Challenges for Plant Nutrition Management: Fertilizer Industry’s Viewpoint

Luc M. Maene and Angela B. Olegario
World cereal situation
World fertilizer situation
Driving forces in agriculture and impact on fertilizer demand
Industry’s capacity to meet demand
Challenges and strategies ahead
Population trends and nitrogen use during the 20th century

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Adapted from Erisman, et al. 2008
World cereal production and utilization

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| Source: FAO |
## World cereal forecast

<table>
<thead>
<tr>
<th>Million tonnes</th>
<th>2008/09 (e)</th>
<th>2013/14 (f)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Production</td>
<td>Utilization</td>
</tr>
<tr>
<td>WHEAT</td>
<td>683</td>
<td>654</td>
</tr>
<tr>
<td>MAIZE</td>
<td>791</td>
<td>784</td>
</tr>
<tr>
<td>RICE</td>
<td>439</td>
<td>432</td>
</tr>
</tbody>
</table>

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*Source: FAPRI*
Key drivers in world agriculture and fertilizer demand
Key drivers in world agriculture and fertilizer demand

- **Continued world population growth:** more food and fiber
- **Income growth:** more meat, fish, fruits, vegetables, sugar and vegetable oils; less cereals and pulses per capita
- **High oil prices:** strong incentives for bioenergy production; ag commodity prices higher and more volatile
- **Limited immediately available additional arable land:** no alternative to increasing yields; increased cultivated area in Latin America and SE Asia
- **Growing environmental concerns:** increased recycling of organic nutrient sources; optimization of nutrient use efficiency
- **Improved technologies:** higher resource use efficiency
Divergent expectations of farming and urban populations

Population in billion people

- Sufficient, affordable, safe, nutritious food
- Clean water and air
- Conservation of wildlife and biodiversity
- Affordable and reliable energy supplies
- Higher and more stable produce prices
- Greater yields with lower input costs
- Greater respect for the farming profession

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World fertilizer situation
Global fertilizer consumption
Short-term forecasts

Million tonnes nutrients

<table>
<thead>
<tr>
<th></th>
<th>2007/08 (e)</th>
<th>2008/09 (f)</th>
<th>Change</th>
<th>2009/10 (f)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>101.0</td>
<td>99.4</td>
<td>-1.6%</td>
<td>102.1</td>
<td>+2.6%</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>38.8</td>
<td>36.0</td>
<td>-7.3%</td>
<td>38.1</td>
<td>+6.1%</td>
</tr>
<tr>
<td>K₂O</td>
<td>28.3</td>
<td>24.3</td>
<td>-14.4%</td>
<td>25.3</td>
<td>+4.1%</td>
</tr>
<tr>
<td>Total</td>
<td>168.1</td>
<td>159.6</td>
<td>-5.1%</td>
<td>165.4</td>
<td>+3.6%</td>
</tr>
</tbody>
</table>

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Source: IFA, 2009
Total fertilizer use by crop at the global level in 2006/07 (%)

- Fruits & veg.: 17%
- Maize: 16%
- Wheat: 15%
- Rice: 15%
- Other crops: 13%
- Oil palm: 2%
- Sugar crops: 4%
- Cotton: 4%
- Soybean: 4%
- Other OS: 5%
- Other CG: 5%

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Source: IFA Agriculture Committee
Nutrient use by crop (%)

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Source: IFA
World nitrogen consumption by product

<table>
<thead>
<tr>
<th>Product Type</th>
<th>1976/77</th>
<th>2006/07</th>
</tr>
</thead>
<tbody>
<tr>
<td>NK/NPK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amm. Phos./other NP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amm. Sulfate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia/N Solutions/ other N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AN/CAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urea</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Million tonnes N

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Source: IFA
Challenges for Plant Nutrition Management:
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Source: IFA
World potash consumption by product

<table>
<thead>
<tr>
<th>Product</th>
<th>1976/77</th>
<th>2006/07</th>
</tr>
</thead>
<tbody>
<tr>
<td>NK/PK/NPK</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Other K</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Potassium chloride</td>
<td>11</td>
<td>18</td>
</tr>
</tbody>
</table>

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Source: IFA
Anticipated variation of regional fertilizer demand in 2008/09 and 2009/10

Aggregate Fertilizer Demand

| Source: IFA Agriculture Committee

Challenges for Plant Nutrition Management:
Fertilizer Industry’s Viewpoint
Global fertilizer consumption
Medium-term forecasts

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Av. 2006/07 to 2008/09 (f)</th>
<th>2013/14 (f)</th>
<th>Change p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>99.3</td>
<td>111.2</td>
<td>+1.9%</td>
</tr>
<tr>
<td>P\textsubscript{2}O\textsubscript{5}</td>
<td>37.6</td>
<td>44.5</td>
<td>+2.8%</td>
</tr>
<tr>
<td>K\textsubscript{2}O</td>
<td>26.5</td>
<td>31.3</td>
<td>+2.8%</td>
</tr>
<tr>
<td>Total</td>
<td>159.6</td>
<td>187.0</td>
<td>+2.3%</td>
</tr>
</tbody>
</table>

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Source: IFA, 2009
World nitrogen supply/demand balance

Supply: 133.5 Mt (2009) to 154.7 Mt (2013): +16%

Demand: 126.9 Mt (2009) to 141.7 Mt (2013): +12%

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Source: IFA, PIT Committee
World urea supply/demand balance (Million tonnes urea)

Urea accounting for 64% of total N nutrients

Supply: + 5.0 % p.a.

