

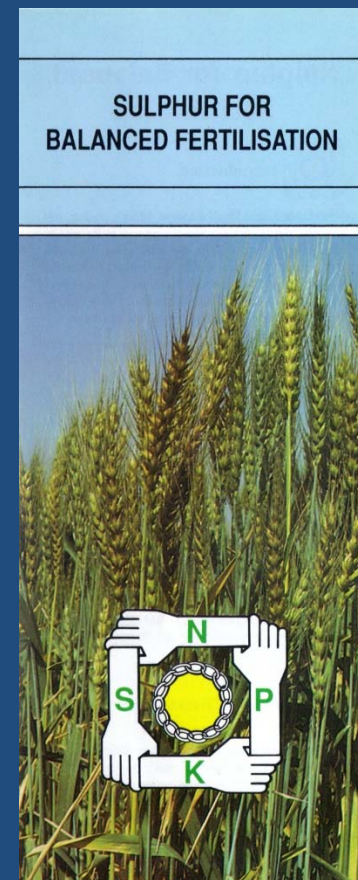
Sulphur in Agriculture: Raw Material and Valuable Nutrient

- Sulphur is not only a raw material to produce phosphate and ammonium fertilizers, it is an essential nutrient:

Deficiencies are increasing with:

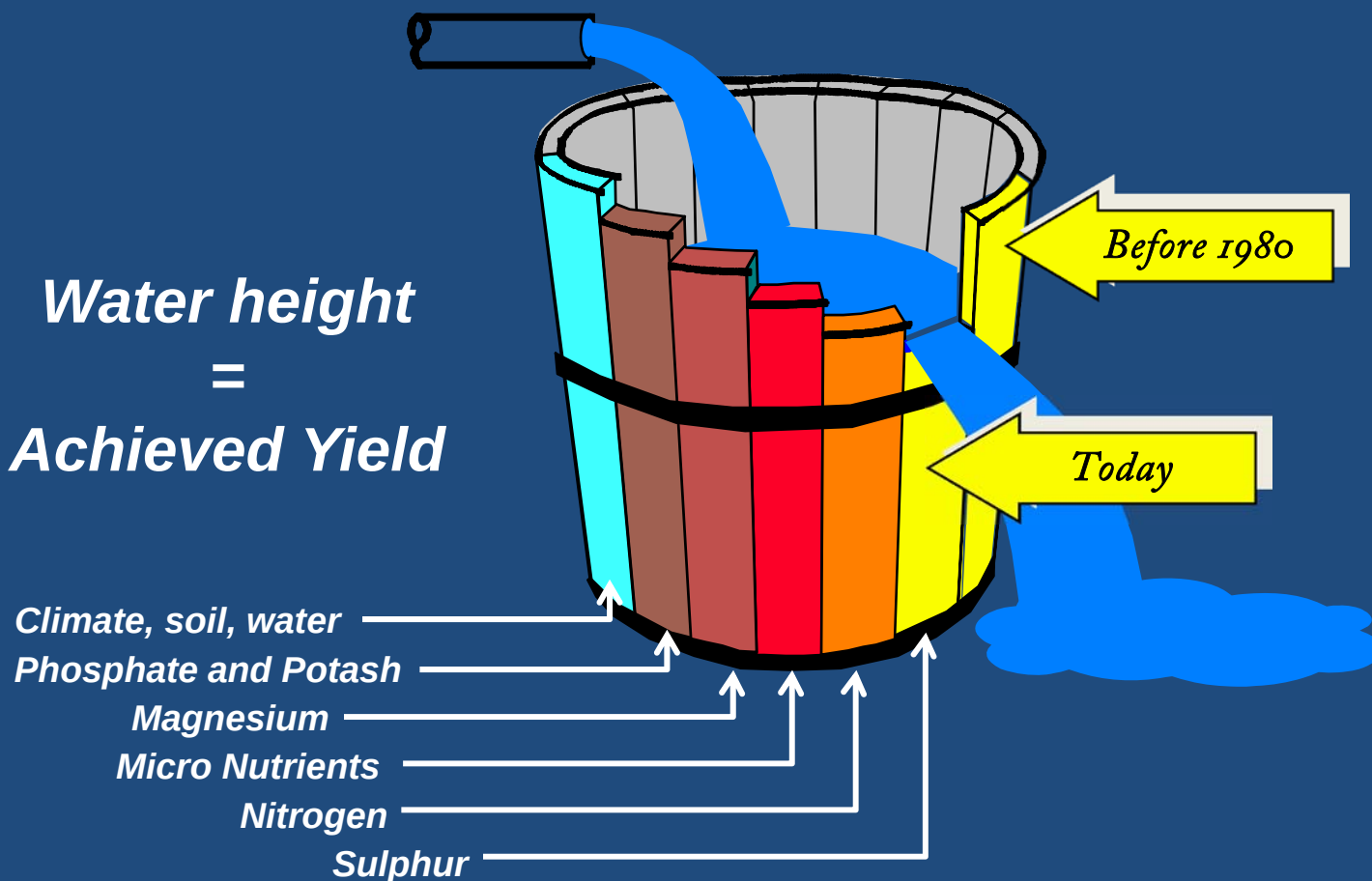
- Reduction in traditional S-containing materials
- Cleaner air programs
- Intensified agriculture increasing crop demand

