# Biology, Innovation and the Fertilizer Industry
## *Is the Change Imperative?*

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## Forces Driving Change

- **Better educated farm customer base**
  - more technically literate, educated, demanding
  - supported by easy access to information
- **Integrated Management Practices**
  - problems are increasingly challenging
  - no one product or process will solve them
  - integrating of technology is crucial
  - and the technology is being used (eg. IPM)

## Social-Political Trends

- **Government Regulations Contradictory**
  - political and business desire to reduce regulations, to stream-line the system
  - counterbalanced by a need to ensure a safe and healthy environment
- **Environmental Stewardship**
  - continued focus on safety and the environment
  - lead by industry (eg Responsible Care) to self regulate
- **Chemophobia**
  - pressure to reduce chemicals, to increase efficiency of Active Ingredients
- **Scientific Literacy**
  - public, press are more aware
  - but don't know how to manage risk

## The Challenge to the Fertilizer Industry

- **Fertilizer uptake by plants is unacceptably low**
  - FUE @ <50%(N), <20%(P), <10%(S)
- **"Collateral Damage" due to fertilizer misuse**
  - Hypoxia, "blue babies", algal blooms
  - not all caused by fertilizers
- **No chemical industry has ever won the environmental battle**
  - educating the public requires long-term effort
- **R&D and New Product Development not an industry focus**
  - locked in a commodity mentality

# The Changing Competitive Environment

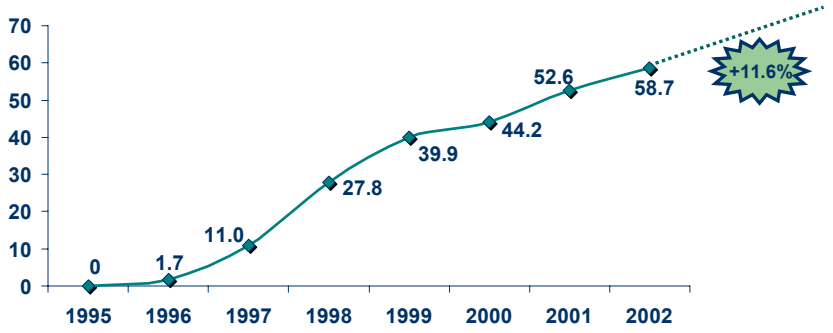
- **Industry rationalization to fewer players**
  - but not yet world scale (except in potash)
- **Competing in a global economy**
- **Non-traditional competitors**
  - seed & ag-chem companies
  - vertically integrated through the ag value chain
  - global marketing reach
  - drawing on high-tech product development

# Continued Improvement of Crop Yielding Potential

- **Biotech: a new tool for plant breeders**
- **58.7 Mha grown with GM crops in 2002**
  - "Input traits" : insect resistance (Bt), herbicide tolerance
- **Increased yield = increased fertilizer demand**
- **"Output traits" to come soon**
- **Improved nutrient and water use efficiency not yet at commercial stage**

Courtesy of Monsanto

# Genetically-Altered Crops Are A Fact (M ha)




# Cultivation of Transgenic Crops in 2002, by Country (Mha)

| | |
|---|---|
| USA | 39.0 |
| Argentina | 13.5 |
| Canada | 3.5 |
| China | 2.1 |

***Other countries***

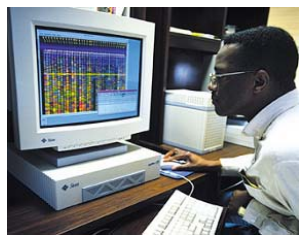
- Africa: South Africa
- Asia: India, Indonesia
- Latin America: Mexico, Uruguay
- Europe: Bulgaria, Romania, Spain
- Oceania: Australia

# Current Traits Focused on Pest Control (2001)

| Crop | Trait | Acreage (Mha) | Transgenic Area as % of Global Area |
|---|---|---|---|
| Soybean | HT | 33.3 | 46 % |
| Maize | Bt | 5.9 | 7 % |
| | HT | 2.1 | |
| | Bt + HT | 1.8 | |
| Cotton | HT | 2.5 | 20 % |
| | Bt + HT | 2.4 | |
| | Bt | 1.9 | |
| Rapeseed | HT | 2.7 | 11 % |

# "Output" Traits to Come

- **Remedy to deficiencies:** higher vitamin and iron content
- **Improved nutritional profile:** improved amino acid and fatty acid composition
- **Improved processing properties:** modified starch, higher solid content, improved fiber quality
- **Reduction of post-harvest losses:** delayed ripening, improved storage capacity