Demand: + 3.7 % p.a.

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Source: IFA, PIT Committee
World phosphoric acid supply/demand balance

Million tonnes $P_2O_5$

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Source: IFA, PIT Committee
World potash supply/demand balance

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Source: IFA, PIT Committee
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Adapted from Bationo, 2009
## Nitrogen use efficiency – Low PFP<sub>N</sub>

<table>
<thead>
<tr>
<th>Crop</th>
<th>Country</th>
<th>N fertilizer use (kg N/ha)</th>
<th>Yield (t/ha)</th>
<th>PFP&lt;sub&gt;N&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>RICE</td>
<td>Japan</td>
<td>78</td>
<td>6</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>South Korea</td>
<td>110</td>
<td>7</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>193</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>WHEAT</td>
<td>Japan</td>
<td>117</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>80</td>
<td>7</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>190</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>MAIZE</td>
<td>U.S.A.</td>
<td>150</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Argentina</td>
<td>150</td>
<td>5</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>China</td>
<td>188</td>
<td>5</td>
<td>17</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Source: FAO, 1997-2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhang, F., 2009</td>
</tr>
</tbody>
</table>
### Average recovery efficiencies of N, P and K from manufactured fertilizers in Asia

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen (kg increase in uptake / kg nutrient applied)</th>
<th>Phosphorus</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rice in S, E and SE Asia, farmers' practice</strong>¹</td>
<td>0.33</td>
<td>0.24</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Rice in S, E and SE Asia, site-specific management</strong>¹</td>
<td>0.43</td>
<td>0.25</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Wheat in India</strong>²</td>
<td>0.58</td>
<td>0.27</td>
<td>0.51</td>
</tr>
<tr>
<td><strong>Wheat in China</strong>²</td>
<td>0.45</td>
<td>0.22</td>
<td>0.47</td>
</tr>
<tr>
<td><strong>Maize in China</strong>²</td>
<td>0.50</td>
<td>0.24</td>
<td>0.44</td>
</tr>
</tbody>
</table>

¹ Recommended rates - ² Rates currently applied by farmers

Source: Dobermann A. (2007)
Higher N use efficiency is possible

Source: Cassman et al, 2002 and Fixen and West, 2002
Contemporary nutrient use issues

Increased crop & fertilizer demand from:
- Population growth & economic development
- Biofuels
- Reduced area of crops competing with corn
- Higher crop prices
- Higher fertilizer costs

Public concern about:
- GHG emissions from fertilizer & land use change
- Reduction in water or air quality
- Food supply & cost

Urgency for improved crop yields
Credible fertilizer use data
Increased public & farmer scrutiny of fertilizer use

Development and Adoption of Fertilizer BMPs for:
- Higher yielding systems
- More efficient fertilizer use
- Reduction of nutrient losses to air & water
- Greater resistance to biotic & abiotic stress
- Demonstration of responsible fertilizer use

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| Source: IPNI |
“BEST” for doing what?

- Maximize crop uptake per unit of nutrient applied
- Maximize yield increase per unit of nutrient taken up
- Maximize yield increase per unit of nutrient applied
- Maximize farmer profit
- Reduce greenhouse gas emissions
- Limit nutrient run-off
- Replenish degraded soils
- Biofortify crops for human nutrition
- Adapt to climate change
Some key questions for crop nutrition

• How to better integrate fertilizers with manures, biofuel co-products and urban wastes given the high costs of transporting the latter?

• What role do all the micronutrients play? How do they interact with each other, the major nutrients, anti-nutrients and other molecules? How do we manage nutrients where toxicity thresholds are low?

• How can we raise global nutrient use efficiency? How do we reconvert nutrients escaping the agricultural system to inert forms?

• How can economic incentives for enhanced-efficiency products and other “improved” crop nutrition services become more positive?
Some key questions for crop nutrition

• What will be the impact of modern biotechnology? The spread of bioenergy crop varieties?

• How do crop nutrients interact with soil biology?

• How does crop nutrition interact with other facets of integrated crop management (water, waste and pest management, among others)?

• How do we develop and disseminate best management practices for all crop/agro-climatic combinations?
Public sector investments in ag research have slowed.
How agricultural R&D is funded (2000)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Public</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developed</td>
<td>62%</td>
<td>44%</td>
<td>93%</td>
</tr>
<tr>
<td>Developing</td>
<td>38%</td>
<td>56%</td>
<td>7%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Total - $36 billion**

(2000 international dollars)

Developed
- Public 10.2
- Private 12.1

Developing
- Public 12.8
- Private 0.9

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| Source: Pardey et al. |
The challenges ahead

• The scientific challenge of achieving global food security AND protection of natural resources has been grossly underestimated.

• Average farm yields must reach 85-90% of genetic yield potential in the major cereal cropping systems—especially on irrigated land.

• Innovative, efficient and profitable nutrient management should be a high priority!
Beyond the factory gate...

- Our business impacts throughout the global community
- We have to manage that relationship
- Develop partnerships

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