- Sulphur is gaining prominence as a major nutrient with N-P-K.



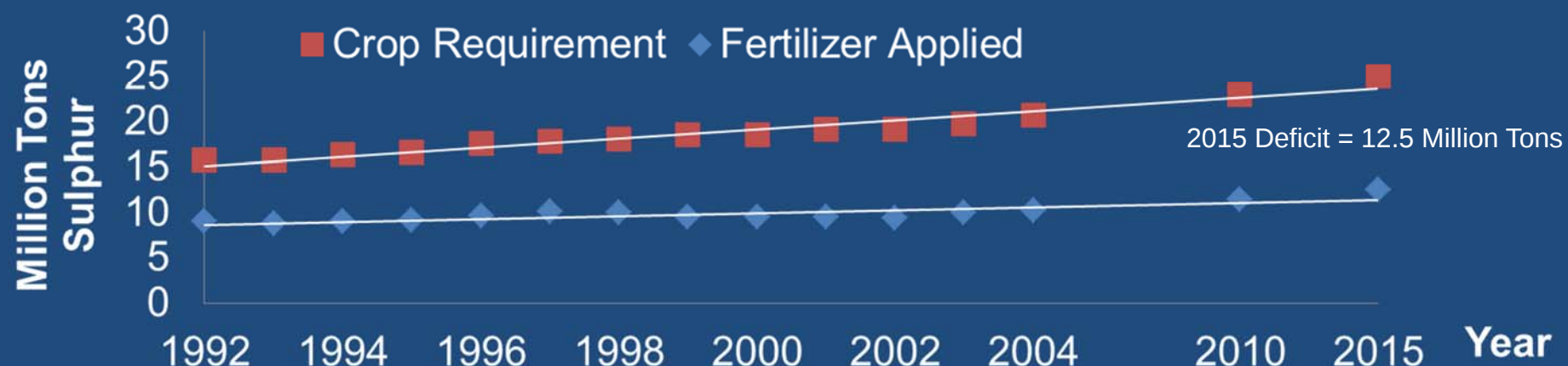
Sulphur Deficit: Limiting Crop Yield in Agriculture; Creating Market Potential for Fertilizer Industry

