Chemicals for the Non-Chemist

Plant Nutrients and Plant Nutrient Markets

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The Mosaic Company
Safe Harbor

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The Mosaic Company
The Mosaic Company – Leading Miner of Agricultural Minerals

Mosaic helps the world grow the food it needs by mining phosphorus (P) and potassium (K) minerals and refining these ores into plant nutrient products that are essential for global agriculture.

In big round numbers, our North American operations typically dig, pump, cut, convey and hoist 105 million tonnes of raw P&K ores from the earth each year. We remove the sand, clay, salt and other elements to produce roughly 26 million tonnes of refined ores.

We then process these refined ores into about 19 million tonnes of finished products using an additional six million tonnes of purchased or manufactured raw materials such as sulphur and anhydrous ammonia.
The Mosaic Company

Mosaic’s U.S. Phosphate Operations

Based on 2015 production
P$_2$O$_5$ production based on PACID and SSP production
K$_2$O production includes MOP, KMS, and SOP
Source: Company reports, IFA, CRU, and Mosaic estimates

Chemicals for the Non-Chemist
Plant Nutrients
Plant Nutrients

- Plant nutrients are plant food (and common chemical elements)
- 17 chemical elements are required for plant growth
- N-P-K: the carbohydrates, protein and fat of a plant’s diet
- Growing importance of secondary nutrients and micronutrients especially in high yield systems
- Justus von Liebig and the Law of the Minimum
Plant Nutrient Products

- Plant nutrients are contained in a variety of products
  - Much like nutrients for animals are contained in a variety of feed ingredients
  - Each plant nutrient product is identified by three numbers
    - Referred to as its “analysis”
    - Percentage of each primary nutrient contained in a unit of the product

<table>
<thead>
<tr>
<th>Plant Nutrient Analysis</th>
<th>N</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>46-0-0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diammonium Phosphate (DAP)</td>
<td>18-46-0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muriate of Potash (MOP)</td>
<td>0-0-60</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Challenge: Maintaining Soil Fertility and Safeguarding the Environment

- Soil fertility is maintained by replenishing the nutrients removed by crops each year

- Farmers maintain soil fertility and safeguard the environment by following the 4-Rs of nutrient stewardship

- The 4-Rs of nutrient stewardship
  - Right source
  - Right rate
  - Right time
  - Right place

- Best practices
  - Soil testing
  - Plant nutrient accounting
  - Variable rate technology
  - Multiple applications
  - Nitrogen inhibitors and slow release products

<table>
<thead>
<tr>
<th>Nutrient Removal by Crop</th>
<th>lbs Acre</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn - 200 Bu Acre Yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain</td>
<td></td>
<td>180</td>
<td>76</td>
<td>54</td>
<td>16</td>
</tr>
<tr>
<td>Stalks</td>
<td></td>
<td>90</td>
<td>32</td>
<td>220</td>
<td>14</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>270</td>
<td>108</td>
<td>274</td>
<td>30</td>
</tr>
<tr>
<td>Soybeans - 70 Bu Acre Yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain</td>
<td></td>
<td>266</td>
<td>59</td>
<td>91</td>
<td>13</td>
</tr>
<tr>
<td>Stover</td>
<td></td>
<td>77</td>
<td>17</td>
<td>70</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>343</td>
<td>76</td>
<td>161</td>
<td>25</td>
</tr>
<tr>
<td>Wheat - 80 Bu Acre Yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain</td>
<td></td>
<td>120</td>
<td>48</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td>Straw</td>
<td></td>
<td>56</td>
<td>13</td>
<td>96</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>176</td>
<td>61</td>
<td>123</td>
<td>19</td>
</tr>
</tbody>
</table>

*Source: IPNI*
Increasing Efficacy of Plant Nutrient Use

The efficacy of plant nutrient use has increased significantly in the United States during the last few decades. U.S. corn yield 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.

- **N** use per bushel of corn harvested declined one-third from about 1.45 pounds in 1970 to less than 0.9 pounds in 2010.
- **P₂O₅** use per bushel of corn dropped more than 60% from about 0.7 pounds in 1970 to roughly 0.3 pounds in 2010.
- **K₂O** use per bushel of corn also dropped more than 60% from about 0.8 pounds in 1970 to 0.3 pounds in 2010.

Manure usage has increased during this period, but **U.S. farmers today are harvesting twice as much corn per acre with the same amount of commercial plant nutrients as used in 1970!**
Top Fertilizer Raw Material Producers

Ammonia Production 2015
- China
- Russia
- India
- USA
- Trinidad

Phosphate Rock Production 2015
- China
- USA
- Morocco
- Russia
- Jordan

MOP Production 2015
- Canada
- Russia
- Belarus
- Germany
- Israel

Source: CRU and Mosaic
Primary Plant Nutrient Overview

- **Nitrogen (N)**
  - Production process: highly energy intensive Haber-Bosch process to synthesize ammonia (NH₃) from inert atmospheric N and H
  - Key input: hydrocarbon feed stock (two-thirds produced from natural gas)
  - Global agricultural use: ~114 million tonnes N in 2014 or about 308 million tonnes of product
  - Main nitrogen products
    - Anhydrous ammonia (82% N – gas at normal temperatures and pressures)
    - Urea-ammonium nitrate (UAN) solution (28%-32% N – liquid)
    - Urea (46% N – solid)
    - Ammonium nitrate (34% N – solid)
    - Ammonium sulphate (21% N – solid)
    - Ammonium phosphate (DAP and MAP) products (10%-18% N – solid)
  - Leading producers: China, India, Russia, United States, Indonesia, Trinidad and Tobago, Ukraine, Canada, Middle East

