosphate content or grade of phosphate rock is expressed as phosphorus pentoxide (P2O5). In the phosphate industry and consequently Argus reports, the phosphate content of the rock is usually expressed as tricalcium phosphate and traditionally referred to as bone phosphate of lime (BPL) (P2O5 × 2.1853 = BPL). Manufacturers of phosphoric acid and phosphate fertilizers normally stipulate a minimum content of 28pc P2O5, and most marketed grades of phosphate rock contain more than 30pc P2O5 (65pc BPL). The concentration of P2O5 in the rock determines its quality. The higher the P2O5 content, the higher the rock quality. Phosphate rock is washed and treated to remove impurities at the mine. It is then processed through reaction with sulphuric acid to make phosphoric acid. Phosphoric acid is the main intermediate product used to make DAP, MAP, TSP and some compound fertilizers. The production of 1t of phosphoric acid requires approximately 3.5t of phosphate rock.

Markets covered

Spot prices

DAP/MAP/TSP — fob bulk

DAP/MAP Tampa
The DAP/MAP Tampa price is predominantly assessed on the basis of sales to Central and Latin America by US producer Mosaic, which forms the high end of the range. Spot sales to India normally during the second and third quarters of the year sometime form the low end of the assessed price range. Trader activity selling domestic material is extremely rare but is considered for inclusion in the assessment. During periods of illiquidity, Argus may calculate a netback fob price on the basis of achievable cfr prices in Latin America. Normally, the price is rolled over if no new business or offers are reported.

Netbacks from shipments of US product to Mosaic's distributions systems offshore — particularly in Brazil and India — are not included in the range, nor are netbacks from contract DAP shipments to Japan, Australia and Canada.

DAP/MAP Tampa fob equivalent netback Brazil
The Argus MAP cfr Brazil price assessment less the Argus Tampa-Brazil (25,000-35,000t) freight rate assessment giving an equivalent netback for US product moving to Brazil under contract.

See the Argus Brazil Grains and Fertilizer methodology for more information on the DAP cfr Brazil price assessment.

DAP fob Tampa equivalent netback India
The cfr DAP India price less the Argus Tampa-west coast India (55,000-60,000t) freight rate assessment.

The result is a theoretical netback to Tampa from Mosaic's distribution business within India.

DAP Tunisia
The price range is almost entirely defined on the basis of sales to the European and Turkish markets by Groupe Chimique Tunisien (GCT).

Because production is restricted premium markets in the Mediterranean region are preferred over deepsea markets such as Latin America and southeast Asia.

During periods of illiquidity, the range may be defined on the basis of Moroccan DAP pricing, as both serve similar markets and prices tend to be strongly correlated. Allowance is made for freight differentials. Contract shipments to Bangladesh are not included.

DAP Morocco
This price range is defined by sales made by Office Cherifiens des Phosphates (OCP). OCP exports globally but European sales usually set the high end of the range, and deepsea exports, mainly to Latin America, usually set the low end of the range.

Morocco DAP fob equivalent netback US terminals
The Argus DAP Twin Cities fot price assessment less the Argus Mississippi river-St Paul spot barge freight rate assessment, throughput costs regularly reviewed by Argus including loading and unloading from barges at New Orleans and at the terminal, and an estimated freight from Jorf Lasfar to New Orleans.

See the Argus North American Fertilizer methodology for more information on the DAP Twin Cities fot price and barge freight rate assessments. The price is a theoretical netback to OCP Morocco.

Note: US price and barge freight assessments are converted from short to metric tonnes as part of the netback calculation

DAP Lithuania Baltic
DAP exported through the Baltic Sea out of the port of Klaipeda. European sales usually form the high end of the range with Latin American or Indian sales forming the lower end. The exporting company is EuroChem, from the Lifosa facility. Lithuanian DAP is duty free into the EU. The netback from European sales is almost always higher than for Russian DAP shipments into the EU.

DAP Russia Baltic/Black Sea

The DAP price allows for the 6.5pc duty applicable to Russian DAP delivered to the EU. European sales usually form the high end of the range with Latin American or Indian sales forming the lower end. The main exporting company is PhosAgro although EuroChem also exports DAP from its Kingisepp facility.

DAP China

The Chinese DAP price is mostly defined by cfr prices available in south Asian markets, predominantly India, Pakistan and Bangladesh, although southeast Asia also takes sizeable volumes. Many sales are now direct, rather than through traders. Vietnam imposes an anti-dumping duty on Chinese DAP to protect the local industry, greatly reducing exports.

DAP Saudi Arabia (KSA)

Ma'aden Phosphate Company (MPC) is the producer in Saudi Arabia and product is marketed primarily through Ma'aden and to a lesser extent by Sabic. The price is primarily defined on sales to west coast India. For geographical reasons, Saudi DAP is also exported to east coast Africa and netbacks from this trade are included when verified by counterparties. Typically DAP from Saudi Arabia trades at a small premium to Chinese material on the Indian subcontinent. Spot sales to Latin America are also included although the majority of Saudi sales are on a formula basis

DAP fob Aqaba Jordan

The price range is defined almost exclusively on sales to India at the lower end and Turkish and Iraqi sales at the higher end. Product sold by both Jordan Phosphate Mines Company and Nippon Jordan is included in the range.

DAP Mexico

Mexican DAP is supplied from Pemex on the west coast and has a natural freight advantage to west coast Central and Latin American markets, especially Chile. Accordingly, Mexican DAP typically trades at a fob premium to US DAP coming out of the Gulf of Mexico and avoiding the Panama Canal in these markets.

DAP/MAP Australia

DAP is exported by Incitec Pivot, which ships out of Townsville on the northeast coast of Australia. Trading firm Quantum handles all exports as agent. Australian DAP/MAP is exported all year round, although liquidity is higher in the middle of the year, coinciding with the off-season in the Australian domestic market. The main export destinations are Bangladesh, Pakistan and India, although Latin America also takes MAP.

DAP US Gulf domestic barge

See DAP Nola barge fob in the Argus North American Fertilizer methodology.

DAP Central Florida railcar

See DAP Central Florida rail in the Argus North American Fertilizer methodology.

DAP China ex-works

This price is assessed using the yuan/$ exchange rate at the time of assessment, usually on Thursday afternoon.

DAP Benelux fot/fob duty paid/duty free

This is the price in the Benelux/Terneuzen region on an fot basis. As there is limited DAP production in northwest Europe, significant DAP imports are taken from Russia, Lithuania (both through the Baltic) and Morocco. There is a 6.5pc duty on Russian DAP into the EU but the other sources enjoy duty-free status. Imports are taken in and then sold on an fca/ex-warehouse basis.

MAP Baltic

Sales to the European market usually define the high end of the range, with deepsea sales, often to Latin America, usually defining the low end. MAP exports to the EU from Russia are subject to a 6.5pc duty, which is taken into account in the assessment. In contrast, because EuroChem does not normally produce MAP at the Lifosa facility in Lithuania, there are no duty-free exports to the EU.

MAP China 11-44 fob

The MAP price is defined almost exclusively by trader sales of Chinese 11-44 to the Brazilian market. In the absence of liquidity, the price can be defined on the basis of 11-52 MAP cfr prices in Brazil, allowing for nutrient differentials. There is often a difference between fob China asking prices and trader's cfr sales prices into Brazil depending on the position of the seller. Accordingly, fob China offers are given most weight in the assessment. Globally active traders and Chinese producers are consulted to form the range.

MAP China 10-50 fob

As with 11-44, the 10-50 price is defined almost exclusively on sales to Brazil although some sales to the US domestic system also take place and netbacks from this market are also taken into account. The assessment rationale is the same as for 11-44.

MAP China 11-52 fob

11-52 is traded in the same way as Chinese 10-50 and 11-44. The main outlet is Brazil and the assessment rationale is the same as for 11-44 and 10-50.

MAP Morocco

Most Moroccan MAP is shipped to Brazil and prices are typically on a par with Moroccan DAP prices. Sales to European markets normally define the high end of the range.

MAP Saudi Arabia (KSA)

Much of the MAP sold is to Latin America (almost exclusively Brazil) and is done so on a formula basis either directly or through traders. Where this trade is discovered, Argus will assess the price on the basis of cfr prices in Brazil less freight rates to Ras Al Khair. Argus also includes spot business in Brazil and other Latin American markets both as direct sales from producers or where traders are involved.

TSP Tunisia
GCT sells much of its TSP to Bangladesh under government-to-government contracts priced under formula, limiting price transparency. Prices are defined mainly by sales to European markets. The price typically tracks the Moroccan TSP price closely.

TSP Morocco
The TSP Morocco price assessment is defined by sales made by OCP to Europe at the high end of the range and to Latin America at the low end.

TSP China
The Chinese TSP price is assessed mainly on sales to southeast Asia, particularly Indonesia, as well as sales to Brazil and Latin America. Iran is also an occasional outlet although this price is not included in the assessment.

TSP eastern Med (Lebanon/Israel)
The price predominantly refers to Lebanese TSP produced by LCC Lebanon, which primarily goes to European markets as well as Latin America and Bangladesh. Israel exports to Europe, the US and Brazil.

DAP/MAP/TSP — fob bulk

DAP/MAP cfr bulk Argentina/Uruguay
Argentina and Uruguay usually pay the same price for DAP and MAP and shipments are often combined. The market usually trades at a premium to the Brazilian cfr price owing to freight and logistic costs. The price assessment is predominantly defined on the basis of trader sales, although some producers such as OCP occasionally sell directly.

MAP Brazil
Brazil is the most competitive MAP market as no one producer has a distinct freight advantage. Brazil imports MAP throughout the year from a variety of origins, both through direct producer sales and through traders. The market is liquid and often the range is assessed on the basis of transactions, although bids and offers are also included when liquidity or confirmation of trades is lacking.

MAP 10-50 (ex-China) cfr Brazil
See the Argus Brazil Grains and Fertilizer methodology.

MAP 11-44 (ex-China) cfr Brazil
See the Argus Brazil Grains and Fertilizer methodology.

MAP South Africa
The price is assessed on the basis of conversations with Russian and Saudi suppliers and local and regional traders and importers.

DAP India
The cfr price in India is ultimately capped by importer economics relative to the current subsidy in place, the value of the Indian rupee and the maximum retail price in force. The price assessment is usually defined on the basis of sales by Chinese producers at the lower end and Saudi product at the higher end, which trades at a slight premium. Offers in specific purchase tenders are also taken into account if an award is made.

DAP Pakistan
Pakistan usually trades at a slight premium to India owing to freight economics. Chinese DAP dominates the market with Saudi DAP discouraged due to colour issues. Australian DAP usually commands a slight premium over other sources.

DAP Turkey duty paid/duty free
This is the price paid by Turkish importers for DAP on a duty free/duty paid basis. A duty of 6.5pc is paid on DAP from Russia, Saudi Arabia, the US, China and Australia. However there is no duty on imports from Morocco, Tunisia and Jordan (from which the majority of DAP is sourced). North African producers agree volume contracts which are priced on a cargo by cargo basis. There are additionally spot trader sales particularly of Jordanian material. Turkey is most active during the third quarter but imports throughout the year both for direct application and use in NPK manufacture. The price is influenced by the relative price of NPKs in the domestic sector. Low NPK prices tend to encourage a switch away from DAP and hence lower prices.

DAP east coast Africa
The price is assessed on the basis of conversations with producers and local importers and traders in Kenya and Tanzania. Prices given in tenders, for example, are netted to a cfr value accounting for local port and any financing costs.

Raw material contracts

Phosphoric acid/t P2O5

Cfr India
The price is usually settled on a quarterly basis with OCP leading negotiations. The price is settled in $/t P2O5 cfr with 30 days credit. On occasion, the price is settled for six months. This is explained in the text and the quarterly price is moved at the appropriate time. Contract negotiations can be protracted and the price does not always settle promptly.

Cfr western Europe
Imports are primarily from OCP Morocco for producers in Belgium, France and the Netherlands. Prices are agreed on a quarterly basis. The price change from quarter to quarter usually tracks the Indian price.

Cfr Brazil
OCP Morocco provides most of the phosphoric acid to Brazil and the price usually moves in tandem with those for India and western Europe.

Phosphate rock (% BPL)

Fob Jordan (68-70)
JPMC is a major phosphate rock producer, and much of its exports go to India.

Phosphate rock fob Algeria 29-30pc P205 contract
The majority of trade takes place under annual or six-month contracts. The price will be assessed on the basis of conversations with importers and with local producer Somiphos.

Cfr India (68-70), cfr India (70-72)
India is the major phosphate rock buyer globally. It buys from Egypt, Israel, Morocco and Togo as well as Jordan, the largest supplier.

Fob north Africa (69pc)
Defined by sales to Europe, India and Brazil from OCP/GCT.

Relative nutrient values

The price of various products in their pure P2O5 nutrient form, with the value of nitrogen extracted. As DAP (18pc) and MAP (11pc) contain nitrogen elements, these have been extracted to calculate a pure phosphate nutrient value.

Fob DAP Morocco $/t P2O5, $/unit
The value of Moroccan DAP in P2O5 terms per tonne and per unit, useful in comparing Moroccan DAP prices and netbacks to the price of phosphoric acid contracts in India, a relationship that shapes quarterly phosphoric contract negotiations.

Calculated as:
$/t P2O5 = (DAP Morocco – (18/46*North Africa Urea))*100/46

A $/unit value figure is also provided, calculated as the $/t P2O5 value divided by 100.

Fob DAP China $/t P2O5, $/unit
The value of Chinese DAP fob in P2O5 terms per tonne and per unit, useful in comparing Chinese DAP export values to other phosphate exports and to netbacks from the domestic sector.

Calculated as:
$/t P2O5 = (DAP China fob – (18/46*China prilled urea fob))*100/46

A $/unit value figure is also provided, calculated as the $/t P2O5 value divided by 100.

Cfr MAP 11-52 Brazil $/t P2O5, $/unit
The value of 11-52 MAP sourced from China for export to Brazil, useful in comparing the relative P2O5 values of 11-52, 10-52 and 11-44. Typically there is a discount in the price of 11-44 and 10-50 to 11-52 when relative nutrient values are taken into account. In recent years, this discount has narrowed, reflecting Chinese producer export strategies and the pull on MAP from the Chinese domestic sector.

Calculated as:
$/t P2O5 = (Brazilian MAP 11-52 cfr range – (11/46*Brazilian granular urea cfr))*100/52

A $/unit value figure is also provided, calculated as the $/t P2O5 value divided by 100.

Cfr MAP 11-44 Brazil $/t P2O5, $/unit
Calculated as:
$/t P2O5 = (Brazilian MAP 11-44 cfr range – (11/46*Brazilian granular urea cfr))*100/44

A $/unit value figure is also provided, calculated as the $/t P2O5 value divided by 100.

Cfr MAP 10-50 Brazil $/t P2O5 and $/unit
Calculated as: $/t P2O5 = (Brazilian MAP 10-50 cfr range – (10/46*Brazilian granular urea cfr))*100/50

A $/unit value figure is also provided, calculated as the $/t P2O5 value divided by 100.

Argus DAP index

A weekly global composite DAP index based on a basket of Argus price assessments weighted by annual export volumes.

Component assessments
The index is based on five Argus price assessments:
- DAP bulk fob China
- DAP bulk fob Morocco
- DAP bulk fob Saudi Arabia
- DAP bulk fob Russia
- DAP/MAP bulk fob Tampa

Weighting
Those prices are weighted in the index in proportion to the country of origin's exports, according to the latest available IFA data. The index is re-weighted in the first report following the publication of the latest IFA DAP data – historical re-weighting dates are shown in the table below.

Weighted prices are totalled and indexed such that 1 June 2017 = 100.

Weighting

Statistical year	2015	2016	2017	2018
Weighting effective date	13/10/2016	12/10/2017	25/10/2018	28/11/2019
China	0.53787	0.51144	0.45508	0.47998
Morocco	0.08712	0.12949	0.16473	0.19513
Saudi Arabia	0.15643	0.13953	0.18421	0.17721
Russia	0.079	0.09072	0.07807	0.08261
US	0.13958	0.12882	0.11791	0.06507

Freight

Argus Phosphates includes several freight rate assessments. Prices are assessed as a range and include information collected over the course of the trading week.

Freight rate assessments are established by surveying freight providers and buyers of spot freight, maintaining a balance between both parties. The assessment is for cargoes that will load and move within the next 30-40 days.

Finished phosphates

- Tampa-west coast India (55,000-60,000t)
- Morocco-Brazil (25,000-35,000t)
- Tampa-Brazil (25,000-35,000t)
- Baltic-Brazil (25,000-35,000t)
- Baltic-India (25,000-35,000t)
- Kingdom of Saudi Arabia (KSA)-east coast India

Phosphate rock

- Morocco-South Brazil (30,000t)
- Red Sea-west coast/east coast India (25,000-35,000t)
- Red Sea-Indonesia (25,000-35,000t)
- Morocco-US (25,000-35,000t)

Exhibit I-21

DECLARATION OF [ ]

I, [ ], pursuant to 28 U.S.C. § 1746, hereby declare as follows:

1. I am over 18 years of age and competent to make this declaration.

2. My name is [ ] and I am currently employed as a [ ] at the Mosaic Company. I have been with the Mosaic Company for [ ] years, and I have been in my current role as [ ] for the past [ ] years. Previously I was a [NARRATIVE] at Mosaic.

3. As a [NARRATIVE]. I have first-hand knowledge of sales discussions that have occurred with the company's [ ] accounts from 2017 through the present.

4. Based on my experience working in sales for Mosaic, U.S. customers for phosphate fertilizers include a mix of distributors, retailers, and end users/consumers. Some of our customers act as both distributors and retailers, and some also import directly. For example, [COMPANY NAMES] are retailers; [ ] is an importer and distributor; [ ] is primarily a retailer but also acts as a distributor; and [ ] is an importer that acts primarily as a distributor but is also a retailer. Most of Mosaic's U.S. customers purchase a variety of phosphate fertilizers, including MAP, DAP, and Mosaic's proprietary Microessentials product (or products developed by our Moroccan and Russian competitors).

5. Mosaic's phosphate fertilizer products compete with imported phosphate fertilizers across all channels of distribution. Most imported product arrives in the United States at the Port of New Orleans (Nola), or Ports of Houston or Galveston, and is loaded on barges. Major

importers such as [COMPANY NAMES] and Eurochem often sell phosphate fertilizer to customers by the barge, where a barge is 1,500 short tons, and prices are typically quoted as "Nola barge" prices. Some phosphate fertilizer imports are sold by the rail or truck-load out of Houston and Galveston. A railcar or truck is approximately 100 short tons of fertilizer. Sales negotiations often start with quotes for a barge price, even if the customer actually intends to purchase a smaller volume, either on a truck-load basis or by the ton.

6. A few importers also have warehouse space along the Mississippi River, as does Mosaic, and price imported product for customers based on the truck-load or by the ton for delivery out of a warehouse. In addition, some Moroccan and Russian foreign producers, or their affiliates, have significant U.S. sales operations to facilitate the marketing, sale, and/or distribution of their imported phosphate fertilizer products in the U.S. market.

7. In my experience, sales negotiations in the phosphate fertilizer market are highly transparent, and price is one of the primary factors our customers consider in deciding to make a purchase. The prices of different types of phosphate fertilizer products are often tied to one another and move in tandem. For example, [NARRATIVE]. Prices for phosphate fertilizers are also published on a weekly, or even daily basis, by industry publications such as Argus.