Water height
=
Achieved Yield



Sulphur Deficit and Requirement: Global

Plant Nutrient Sulphur Requirement and Deficit



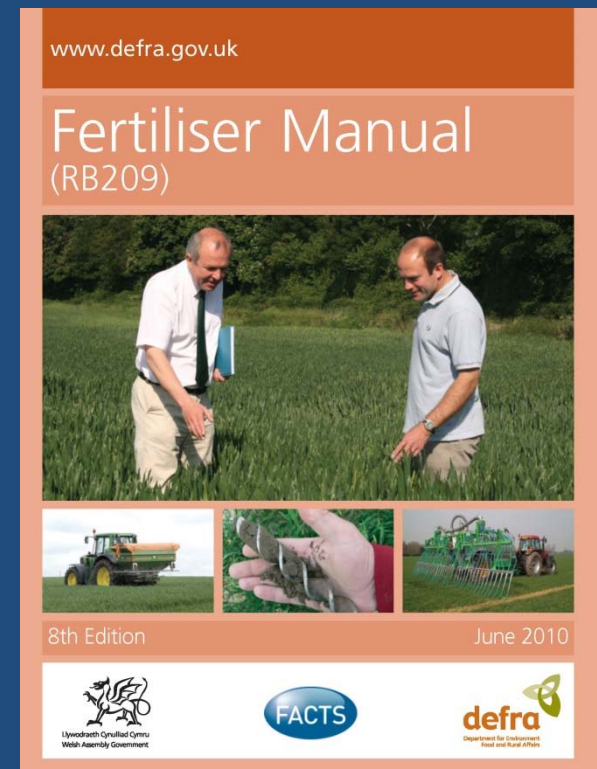
- Sulphur is the fourth major nutrient, required in similar amounts as P, about 20.6 million tons S in 2010.
- 10 million tons S applied worldwide
- An additional market potential for 10.6 million tons S exists today, mainly in Asia and the Americas.

Regional Plant Nutrient Sulphur Deficit Worldwide



The European Situation

- Sulphur fertilizer increased cereal grains yield ranging from 10% to 30% and from 20% to 40% on oilseed crops. Crop quality and economic returns of fertilizer are also improved.
- New Sulphur Fertilizer Recommendation for optimal yield:
 - Oil crops 20 to 40 lbs S/acre
 - Legume Crops 20 to 30 lbs/acre
 - Cereals 20 to 35 lbs/acre



The European governments and fertilizer industry recognize the need...



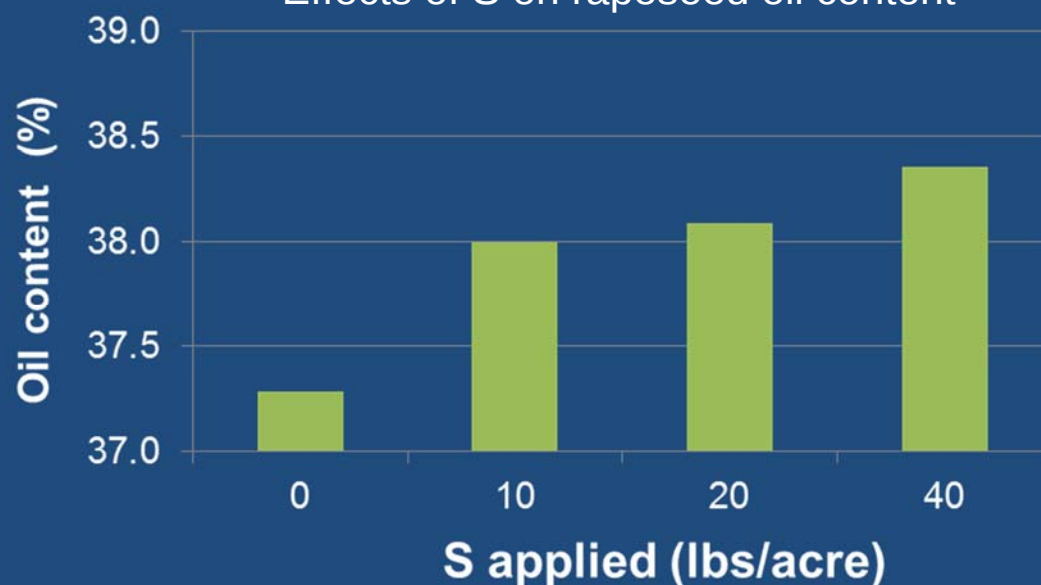
- 16 countries
- 25 products
- 500,000 tons S consumed annually
- France, Germany and Spain represent the largest diversity of companies and products involved, including micronized, sulphur bentonite, liquids, sulphate carriers and compounds with S
- Increase of oilseed rape production for biofuel increases S fertilizer demand