![Diagram showing N Use by Crop and Product](source: IFA, CRU, FERTECON AND MOSAIC)
Global Ammonia Production

Gross Ammonia Production
Average 2011 - 2015

- > 1.0 million tonnes
- 1.0 - 5.0 million tonnes
- 5.0 - 9.0 million tonnes
- 9.0 - 14.0 million tonnes
- > 14.0 million tonnes

Source: CRU and Mosaic
Million Tonnes of NH₃
Primary Plant Nutrient Overview

- **Phosphate (P)**
  - The production process - making phosphorus water soluble
  - Key inputs: phosphate rock mineral ore, sulphur and ammonia
  - Global agricultural use: ~44 million tonnes $P_2O_5$ in 2014 or about 129 million tonnes of product
  - Main phosphate products
    - Diammonium phosphate (DAP) (46% $P_2O_5$ – solid)
    - Monoammonium phosphate (MAP) (52% $P_2O_5$ – solid)
    - Triple superphosphate (TSP) (46% $P_2O_5$ – solid)
    - Single superphosphate (SSP) (18%-22% $P_2O_5$ – solid)
    - NPK and NP compounds (% $P_2O_5$ varies – both solid and liquid)
  - Leading producers: China, United States, Morocco/North Africa, India, Russia, Brazil, Saudi Arabia

SOURCE: IFA, CRU, FERTECON AND MOSAIC
Global Phosphate Rock Production

Phosphate Rock Production Average 2011 - 2015
- < 2.0 million tonnes
- 2.0 - 5.5 million tonnes
- 5.5 - 15.0 million tonnes
- 15.5 - 30.0 million tonnes
- > 30.0 million tonnes

Source: CRU and Mosaic
Million Tonnes of Phosphate Rock

Chemicals for the Non-Chemist
Primary Plant Nutrient Overview

- **Potash (K)**
  - Production process: simple separation processes
  - Key inputs: potash mineral ore (sylvinite, carnallite and langbeinite)
    - Conventional underground mines (1000+ meters deep)
    - Solution mines
    - Salt lake brines (e.g. Dead Sea, Qinghai and Great Salt Lake)
  - Global agricultural use: ~35 million tonnes K₂O in 2013 or about 61 million tonnes product
  - Main potash products
    - Potassium chloride or muriate of potash (MOP) (60-62% K₂O – solid)
    - Potassium sulphate or sulphate of potash (SOP) (50% K₂O – solid)
    - Potassium-magnesium-sulphate (22% K₂O – solid)
  - Leading producers: Canada, Russia, Belarus, Germany, China, Israel, Jordan

SOURCE: IFA, FERTECON AND MOSAIC
Global MOP Production

MOP Production
Average 2011 - 2015
- < 1.0 million tonnes
- 1.0 - 4.5 million tonnes
- 4.5 - 7.5 million tonnes
- 7.5 - 13.0 million tonnes
- > 13.0 million tonnes

Source: CRU and Mosaic
Million Tonnes of MOP

Chemicals for the Non-Chemist
Lower fertilizer prices in 2016 underpin demand as crop nutrients became more affordable.

- Our plant nutrient affordability metric has bobbed and weaved with changes in agricultural commodity and plant nutrient prices, but the current reading indicates that plant nutrients are among the most affordable they have been in the past three years.
- Versus a year ago, affordability has improved due to crop prices holding up but significantly lower plant nutrient costs.

Source: Weekly Price Publications, CME, USDA, AAPFCO, Mosaic
The Phosphate Market and Industry
Global Phosphate Reserves

Global Phosphate Rock Reserves
Million Tonnes Phosphate Rock
Source: USGS, 2014

Chemicals for the Non-Chemist
Global Phosphoric Acid Production: All about China over the past 25 years

Top Producing Countries 1990

- USA
- Morocco
- Russia
- Tunisia
- Ukraine
- Uzbekistan
- Brazil
- France
- Spain
- Mexico

Top Producing Countries 2015

- China
- USA
- Morocco
- Russia
- India
- Brazil
- Saudi Arabia
- Jordan
- Tunisia
- Israel

Tonnes Phosphoric Acid
Source: Fert econ and Mosaic

Tonnes Phosphoric Acid
Source: CRU and Mosaic
Global Phosphate Product Shipments

Source: CRU and Mosaic
Global Phosphate Product Production (DAP/MAP/NPS/TSP)

Source: CRU and Mosaic
Chinese Exports Falter in 2016: A New Normal?