8. Customers generally contact Mosaic and ask for our current pricing on a particular type of fertilizer product, which we will provide. It is very common for a customer to then report that they have received a lower quote from another supplier, often for imported product, and ask Mosaic to match the lower price. The overwhelming majority of imported product in the U.S. market originates from Morocco or Russia. Imported phosphate fertilizers are often

priced [ ] per ton lower than Mosaic's current prices. Our customers frequently negotiate by saying they value Mosaic's products and the quality we provide, but they want us to match a more competitive price being offered for imported product or to lower our prices to be closer to the price of the imported product.

9. Throughout 2019, this happened on an almost weekly basis as prices fell dramatically and the market was heavily oversupplied. We heard from several of our customers that importers were approaching them and offering to sell imported phosphate fertilizer from foreign producers such as OCP, PhosAgro, and EuroChem at prices below the prior week's published price or even asking what price it would take for the customer to be willing make a purchase.

10. In most cases, when a customer asks Mosaic to match a lower price being offered for imported product, we are unable to do so because the sale would be unprofitable for us. Within the past month, I was involved in sales negotiations with a mix of customers where the price point was so low that Mosaic was unable to compete, and we missed out on sales ranging from 20,000 to 100,000 tons. I understand that in this instance, the price discussions were primarily being driven by EuroChem, which was offering to sell imported phosphate fertilizer from Russia. [NARRATIVE].

I declare under penalty of perjury that the foregoing is true, correct, and accurately portrays my knowledge and experience.

Dated 6-19-20 at Minneapolis, Minnesota

[ ]

[ ]

Exhibit I-22

CRU

Phosphate Fertilizer
Market Outlook

July 2017

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Glossary of terms

Concentrated phosphates	DAP, MAP, TSP
DAP	Di-ammonium phosphate, typically 18-46-0
DCP	Di-calcium phosphate, typically 41% P_2O_5
DFP	De-fluorinated phosphate, typically 41% P_2O_5
DSP	Double super-phosphate, typically 0-32-0-(6S)
HCl	Hydrochloric acid
IFP	Inorganic feed phosphates
KCl	Potassium chloride
MAP	Mono-ammonium phosphate, typically 11-52-0
MCP	Mono-calcium phosphate, typically 50% P_2O_5
MES	MicroEssentials
MGA	Merchant-grade acid, typically 52-54% P_2O_5
NP	Nitro-phosphates
PPA	Purified phosphoric acid, typically 61% P_2O_5
SPA	Superphosphoric acid, typically ≥ 70% P_2O_5
SSP	Single super-phosphate, typically 0-18-0-(10S)
STPP	Sodium tri-polyphosphate
TSP	Triple super-phosphate, typically 0-46-0
ANDA	Associação Nacional para Difusão de Adubos (Brazil)
CFMW	China Fertilizer Market Week (China)
CPPA	Chinese Phosphate Producers Association (China)
FAI	The Fertilizer Association of India (India)
FAO	Food and Agriculture Organization of the UN (global)
FAPRI	Food and Agricultural Policy Research Institute (global)
FW	Fertilizer Week (global, part of CRU)
GTIS	Global Trade Information Services Inc. (global)
IFA	International Fertilizer Association
NBS	National Bureau of Statistics (China)
	OR Nutrient Based Subsidy (India)
TFI	The Fertilizer Institute (USA)
USDA	United Stated Department of Agriculture (USA, global)

Chapter 1
Demand

1.1 Overview of global phosphate demand

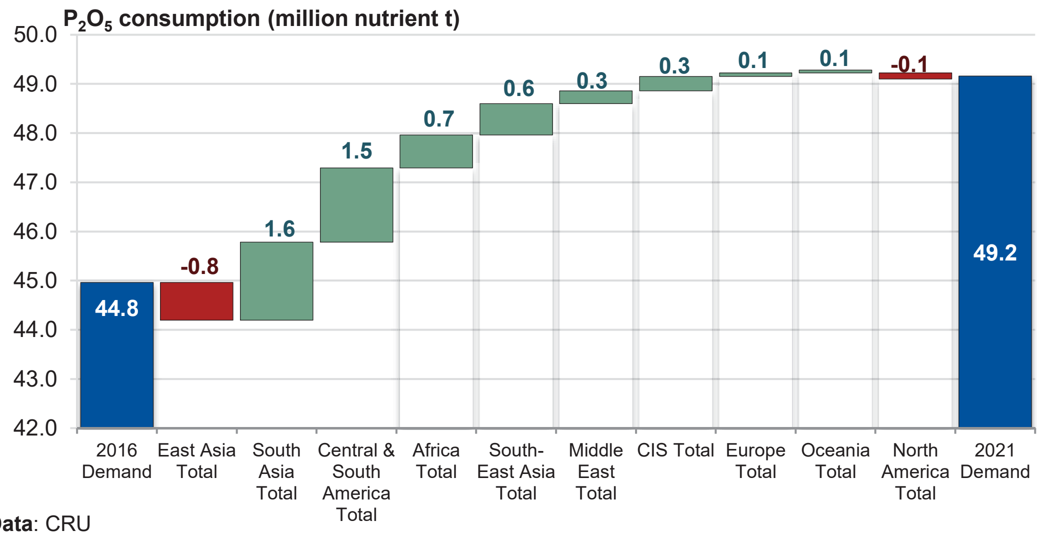
The estimate of global phosphate fertilizer demand in 2017 has been increased from the April 2017 outlook, owing to rising use in **Brazil, India** and **Russia.** Total P_2O_5 consumption in 2017 is projected up 1.8% y/y to 53.1 million nutrient tonnes, of which 45.9 million nutrient tonnes will be used in the agricultural sector.

Table 1.1: Global P_2O_5 demand, million nutrient tonnes

	2015	2016	2017	2018	2019	2020	2021
DAP	16.4	15.8	16.0	16.1	16.3	16.6	16.9
MAP	11.9	12.3	12.8	13.0	13.1	13.3	13.4
SSP	4.2	4.2	4.3	4.3	4.3	4.4	4.4
TSP	2.3	2.3	2.5	2.5	2.5	2.6	2.6
Other nutrient demand (NP/NPS/NPK)	8.9	10.4	10.3	10.7	11.0	11.4	11.8
Total P_2O_5 Nutrient (100% P_2O_5)	**43.7**	**45.0**	**45.8**	**46.5**	**47.2**	**48.2**	**49.2**
Other P_2O_5 demand (feed/industrial)	7.2	7.2	7.3	7.4	7.5	7.6	7.8
Total P_2O_5 (100% P_2O_5)	**50.9**	**52.2**	**53.1**	**53.9**	**54.7**	**55.8**	**56.9**

Data: CRU, AFA, ANDA, Azotecon, CFMW, CPPA, FAI, Fertilizer Week, GTIS, IFA, NBS, NFDC, TFI

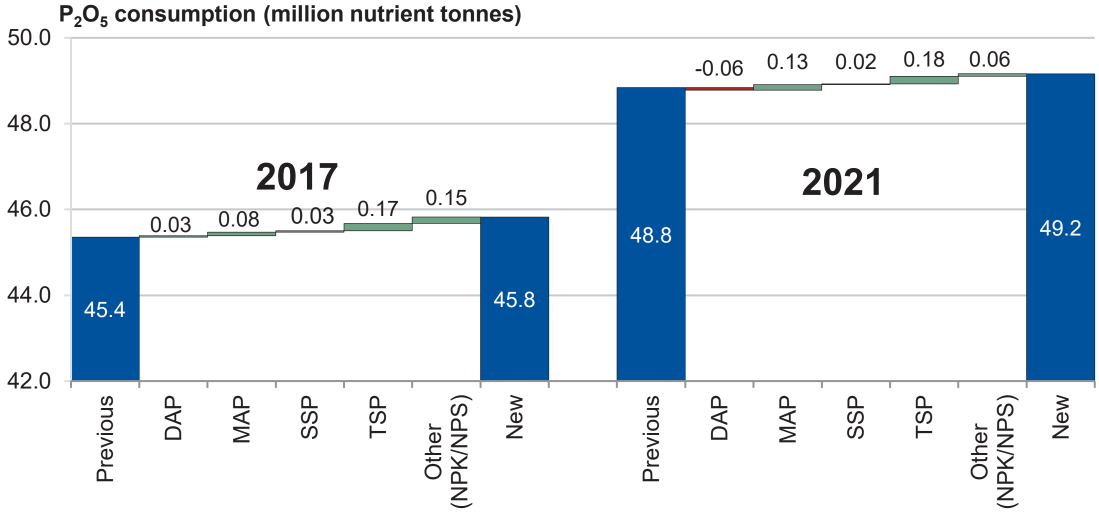
Components of medium term phosphate fertilizer demand



Data: CRU

The forecast for phosphate fertilizer consumption through to 2021 has been raised fractionally in this outlook because of growth in South Asia and agricultural expansion in Central and South America. In terms of the product mix, the share of DAP is likely to be eroded by the growing use of MAP, TSP and NPK/NPS fertilizers over the medium term. Total phosphate consumption is set to expand at a compound annual rate of 1.8% through to 2021, when total P_2O_5 consumption is estimated to reach 56.9 million tonnes.

Revisions in P_2O_5 nutrient forecast, July vs April outlook



Data: CRU

In **China** fertilizer consumption continues to be pressurised by lower agricultural prices and falling application rates. The abolishment of China's government price support for corn has led to a dramatic shift in area to crops like soybeans, which have a lower phosphate requirement. Also, tightening farm margins have pushed farmers to switch to cheaper substitute products with lower nutrient content. 2017 fertilizer P_2O_5 demand is estimated to fall 3.1 % y/y to 10.7 million nutrient tonnes.

Demand in **India** is forecast to increase in 2017, prompted by improved weather prospects and favourable crop conditions. Farmers are currently planting the Kharif crop and an increase in planted area is forecast alongside a 'normal' monsoon period. Sales of DAP have been subdued in recent months following uncertainty over the implementation of a country-wide goods and services tax (GST). However, the introduction of a 5% GST rate on finished fertilizers is lower than what sector participants were expecting, meaning demand growth should continue. P_2O_5 fertilizer consumption is forecast to increase by 2.8% y/y to 7.1 million nutrient tonnes in 2017.

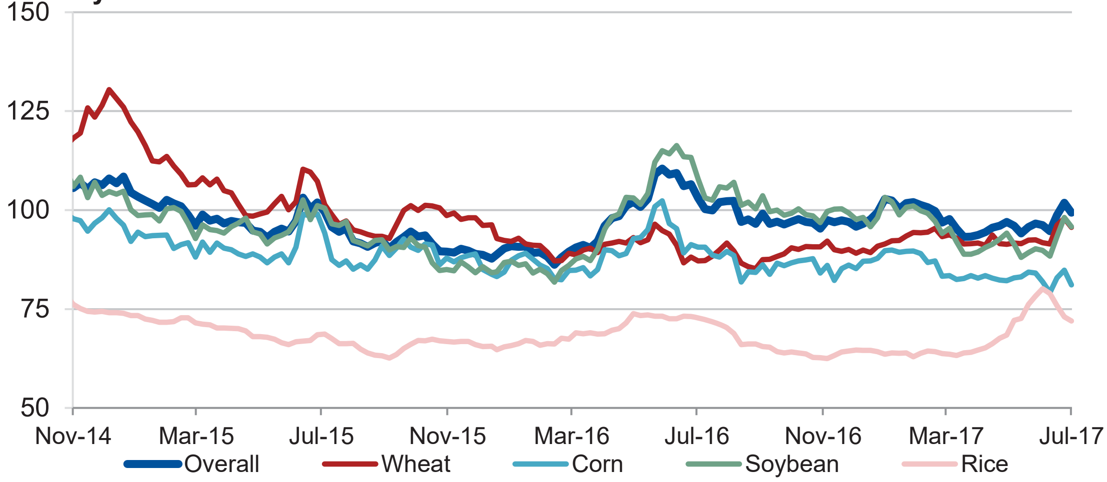
Brazilian P_2O_5 demand is projected to continue expanding in 2017 underpinned by rising area of key crops (corn, soybeans) and good cropping conditions. Import data suggest a large build-up of MAP stocks ahead of soybean planting in Q3. The completion of the planting season in the **USA** has brought the main phosphate application period to an end. Demand is expected to see a marginal decline in 2017 after a record application in 2016 and following a shift from corn to soybean planting. In other markets, **Russia** is expected to have strong consumption, with phosphate fertilizer reportedly displacing some nitrogenous fertilizers in Q12017. In **Pakistan** tax/subsidy policy changes encouraging fertilizer use have driven DAP offtake higher.

1.2 Agricultural Market Overview

The CRU crop price index has moved 5 points higher from the April market outlook, underpinned by **soybean** and **wheat** prices. A major contributing factor of this strengthening has been drier weather in USA's Great Plains and Midwest, impacting crop conditions and yield potential. **Corn** prices have seen some spill-over support from soybean and wheat, but the ongoing record safrinha harvest in Brazil is likely to prevent any further upward movement. **Rice** prices increased substantially in Q2, spurred by tighter global supplies, but have now started to fall as demand has dissipated and production prospects in India remain strong.

CRU Crop Price Index

January 2010=100

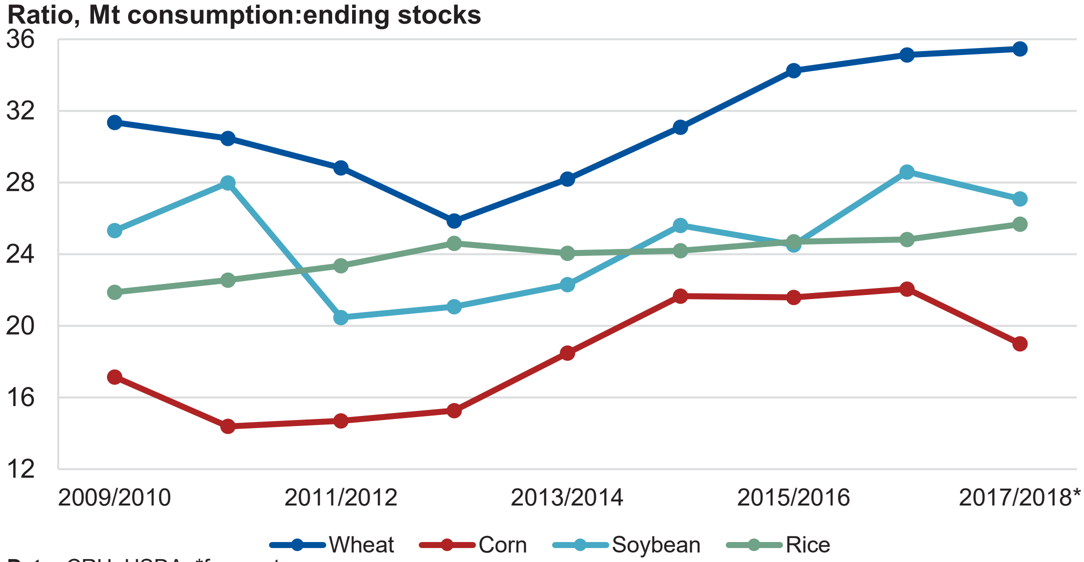


Data: CRU, IGC

Global stocks to use ratios of major crops in the diagram below indicate a significant stock build in recent years, owing to rising production. Despite the recent weather related volatility in crop values, any upward price movement in 2017/18 is likely to be capped by high stock levels.

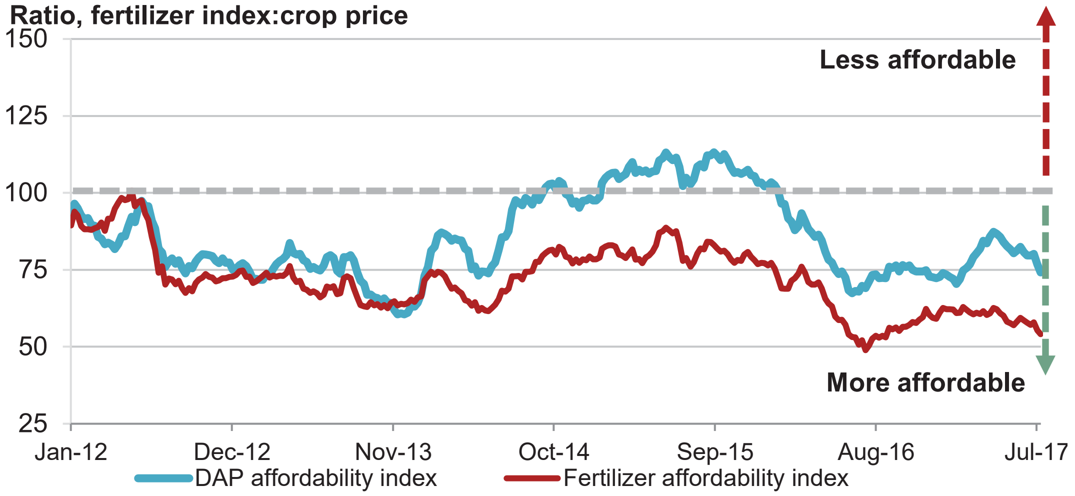
Crops stocks:use ratio

Ratio, Mt consumption:ending stocks



Data: CRU, USDA, *forecast

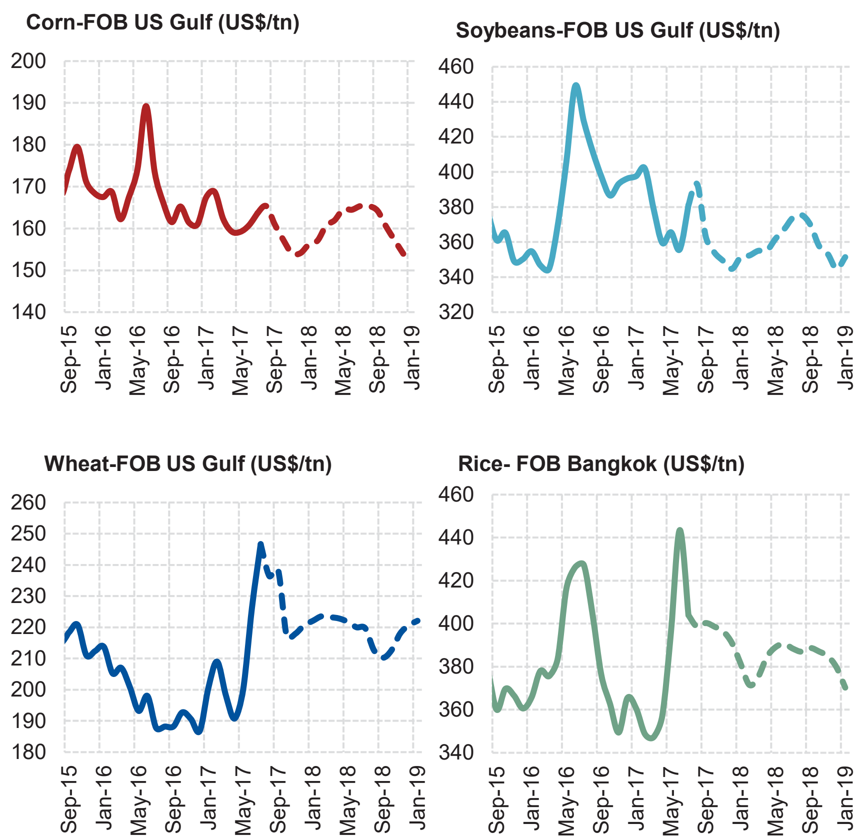
Global DAP affordability dynamics



Data: CRU, Fertilizer Week

Crop prices are relatively low compared to historic trends due to abundant stocks and generally good supply prospects across the grains and oilseeds complex. However, fertilizer prices also remain low, meaning fertilizer affordability remains good relative to crop prices, a positive for demand.