Sulphur Fertilizer Effect on Crop Quality

- Sulphur Fertilizer Effect on Synthesis of Oil:

- Sulphur fertilization increased oil content of rapeseed oil content in the UK by 3.02%

IACR, Rothamsted Research Group, UK
Effects of S on rapeseed oil content

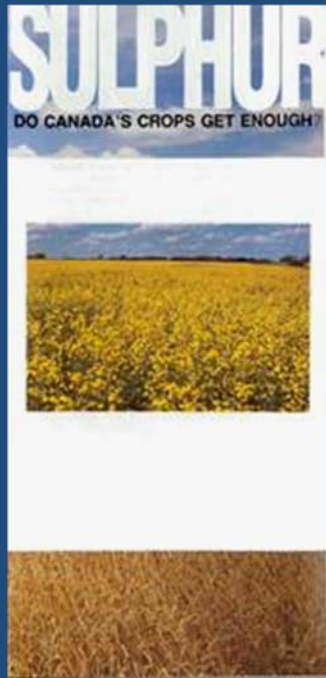


North American Situation



- The U.S. Clean Air Act is impacting crop sulphur requirements
- Today, significant areas of the southern and northwestern United States have sulphur recommendations.
 - Mid-Atlantic 20 to 40 lbs/acre
 - Southern states 10 to 20 lbs/acre
 - Forages 25 to 50 lbs/acre

North American Situation



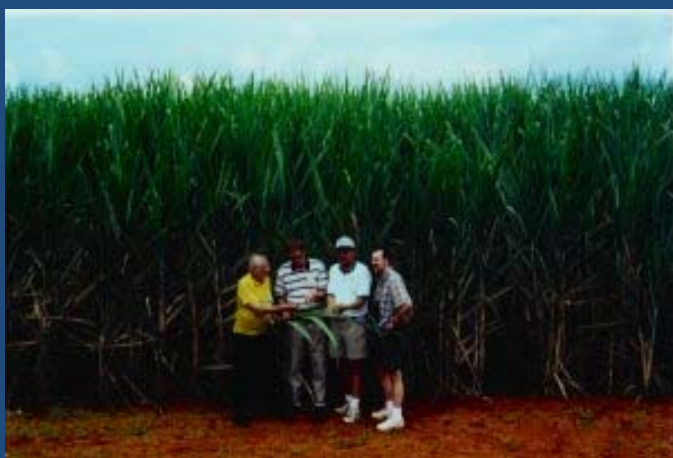
- In Canada, canola frequently has yield increases ranging from 10% to 40% and from 10% to 30% on other crops, with some variance depending on province.
- Common sulphur recommendations include:
 - Non-Irrigated Oil and Legume Crops 40 to 50 lbs/acre
 - Irrigated Legume Oil and Crops 20 to 60 lbs/acre
 - Cereals 15 to 30 lbs/acre

Sulphur Fertilizer Market in North America



- **Current consumption about 1.6 million tons S annually.**
- **New sulphate and elemental S fertilizers are coming on the market.**

Latin American: Another Big Sulphur Fertilizer Market



- Agricultural production recovery driven by strong demand for food and biofuel: soybean, corn and sugarcane
- S fertilizer requirements increase to 2.6 million tons S, second biggest market only to Asia
- S fertilizer consumption increases to 1.8 million tons
- Still large deficit
- More sulphate and ES fertilizers come to market also ammonium thiosulphate

Australia and New Zealand

Widespread S deficiencies resulted in the development of a wide range of crop and pasture S-containing fertilizers.



Fertilizer manufacturers have introduced new products to meet the increasing demand of S containing NP or NPK compound fertilizers or ES enriched N, P, and NPK fertilizers based on specific crop and soil needs.