Courtesy of Syngenta

# New Crop Traits with Potential Impact on Fertilizer Consumption

- Enhanced potassium absorption
- Higher bioavailable phosphorus content
- Improved protein content
- Improved content in essential amino acids
- Higher iron content
- Other functional foods, nutraceuticals
- Tolerance to drought and salinity
- Aluminium tolerance
- Phytase-excreting plants
- Improved nutrient uptake and metabolism efficiency
- Genetic control of heavy metals uptake and/or tolerance
- Improver energy efficiency of energy crops
- Low lignin
- C4 genes

# Expected Positive Impacts of Biotech on Fertilizer Demand

| | | | |
|---|---|---|---|
| **Today -** | Essential amino acids | **S++** | |
| | Higher protein content | **N++** | |
| | Higher iron content | **Fe++** | |
| | Functional foods/nutraceuticals | **K+, S+, micro+** | |
| **2008 -** | Tolerance to drought/salinity | **All +** | |
| | Tolerance to acid soils | **All++** | |
| : | Improved energy crops | **All++** | (if policy support) |
| : | | | |
| **2020 -** | Low lignin | **All +** | |
| | C4 genes | **All ++** | |

# Expected Negative Impacts of Biotech on Fertilizer Demand

| | | | |
|---|---|---|---|
| **Today -** | Herbicide tolerance | **P-** | |
| | Higher phytase production | **P--** | (feed grade) |
| | Essential amino acids | **N--** | |
| **2008 -** | Tolerance to acid soils | **P--** | (temporary) |
| | Nutrient use efficiency | **N--, P---** | |
| **:** | | | |
| **:** | | | |
| **2020 -** | | | |
| | Nitrogen fixation | **N---** | (theoretically) |

# From Potential to Likely Impact: Some Questions to Be Answered

***Example: Transfer of symbiotic ability to cereals***

- Timeframe required for transferring the gene(s)
- Expected problems associated with the gene expression
- Tentative release date
- Expected yield loss associated with symbiosis
- Intellectual property issues
- Economic benefit for the farmers (by farming system)
- Impact of fertilizers with improved use efficiency
- Impact of environmental regulations

# Biologicals: Harnessing the Rhizosphere

- **Focus on "The Hidden Half"**
  - root health critical to nutrient, water uptake
  - manipulation of this "source sink" is critical
- **Plant Growth-Promoting Rhizobacteria (PGPR)**
- **Biological Control Agents (BCA's)**

Courtesy of Monsanto

# Improvement of Mircoorganisms and Symbiosis

- **Phosphorus solubilization**
- **Sulphur oxidization**
- **Ability to develop symbiosis with nitrogen fixing bacteria**
- **Improved nitrogen fixation in legumes**

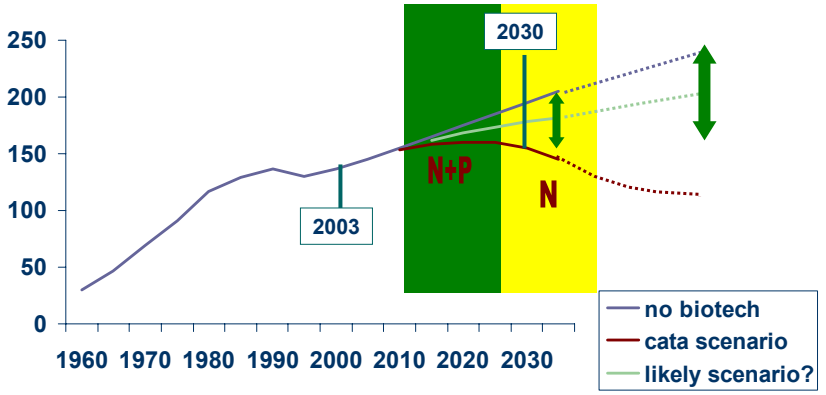
Courtesy of Syngenta

# Some Developments in Other Technologies

- Conservation farming
- Seed coating with phosphorus
- Improved FUE:
  polymers, inhibitors
- Improved catalysis:
  transition metal chemistry
- Solar-powered urea plants in LDC's

Courtesy of Monsanto

# Fertilizer Demand Forecasts (Mt) The Senarios



# Conclusions

- Many inventions with potential impact on crop nutrition
- Impact: either positive or negative
- What about likely impact on fertilizer demand?
- Probably slightly positive in 15-year timeframe; then reversal

- Shift from fertilizer to plant nutrient to crop input management suppliers
- Lead by developing disruptive technologies before non-traditional competitors do
- Ensure more fundamental R&D and engineering base in the public sector
- Forge strong links between the seed and fertilizer industry