Grain and oilseed prices – 18 month outlook



Key developments

As Brazil enters its safrinha corn harvest, with record output expected, **corn** prices are forecast to continue their decline. **Soybean** prices are forecast to move lower over the coming months due to excellent yields in Brazil and expected strong production in the US. Prices of **wheat** are forecast to see fluctuations from annual seasonal patterns but will remain capped by high stocks. **Rice** prices should fall in the coming months as supplies from India enter the market.

Data: CRU, IGC, IMF, World Bank, EIU

Exhibit I-23

Industry & Trade Summary

Fertilizers

USITC Publication 3082
March 1998

OFFICE OF INDUSTRIES
U.S. International Trade Commission
Washington, DC 20436

UNITED STATES INTERNATIONAL TRADE COMMISSION

This report was prepared principally by

Cynthia Trainor

Energy, Chemicals, and Textiles Division
Organic and Inorganic Chemicals Branch

Address all communications to
Secretary to the Commission
United States International Trade Commission
Washington, DC 20436

PREFACE

In 1991 the United States International Trade Commission initiated its current *Industry and Trade Summary* series of informational reports on the thousands of products imported into and exported from the United States. Each summary addresses a different commodity/industry area and contains information on product uses, U.S. and foreign producers, and customs treatment. Also included is an analysis of the basic factors affecting trends in consumption, production, and trade of the commodity, as well as those bearing on the competitiveness of U.S. industries in domestic and foreign markets.[1]

This report on fertilizers covers the period 1992 through 1996. Listed below are the individual summary reports published to date on the energy, chemicals, and textiles sectors.

USITC publication number	*Publication date*	*Title*
Energy and Chemicals:		
2458	November 1991	Soaps, Detergents, and Surface-Active Agents
2509	May 1992	Inorganic Acids
2548	August 1992	Paints, Inks, and Related Items
2578	November 1992	Crude Petroleum
2588	December 1992	Major Primary Olefins
2590	February 1993	Polyethylene Resins in Primary Forms
2598	March 1993	Perfumes, Cosmetics, and Toiletries
2736	February 1994	Antibiotics
2739	February 1994	Pneumatic Tires and Tubes
2741	February 1994	Natural Rubber
2743	February 1994	Saturated Polyesters in Primary Forms
2747	March 1994	Fatty Chemicals
2750	March 1994	Pesticide Products and Formulations
2823	October 1994	Primary Aromatics

[1] The information and analysis provided in this report are for the purpose of this report only. Nothing in this report should be construed to indicate how the Commission would find in an investigation conducted under statutory authority covering the same or similar subject matter.

USITC publication number	*Publication date*	*Title*
Energy and Chemicals—Continued:		
2826	November 1994	Polypropylene Resins in Primary Forms
2845	March 1995	Polyvinyl Chloride Resins in Primary Forms
2846	December 1994	Medicinal Chemicals, except Antibiotics
2866	March 1995	Hose, Belting, and Plastic Pipe
2943	December 1995	Uranium and Nuclear Fuel
2945	January 1996	Coal, Coke, and Related Chemical Products
3014	February 1997	Synthetic Rubber
3021	February 1997	Synthetic Organic Pigments
3081	March 1988	Explosives, Propellant Powders, and Related Items
3082	March 1998	Fertilizers
3093	March 1998	Adhesives, Glues, and Gelatin
Textiles and apparel:		
2543	August 1992	Nonwoven Fabrics
2580	December 1992	Gloves
2642	June 1993	Yarn
2695	November 1993	Carpets and Rugs
2702	November 1993	Fur Goods
2703	November 1993	Coated Fabrics
2735	February 1994	Knit Fabric
2841	December 1994	Cordage
2853	January 1995	Apparel
2874	April 1995	Manmade Fibers

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ABSTRACT

This report addresses trade and industry conditions for fertilizers for the period 1992-96.

- The United States ranks among the top five world fertilizer producers for all major nutrients: nitrogen, phosphorus, potassium, and sulfur. The United States remains the primary world producer of phosphatic fertilizers and sulfur, is second only to China for nitrogenous fertilizer production, and ranks fifth in production of potassic fertilizers.

- U.S. fertilizer production is inadequate to satisfy domestic demand; therefore, imports account for a significant share of domestic consumption. On a nutrient basis, a significant portion of domestic demand for nitrogenous and potassic fertilizers is satisfied by imports. However, U.S. production of phosphatic fertilizers is both sufficient to satisfy domestic demand and to account for the majority of U.S. fertilizer exports, while U.S. sulfur imports satisfy a relatively small share of domestic demand.

- Producers of these products in the United States had annual production averaging approximately $8.8 billion during 1992-96, with employment of over 37,000 persons. Imports comprised approximately a quarter of U.S. consumption of fertilizer products with significant quantities coming from producers in Canada, Trinidad and Tobago, Russia, and Mexico. The top markets for U.S. exports were China, India, Australia, Canada, and Japan with total U.S. exports representing approximately one-third of U.S. production.

- The primary U.S. consumers of these fertilizer products include farmers, nurseries, golf courses, and landscapers. Consumer demand for these fertilizer products closely parallels the condition of the U.S. farm economy. In particular, fertilizer demand is affected from year to year by highly variable factors, such as weather conditions, grain inventories, U.S. and foreign government agricultural policies, world economic conditions, and world trade of fertilizers and agricultural products.

INTRODUCTION

This summary of industry and trade information on fertilizers is organized into four sections: U.S. industry profile, U.S. market, U.S. trade, and foreign industry profile. The U.S. industry section discusses types of fertilizers, industry structure, costs, distribution channels, and restructuring. The U.S. market section provides information on U.S. apparent consumption, production, and end-market environment. The section on U.S. trade includes information on the U.S. tariff structure and trade-related investigations as well as the tariff structures of major U.S. export markets. The foreign industry profile section examines the major world fertilizer producers and markets. Most of the information in this report is provided in the context of a 5-year (1992-96) timeframe.

Fertilizers, which supply nutrients to vegetable matter, are grouped by nutrients provided. Fixed nitrogen (N), water-soluble phosphorus (P), and water-soluble potassium (K) are the primary fertilizer nutrients. Sulfur (S) is considered the most important secondary nutrient. Information concerning additional secondary and minor plant food elements, which include calcium, magnesium, iron, manganese, copper, zinc, boron, and molybdenum, are included in aggregated trade and production data.

Of the three primary crop nutrients, nitrogen is the leading nutrient applied by farmers in the United States. Nitrogen promotes plant growth and production of chlorophyll. Natural gas and nitrogen from the atmosphere are the primary input raw materials for all nitrogenous fertilizer production.[1] There are several different nitrogenous fertilizers, such as anhydrous ammonia, urea, and ammonium nitrate, each with its own advantages and disadvantages.

Anhydrous ammonia, which is 82.2 percent nitrogen, has the highest nitrogen content of all the nitrogen fertilizers. It is produced from natural gas and nitrogen from the air, and per unit of nitrogen, is the lowest cost nitrogen fertilizer. However, ammonia application requires specialized equipment. At ambient temperature and atmospheric pressure, ammonia is a toxic gas. Consequently, storage and distribution are expensive, because ammonia must either be cooled to a liquid by refrigeration or stored and transported in high-pressure containers. Ammonia application is also expensive because special plows are required that inject the ammonia, as a gas, under the soil. In addition, soil conditions must be such that ammonia will be retained until it is nitrified by soil microorganisms. More than 90 percent of all ammonia use occurs as fertilizer or as an input to further fertilizer production, with the balance consumed as a reagent-grade chemical or as input to non-fertilizer chemical manufacturing processes.

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[1] The U.S. nitrogenous fertilizer industry exhibits a high degree of vertical integration, with ammonia, urea, urea ammonium nitrate solutions (UAN), and ammonium nitrate often produced by the same company at the same production site.

Urea has the highest nitrogen content (46.6 percent) of solid nitrogen fertilizers. Most urea is produced as granules and prills[2] from ammonia and carbon dioxide, is safe to store and easy to handle, and has a transportation advantage in that it can be shipped, or back-hauled, in the same vessels used to transport bulk cargos such as grain. More than 85 percent of urea produced is used as fertilizer, including solid and nitrogen solutions of urea. The balance is primarily consumed as livestock feed and in the production of urea-formaldehyde resins and melamine.

Ammonium nitrate (35.0 percent nitrogen) is produced from ammonia and nitric acid, and is marketed as prills and granules that look very much like those of urea. However, ammonium nitrate is hygroscopic and can also present fire or explosion hazards. Ammonium nitrate's principal advantage is that part of its nitrogen content is in the form of nitrate that can be immediately utilized by crops. Other than fertilizer, the major end use of ammonium nitrate is in mixtures with fuel oil to produce explosives.

Nitrogen solutions are aqueous mixtures, usually of urea and ammonium nitrate (UAN), whose temperature-sensitive nitrogen content usually ranges from 28 to 32 percent. UAN solutions are easy to handle, can be more uniformly applied to the soil than solid fertilizers, can be metered into irrigation water to provide nitrogen to growing crops, and are less costly than ammonia to transport and store. Moreover, direct production of these solutions from urea and ammonium nitrate reactor solutions eliminates prilling or granulating costs. However, the lower UAN nitrogen content increases shipping costs per unit of nitrogen and different equipment is required for application than that used to apply dry fertilizers.

The nutrient phosphorus has often been called the master key to agriculture in that it has a marked influence on root development, plant maturation, and crop yield. Phosphorus is delivered to plants chiefly through the two-nutrient (N and P) ammonium phosphate salts that are generally derived from the reaction between ammonia and phosphoric acid. More than 95 percent of the use of ammonium phosphates is as fertilizers. Diammonium phosphate (DAP) accounts for the bulk of total reported production of all solid ammonium phosphates in the United States. Monoammonium phosphate (MAP), which gives a lower percentage of nitrogen inherent to the compound, is also chiefly used as a fertilizer.

A number of potassium salts, commonly referred to as potash, are used as fertilizers. Because the term potash can refer to any of several compounds, the potassium content of a fertilizer is usually stated in terms of the oxide, K_2O, although it is not itself a naturally occurring chemical compound. Potassium aids in the synthesis of starch and sugar, stiffens straw in cereal grains, promotes root growth, and enables plants to better withstand disease and adverse conditions of climate. Potassium chloride (KCl), also known as muriate of potash, is the chief source of fertilizer potassium applied to fields in the United States. Most potassium chloride in the United States exists in underground deposits. Approximately 80 percent of this total is exploited by conventional shaft-mining techniques. The remainder is obtained either from solution mines or recovered from surface brines.

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[2] Defined as hollow spherical or tear-shaped particles.

Sulfur is both a necessary plant nutrient and also an input for other types of fertilizer production. The largest single end use of sulfur is to produce sulfuric acid used for production of phosphatic fertilizers. Elemental sulfur may be produced by discretionary mining of native sulfur associated with the cap rock of salt domes and in sedimentary deposits by the Frasch hot-water method in which the native sulfur is melted underground and brought to the surface by compressed air. Sulfur compounds are also nondiscretionary by-products from petroleum refining, natural gas processing, and coking plants, captured primarily to comply with environmental regulations that seek to reduce the sulfur content of emissions from processing facilities. The sulfur content of fuels sold or used by such facilities is also regulated.

Overall, U.S. fertilizer production is inadequate to satisfy domestic demand; therefore, imports account for a significant share of domestic consumption. On a nutrient basis, a significant portion of domestic demand for nitrogenous and potassic fertilizers is satisfied by imports. However, U.S. production of phosphatic fertilizers is both sufficient to satisfy domestic demand and to account for the majority of U.S. fertilizer exports, while U.S. sulfur imports satisfy a relatively small share of domestic demand.

U.S. INDUSTRY PROFILE

Industry Structure

The U.S. industry is composed of establishments primarily engaged in (1) manufacturing nitrogenous fertilizer materials or mixed fertilizers from nitrogenous materials produced in the same establishment, as classified in Standard Industrial Classification (SIC) Industry No. 2873; (2) manufacturing phosphatic fertilizer materials, or mixed fertilizers, from phosphatic materials, produced in the same establishment, as classified in SIC Industry No. 2874; (3) mixing fertilizers from purchased fertilizer materials, as classified in SIC Industry No. 2875; (4) manufacturing industrial inorganic chemicals, such as calcium phosphates, phosphorous, and potassium nitrates, classified as part of SIC Industry No. 2819; (5) mining, milling, or otherwise preparing natural potash and potassium compounds, classified as part of SIC Industry No. 1474; and (6) mining, milling, or otherwise preparing sulfur and guano, classified as part of SIC Industry No. 1479.

The aggregated U.S. fertilizer industry was composed of about 350 establishments, with approximately 37,400 total employees during 1996.[3] Changes in size and number of firms during 1992-96 have primarily occurred in response to such factors as price changes for natural gas, grain surpluses, natural resource depletion, and environmental constraints on

[3] Estimated by USITC staff from statistics compiled by the U.S. Department of Commerce, Bureau of the Census, *1992 Census of Manufactures: Agricultural Chemicals*, MC92-1-28G Industry Series, (Washington, DC), p. 28G-7.

production and consumption. In general, the geographic distribution of the U.S. fertilizer industry is dictated by proximity to its natural resources, primary inputs, or end-use markets and is clustered by nutrient along the gulf coast (N and S), Florida and North Carolina (P), and New Mexico (K). Fertilizer production may be characterized overall as moderately labor intensive.

Nitrogenous fertilizer and sulfur production processes are computer controlled; however, the mining components of phosphatic and potassic fertilizer production require significant manual labor input. When feasible, vertical integration is used as a logical strategic cost control measure. Frequently, the U.S. nitrogenous fertilizer industry exhibits a high degree of vertical integration with ammonia, urea, UAN, and ammonium nitrate often produced at the same production site. Figure 1 shows the interrelated nature of stages of fertilizer product manufacture from raw material inputs to finished fertilizer product. In general, fertilizers are marketed through long-term agreements by corporate sales forces, with prices reflecting supply-demand situations. Because the fertilizer industry is considered to be a mature industry, research and development expenditures are concentrated on increasing process yield and efficiency and compliance with environmental production constraints.

Several regulatory issues affect the fertilizer industry, including Superfund,[4] the General Agreement on Tariffs and Trade (GATT),[5] and the Farm Bill. Superfund required EPA to establish a national inventory of toxic chemical emissions called the Toxics Release Inventory (TRI).[6] As this legislation affects production of each major fertilizer nutrient product group, the impact will be addressed separately for each nutrient, as appropriate.

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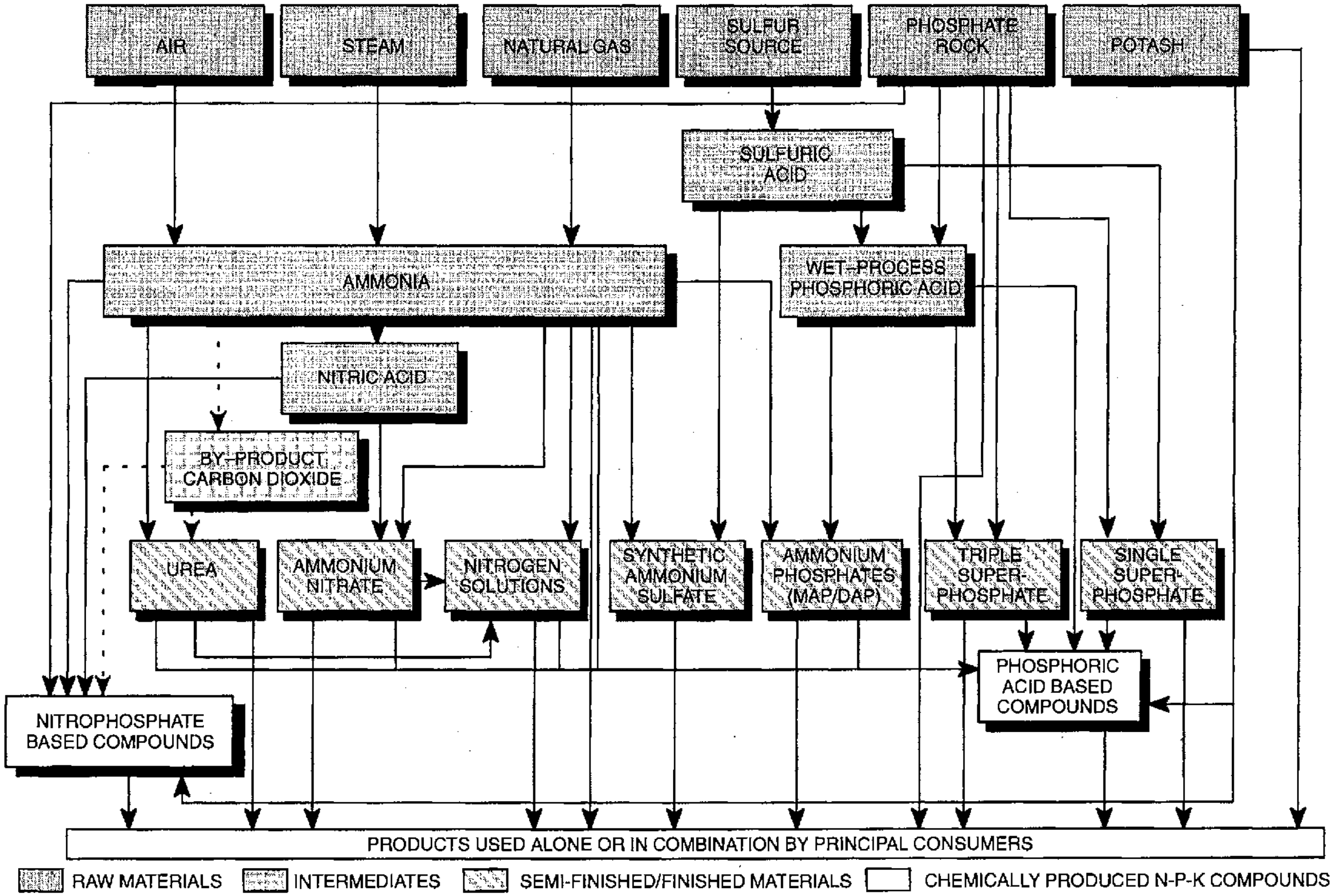
[4] Section 313 of the Environmental Protection Agency's (EPA) Emergency Planning and Community Right-to-Know Act of the Superfund Amendments and Reauthorization Act (SARA) of 1986 (Public Law 99-499).

[5] Now the World Trade Organization (WTO).

[6] U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics, *Toxics Release Inventory 1992*, Public Data Release, EPA 745-R-94-001, (Washington, DC), Apr. 1994.