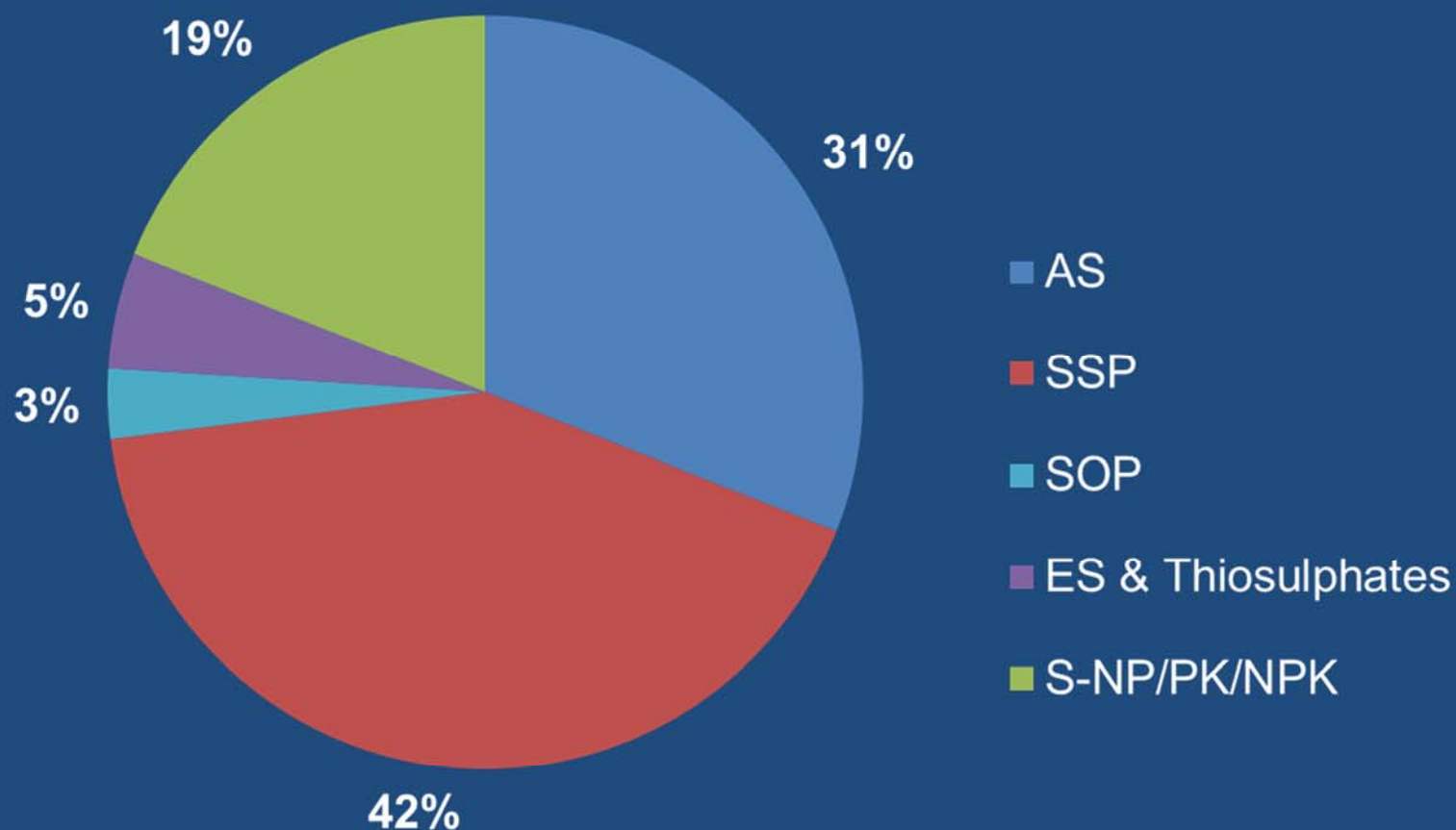
World Plant Nutrient Sulphur Deficit and New Market Potential for Sulphur Fertilizer