China DAP/MAP/TSP Net Exports

Source: China Customs, Fertecon, Mosaic

Actual
Forecast

Mil Tonnes

2016 YTD
Evolution of the U.S. Phosphate Industry
(Phosphoric Acid Facilities/Capacity)

| Firms: | 18 | 12 | 4 |
| Facilities: | 21 | 20 | 12 |
| Capacity (mmt P$_2$O$_5$): | 10.9 | 12.3 | 8.8 |

Capacity (mmt P$_2$O$_5$) Percent NA Capacity

- **1990**
  - Plant City, FL: CF Industries
  - Green Bay, FL: Farmland-Hydro
  - Piney Point, FL: Royster Clark
  - Mulberry, FL: Mulberry Phosphates
  - Riverview, FL: Cargill
  - Bartow, FL: Tosco
  - New Wales, FL: IMC Global
  - Nichols, FL: Conserv
  - South Pierce, FL: Freeport McMoran
  - Faustina, LA: Occidental
  - Uncle Sam, LA: Texas Gulf
  - White Springs, FL: Arcadian
  - Aurora, NC: Mississippi Chemical
  - Geismar, LA: Ft. Meade Chemical
  - Pascagoula, MS: SF Phosphates
  - Ft. Meade, FL: U.S. Agri-Chem

- **2000**
  - PotashCorp
  - Mississippi Phosphates
  - U.S. Agri-Chem

- **2005**
  - Simplot
  - Agrifos

- **2010**
  - Agrifos
  - Imperial Oil

- **2015**
  - Agrifos
  - NuWest
  - Mobil Mining & Materials
  - Simplot

Chemicals for the Non-Chemist
The Potash Market and Industry
Global Potash Reserves

Source: USGS, 2016
Global Potash Production (MOP)

World MOP Production

Source: CRU and Mosaic

Mil Tonnes KCl

Canada  FSU  Middle East  Europe  China  Others

Source: CRU and Mosaic
Production in Canada and FSU has grown to meet global demand, and China built an industry

Top MOP Producing Countries 1990
- Canada
- Belarus
- Germany
- Russia
- France
- Israel
- USA
- Jordan
- Spain
- UK

Top MOP Producing Countries 2015
- Canada
- Russia
- Belarus
- China
- Germany
- Israel
- Jordan
- Chile
- Spain
- UK

Source: Fertecon and Mosaic

Source: CRU and Mosaic
Global Potash Shipments (MOP)

Global Potash Shipments

Mil Tonnes KCl

Source: Company Reports, CRU and Mosaic
Global Potash Shipments (MOP)

CAGR of Global MOP Shipments 2006-2016

- Other: 51.2 million tonnes (0.4% CAGR)
- Brazil: 59.6 million tonnes (3.4% CAGR)
- Indonesia: 3.4 million tonnes (6.7% CAGR)
- Malaysia: 0.9 million tonnes (0.9% CAGR)
- India: -0.2 million tonnes (-0.2% CAGR)
- China: 3.0 million tonnes (3.0% CAGR)

Source: Company Reports, CRU and Mosaic
MOP Trade Flows Dominated by Canada / FSU

MOP Top 10 Trade
Estimated 2015
Size Reference (Million tonnes)

Source: CRU
Global Import and Export Totals 2015 Top 10
The Nitrogen Market and Industry
Urea Production and Trade

Top Producing Nations
- China
- India
- Indonesia
- Russia
- Qatar
- Pakistan
- Iran
- Saudi Arabia
- Canada
- Oman

Source: IFA
Top producers in 2015

Top Exporting Nations
- China
- Qatar
- Saudi Arabia
- Oman
- Russia
- Ukraine
- Kuwait
- Canada
- Netherlands
- Iran
- UAE
- Korea

Source: IFA
Top exporters in 2015

Top Importing Nations
- India
- USA
- Brazil
- Thailand
- Australia
- Mexico
- Turkey
- Bangladesh
- France
- Philippines

Source: IFA
Top importers in 2015
Nitrogen (urea) Trade Flows

Urea Top 10 Trade
Estimated 2015
Size Reference (Million tonnes)

- Exports
- Imports

Source: CRU
Global Import and Export Totals 2015 Top 10
Chinese urea exports slowed dramatically in 2016

**Year-To-Date**

<table>
<thead>
<tr>
<th>1000 MT</th>
<th>YTD 2016</th>
<th>YTD 2015</th>
<th>% Chg</th>
<th>7-Yr Avg</th>
<th>% Chg 7-Yr Avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea Exports</td>
<td>7,459</td>
<td>9,529</td>
<td>-22%</td>
<td>4,390</td>
<td>70%</td>
</tr>
</tbody>
</table>

*Source: China Customs (through September)*
Chemicals for the Non-Chemist

Ever Evolving U.S. Nitrogen Industry

Natural Gas Costs in Key N-Producing Regions
Estimated Annual Average Price

Source: Fertecon

U.S. Gross Ammonia Production

Source: Fertecon
This presentation and other products available on the Mosaic website

- Mosaic Stakeholder Handbook
- Market Mosaic

- Market Alerts
- Past Presentations

http://www.mosaicco.com/resources/market_analysis.htm
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Thank You!