Figure 1
U.S. fertilizer industry: Principal raw materials, intermediates, and products



Source: Adapted from "Principal Fertilizer Raw Materials, Intermediates, and Products," © 1986 The British Sulphur Corporation Ltd., 31 Mount Pleasant, London WC1X OAD, England. Reproduced with permission of British Sulphur.

The President signed the Uruguay Round Agreements Act[7] on December 8, 1994. By this act, the new multilateral GATT (now WTO), implemented on January 1, 1995, is expected to gradually result in the lowering of global tariff barriers, thus improving the prospects for improved access of U.S. agricultural exports to major countries around the globe.[8] The "Freedom to Farm" U.S. Farm Bill was enacted on April 4, 1996. This legislation withdraws the Acreage Reduction Plan restrictions on planted acreage of grains, oilseeds and fibers. While the exact implementation mechanism is unclear at this time, there will be no governmental restrictions on planted acreage.[9]

The U.S. fertilizer industry is part of a global industry and it ranks among the top five world producers for N, P, K, and S nutrients. Detailed nutrient-specific industry discussions follow.

Nitrogenous Fertilizers

There were 152 establishments, with 7,400 employees, producing nitrogenous fertilizers in the United States during 1992.[10] Since 1987, both the number of establishments and workers employed in the nitrogenous fertilizer industry increased from 117 establishments with 7,000 employees.[11] Nitrogenous fertilizer production is not considered labor intensive because most production processes are computer controlled.

Changes in size and number of firms comprising the U.S. nitrogenous fertilizer industry have primarily occurred to capitalize on economies of scale and to respond to such events as price changes for natural gas and ammonia inputs, increases in world nitrogenous fertilizer trade, and changes in environmental protection regulations. In the 1980s, industry analysts predicted that several ammonia plants would close as a result of significant increases in the U.S. price of natural gas. Several U.S. ammonia plants did close during the mid-1980s, since which time U.S. production has been inadequate to satisfy demand, and current predictions are that U.S. ammonia capacity will increase during 1998-2000. The U.S. nitrogenous fertilizer industry has also become more concentrated. In 1992, the six largest companies accounted for 56 percent of total U.S. ammonia production capacity; in 1996, the six largest companies accounted for 68 percent. The U.S. nitrogenous fertilizer industry is predominantly controlled by domestic companies, with significant foreign direct investment interests. Currently the top four nitrogenous fertilizer producing companies are Farmland Industries, Inc., The Potash Corporation of Saskatchewan (PCS), Terra International, Inc., and CF Industries.[12]

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[7] H.R. 5110 - Public Law No. 103-465.

[8] U.S. President, *Presidential Documents*, V. 30, No. 49, Dec. 12, 1994. Office of the Federal Register, (Washington, DC), pp. 2478-2480.

[9] John Douglas, "Outlook 1996: An Excellent Picture," *Fertilizer International*, No. 352 (May/June 1996), British Sulphur Publishing, p. 93.

[10] U.S. Department of Commerce, *1992 Census of Manufactures: Agricultural Chemicals*, p. 28G-7.

[11] Ibid.

[12] U.S. Department of the Interior, Bureau of Mines, *Nitrogen*, (1992 Annual Report) by Raymond L. Cantrell, (Washington, DC), Aug. 1993, p. 2, and U.S. Department of the Interior,

(continued...)

Nitrogenous fertilizers are most frequently produced near the site of their primary input, natural gas. U.S. nitrogenous fertilizer production capacity is primarily concentrated in the States of Louisiana (40 percent), Oklahoma (14 percent), and Texas (6 percent), owing to large indigenous reserves of natural gas feedstock. Plants in several Midwestern States also account for significant capacity (16 percent) with the remainder equally divided between the Southern and Southeastern States, and Western States (12 percent each).[13]

Since ammonia is required for all downstream nitrogenous fertilizer production, vertical integration is viewed as a logical economic move to exert some control over costs.[14] Nitric acid, urea, ammonium nitrate, and urea ammonium nitrate solutions are often produced at a single highly-integrated production location.

In general, nitrogenous fertilizer prices reflect the supply situation for ammonia. Approximately 7 percent of total annual industrial natural gas use in the United States goes to nitrogenous fertilizer production as both fuel and feedstock. The primary nitrogenous fertilizer product produced from natural gas is ammonia, which, in turn, is both an end-use nitrogenous fertilizer product and a primary input for all other nitrogenous fertilizer production.

Firms that must purchase ammonia on the open market typically obtain long-term contracts with suppliers to secure a steady supply and to hedge against price volatility. U.S. ammonia capacity, overbuilt in the 1970s and rationalized in the late 1980s-early 1990s, is currently inadequate to meet demand;[15] therefore, U.S. demand is satisfied by ammonia imports.

The primary market for nitrogenous fertilizers is in agriculture, mainly for the nitrogen-intensive crops of corn, wheat, cotton, and rice. Because three of these crops are planted only in the spring, demand for nitrogenous fertilizers tends to be seasonal. Producers typically sell under contract to distributors and dealers who, in turn, supply farmers. An exception is the farmer-owned co-operative, CF Industries, whose ownership structure both eliminates distribution channel intermediates and assures an adequate captive supply to its members.

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[12] (...continued)
U.S. Geological Survey (formerly Bureau of Mines), *Nitrogen*, (Annual Review - 1996) by Jim F. Lemons, Jr., (Washington, DC), Aug. 1997, p. 2.

[13] U.S. Department of the Interior, *Nitrogen*, (Annual Review - 1996), Aug. 1997, p. 2.

[14] The cost of producing ammonia is largely determined by the price of natural gas, which accounts for approximately 75 percent of total ammonia production cost. In 1991, the cost of producing ammonia at the large U.S. plants averaged about $87 per ton. At a natural gas cost of $1.80 per million cubic feet (MMCF), gas constituted 72 percent of the total cost to produce ammonia. However, many overseas competitors enjoyed lower gas costs. If gas is priced at a collection value of about $1 per MMCF (which is commonly done in countries where gas is readily available), the cost of ammonia production drops from $87 to $59 per ton and gas constitutes 59 percent of the total cost of production. The ability to compete in world nitrogenous fertilizer markets, therefore, depends mainly on the relative price of natural gas.

[15] Karen Chasez, "Effect of Ammonia Expansions on the Latin American Nitrogen Industry," (paper presented at the British Sulphur 7th Fertilizer Latin America Conference, Tampa, FL, Mar. 4, 1996), p. 1.

Soils do not retain nitrogen from year to year; therefore, nitrogen fertilizer must be added during each planting season to ensure optimum growth and yield conditions. There is a close relationship between relative nitrogenous fertilizer prices and nutrient source product selection. For example, if solid urea prices in the United States fell more rapidly than those of anhydrous ammonia, this might lead to increased consumption of solid urea at the expense of decreased consumption of anhydrous ammonia. However, concerns regarding the safety and environmental effects of anhydrous ammonia and ammonium nitrate may also affect nitrogen source choice. Differences in weather, temperature, and soil conditions can also result in switching from one type of nitrogenous fertilizer to another.

The U.S. nitrogenous fertilizer industry is considered to be a mature industry with minimal research and development expenditures. Research and development funds are spent on process automation and control upgrades, improving energy efficiency, de-bottlenecking, and environmental compliance. However, research was recently undertaken by the U.S. Bureau of Mines Pittsburgh Research Center on methods of desensitizing ammonium nitrate to detonation while retaining its benefit as a fertilizer. The Bureau found that ammonium nitrate containing 20 percent urea diluent will not detonate based on the customary simple addition of fuel oil.[16] The primary use for ammonium nitrate mixed with fuel oil is in explosives.

In regard to environmental concerns, EPA's 1992 TRI revealed that ammonia ranked high both in terms of total releases and in terms of direct releases to the air, water, and land. Ammonia ranked first in terms of underground injection, second in discharges to surface water, and third in terms of the largest emissions to the air. Ammonium nitrate solution, nitric acid, and ammonium sulfate solution were also listed among the top 50 releases, in order of importance.[17]

The U.S. nitrogenous fertilizer industry is part of a global industry and ranked second among the top five world ammonia producers during 1996: China (20.7 percent), United States (14.6 percent), Russia (8.2 percent), India (8.1 percent), and Canada (3.8 percent).[18] Canada and Trinidad and Tobago are the two largest sources of overall U.S. nitrogenous fertilizer imports.

Significant industry acquisitions, expansions, consolidation, and joint ventures occurred during 1992-96. In 1996, nitrogen producer Arcadian Corp.[19] was acquired by The Potash

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[16] "House Explores Ammonium Nitrate Issue," *Green Markets, Fertilizer Market Intelligence Weekly*, June 19, 1995, pp. 8-9.

[17] U.S. Environmental Protection Agency, *Toxics Release Inventory 1992.*

[18] Based on data reported to the International Fertilizer Industry Association (IFA), Paris, France.

[19] In 1993, Arcadian Corp., one of the largest U.S. producers of nitrogenous fertilizers, purchased two adjacent fertilizer plants in the Republic of Trinidad and Tobago, an island country in the Caribbean Sea off the coast of Venezuela, rich in natural gas reserves. This move enhanced Arcadian's strategy of improving competitiveness through the acquisition of production capacity in close proximity to key market areas. The ammonia units purchased had been jointly owned by Amoco Corp. of the United States and Fertilizers of Trinidad and Tobago, Ltd. (FERTRIN), while the urea plant purchased -- Trinidad and Tobago Urea Co., Ltd. -- was wholly owned by Trinidad and Tobago. (U.S. Department of the Interior, *Nitrogen*, (1993 Annual

(continued...)

Corp. of Saskatchewan (PCS), a major North American potash and phosphate fertilizer manufacturer; Mississippi Chemical Corp. acquired the nitrogen facilities of First Mississippi Fertilizer Inc. (Ampro) and of Triad Chemical Co. PCS initiated production of a 255-ton-per-year ammonia plant at Point Lisas, Trinidad, in April 1996. Farmland Industries, Inc. and Mississippi Chemical Corp. contracted to construct the largest ammonia plant in the world, due on-stream by early 1998, in Trinidad and Tobago.[20] Saskferco, an ammonia and urea production joint-venture between Cargill Fertilizer of Minneapolis, MN, the Crown Corp. of Saskatchewan, and Citibank Canada, came on-stream in the fall of 1992 at Belle Plaine, Saskatchewan.[21]

Phosphatic Fertilizers

There were 75 establishments, with 9,500 employees, producing phosphatic fertilizers in the United States during 1992.[22] As discussed below, however, the number of firms in the market decreased considerably during 1992-96. Phosphatic fertilizer production is considered moderately labor intensive, since mined phosphate rock must be washed, crushed, and classified before digestion by acid. However, further downstream production processes of finished phosphates are computer-controlled. Since the late 1980s, the number of workers employed in the phosphatic fertilizer industry has increased slightly from 9,300 employees, while the number of establishments producing phosphatic fertilizers has decreased slightly from 77.[23] Phosphatic fertilizer production processes require significant electrical energy inputs; therefore, energy costs play a major role in determining commodity prices and competitive advantage. Higher energy costs in industrialized countries are a factor in the emergence of the phosphatic fertilizer industry in some less developed countries.[24]

The United States is the world's leading producer and consumer of phosphatic fertilizers. Currently the top three domestic phosphatic fertilizer-producing companies are IMC-Agrico Co.[25] (36 percent), Cargill Fertilizer, Inc. (15 percent), and CF Industries, Inc. (12 percent). In 1990, the top three companies accounted for 42 percent of total U.S. phosphatic fertilizer production capacity; in 1996, the top three companies accounted for 63 percent.[26] The changes in the size and number of firms comprising the U.S. phosphatic fertilizer industry,

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[19] (...continued)
Report), Aug. 1994, p. 6, and U.S. Department of the Interior, *Nitrogen*, (Annual Review - 1996), Aug. 1997, p. 1.)

[20] U.S. Department of the Interior, Bureau of Mines, *Nitrogen*, (Annual 1994), by Raymond Cantrell (Washington, DC), Aug. 1995, p. 5.

[21] U.S. Department of the Interior, Bureau of Mines, *Nitrogen*, (Annual 1993), by Raymond Cantrell (Washington, DC), Aug. 1994, p. 6.

[22] U.S. Department of Commerce, *1992 Census of Manufactures: Agricultural Chemicals*, p. 28G-7.

[23] Ibid., p. 28G-5.

[24] As noted later in the report, energy resources in such countries are often state-owned and provided to domestic industrial users at prices below the world market value of the product.

[25] A joint-venture partnership between IMC Fertilizer Group, Inc. and Freeport-McMoRan Resource Partners, L.P.

[26] U.S. Department of the Interior, *Nitrogen*, (Annual 1992 and 1996).

and their degree of concentration, were due to major industry consolidation and restructuring in Florida and the Western States during the past few years. A protracted period of global phosphate fertilizer oversupply, grain surpluses, and depressed prices between 1981 and 1986 were factors in the U.S. industry consolidation, as well as its incorporation of advanced technologies in the wet-process phosphoric acid (WPPA) manufacturing process, including wet rock grinding, and the cogeneration of electrical power from by-product steam. The net result was that, by 1994, a few major firms, operating under vastly improved economies of scale, dominated the industry. An added benefit was more effective vertical integration between phosphate rock mining, finished phosphate manufacture, and marketing. No new U.S.-owned capacity is anticipated; rather, existing plants may be debottlenecked and idle plants may be recommissioned. However, a new monoammonium phosphate plant is under construction at Bartow, FL, by the Chinese Government-owned Sinochem USA.

Most (about 85 percent) U.S. phosphatic fertilizer production capacity is concentrated near phosphate rock mineral deposits in Florida and North Carolina. The United States produces approximately one-third of the world's phosphate rock. Two new U.S. phosphate rock mines, owned by Cargill and CF Industries, were commissioned during 1995, yet industry sources expect U.S. phosphate rock exports to decline as export emphasis is placed on downstream higher-value-added phosphatic fertilizers. Phosphate rock imports are expected to increase to feed plants in the Mississippi River area,[27] whose location and cost-effective production facilities make them highly competitive in the global marketplace. Phosphatic fertilizers are also produced near rock deposits in the Western States of Idaho, Wyoming, and Utah. These latter production facilities provide fertilizer to consuming States in a vast region extending from the Midwest to the Pacific Coast and into Canada.[28] Because transportation costs are an important factor for fertilizer distribution, the primary channels of distribution require access to deep water ports, inland waterways, and proximity to world trade routes.

Vertical integration of phosphatic fertilizer production is viewed as a logical strategic move to exert control over input costs. Required sulfuric and phosphoric acid input plants are generally at the integrated phosphate rock mine site. Firms that must purchase phosphate rock on the open market typically obtain long-term contracts with suppliers to secure a steady supply and to hedge against price volatility.

Because product differentiation and quality differences are almost nonexistent, individual phosphatic fertilizer products are generally, with few exceptions, marketed on the basis of price by the private companies' marketing and sales forces. However, some international marketing arrangements are handled through international traders and collaborative industry organizations have been organized for such purposes. Phosphate finished products are exported through the Phosphate Chemicals Export Association (PhosChem), a group of producers formed under provisions of the Webb-Pomerene Act. Beyond pricing policies, marketing methods may also depend on extension of credit.

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[27] Pierre L. Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances," (paper presented at the 64th Annual Conference of the International Fertilizer Industry Association (IFA), in Berlin, Germany, May 20-23, 1996), pp. 19-20.

[28] U.S. Department of the Interior, Bureau of Mines, *Phosphate Rock*, (Annual 1994), by Raymond Cantrell (Washington, DC), Sept. 1995, p. 3.

In general, heavy demand for downstream phosphate fertilizer products is reflected in rising prices. Industry consolidation and restructuring resulted in improved operating efficiencies and lower raw materials costs. The price of domestic phosphate rock raw material is an indicator of finished phosphatic fertilizer product merchant market prices because of the high degree of vertical integration between captive phosphate rock production and upgraded phosphate manufacture.

There is a relatively low level of research and development expenditure in the phosphatic fertilizer industry, probably because of the relatively mature technology used worldwide to produce these commodity products. Phosphatic fertilizer research and development expenditures generally focus on chemical process upgrades or modifications, mining and beneficiation improvements, reclamation, and environmental compliance in the areas of process emission, effluent, and phosphogypsum tailings disposal and handling. Much of phosphatic fertilizer production occurs in or close by the nature preserves and wetlands of Florida; therefore, a significant portion of research expenditures is allocated to restore and preserve these areas.

As phosphoric acid is produced through the digestion of phosphate rock by sulfuric acid, and a further wide range of high-grade downstream phosphatic fertilizers is derived from the reaction between ammonia and phosphoric acid, process emissions are closely regulated. EPA's 1992 TRI revealed that phosphoric acid emissions ranked fourth in terms of total releases by the top 50 TRI chemicals, and accounted for about 7 percent of the total.[29]

The U.S. phosphatic fertilizer industry is part of a global industry, and has the largest phosphate rock capacity and production in the world. Ownership of the U.S. phosphatic fertilizer industry is predominantly private and domestic with foreign direct investment in certain U.S. companies. To minimize capital outlay, commitment, and risk, the preferred market entry strategy for foreign suppliers appears to be the export of raw material or intermediate inputs to the United States to companies producing phosphatic fertilizers in geographic regions without close-by phosphate rock natural resources. As the industry consolidates, the degree of integration with foreign investors, producers, and suppliers appears to be on the increase. During 1995, PCS (Canada) acquired Texasgulf's[30] ammonium phosphates business and Occidental's White Springs Agricultural Chemicals business, thus becoming the second largest U.S. ammonium phosphate producer. In late 1995, Agrium Inc. (Canada) acquired Nu-West Industries, Inc. Nu-West now operates as a manufacturing subsidiary of Agrium, with sales handled through Agrium.[31] U.S. Agri-Chemicals Corporation's central Florida phosphate rock mining and processing facilities operate as a wholly-owned subsidiary of China's Sinochem; wet process phosphoric acid (WPPA) and ammonium phosphate plants at Green Bay, Florida, operate as a joint venture between Farmland Industries, Inc. and Norsk Hydro, L.P.; a purified WPPA plant in North Carolina is cooperatively operated by Texasgulf Chemicals Co. and Albright and Wilson, Ltd. of the

[29] U.S. Environmental Protection Agency, *Toxics Release Inventory 1992*.

[30] Texasgulf is owned principally by Elf Aquitaine S.A. of France; the Williams Companies, Inc., of the United States holds a minority interest.

[31] U.S. Department of the Interior, U.S. Geological Survey (formerly Bureau of Mines), *Phosphate Rock*, (Annual Report--1996), by Joyce Ober (Washington, DC), July 1997, p. 2.

United Kingdom; and Rhone Poulenc of France supplies, under the terms of a 7-year contract negotiated in November 1993, phosphate rock ore to Agrium (formerly Nu-West Industries, Inc.) at Conda, ID, for processing and upgrading to WPPA, SPA, and ammonium phosphates.[32]

Potassic Fertilizers

There were 33 establishments, with 5,500 employees, producing the potash, soda, and borate minerals of SIC industry 1474 in the United States during 1992.[33] Certain potassium salts primarily used as fertilizers, and collectively referred to as potash, comprise a portion of SIC industry 1474. In 1996, there were 10 establishments, with 1,690 employees producing potash in the United States.[34] Since 1992, the number of workers employed in the potassic fertilizer industry decreased irregularly from 2,180 while the number of establishments producing potassic fertilizers decreased from 12 to 10.[35] Three potash mines have closed since 1978, and a fourth will probably close before 2010. However, if the price for KCl stays relatively steady, one closed mine may reopen as a result of mining technology improvements and the use of a different mill.[36] Employment in the U.S. industry declined steadily between 1981 and 1987[37] as a result of the depletion of the U.S. reserve base, mine closures, and increased import reliance. Then, as a result of a re-opened mine, employment subsequently increased through 1992 before decreasing irregularly through 1996.