**Current Application:
10 Million Tons S**

**Estimated World Annual
Plant Nutrient Sulphur
Deficit In 2015:
12.5 Million Tons S**



Traditional Sulphur Fertilizers Take Major Market Share (2010)



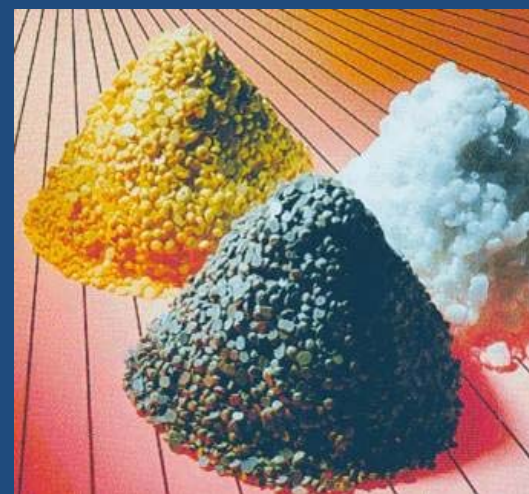
But, new products are emerging and growing in volumes!

Fertilizers Containing Sulphate

- **Traditional:**
 - Single Superphosphate (0-16-0 12S)
 - Ammonium Sulphate (21-0-0 24S)
 - Potassium Sulphate (0-0-50 18S)
- **Emerging:**
 - Ammonium Phosphate-Sulphate (20-20-0 15S)
 - Potassium Magnesium Sulphate (0-0-27 22S)
 - Various Micronutrient Sulphate Salts
 - Ammonium Nitrate-Sulphate (26-0-0 14S)
 - Sulphate-NPK compound fertilizers (15-16-15 11S)
 - Urea-Ammonium Sulphate (40-0-0 9S)

Elemental S: Emerging Fertilizer Product and Market

- Elemental Sulphur
- Micronized Granular Elemental Sulphur
- Elemental Sulphur Enhanced/Enriched Nitrogen/Phosphate Fertilizers
- Sulphur Coated Fertilizers



Improving Fertilizer Efficiency

- Elemental sulphur (S^0) is a slow release fertilizer because it is water insoluble.
- Must be oxidized by microbes to SO_4^{2-} to be available for plant uptake.
- Ideal where SO_4^{2-} leaching is serious.
- Most concentrated S-fertilizer with lower transportation, handling, and storage costs.
- Beneficial reactions in soil improve major nutrients efficiency to plants.



Granular Dispersable Elemental Sulphur (90 to 99% S)

- Dispersible in soil and water, releasing finely micronized S particles (40 to 150 μm), effectively converted into sulphate by soil microorganisms in the early growing season.
- Season long S supply with minimized risk of leaching loss.
- Increases in production and marketing in America (N+L), Europe, Oceania, Asia, and Africa.

Elemental Sulphur Enriched Nitrogen/Phosphate Fertilizers

- Liquid S is added into NP or NPK fertilizer product with various technologies to provide 5-20% S.
- New ES enriched fertilizers: Sulphate and ES enriched MAP; ES enhanced DAP; ES-enriched SSP.
- Increases in production and marketing in N. America, Europe, Oceania and Asia.

Elemental Sulphur Enriched Nitrogen/Phosphate Fertilizers

- Sulphur-Coated Urea (SCU) and compound fertilizers: Slow or controlled release S and other nutrients
- Sulphur Coated TSP; DAP/MAP
- New products made by coating urea with micronized S using binders
- Huge market potential: >1 million tons S



Palmers Chemical
International Trading Company

Sulphur Fertilizers: New Ground for Fertilizer Industry

- Current production will not meet increasing demand.
- Sulphur fertilizers provide potential market of 10 million tons of sulphur consumption annually.
- Fertilizer producers need to address this new market potential:
 - Product choice/Promotion of new sulphur fertilizer production and use, including elemental sulphur based new fertilizers.