The number of U.S. establishments producing potassic fertilizers decreased from 12 to 10 during 1992-96.[38] The changes in the size and number of firms comprising the U.S. potassic fertilizer industry were due to natural resource reserve depletion, environmental constraints, industry consolidation, and industry restructuring of firms in New Mexico and Michigan during the past few years. Industry sources report that conventional mining producers in the United States have experienced relatively high production costs and aggressive competition from Canadian and other imported potash, while brine[39] producers have had the advantage of low-cost raw materials, but must abide by environmental impact constraints. Such cost, competition, and constraint factors contributed to the closures of the Horizon potash mine at

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[32] U.S. Department of the Interior, *Phosphate Rock*, (Annual 1994), Sept. 1995, pp. 2-3.

[33] U.S. Department of Commerce, Bureau of the Census, *1992 Census of Mineral Industries: Chemical and Fertilizer Mineral Mining*, MIC92-1-14D Industry Series, p. 14D-5.

[34] U.S. Department of the Interior, Bureau of Mines, "Potash," by James P. Searls, *Mineral Commodity Summaries 1995*, (Washington, DC), Jan. 1995, p. 128.

[35] U.S. Department of the Interior, U.S. Geological Survey (formerly Bureau of Mines), *Potash*, by James P. Searls, (Annual Review - 1996), July 1997, (Washington, DC), p. 1.

[36] Ibid.

[37] Year of suspension agreement of Canadian antidumping investigation, and following 1985 ITC potash antidumping investigations with regard to the Former Soviet Union, East Germany, and Israel.

[38] U.S. Department of the Interior, Bureau of Mines, *Potash*, by James P. Searls, (Annual Report - 1992), (Washington, DC), Sept. 1993, pp. 4-5, and U.S. Department of the Interior, *Potash*, (Annual Review - 1996), July 1996, p. 1.

[39] The water of a salt lake or water saturated or strongly impregnated with potassium salts.

Carlsbad, NM, during 1994,[40] and the North American Chemical (Harris & Associates) brine facility at Trona, CA, in March 1996.[41]

The U.S. potash industry consists of companies operating underground mines (3), companies recovering potash from brines (2), and companies operating solution mines (2). Underground mined potash production is centered in Southeastern New Mexico where three companies operate five mine establishments by conventional mining of bedded deposits. These establishments produce about 85 percent of domestic potash. The ore is mined, hoisted to the surface, ground, and screened. The chloride components are separated by crystallization or froth flotation. Three companies in Utah produced potash through recovery from solution mining of underground deposits, from subsurface brines, or from surface brines by solar evaporation and flotation. In Michigan, a pilot-plant development of a deep ore body by solution mining technology continues.[42]

Potassic fertilizer production is considered moderately labor intensive. Conventionally mined potash rock must be beneficiated[43] by flotation, heavy media separation, dissolution-recrystallization, and washing. Brine or solution mine recovery requires evaporation, concentration, and/or flotation. These processes require personnel to run and monitor necessary process equipment.

U.S. potash production will likely continue to decrease as reserves are exhausted. According to the Bureau of Mines, certain New Mexico mined deposits are expected to be depleted in the 1990s, while others appear to be sufficient to sustain mining operations past the year 2000.[44]

Potassic fertilizers are often produced at the site of the primary input mined ore as a logical strategic cost control. Vertical integration is confined to processes which upgrade mined ore to end-use fertilizer product. Potash refers to a number of potassium salts derived from soluble subsurface deposits of potassium minerals, and product diversity is determined by the nature of the mineral deposit mined. For example, sylvanite, the highest grade potash ore, is a mixture of potassium chloride and sodium chloride; through processing it yields potassium chloride product. Langbeinite, a rare form of chloride-free potassium sulfate ore that also contains magnesium sulfate, yields potassium magnesium sulfate (K_2MgSO_4). Kainite ore contains potassium chloride and magnesium sulfate. Evaporation of Great Salt Lake brines yields sulfate of potash.[45]

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[40] Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), p. 41.

[41] Pierre L. Louis, "The Outlook for Phosphates and Potash, with Special Reference to Latin America," (IFA paper presented at the British Sulphur 7th Fertilizer Latin America International Conference, Tampa, FL, Mar. 3-5, 1996), p. 6.

[42] Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), p. 41.

[43] Treatment methods used on raw materials to improve properties.

[44] U.S. Department of the Interior, Bureau of Mines, "Potash," by James P. Searls, *Mineral Facts and Problems*, (1985 edition), p. 14.

[45] U.S. Department of the Interior, Bureau of Mines, *Potash 1992*, by James P. Searls, (Annual Report), (Washington, DC), Sept. 1993, p. 1.

Potash is marketed through several channels of distribution. In general, potash is transported by train, truck, and barges to warehouses, wholesalers, and retailers. Some potash is sold directly from barges used as temporary warehouses. Retailers sell potash and potash blended with other fertilizers in dry or liquid form for distribution over fields in both spring and fall.[46] In addition, PCS markets potash exports for three New Mexico operations, now in a single company owned by Mississippi Chemical, as a cost-cutting measure.[47]

A protracted period of global potash fertilizer overcapacity has resulted in producers around the world operating at partial capacities to maintain prices. This situation is the result of a decline in demand among the developed market countries since 1979 (i.e., the second oil shock) and in many of the former centrally planned economies since 1988.[48] Developed economy demand dropped as subsidies for agriculture declined; demand in the former Soviet Union (FSU)[49] and other centrally planned economies fell in response to declining state assistance and changing market and political conditions.[50] Historically, in times of economic downturn, potassium is the first nutrient deleted in crop production.[51] During 1992-96, the average annual value of U.S. potash product sales of all types and grades increased irregularly from $96.45 to $101.08 per metric ton f.o.b. mine.[52]

Although domestic production of potash continues to decline, certain specific research and development continues. For example, in the State of Michigan, IMC-Kalium developed an experimental pilot-plant to extract KCl from a deep ore body through solution mine technology. As this facility is close to a main consumption area, production at this mine is likely to continue.[53]

Potash from Canada is the subject of a suspension agreement between the International Trade Administration of the U.S. Department of Commerce and the Canadian Potash producers. The agreement resulted from a 1987 antidumping investigation.[54] The action is slated to be reviewed beginning in March 1999 under the sunset provision of the antidumping law. In recent years, U.S. pricing practices of U.S. and Canadian producers have been the subject of

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[46] U.S. Department of the Interior, Bureau of Mines, "Potash," by James P. Searls, *Mineral Commodity Summaries 1995*, (Washington, DC), Jan. 1995, p. 128.

[47] U.S. Department of the Interior, *Potash*, (Annual Review - 1996), July 1996, p. 2.

[48] U.S. Department of the Interior, *Potash 1992*, (Annual Report), Sept. 1993, p. 9.

[49] For this report, FSU is used to refer to the nations that once comprised the Soviet Union because historical data needed to provide a baseline analysis were, and in some cases continue to be, compiled under the name Soviet Union.

[50] Louis, "The Outlook for Phosphates and Potash, with Special Reference to Latin America," Mar. 1996, p. 5.

[51] Potassium use yields hidden benefits, such as withstanding disease and adverse climate conditions, promotion of root growth, and strong stalks, whereas the benefits of nitrogen and phosphorus use, such as plant growth, chlorophyll production (greening), plant maturation, and crop yield, are clearly visible to the farmer.

[52] U.S. Department of the Interior, *Potash*, (Annual Review - 1996), July 1996, p. 6.

[53] Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), p. 41.

[54] USITC, *Potassium Chloride from Canada*, (investigation No. 731-TA-374 (preliminary)), USITC publication 1963, Mar. 1987; for further information, see section entitled, "U.S. government trade-related investigations."

a Justice Department investigation and at least two lawsuits. In June 1996, the Antitrust Division of the U.S. Department of Justice concluded an investigation, begun in 1993, into allegations that North American potash producers acted together to fix the price of potash sold in the United States between 1987 and 1994. The companies under investigation were advised that no action would be taken. In September 1996, a U.S. Federal District Court in St. Paul, MN, dismissed civil antitrust lawsuits alleging that Canadian and some U.S. potash producers were engaging in collusive pricing. Indirect purchasers residing in California filed similar collusive pricing allegations in California State courts. As of the end of 1996, the California suits were still pending, with no discovery proceedings having occurred.[55]

The U.S. potassic fertilizer industry is part of a global industry, and is the fifth-largest potash producer in the world. The degree of integration with foreign investors, producers, and suppliers is shown by such examples as International Minerals and Chemicals Corp.'s (IMC) direct ownership investment in potash mines in both the United States and Canada and by the PCS export marketing agreement for Mississippi Chemicals' consolidated production.[56] Advantages of these arrangements center on supply availability to primary use markets, source-dependent pricing flexibility,[57] and cost-effective marketing.

Sulfur

There were 99 establishments, with 4,100 employees, producing the mined chemical and fertilizer minerals, not elsewhere classified, of SIC industry 1479 in the United States during 1992.[58] By 1996, the number of establishments producing sulfur had increased to 2 establishments producing mined native sulfur and 137 establishments that recovered elemental sulfur as a nondiscretionary by-product from petroleum refining, natural gas processing, and coking plants, primarily to comply with environmental regulations directly applicable to the processing facility or indirectly through restrictions on sulfur content of fuels sold or used by the facility.[59] Total employment, in sulfur mines and/or plants, has been relatively stable at approximately 3,100 employees for the period 1992-96.[60]

Although elemental sulfur and by-product sulfuric acid are produced in 26 States, Texas and Louisiana accounted for 50 percent of domestic production during 1996.[61] Recovered sulfur represented 73 percent of elemental sulfur production with the balance consisting of

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[55] U.S. Department of the Interior, *Potash*, (Annual Review - 1996), July 1996, p. 1.

[56] Ibid., p. 2.

[57] When one producer owns manufacturing establishments in two different geographical locations or countries, with different grade ore beds, different mining processes, and different available modes of transportation, product price may depend upon product source facility.

[58] U.S. Department of Commerce, *1992 Census of Mineral Industries: Chemical and Fertilizer Mineral Mining*, p. 14D-5.

[59] U.S. Department of the Interior, Bureau of Mines, *Sulfur*, (Annual Review - 1994), by Joyce A. Ober, (Washington, DC), Nov. 1995, pp. 1-2.

[60] U.S. Department of the Interior, Bureau of Mines, "Sulfur," by Joyce A. Ober, *Mineral Commodity Summaries 1996*, (Washington, DC), Jan. 1997, p. 166.

[61] Ibid.

discretionary Frasch mined production. In addition, by-product sulfuric acid was recovered at 16 nonferrous smelters in 10 States by 11 companies.[62]

Domestic production of recovered sulfur continued to grow, as mine production decreased with the closure of an older Freeport Sulfur Frasch operation in the Gulf of Mexico early in 1994. Soon after the newest Freeport Sulfur Frasch mine attained design capacity at the end of 1993, the company made the decision to close the older mine to take full advantage of the lower cost and higher efficiency at the newer facility.[63] The two remaining Frasch producers, both also controlled by Freeport Sulfur, are located (one each) in Texas and off-shore Louisiana. Pennzoil announced an agreement to sell virtually all of its sulfur assets to Freeport in a sale that was officially effective January 3, 1995.[64]

Frasch mined sulfur production is considered moderately labor intensive in that native sulfur is melted underground and brought to the surface by compressed air. Recovered sulfur is not considered labor intensive in that it is produced by on-site computer-controlled processes to comply with environmental regulations, regardless of demand.

Vertical integration in the sulfur industry is dictated by use. The largest use of sulfur in all forms is in agriculture, often as a process intermediate input in the form of sulfuric acid.[65] In particular, processing phosphate rock to higher-value-added fertilizer products often requires investment in a sulfuric acid plant as part of integrated phosphatic fertilizer production. In the absence of such a plant, sulfuric acid must be purchased. Product diversity is limited by the intermediate input usage of the sulfuric acid primary product.

In general, sulfur is sold directly by producers' sales forces to chemical and fertilizer producers. It is transported by train, truck, or barge directly to the production site where it is then converted to sulfuric acid to be used as a process intermediate input.

The posted price for Frasch sulfur ranged from \$65 to \$70 per metric ton during the first quarter of 1994, then reached and maintained \$77 per metric ton through fourth quarter 1994.[66] Following the January 1995 consolidation of Frasch sulfur production under sole control of Freeport Sulfur, average price values are unpublishable to protect business-confidential information. However, industry sources reported that Frasch prices increased during 1996 and recovered prices decreased. Sulfur prices, reported as average value in dollars per ton of elemental sulfur, f.o.b. mine and/or plant, decreased irregularly during 1992-96, from \$48.14 to \$38.00 (estimated).[67] The price decline reflects the increased production and reliance on by-product recovered, rather than mined, sulfur as dictated by the early 1994 Frasch mine closure discussed previously. Freeport Sulphur announced plans early in 1996

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[62] Ibid.

[63] "Freeport-McMoRan to Idle Caminada Sulfur Mine," *Green Markets*, v. 17, No. 42, pp. 1 and 10.

[64] "Freeport to Buy Most of Pennzoil Sulphur," *Fertilizer Markets*, v. 5, No. 14, p. 1.

[65] According to the U.S. Geological Survey, agricultural chemicals (primarily fertilizers) comprised approximately 67 percent of sulfur demand; about 90 percent of sulfur was consumed in the form of sulfuric acid.

[66] U.S. Department of the Interior, *Sulfur*, (Annual Review - 1995), Mar. 1997, pp. 2-3.

[67] U.S. Department of the Interior, "Sulfur," 1997 Summary, Jan. 1997, p. 166.

to cut production at both of its Frasch mines to better balance supply and demand to maintain prices.[68]

R & D expenditures focus on the low-cost removal of sulfur from petroleum products. Energy Biosystems Corp. (EBC) of Houston, TX, has developed a unique process for this purpose which is being tested in a pilot plant. Genetically engineered microorganisms remove sulfur from petroleum products by biocatalytic desulfurization, or by virtually eating the sulfur, without consuming carbon and wasting valuable fuel. Construction and operating costs of biological desulfurization units are projected to be significantly less than those of more traditional systems.[69]

Sulfur is also subject to several EPA requirements. The first stage of Clean Air Act Amendments (CAAA) of 1990 required electric utilities, in particular coal-fired power plants, to reduce sulfur dioxide emissions significantly in 1995, and all power companies to limit sulfur dioxide emissions to 1990 levels by the year 2000. As a result companies are implementing developed research processes to recover saleable by-products such as commercial grade elemental sulfur, sulfuric acid, and liquid sulfur dioxide rather than invest in costly disposal of these environmental pollutants.[70]

The U.S. sulfur industry is part of a global industry, and the United States is the largest sulfur producer in the world. Examples of the degree of integration with foreign investors, producers, and suppliers are shown through foreign parentage of certain U.S. refinery or natural gas producers, such as Shell Oil (Anglo-Dutch) and BP Oil (British). Advantages of these arrangements center on supply availability to primary use markets, source dependent pricing flexibility, and cost-effective marketing.

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[68] Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), p. 32.

[69] A.K. Rhodes, "Enzymes Desulfurizing Diesel Fuel in Pilot Plant Tests," *Oil & Gas Journal*, v. 93, No. 20, (1995), p. 33.

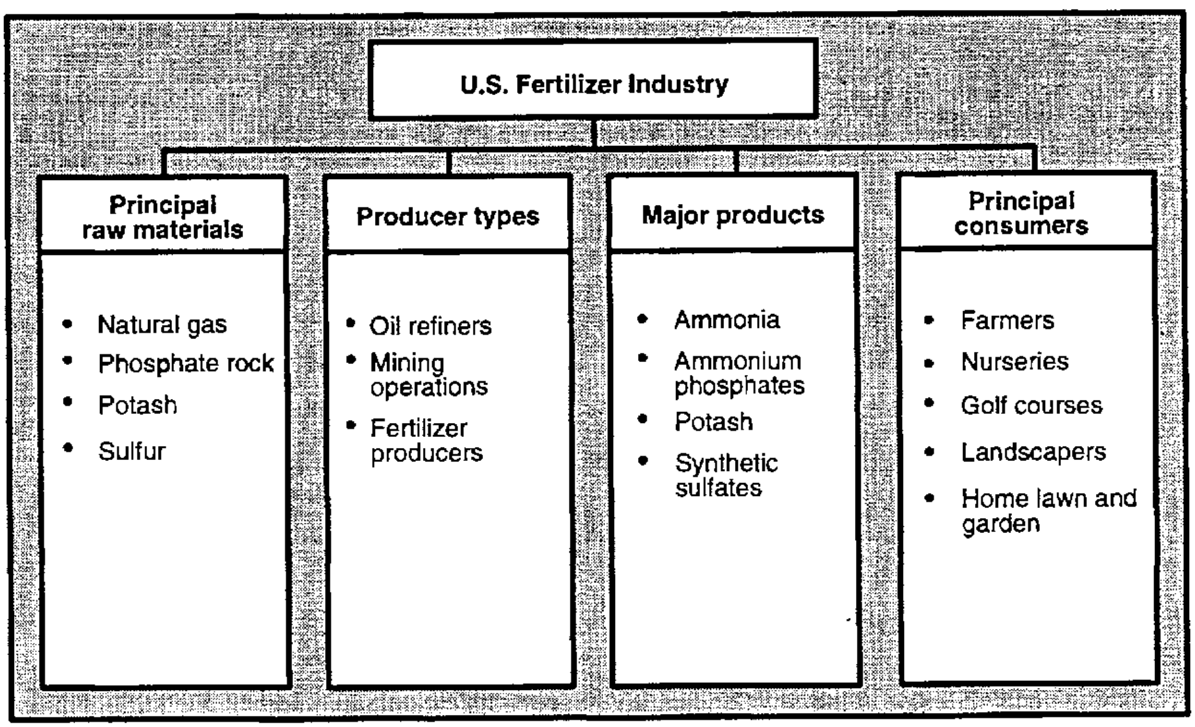
[70] U.S. Department of the Interior, *Sulfur*, (Annual Review - 1994), Nov. 1995, p. 4.

U.S. MARKET

Consumer Characteristics and Factors Affecting Demand

U.S. agriculture is by far the major consumer of fertilizers (figure 2). More than 85 percent of fertilizers consumed in the United States is by farmers in crop production. Specific fertilizer concentration and nutrient mix applied is dictated by soil conditions and crop needs. For example, four crops together account for the majority of nitrogenous fertilizer use: corn, wheat, cotton, and rice; more than one-half of potash consumed is for corn and soybeans; and more than one-half of phosphatic fertilizers consumed are used in the production of corn and wheat. Golf courses, landscapers, and nurseries together account for approximately 10 percent of domestic fertilizer use, with strong demand for nitrogenous fertilizers to ensure greening and quick growth. The home lawn and garden market accounts for the remaining 5 percent of domestic fertilizer consumption with specific usage determined by climate, soil, and plant need.

Figure 2
U.S. fertilizer industry: Principal raw materials, producer types, major products, and principal consumers



Source: U.S. International Trade Commission.

Fertilizer demand may be influenced by weather conditions, trade disputes, political unrest, general economic agricultural conditions, crop prices, and product supply. There are no substitutes for fertilizers in plant growth. However, within each necessary nutrient group, each nutrient may be supplied through a variety of products. Within crop and soil requirements, farmers often select the nutrient vehicle used by price and product supply. Demand is typically the greatest during the spring planting season and in the fall for winter top dressing of soil after crop harvest.

Consumption

Fertilizers are consumed in all 50 States and the District of Columbia. Illinois, Iowa, and Texas consumed the largest amounts of fertilizers, with a combined share of about 25 percent of total U.S. production during 1992-96.[71] Fertilizer use has fluctuated since the early 1980s, affected by the world economic recession, problems specific to the U.S. agricultural economy, and government acreage reduction programs. Total consumption of fertilizers increased irregularly from $7.5 billion in 1992 to $9.0 billion in 1996 (table 1 and figure 3). Imports supplemented U.S. production and import share increased consistently, from 19.6 percent to 27.7 percent of U.S. fertilizer consumption, during 1992-96.

The primary use for fertilizers is in the production of agricultural crops. U.S.-produced fertilizers are considered to be of high quality, and to exhibit stable handling, good storage, and long shelf life characteristics. U.S. producers are considered to be the most secure source of supply in the world. To illustrate the importance of security of supply, one of the most highly integrated U.S. fertilizer production facilities is owned by a farmers' co-operative, which also eliminates markup on distribution.

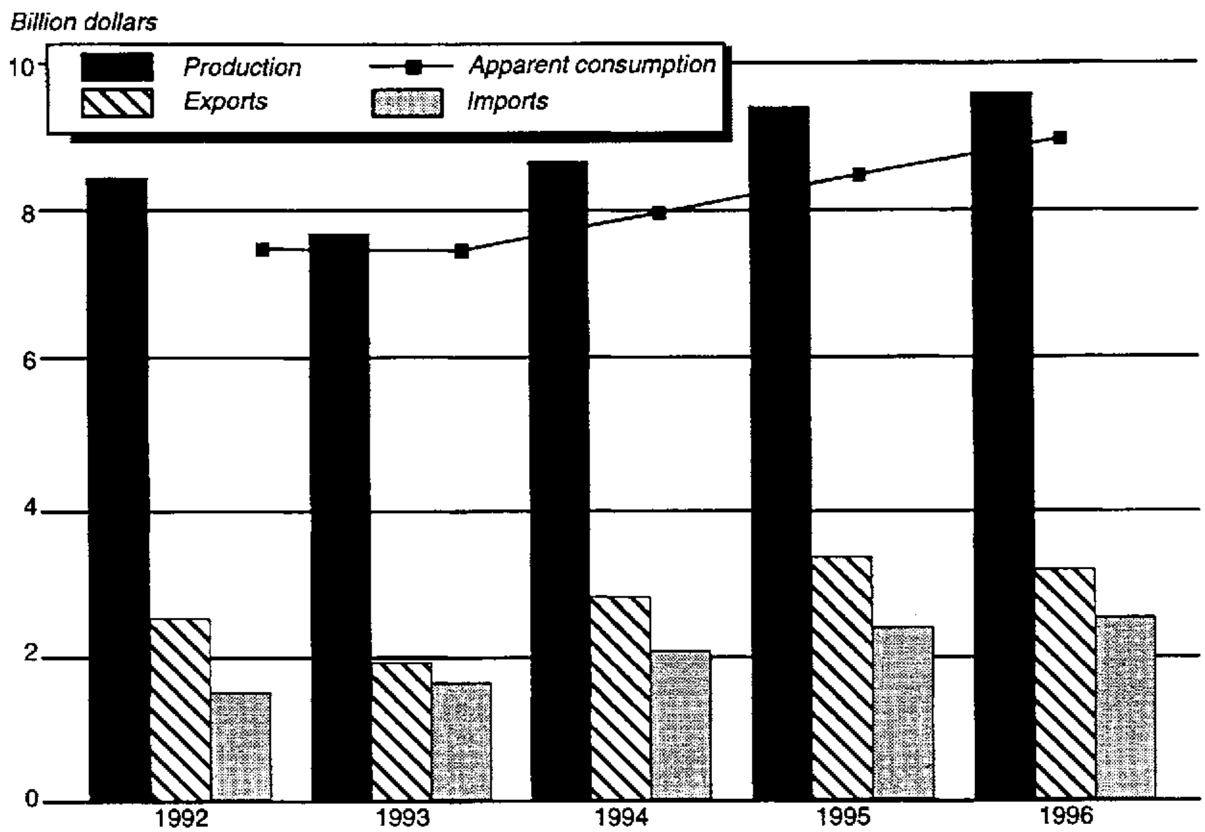
Table 1
Fertilizers: U.S. production, exports of domestic merchandise, imports for consumption, and apparent consumption, 1992-96

Year	U.S. production	U.S. exports	U.S. imports	Apparent U.S. consumption	Ratio of imports to consumption
	Million dollars				*Percent*
1992	8,515	2,483	1,471	7,503	19.6
1993	7,758	1,877	1,600	7,481	21.4
1994	8,737	2,780	2,040	7,997	25.5
1995	9,480	3,319	2,357	8,518	27.7
1996	9,670	3,151	2,489	9,008	27.6

Source: Compiled from official statistics of the U.S. Department of Commerce.

[71] The Association of American Plant Food Control Officials and The Fertilizer Institute, *Commercial Fertilizers 1996*, p. 6.

Figure 3
Fertilizers: U.S. production, exports, imports, and apparent consumption, 1992-96



Source: Compiled from official statistics of the U.S. Department of Commerce.

Production

Much U.S. fertilizer production occurs near raw materials sources. During 1992-96, the value of U.S. production of fertilizers increased irregularly by approximately 3 percent per year, from $8.5 billion in 1992 to approximately $9.7 billion in 1996. The major fertilizer products shipped were ammonium phosphates, urea, and ammonium nitrate, with an estimated 26, 20, and 13 percent, respectively, of the total value of U.S. production of fertilizers in 1996. In general, inventories of dry, storable fertilizers such as DAP, urea, and potash are built up over the winter months for late winter/early spring deliveries targeted for use during the spring planting season. These inventories are often held in storage facilities along traditional delivery routes, such as along the Mississippi River.

U.S. TRADE

Overview

During 1992-96, the United States maintained a positive balance of trade in fertilizers (table 2). The positive trade balance has, however, deteriorated irregularly from $1.0 billion in 1992 to $662 million in 1996. This decline may be primarily attributed to irregular ammonium phosphate exports to China and India and significant increases in imports of nitrogenous fertilizers from Trinidad and Tobago, Russia, Ukraine, and Saudi Arabia.

Table 2
Fertilizers: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1992-96[1]

(Million dollars)

Item	1992	1993	1994	1995	1996
U.S. exports of domestic merchandise:					
Canada	204	216	207	261	276
China	630	293	944	1,204	893
Trinidad and Tobago	([2])	([2])	1	([2])	1
Australia	130	131	162	207	295
Japan	166	165	186	218	186
Russia	1	([2])	([2])	([2])	2
Mexico	95	133	160	83	168
Saudi Arabia	1	6	1	1	1
Brazil	124	92	179	113	137
Argentina	35	26	38	59	134
Ukraine	0	0	0	0	2
India	263	173	134	284	81
All other	834	642	768	889	975
Total	2,483	1,877	2,780	3,319	3,151
EU-15	145	71	113	100	68
OPEC	104	41	58	80	37
Latin America	495	439	623	524	784
CBERA	91	64	89	108	118
Asian Pacific Rim	1,128	798	1,518	1,937	1,724
ASEAN	81	64	97	116	174
Central and Eastern Europe	6	1	([2])	([2])	([2])

See footnotes at end of table.

Table 2—*Continued*

Fertilizers: U.S. exports of domestic merchandise, imports for consumption, and merchandise trade balance, by selected countries and country groups, 1992-96[1]

(*Million dollars*)

Item	1992	1993	1994	1995	1996
U.S. imports for consumption:					
Canada	928	943	1,067	1,111	1,097
China	([2])	1	1	2	3
Trinidad and Tobago	101	138	238	330	327
Australia	1	([2])	([2])	([2])	([2])
Japan	7	9	11	13	13
Russia	42	47	98	208	170
Mexico	130	69	145	163	165
Saudi Arabia	0	9	40	59	141
Brazil	2	14	9	([2])	5
Argentina	0	([2])	([2])	0	([2])
Ukraine	26	37	57	61	133
India	([2])	([2])	1	1	1
All other	234	333	373	409	435
Total	1,471	1,600	2,040	2,357	2,489
EU-15	60	86	71	73	98
OPEC	3	59	76	104	237
Latin America	276	279	436	552	598
CBERA	101	138	238	330	328
Asian Pacific Rim	11	16	22	24	28
ASEAN	([2])	6	9	9	10
Central and Eastern Europe	6	43	92	105	48
U.S. merchandise trade balance:					
Canada	-725	-728	-860	-850	-822
China	629	292	943	1,203	890
Trinidad and Tobago	-101	-137	-238	-330	-326
Australia	129	131	162	207	295
Japan	159	156	175	205	174
Russia	-41	-47	-98	-208	-168
Mexico	-35	64	14	-81	3
Saudi Arabia	1	-4	-39	-58	-140
Brazil	122	78	170	112	132
Argentina	35	26	38	59	134
Ukraine	-26	-37	-57	-61	-131
India	263	173	133	283	80
All other	602	309	395	481	541
Total	1,012	277	740	962	662
EU-15	85	-15	42	27	-30
OPEC	101	-18	-18	-23	-200
Latin America	219	160	186	-28	186
CBERA	-11	-74	-149	-222	-210
Asian Pacific Rim	1,117	782	1,496	1,913	1,696
ASEAN	81	58	87	107	163
Central and Eastern Europe	([2])	-42	-92	-105	-48

[1] Import values are based on Customs value; export values are based on f.a.s. value, U.S. port of export.
[2] Less than $500,000.

Source: Compiled from official statistics of the U.S. Department of Commerce.

U.S. Imports

Principal Suppliers and Import Levels

U.S. imports of fertilizers increased from approximately $1.5 billion in 1992 to $2.5 billion in 1996 (table 3). U.S. fertilizer imports are chiefly composed of potash and nitrogenous fertilizers. Although Canada remained the primary U.S. fertilizer import source during 1992-96, by 1993 Trinidad and Tobago emerged as the second largest source and remained so through 1996. U.S. fertilizer imports from Canada are predominately potash, which account for approximately 80 percent of domestic annual potash consumption. U.S. potash supply capacity is both inadequate to satisfy domestic demand and geographically remote from areas of highest domestic consumption. Further, U.S. potash production locations are landlocked, which necessitates expensive overland transport of this high-weight and low-value commodity to reach primary midwest consumption areas. Canada also exports approximately 25 percent of its domestic ammonia production and about 50 percent of its domestic urea production to the United States. The Canadian agricultural sector is about one-tenth that of the United States. In 1996, the United States was the sole market for Canadian exports of ammonia and accounted for approximately 72 percent of the Canadian export market for urea.[72]

Table 3
Fertilizers: U.S. imports for consumption, by principal sources, 1992-96
(1,000 dollars)

Source	1992	1993	1994	1995	1996
Canada	928,332	943,226	1,067,480	1,110,961	1,097,384
Trinidad & Tobago	101,226	137,761	238,022	330,228	326,571
Russia	41,657	47,389	98,199	208,080	169,609
Mexico	130,325	68,870	145,193	163,366	165,216
Saudi Arabia	0	9,402	39,635	58,932	141,176
Ukraine	26,263	37,294	57,187	61,296	133,106
Venezuela	2,868	25,224	17,989	23,345	55,378
Norway	31,734	31,010	36,119	45,133	54,130
Netherlands	9,888	23,315	25,515	26,823	34,557
Morocco	45,370	27,866	27,226	30,058	33,810
All other	153,289	248,200	287,342	298,584	277,865
Total	1,470,952	1,599,557	2,039,907	2,356,806	2,488,803

Source: Compiled from official statistics of the U.S. Department of Commerce.

[72] International Fertilizer Industry Association (IFA), *Ammonia Statistics 1996*, (Paris, France, May 1997) and *Urea Statistics 1996*, (Paris, France, May 1997).

The agricultural sector of Trinidad and Tobago is very small relative to that of the United States; however, Trinidadian natural gas prices for ammonia production include a relatively low floor price and an escalator clause tied to the price of ammonia.[73] Trinidad and Tobago exports approximately 70 percent of its indigenous ammonia production and about 40 percent of its indigenous urea production to the United States, primarily from U.S.-Trinidadian joint-venture plants at Point Lisas. In 1996, the U. S. market accounted for 86 percent of Trinidadian ammonia exports and approximately 42 percent of the Trinidadian urea exports.[74]

U.S. Trade Measures

Tariff measures

Table 4 shows the rates of duty for U.S. imports of the products covered in this summary under the *Harmonized Tariff Schedule of the United States (HTS)*. The column 1 rates of duty for countries considered for general or most-favored-nation (MFN) treatment, as well as duty rates under column 1 for countries qualifying for special tariff programs, are free unless subject to special duty provisions.[75]

U.S. government trade-related investigations

The Commission has conducted several investigations in recent years with respect to products covered in this summary (table 5). As a result of final affirmative Commission determinations under U.S. antidumping (AD) and countervailing duty (CVD) laws,[76] the U.S. Department of Commerce has issued AD orders with respect to urea from the former German Democratic Republic, Romania, and the former Soviet Union, and elemental sulfur from Canada; and AD and CVD orders with respect to phosphoric acid from Belgium and Israel. In addition, potassium chloride from Canada is subject to terms of a suspension agreement. Beginning in mid-1998, outstanding AD and CVD orders will become subject to sunset reviews by Commerce and the Commission.

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[73] As the price of ammonia goes up, the price of input gas goes up also; Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), p. 5.

[74] IFA 1996 Ammonia and Urea Statistics.

[75] See app. A for an explanation of rate of duty columns.

[76] 19 U.S.C. 1671 et seq.

Table 4

Fertilizers: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1997; U.S. exports, 1996; and U.S. imports, 1996

HTS heading or subheading	Description	Col. 1 rate as of Jan. 1, 1997 General	Special	U.S. exports[1] 1996	U.S. imports 1996
				Million dollars	
2503.00.00	Sulfur of all kinds, other than sublimed sulfur, precipitated sulfur and colloidal sulfur	Free		35.0	94.1
2510	Natural calcium phosphates, natural aluminum calcium phosphates and phosphatic chalk:				
2510.10.00	Unground	Free		0	29.6
2510.20.00	Ground	Free		0	0.1
2802.00.00	Sulfur, sublimed or precipitated; colloidal sulfur	Free		9.8	232.4
2804.70.00	Phosphorus	Free		25.5	3.1
2814	Ammonia, anhydrous or in aqueous solution:				
2814.10.00	Anhydrous ammonia	Free		0	688.9
2814.20.00	Ammonia in aqueous solution	Free		3.3	1.3
2834	Nitrites; nitrates:				
	Nitrates:				
2834.21.00	Of potassium	Free		6.5	8.7
2834.29	Other:				
2834.29.10	Of calcium	Free		0.8	7.8
3101.00.00	Animal or vegetable fertilizers, whether or not mixed together or chemically treated; fertilizers produced by the mixing or chemical treatment of animal or vegetable products	Free		(2)	3.2
3102	Mineral or chemical fertilizers, nitrogenous:				
3102.10.00	Urea, whether or not in aqueous solution	Free		(2)	415.6
	Ammonium sulfate; double salts and mixtures of ammonium sulfate and ammonium nitrate:				
3102.21.00	Ammonium sulfate	Free		(2)	35.4
3102.29.00	Other	Free		(2)	0.1
3102.30.00	Ammonium nitrate, whether or not in aqueous solution	Free		(2)	101.5

See footnotes at end of table.

Table 4—*Continued*

Fertilizers: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1997; U.S. exports, 1996; and U.S. imports, 1996

HTS heading or subheading	Description	Col. 1 rate as of Jan. 1, 1997 General	Special	U.S. exports[1] 1996	U.S. imports 1996
				— *Million dollars* —	
3102.40.00	Mixtures of ammonium nitrate with calcium carbonate or other inorganic nonfertilizing substances	Free		(2)	9.7
3102.50.00	Sodium nitrate	Free		(2)	16.6
3102.60.00	Double salts and mixtures of calcium nitrate and ammonium nitrate	Free		(2)	10.0
3102.70.00	Calcium cyanamide	Free		(2)	0.2
3102.80.00	Mixtures of urea and ammonium nitrate in aqueous or ammoniacal solution	Free		(2)	107.7
3102.90.00	Other, including mixtures not specified in the foregoing subheadings	Free		(2)	14.8
3103	Mineral or chemical fertilizers, phosphatic:				
3103.10.00	Superphosphates	Free		(2)	6.2
3103.20.00	Basic slag	Free		(2)	1.1
3103.90.00	Other	Free		(2)	2.4
3104	Mineral or chemical fertilizers, potassic:				
3104.10.00	Carnallite, sylvite and other crude natural potassium salts	Free		(2)	3.1
3104.20.00	Potassium chloride	Free		(2)	544.5
3104.30.00	Potassium sulfate	Free		(2)	11.3
3104.90.00	Other	Free		(2)	5.9
3105	Mineral or chemical fertilizers containing two or three of the fertilizing elements nitrogen, phosphorus and potassium; other fertilizers; goods of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg:				
3105.10.00	Products of this chapter in tablets or similar forms or in packages of a gross weight not exceeding 10 kg	Free		(2)	0.1
3105.20.00	Mineral or chemical fertilizers containing the three fertilizing elements nitrogen, phosphorus and potassium	Free		(2)	24.5
3105.30.00	Diammonium hydrogenorthophosphate (Diammonium phosphate)	Free		(2)	16.8
3105.40.00	Ammonium dihydrogenorthophosphate (Monoammonium phosphate) and mixtures thereof with diammonium hydrogen-orthophosphate (Diammonium phosphate)	Free		(2)	49.1

See footnotes at end of table.

Table 4—*Continued*

Fertilizers: Harmonized Tariff Schedule subheading; description; U.S. col. 1 rate of duty as of Jan. 1, 1997; U.S. exports, 1996; and U.S. imports, 1996

HTS heading or subheading	Description	Col. 1 rate as of Jan. 1, 1997 General	Col. 1 rate as of Jan. 1, 1997 Special	U.S. exports[1] 1996	U.S. imports 1996
				Million dollars	*Million dollars*
	Other mineral or chemical fertilizers containing the two fertilizing elements nitrogen and phosphorus:				
3105.51.00	Containing nitrates and phosphates	Free		([2])	10.7
3105.59.00	Other	Free		([2])	0.4
3105.60.00	Mineral or chemical fertilizers containing the two fertilizing elements phosphorus and potassium	Free		([2])	1.4
3105.90.00	Other	Free		([2])	30.6

[1] Effective July 1985, the U.S. Department of Commerce discontinued publishing export statistics for fertilizers by individual Schedule B item classifications to protect confidential business information. U.S. export data reported under individual Chapter 31 HTS subheadings are collected and the aggregate statistics are published under the "dummy" subheading 3100.00.00. U.S. fertilizer exports aggregated under HTS "dummy" subheading 3100.00.00 are equivalent to $3.1 billion during 1996.

[2] Data suppressed.

Source: U.S. exports and imports compiled from official statistics of the U.S. Department of Commerce, and tariff information was obtained from the *Harmonized Tariff Schedule of the United States (1997)*, supplement 1.

Table 5
Certain U.S. International Trade Commission investigations related to trade in fertilizers, 1973-96

Nutrient	Date	Type of investigation	Product	Petitioner	Respondent/ source country	Final outcome
Nitrogen (N)	1979	Market disruption (406-TA-5)	Anhydrous ammonia	Ad Hoc Committee of Domestic Nitrogen Producers[1]	Occidental Petroleum Corp./U.S.S.R.	Affirmative ITC determination;[2] quotas recommended; President took no action
	1980	Market disruption (406-TA-6)	Anhydrous ammonia	Presidential request	Occidental Petroleum Corp./U.S.S.R.	Negative ITC determination[3]
	1987	Antidumping (731-TA-338)	Urea	Ad Hoc Committee of Domestic Nitrogen Producers[4]	Soyuzpromexport, U.S.S.R.; Philipp Brothers, U.S.S.R.; ICEC, Romania; East Germany	Affirmative ITC and Commerce determination;[5] AD order issued by Commerce
Phosphorus (P)	1987	Countervailing duty (701-TA-286) and Antidumping (731-TA-365 and 366)	Industrial phosphoric acid	FMC Corp., Chicago, IL; and Monsanto Co., St. Louis, MO	Negev Phosphates, Israel; Haifa Chemicals Ltd., Israel; Societe Chemique Prayon-Rupel, Belgium	Affirmative ITC and Commerce determination;[6] AD and CVD orders issued by Commerce
Potassium (K)	1984	Countervailing duty (303-TA-15 and 701-TA-213)	Potassium chloride	Amax Chemical Inc., Lakeland, FL; Kerr-McGee Chemical Corp., Oklahoma City, OK	Israel and Spain	Negative ITC determination[7]
	1984	Antidumping (731-TA-184-186)(Final)	Potassium chloride	Amax Chemical Inc., Lakeland, FL; Kerr-McGee Chemical Corp., Oklahoma City, OK	East Germany, Israel, and Spain	Negative Commerce determination East Germany and Israel; petition re Spain withdrawn

See footnotes at end of table.

Table 5—*Continued*
Certain U.S. International Trade Commission investigations related to trade in fertilizers, 1973-96

Nutrient	Date	Type of investigation	Product	Petitioner	Respondent/ source country	Final outcome
Potassium (K)—Cont.:						
	1985	Antidumping (731-TA-187) (Final)	Potassium chloride	Amax Chemical Inc., Lakeland, FL; Kerr-McGee Chemical Corp., Oklahoma City, OK	U.S.S.R.	Negative ITC determination[8]
	1987	Antidumping (731-TA-374)	Potassium chloride	New Mexico Potash, Carlsbad, NM and Lundberg Industries, Carlsbad, NM	Canada	Suspension agreement[9]
Sulfur (S)	1973	Antidumping (AD-127)	Elemental sulfur	Pennzoil United Inc., Houston, TX	Canada	Affirmative ITC and Commerce determination;[10] AD order issued by Commerce

[1] The Ad Hoc Committee of Domestic Nitrogen Producers was composed of the following firms: Agrico Chemicals Co.; CF Industries Inc.; Felmont Oil Corp.; First Mississippi Corp.; W.R. Grace Co.; International Minerals & Chemical Co.; Mississippi Chemical Corp.; Olin Corp.; Terra Chemicals International, Inc.; Union Oil of California; Vistron Corp., and Wycon Chemical Co.

[2] USITC, *Anhydrous Ammonia from the U.S.S.R.*, (investigation No. TA-406-5), USITC publication 1006, Oct. 1979.

[3] USITC, *Anhydrous Ammonia from the U.S.S.R.*, (investigation No. TA-406-6), USITC publication 1051, Apr. 1980.

[4] The Ad Hoc Committee of Domestic Nitrogen Producers was composed of the following firms: Agrico Chemical Co.; American Cyanamid Co.; CF Industries; First Mississippi Corp.; Mississippi Chemical Corp.; Terra International, Inc.; and W.R. Grace & Co.

[5] USITC, *Urea from the German Democratic Republic, Romania, and the Union of Soviet Socialist Republics*, (investigations Nos. 731-TA-338- 340 (final)), USITC publication 1891, July 1987.

[6] USITC, *Industrial Phosphoric Acid from Belgium and Israel*, (investigation Nos. 701-TA-286 (final) and 731-TA-365 and 366 (final)), USITC publication 2000, Aug. 1987.

[7] USITC, *Potassium Chloride from Israel and Spain*, (investigation Nos. 303-TA-15 and 701-TA-213 (final)), USITC publication 1596, Nov. 1984.

[8] USITC, *Potassium Chloride from the U.S.S.R.*, (investigation No. 731-TA-187 (final)), USITC publication 1985, Mar. 1985. See Commerce notice published in the *Federal Register* of Jan. 31,1985 (50 F.R. 4559).

[9] Commerce investigation suspended on the basis of an agreement by Canadian producers/exporters to revise their U.S. prices to eliminate the injurious effects of exports of potassium chloride to the United States. See Commerce notice published in the *Federal Register* of Jan. 19, 1988 (53 F.R. 1393).

[10] USITC, *Elemental Sulfur from Canada*, (investigation No. AD-127), TC publication 617, Oct. 1973. Elemental sulfur from Canada is still subject to antidumping orders; however, the antidumping duties imposed have fluctuated based on Commerce annual review determinations.

U.S. Exports

Principal Markets and Export Levels

The United States is considered to be the most secure source of nitrogenous and phosphatic fertilizers in the world. These fertilizers are of a high quality in terms of nutrient content, handling, storage, and use characteristics. Despite slightly higher prices, U.S. fertilizers are highly demanded on the world market. Prices of U.S. fertilizers vary by product within specific nutrient selected, geographic production and shipping locations, and quality. For example, recovered sulfur is generally lower priced than Frasch mined sulfur. Dual nutrient, more highly processed and value-added, fertilizers such as DAP are generally higher priced than single nutrient fertilizers such as potash. Because fertilizers are high-weight/low-value commodities, transportation costs add significantly to the delivered price of fertilizers.

U.S. fertilizer exports comprise a significant market for U.S. fertilizer production. The level of fertilizer exports, consisting primarily of phosphatic and nitrogenous fertilizers, is influenced by a number of factors, such as changes in the political or economic conditions in the fertilizer-importing nations, price competition, weather, transportation infrastructure, and agricultural policies. U.S. fertilizers are currently exported to more than 100 countries. U.S. fertilizer exports increased irregularly from $2.5 billion in 1992 to approximately $3.2 billion in 1996 (table 6), largely because of the purchasing policies of the Government of China, the sole importer of fertilizers into China.

Table 6
Fertilizers: U.S. exports of domestic merchandise, by principal markets, 1992-96
(1,000 dollars)

Market	1992	1993	1994	1995	1996
China	629,649	292,819	944,340	1,204,472	893,149
Australia	130,190	130,866	162,478	207,491	295,380
Canada	203,809	215,599	207,310	261,238	275,843
Japan	166,090	164,913	186,105	217,734	186,477
Mexico	94,571	133,167	159,571	82,611	168,234
Brazil	123,587	92,457	179,012	112,746	136,593
Argentina	35,113	26,442	37,517	58,883	133,864
Pakistan	104,152	87,957	85,458	55,363	127,515
Korea	83,750	92,919	75,327	115,883	108,236
Thailand	23,786	18,627	42,315	59,233	88,411
Chile	53,965	52,883	53,672	42,667	81,779
India	263,163	172,808	133,563	283,982	80,972
All other	571,127	395,820	513,474	616,700	574,293
Total	2,482,953	1,877,277	2,780,141	3,319,005	3,150,748

Note.—Fertilizer export quantity data are suppressed by the U.S. Department of Commerce.

Source: Compiled from official statistics of the U.S. Department of Commerce.

Diammonium phosphate is the mainstay of U.S. fertilizer exports, accounting for approximately 60 percent of total fertilizer exports. As stated previously, world demand for fertilizers declined during 1992 and 1993 in response to the economic recession. China has been the principal market for U.S. fertilizer exports, principally DAP, but also significant quantities of urea and potassium sulfate, with Australia ranked second in 1996. India[77] and Canada are the other traditionally significant U.S. fertilizer export markets, again principally for DAP. About 65 percent of total U.S. fertilizer exports are shipped from the U.S. Gulf Coast and Florida.

Foreign Trade Measures

Tariff measures

Major U.S. trading partners in fertilizers generally apply equivalent duty-free treatment for fertilizer products. U.S. exports of fertilizers generally receive duty-free treatment in Canada, Japan, and Mexico. The current tariff rate for certain U.S. fertilizer products entering Australia is low (2 percent) while all other fertilizer products enter Australia duty-free. Chinese MFN tariffs for fertilizers generally range from 5 to 6 percent.[78] Although the current tariff rates for fertilizers entering India range from 5 to 30 percent, there is a 100 percent tariff concession for all fertilizers.[79]

Nontariff measures

The EU imposes certain non-tariff barriers on imports of fertilizers. For example, the EU imposes a 93 percent water solubility standard for triple superphosphate (TSP) before it can be marked "EC-Type Fertilizer."[80] TSP manufactured from U.S. phosphate rock raw material is unable to meet this EU solubility standard, while TSP manufactured from Moroccan phosphate rock does. Numerous agronomic studies show that there is no technical or scientific basis for this standard.[81]

[77] India is historically the second largest market for U.S. fertilizer exports. Official statistics concerning U.S. exports of fertilizers to India during 1996 are currently under review by the U.S. Department of Commerce.

[78] U.S. Department of Commerce country desk staff and country specific tariff schedules.

[79] S. K. Kohli, K. K. Bassi, and Preeti Avasthi, *Custom Tariff of India 1997-98*, (20th Edition), (Cen-Cus Publishers, New Delhi, 1997), pp. I/18, I/46, and III/203.

[80] EU Directive (76/116/EEC).

[81] Written submission from Mr. Gary Meyers, President, The Fertilizer Institute, Washington, DC, Sept. 19, 1997.

FOREIGN INDUSTRY PROFILE

The nations of the FSU, primarily the Russian Federation (Russia), together with Canada and the United States, possess the largest volume of recoverable natural gas, phosphate rock, and potash fertilizer reserves. Much of the fertilizer reserves in Russia are in areas with severe climates that prevent mining for several months of the year and with chemical composition such that they may not be competitive in a free market economy. Canada and the United States are considered by most consuming nations to be secure sources of high-quality fertilizers. Other nations with significant fertilizer natural resource reserves are Morocco, South Africa, Germany, and Poland.[82] However, world fertilizer production and factors of competition are most clearly delineated on a nutrient-specific basis (table 7).

Table 7
Fertilizers: World ammonia (N), phosphate rock (P), potash (K), and sulfur (S) production, 1992-96

Product and Country	1992	1993	1994	1995	1996
			(1,000 metric tons N)		
Ammonia (N):					
China	18,000	19,000	20,075	22,727	24,483
United States	13,400	12,600	13,397	12,977	14,564
India	7,452	7,176	7,503	8,287	8,549
Russia	8,786	8,138	7,264	7,940	7,932
Canada	3,100	3,410	3,474	3,773	3,840
Indonesia	2,690	2,888	3,012	3,336	3,647
Ukraine	3,908	3,242	3,004	3,109	3,302
Germany	2,110	2,101	2,170	2,518	2,512
Netherlands	2,590	2,472	2,479	2,450	2,353
Mexico	2,200	1,758	2,028	1,992	2,054
Trinidad & Tobago	1,570	1,462	1,649	1,696	1,801
Poland	1,490	1,343	1,607	1,890	1,796
All other	26,104	26,110	25,678	27,232	27,734
Total	93,400	91,700	93,340	99,927	104,567
			(1,000 metric tons product)		
Phosphate rock (P):					
United States	47,000	35,581	41,605	44,220	44,665
China	21,400	21,168	24,761	29,500	29,000
Morocco	19,145	18,193	19,765	20,200	20,830
Russia	11,500	10,381	8,021	9,068	8,680
Tunisia	6,400	5,500	5,699	7,241	7,100
Jordan	4,300	4,129	4,216	4,984	5,355
Israel	3,600	3,680	3,961	4,063	3,840
Brazil	2,850	3,419	3,938	3,888	3,823
Togo	2,083	1,794	2,149	2,569	2,731
South Africa, Republic of	3,080	2,466	2,545	2,790	2,655
All others	17,642	12,306	11,183	12,082	12,631
Total	139,000	118,617	127,843	140,605	141,310

See footnote at end of table.

[82] U.S. Department of the Interior, "Phosphate Rock," "Potash," and "Sulfur," *Mineral Commodity Summaries 1997*, Jan. 1997, pp. 125, 129, and 167.

Table 7—*Continued*
Fertilizers: World ammonia (N), phosphate rock (P), potash (K), and sulfur (S) production, 1992-96

Product and Country	1992	1993	1994	1995	1996
	(1,000 metric tons K_2O equivalent)				
Potash (K):					
Canada	7,270	6,840	8,040	8,855	8,170
Germany	3,460	2,860	3,290	3,280	3,200
Belarus	3,310	1,950	3,021	3,211	3,200
Russia	3,470	2,630	2,498	2,800	2,800
United States	1,710	1,510	1,400	1,480	1,390
Israel	1,300	1,310	1,260	1,320	1,320
Jordan	794	822	930	1,070	1,200
All others	2,586	2,478	2,661	2,684	2,620
Total	23,900	20,400	23,100	24,700	23,900
	(1,000 metric tons S)				
Sulfur (S):					
United States	10,700	11,000	11,500	11,800	11,700
Canada	7,490	8,430	8,850	9,010	9,132
China	5,900	6,360	6,900	6,530	7,295
Russia	3,500	3,600	3,510	4,000	3,250
Japan	2,750	2,920	2,820	2,860	3,245
Mexico	2,300	1,640	2,890	2,880	2,880
Germany	1,160	1,171	1,240	1,230	2,180
Poland	3,087	2,119	2,435	2,440	1,860
Saudi Arabia	2,370	2,400	2,300	2,200	1,750
All other	11,443	11,660	11,655	11,350	12,379
Total	50,700	51,300	54,100	54,300	55,671

Source: Compiled from official statistics of the International Fertilizer Industry Association and U.S. Department of the Interior, U.S. Geological Survey (formerly Bureau of Mines).

Nitrogenous Fertilizers

The world nitrogen industry initially developed during the early 1920s to mid-1930s in the developed countries of Western Europe, North America, and Japan. Beginning in the 1970s and early 1980s, much of the construction of new capacity shifted to the gas-rich countries of the Caribbean and the Middle East and to some large consuming countries such as China, India, Indonesia, and Pakistan, while many older plants in Western Europe and Japan closed. Many ammonia plants in the United States were also closed or idled during this period. China and the United States are the leading world producers of nitrogenous fertilizers, as reflected in ammonia production, followed by thc FSU (Russia and Ukraine combined), and India. Available atmospheric nitrogen and sources of natural gas for production of ammonia are considered adequate for all countries listed.

Information about nitrogenous fertilizer production in China is limited and often difficult to interpret; however, it is reported that both production and consumption of nitrogenous fertilizers in China have increased more than anticipated.[83] China is not an exporter; rather, it

[83] Pierre L. Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (paper presented at the 65th Annual Conference of the International Fertilizer Industry Association (IFA), in Beijing, China, during May 19-22, 1997), pp. 14-15.

has been a steady nitrogenous fertilizer importer (in the form of urea), and remains the largest market for U.S. urea exports.[84]

In 1996, Russia ranked fourth in world ammonia production with approximately 70 percent capacity use. Fertilizers are among the most profitable of Russian export products,[85] and in the absence of significant ammonia exports from China, the United States, and India, Russia remains key to the world ammonia supply.

The 1991 dissolution of the FSU saw the domestic Russian fertilizer market essentially collapse. Agricultural consumers were insolvent, the domestic agricultural support budget proved insufficient, federal aid proved ineffective, the government failed to promote domestic demand, interest rates for commercial credits were high, and the fertilizer distribution network was destroyed.[86] Fertilizer producers turned to exports.

Russian export taxes gradually decreased, and then were abolished. Since Russian fertilizers are subject to a standard VAT tax, the domestic supply price was about 20 percent higher than relative f.o.b. export prices. In consideration of delineated domestic market conditions, and with an extremely seasonal domestic fertilizer market, economic prudence dictated export level maintenance of at least 50 percent of sales.[87]

With realization of the necessity for long-term plans and forecasts for considerable growth in domestic Russian fertilizer consumption, solvent Russian fertilizer producers have embraced strategic plans. Investment in production modernization, storage networks in key agricultural regions, ecological improvements, product diversification, and upgraded management systems had begun by 1996.

The Russian Government sustains and controls natural monopolies such as RAO "Gazprom," RAO "UES" (electric monopoly), and the ministry of transportation. However, companies that adapted to market conditions with no outstanding RAO "Gazprom" debts may claim a 40 percent discount on gas for fertilizer production. Companies unable to repay debts, especially for gas, may enter tolling agreements with RAO "Gazprom," whereby gas is paid for with product. Although such tolling produces further debt, bankruptcy remains rare due to social disturbance concerns.[88]

Although seventh in world ammonia production in 1996, the Ukrainian nitrogen industry still faces many challenges, including: working capital limited by high input gas[89] and energy

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[84] International Fertilizer Industry Association, *Urea Statistics 1996*, (Paris, France, May 1997).

[85] Viatcheslav Kantor, "The Russian Nitrogen Industry," (paper presented at the IFA Production and International Trade Committee Meeting, Warsaw, Poland, Oct. 14-15, 1997), p. 2.

[86] Ibid., p. 6.

[87] Ibid., pp. 6-8.

[88] Ibid., p. 9.

[89] Natural gas input to fertilizer production is sourced from Russian or Turkmenistan suppliers; Ukrainian natural gas production satisfies domestic population demand needs.

prices, and capital-intense modernization and repair of production processes and equipment.[90] In addition, total state taxes have increased such that the total of direct and indirect taxes on nitrogenous fertilizers exceeds 50 percent of profit.[91] Further, preferential VAT import taxes (20 percent) on machinery, equipment, and spare parts have been abolished. Most Ukrainian nitrogenous fertilizer enterprises have been privatized and sell product based on price and port of loading. However, a government requirement remains whereby approximately 5 percent of nitrogenous fertilizer production be supplied to local authorities in order to achieve regional agricultural targets.

The Ukrainian Ministry of Foreign Economic Relations and Trade has set criteria for Ukrainian nitrogenous fertilizer exports. These criteria include export shipment pre-payment, export contract registration, export card application and issuance, and correlation between export contract price and an indicative monthly Ministry price. As of 1997, Ukrainian enterprises retain hard currency received in payment for export shipments.[92]

FSU nitrogenous fertilizer exports are expected to increase slightly in 1997. The expected increase may relate to the port of Yuzhny's (Ukraine) investment in new shiploading equipment, Yuzhny plans for railcar unloading debottlenecking, and lower than expected rail transport cost increases.[93]

In India, two ammonia plants and two ammonia-urea complexes are under construction and are expected to be commissioned in 1998. The start-up of a new Indian ammonia-urea complex during late 1996 may slightly decrease ammonia import requirements, but this decrease is expected to be at least partly offset by the commissioning of new DAP plants using imported ammonia. Lacking significant investment to improve existing ports or railway infrastructure, fertilizer plant capacity is being built close to consumption areas so as to satisfy future Indian demand.[94] The two ammonia plants are replacing older capacity. Additional Indian nitrogenous fertilizer projects under consideration include a gas pipeline from Qatar or Iran to India via Pakistan, to be preceded by imports of liquid natural gas with power-generation priority. Despite these plans, the Indian market needs additional fertilizer imports or construction of plants using feedstock other than natural gas to meet demand.

Many developing countries wish to enter the fertilizer market, and request international petroleum and gas companies to explore and develop their resource fields. However, such natural gas production increases would most probably go to satisfy demand for power generation. Therefore, the possibilities of building additional gas-based developing-country ammonia plants are relatively limited.[95]

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[90] Nikolai V. Violentov, "Report on the Situation in the Ukrainian Nitrogen Industry," (paper presented at the IFA Production and International Trade Committee Meeting, Warsaw, Poland, Oct. 14-15, 1997), pp. 2-3.

[91] Thirty percent direct tax on profit, ibid., p. 2.

[92] Ibid., p. 4.

[93] Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Beijing, 1997), p. 16.

[94] Ibid., pp. 6-7.

[95] Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), p. 12-14.

Certain countries are capitalizing on technological innovations such as retrofitting ammonia plants to reduce energy consumption and increase capacity. This process is feasible when plants are rather old, as in the United States. Another recent development is the retrofitting and relocation of second-hand plants. Eight second-hand ammonia plants were recently, or are being, relocated (dismantled, moved, then reassembled) in Pakistan, Trinidad, and the United States.[96]

Phosphatic Fertilizers

The United States and China are the leading world producers of phosphatic fertilizers, as reflected in phosphate rock production, followed by Morocco, Russia, Tunisia, and Jordan. China, despite being the world's second largest phosphate producer, has steadily expanded phosphatic fertilizer imports, as local Chinese supply is inadequate to meet domestic agricultural sector growth demands.[97] China recently expanded, and has to further expand, phosphatic fertilizer production capacity. However, China's phosphatic fertilizer imports, specifically DAP, will likely continue to grow as most Chinese projects for new phosphatic fertilizer plants are close to phosphate deposits in remote areas close to interior end-use agricultural regions.[98] Most Chinese imported phosphatic fertilizer is consumed in areas closer to ports. With reported Chinese railway and road infrastructure improvements, Chinese phosphate exports were estimated at approximately 1 million metric tons during 1996. The majority of Chinese phosphate rock exports likely resulted from operational completion of a Yunan province mine before downstream phosphoric acid and TSP plants were completed.[99] As the Chinese agricultural sector continues to receive end-use priority for domestic phosphate production, export increases are expected to be minor.

Morocco produced about 16 percent of the world's phosphate rock during 1996 through the government-owned Office Cherifien de Phosphates (OCP). Morocco is expected to invest in new capacity or debottlenecking joint ventures before 2000. An OCP joint venture with Prayon-Rupel (Belgium) to produce purified phosphoric acid is targeted for input to increase capacity utilization of downstream Moroccan DAP production. Moroccan phosphate rock

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[96] Ibid., p. 4.

[97] Peter J. Heffernan, "Prospects for Phosphate Production and Trade to 2010," (paper presented at the IFA Production and International Trade Committee Meeting, Warsaw, Poland, Oct. 14-15, 1997), p. 6.

[98] Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Beijing, 1997), p. 35.

[99] Pierre L. Louis, "Update on the Fertilizer Situation in China," (paper presented at the IFA Production and International Trade Committee Meeting, Warsaw, Poland, Oct. 14-15, 1997), pp. 10-11.

exports are expected to increase to supply both French phosphoric acid production and other markets. Phosphoric acid exports are also expected to increase, under a long-term agreement, to supply a DAP plant under construction in Pakistan.[100]

Russia ranked fourth in world production of phosphatic fertilizers during 1996, as measured in phosphate rock output. As internal Russian demand collapsed following the disintegration of the FSU, the Russian industry re-oriented toward significant phosphate exports to preserve production.[101] Such action disrupted world trade patterns and severely depressed phosphate prices during the early 1990s.[102] Before the disintegration of the FSU, traditional export markets for Russian phosphatic fertilizers were the countries of East and West Europe, with small quantities delivered to Cuba. Current Russian phosphate export markets include Norway, Belgium, Poland, Germany, and Romania. Russian exports stabilized as high rail transportation costs contributed to infeasible raw material and product shipments to and from plants isolated from input material sources and overseas consumers, especially during the winter when less expensive river transportation is not possible. Domestic Russian phosphatic fertilizer consumption stabilized during 1996, general economic improvement is anticipated, and recovery of production and demand is expected during the period 1997-2005.[103] Rehabilitation and updating of the Black Sea port terminal of Murmansk to handle high-tonnage vessels is expected to enable Russian phosphate access to remote markets such as Asia and the Americas.[104]

Tunisia and Jordan ranked fifth and sixth in world phosphate production during 1996. The phosphate industry in both countries is government owned and export oriented. Tunisian phosphate rock capacity expansion is not anticipated; however, new Tunisian DAP capacity is scheduled for completion in 1997. New Jordanian phosphatic fertilizer capacity production is expected to reach the export market by 2000. The new Jordanian plants are joint ventures with Japan and India, exports from which are expected to satisfy a portion of these countries' import demand.[105]

World demand for phosphatic fertilizer is expected to increase with population growth; supply is expected to increase first through increased capacity utilization and expansion in major consuming regions. World phosphate resources are plentiful and development limited only by the confluence of available quality phosphate rock, sulfur and other major input raw materials, the world market, and proximity to major demand growth regions.[106]

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[100] Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), pp. 21-22.

[101] Alexandre Gorbatchev, Vladimir Golovanov, and Sergei Kouprianov, "Current Situation and Outlook for Phosphate Production at Kola," (paper presented at the IFA Production and International Trade Committee Meeting, Warsaw, Poland, Oct. 14-15, 1997), p. 8.

[102] Heffernan, "Prospects for Phosphate Production and Trade to 2010," Oct. 14-15, 1997, p. 7.

[103] Gorbatchev, et al, "Current Situation and Outlook for Phosphate Production at Kola," Oct. 14-15, 1997, pp. 4 and 8.

[104] Ibid., p. 9.

[105] Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), pp. 28-29.

[106] Heffernan, "Prospects for Phosphate Production and Trade to 2010," Oct. 14-15, 1997, pp. 8-9.

Potassic Fertilizers

World potash production capacity is primarily resident in Canada, the FSU (Russia and Belarus), and Germany. The potash industry is dominated by world trade. In 1996, 80 percent of all potash production was shipped outside the country in which it was produced. Canada, Jordan, and Israel export virtually all their potash production. These countries have very small domestic potash markets and rely on export sales to keep mines operational.[107]

The global potash industry underwent many changes during 1992-96. The industry changed structurally from a state-owned, broad-based, specialized industry to a mostly privatized, consolidated, and integrated industry.[108] Since 1994, the potash supply environment has been positive; demand recovered and grew; and prices moved upward. Further industry refinements of rationalization, capacity expansions, and differentiated product integration followed.[109]

Significant surplus potash capacity has existed worldwide during 1992-96, mostly in Canada and the FSU (Russia and Belarus combined). As a result, major world producers operated at partial capacity to prevent price erosion. Canadian producers operated at about 75 percent capacity[110] as a "managed recovery" policy, i.e., swift adjustment of production to demand.[111] The October 1997 permanent closure of a New Brunswick mine, idled since summer 1996 due to uncontrollable water inflow, effected a minor reduction in Canadian potash capacity.[112]

After the break-up of the FSU, domestic demand collapsed, internal production declined, and exports increased. A modest recovery in domestic FSU demand, stabilized exports, and a capacity use rate of approximately 60 percent are expected though 2001.[113]

Potash production in the former East and West Germany has been restructured into unified German production. Ten mines were closed and six mines are now in operation, with no major production or export changes anticipated up to 2000.[114]

In December 1996, PCS of Canada, the world's largest potash producer, reached an agreement with the German corporation BASF AG to purchase from them 51 percent of Kali und Salz Beteiligungs AG (K & S AG) of Hanover, Germany. K & S AG also owns 50 percent of

[107] Kenneth F. Nyiri, "Outlook for Potash," (paper presented at The Fertilizer Industry Round Table, St. Petersburg Beach, Oct. 28, 1997), pp. 1-2.

[108] Michel Prud'homme, "World Potash Supply," (paper presented at the IFA Production and International Trade Committee Meeting, Warsaw, Poland, Oct. 14-15, 1997), p. 1.

[109] Ibid.

[110] About 45 percent for the largest producer and 90 percent for all others.

[111] Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances" (IFA Berlin, 1996), p. 40.

[112] "Potacan Mine is Washed Up," *Fertilizer Markets*, vol. 8, No. 15, (Nov. 3, 1997), p. 1.

[113] Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances," (IFA Beijing, 1997), p. 22.

[114] Louis, "Fertilizers and Raw Materials Supply and Supply/Demand Balances," (IFA Berlin, 1996), p. 39.

Potacan, Ltd., in Toronto, Canada, the former[115] operator of a potash mine near Sussex, New Brunswick. Entreprise Miniere et Chemique (EMC) of Paris, France, shares equal ownership of Potacan with K & S AG. This PCS acquisition was denied by the German Cartel Office; the denial was then appealed to the German Monopolies Commission which upheld the Cartel Office ruling. PCS and BASF then appealed directly to the German Ministry of Economic Affairs which also refused to sanction the agreement between the two companies. BASF and PCS have a further line of appeal through the courts, but the two companies are expected to abandon further pursuit of the purchase.[116]

International demand must remain strong to keep potash market supply and demand in balance, and international potash purchases can be very erratic. During some years buyers may build inventory to carry through a portion of next season and thus reduce imports during the following year.[117]

Near term, 1997-2005, developed world potash capacity changes may likely involve capacity curtailment due to ore depletion, further rationalization, or closure of obsolete facilities. With substantial world surplus capacity, expansion projects are expected to be incremental at existing mines, or regional new capacity directed toward domestic internal markets in Asia.[118]

Sulfur

Sulfur is essentially a by-product of oil and gas production, and is produced without regard to market conditions. The United States, Canada, China, and Russia are the world's largest producers of sulfur. Together these countries consistently account for over 55 percent of world production. A world oversupply of sulfur existed during 1996.[119]

Significant portions of Canadian sulfur production are either exported or poured to vatted block stocks.[120] Exports of Canadian sulfur to the U.S. market are low, both for economic reasons and as a result of antidumping actions.[121] Canadian offshore export shipments to Africa, Latin America, and Asia increased significantly during 1996. However, many Canadian producers vatted stocks because the 1996 Vancouver price did not cover forming[122] and transportation costs.[123] Canadian sulfur production is expected to increase during 1997-2002 as production of natural gas increases to meet strong U.S. demand and to feed new gas export pipelines.[124] Canadian producers will continue to respond to market conditions and decrease sulfur supply

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[115] The Potacan mine closed permanently in Oct. 1997 due to flooding. See footnote 112.

[116] "German Setback for PCS," *Fertilizer International*, (No. 360 Sept./Oct. 1997), p. 11.

[117] Nyiri, "Outlook for Potash," Oct. 28, 1997, p. 7.

[118] Prud'homme, "World Potash Supply," Oct. 14-15, 1997, p. 3.

[119] Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Beijing, 1997), p. 40.

[120] The most practical way to store sulfur is in large vat blocks.

[121] See section entitled "U.S. government trade-related investigations."

[122] The process of conversion from molten liquid to a solid form.

[123] Louis, "Fertilizer and Raw Materials Supply and Supply/Demand Balances," (IFA Beijing, 1997), p. 41.

[124] Ibid., p. 40.

by pouring to block storage or increase supply through melting of what had previously been blocked.[125]

Domestic Russian sulfur production decreased irregularly during 1992-96 as domestic consumption declined primarily due to internal factors resulting from the break-up of the FSU. Russian export shipments also declined, due to high rail transportation costs and the seasonal nature of less costly river transportation to deep water ports on the Black Sea. A portion of 1996 Russian sulfur production was stored for replenishment of depleted inventories and in response to previously mentioned logistic and economic conditions. Russian sulfur export shipments are expected to resume during late 1997.[126]

A portion of world sulfur production is market related, particularly Polish sulfur production by the Frasch process. With market oversupply conditions, Polish Frasch producers are expected to progressively reduce production through the year 2000.[127] Significant idle sulfur production capacity in Iraq exhibits a positive effect on market oversupply.[128]

Non-fertilizer sulfur demand has increased, and served to bring sulfur supply and demand close to balance. However, such equilibrium may be disrupted by significant exports of FSU sulfur or resumption of Iraqi exports. Additionally, worldwide recovered sulfur is expected to grow long term and put pressure on remaining Frasch producers.[129]

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[125] Ibid., p. 41.
[126] Ibid., p. 45.
[127] Ibid.
[128] Ibid., p. 48.
[129] Ibid.

APPENDIX A
TARIFF AND TRADE AGREEMENT TERMS

TARIFF AND TRADE AGREEMENT TERMS

In the ***Harmonized Tariff Schedule of the United States*** (HTS), chapters 1 through 97 cover all goods in trade and incorporate in the tariff nomenclature the internationally adopted Harmonized Commodity Description and Coding System through the 6-digit level of product description. Subordinate 8-digit product subdivisions, either enacted by Congress or proclaimed by the President, allow more narrowly applicable duty rates; 10-digit administrative statistical reporting numbers provide data of national interest. Chapters 98 and 99 contain special U.S. classifications and temporary rate provisions, respectively. The HTS replaced the *Tariff Schedules of the United States* (TSUS) effective January 1, 1989.

Duty rates in the ***general*** subcolumn of HTS column 1 are most-favored-nation (MFN) rates, many of which have been eliminated or are being reduced as concessions resulting from the Uruguay Round of Multilateral Trade Negotiations. Column 1-general duty rates apply to all countries except those enumerated in HTS general note 3(b) (Afghanistan, Cuba, Laos, North Korea, and Vietnam), which are subject to the statutory rates set forth in ***column 2***. Specified goods from designated MFN-eligible countries may be eligible for reduced rates of duty or for duty-free entry under one or more preferential tariff programs. Such tariff treatment is set forth in the ***special*** subcolumn of HTS rate of duty column 1 or in the general notes. If eligibility for special tariff rates is not claimed or established, goods are dutiable at column 1-general rates. The HTS does not enumerate those countries as to which a total or partial embargo has been declared.

The ***Generalized System of Preferences*** (GSP) affords nonreciprocal tariff preferences to developing countries to aid their economic development and to diversify and expand their production and exports. The U.S. GSP, enacted in title V of the Trade Act of 1974 for 10 years and extended several times thereafter, applies to merchandise imported on or after January 1, 1976 and before the close of June 30, 1998. Indicated by the symbol "A", "A*", or "A+" in the special subcolumn, the GSP provides duty-free entry to eligible articles the product of and imported directly from designated beneficiary developing countries, as set forth in general note 4 to the HTS.

The ***Caribbean Basin Economic Recovery Act*** (CBERA) affords nonreciprocal tariff preferences to developing countries in the Caribbean Basin area to aid their economic development and to diversify and expand their production and exports. The CBERA, enacted in title II of Public Law 98-67, implemented by Presidential Proclamation 5133 of November 30, 1983, and amended by the Customs and Trade Act of 1990, applies to merchandise entered, or withdrawn from warehouse for consumption, on or after January 1, 1984. Indicated by the symbol "E" or "E*" in the special subcolumn, the CBERA provides duty-free entry to eligible articles, and reduced-duty treatment to certain other articles, which are the product of and imported directly from designated countries, as set forth in general note 7 to the HTS.

Free rates of duty in the special subcolumn followed by the symbol "IL" are applicable to products of Israel under the ***United States-Israel Free Trade Area Implementation Act*** of 1985 (IFTA), as provided in general note 8 to the HTS.

Preferential nonreciprocal duty-free or reduced-duty treatment in the special subcolumn followed by the symbol "J" or "J*" in parentheses is afforded to eligible articles the product of designated beneficiary countries under the ***Andean Trade Preference Act*** (ATPA), enacted as title II of Public Law 102-182 and implemented by Presidential Proclamation 6455 of July 2, 1992 (effective July 22, 1992), as set forth in general note 11 to the HTS.

Preferential or free rates of duty in the special subcolumn followed by the symbol "CA" are applicable to eligible goods of Canada, and rates followed by the symbol "MX" are applicable to eligible goods of Mexico, under the ***North American Free Trade Agreement***, as provided in general note 12 to the HTS and implemented effective January 1, 1994 by Presidential Proclamation 6641 of December 15, 1993. Goods must originate in the NAFTA region under rules set forth in general note 12(t) and meet other requirements of the note and applicable regulations.

Other special tariff treatment applies to particular ***products of insular possessions*** (general note 3(a)(iv)), ***products of the West Bank and Gaza Strip*** (general note 3(a)(v)), goods covered by the ***Automotive Products Trade Act*** (APTA) (general note 5) and the ***Agreement on Trade in Civil Aircraft*** (ATCA) (general note 6), ***articles imported from freely associated states*** (general note 10), ***pharmaceutical products*** (general note 13), and ***intermediate chemicals for dyes*** (general note 14).

The ***General Agreement on Tariffs and Trade 1994*** (GATT 1994), pursuant to the Agreement Establishing the World Trade Organization, is based upon the earlier GATT 1947 (61 Stat. (pt. 5) A58; 8 UST (pt. 2) 1786) as the primary multilateral system of disciplines and principles governing international trade. Signatories' obligations under both the 1994 and 1947 agreements focus upon most-favored-nation treatment, the maintenance of scheduled concession rates of duty, and national treatment for imported products; the GATT also provides the legal framework for customs valuation standards, "escape clause" (emergency) actions, antidumping and countervailing duties, dispute settlement, and other measures. The results of the Uruguay Round of multilateral tariff negotiations are set forth by way of separate schedules of concessions for each participating contracting party, with the U.S. schedule designated as Schedule XX.

Pursuant to the **Agreement on Textiles and Clothing** (ATC) of the GATT 1994, member countries are phasing out restrictions on imports under the prior "Arrangement Regarding International Trade in Textiles" (known as the **Multifiber Arrangement** (MFA)). Under the MFA, which was a departure from GATT 1947 provisions, importing and exporting countries negotiated bilateral agreements limiting textile and apparel shipments, and importing countries could take unilateral action in the absence or violation of an agreement. Quantitative limits had been established on imported textiles and apparel of cotton, other vegetable fibers, wool, man-made fibers or silk blends in an effort to prevent or limit market disruption in the importing countries. The ATC establishes notification and safeguard procedures, along with other rules concerning the customs treatment of textile and apparel shipments, and calls for the eventual complete integration of this sector into the GATT 1994 over a ten-year period, or by Jan. 1, 2005.