Sulphur Fertilization: What Has Changed?

Cynthia Grant – AAFC Brandon
Rigas Karamanos - Viterra

Cynthia.grant@agr.gc.ca
Sulphur Deficiencies are Increasing Internationally

- Air quality standards reduce aerial input
- Purer, high analysis fertilizers reduce S input as “contaminant”
- Higher crop yields increase demand and crop removal
- Organic matter depletion and higher crop removal reduce soil reserves
What’s Changed Locally in Crop Production?

• Increasing production of canola
  – Tighter rotations
• Shift to higher yielding canola hybrids
• More movement towards reduced tillage
• Different S sources
  – MicroEssentials S-15
  – Various elemental products
  – Traditional ammonium sulphate
  – Ammonium thiosulphate
• Weather always changes . . .
Some Things Never Change
Sulphur Deficiency is Very Common In Canola

<table>
<thead>
<tr>
<th></th>
<th>Wheat</th>
<th>Canola</th>
<th>Peas</th>
<th>Alfalfa</th>
<th>Corn</th>
<th>Soybeans</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yield (bu/ac)</strong></td>
<td>40</td>
<td>35</td>
<td>50</td>
<td>5 t/ac</td>
<td>100</td>
<td>35</td>
</tr>
<tr>
<td><strong>Sulphur removal</strong></td>
<td>4</td>
<td>11</td>
<td>7</td>
<td>34</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

- Canola requires more S than cereal and pulse crops.
Sulphur deficiency can severely reduce canola yield
An adequate S Supply is Needed to Avoid Deficiency
Sulphur Supply is Highly Variable Across a Field

- Sulphur deficiencies are usually patchy in a field, since S supply is normally highly variable.
- Variable nature also makes soil testing challenging:
  - High S concentrations in one area can conceal deficiencies in other areas.
- S supply also varies with depth:
  - Gypsum or mild salinity in the lower depths may be missed with shallow soil testing.
Plants Access Sulphate from Soil Solution

Rain, irrigation, atmospheric deposition

S must be in the sulphate form for crop uptake

Mineralization

Soil solution $\text{SO}_4^{2-}$

Gypsum

dissolution

precipitation

leaching

Immobilization
Plants Only Absorb Sulphate-S

Sulphate forms are immediately available

Elemental forms must oxidize to sulphate
A Range of Sulphur Sources Are Available

**Sulphate Sources**
- Ammonium sulphate
- Ammonium thiosulphate
- Gypsum
- Microessentials S-15

**Elemental Sources**
- Elemental S
- Bentonite blends
- Rapid Release Sulphur
- Microessentials S-15

Manage sulphate and elemental sources differently
Ammonium Thiosulphate Converts Rapidly to Sulphate

![Diagram of thiosulfate and sulfate ions](image)
Gypsum is a Traditional S Source in Many Areas

- Calcium sulphate (CaSO$_4$·2H$_2$O)
- Lowers pH if soil pH is greater than 8.5 and increases it if soil is less than 4.5
  - Not common on Manitoba soils
- Used for reclamation of soils that are high in Na
  - Where leaching will move the replaced Na
- Can be used as a sulphate source
  - Solubility is low relative to ammonium sulphate
  - Solubility reduced on soils with high Ca in soil solution
  - The Ca is normally not needed on MB soils
  - Tends to be difficult to handle and apply
  - Strongly marketed because it is a waste product for disposal
Sulphate Sources Are Immediately Available so Timing of Application is Flexible

- Ahead of seeding
  - S portion will not volatilize
  - May possibly immobilize or leach but to lesser extent than nitrate
- Near seeding
  - Readily available
  - Reduces risk of leaching below rooting zone
- Post-seeding
  - Can be effective, even when delayed
  - Option where deficiencies are noticed late
Canola Response is Still Greatest When S is Supplied Near Seeding

Malhi and Leach, 2002
Managing Post-Emergence Sulphur

- Watch for deficiencies early – spraying time.
- Act quickly when you see a problem and use sulphate sulphur.
- Understand the deficiencies may “disappear” with crop rooting into gypsum, salts or leached S
  - Need to assess sulphate supply below the plough layer
Sulphate Sources Are Mobile in the Soil so Placement Options Are Flexible

- Banding – pre-plant, mid-row or side-banding
- Broadcast
- Dribble-band
- Seed-placement
  - Avoid excesses that could cause toxicity
Excess Seed-placed Ammonium Sulphate can Cause Seedling Damage in Canola

- Stand density decreased with increasing rates of ammonium sulphate and MAP
- Most damage occurred with highest rates of MAP and AS
Elemental Sources Must Oxidize to Sulphate

- Requires time and conditions for microbial activity
- Apply far before crop requirement
- Use finely divided product
- Broadcast rather than band
  - Want to maximize contact with microbes
- Leave on surface to “weather”
- Incorporate after weathering
  - Conversion may be slower if left on surface under reduced tillage
Environmental Conditions Affect Oxidation to Sulphate

- Conversion for elemental S to available sulphate is mainly by microorganisms.
- More rapid conversion when soils are warm and moist
  - Slower under very wet or very dry conditions
  - Slower under cold conditions
- Under Canadian conditions, we cannot rely on elemental sources to provide enough available sulphate on deficient soils during the following crop year
  - May be beneficial in long-term planning.
Sulphur Source Study at Melfort from 1996 to 1998

One broadcast application of 20 kg S ha\(^{-1}\) in 1996
Sulphur Products in a Broadcast Application

Alfalfa Yield (t ha\(^{-1}\))

Year 1 (1998)
Year 2
Year 3

S surface broadcast applied at 50 kg ha\(^{-1}\) once in spring 1998

Source: Cowell and Johnston, Ag Canada, 2001
Weathering on the soil surface speeds breakdown, while band-placement restricts it.

Freshly applied T-90 pellet

T-90 pellet after 90 days in seed-row

Pellet after weathering on soil surface
In-Soil Banding Delays the Availability of Elemental S
New Products Aim to Hasten Conversion of Elemental S

- MicroEssentials S15
  - Onionskin
- RRS, sulphur95
  - Greater dispersion
  - Smaller particles

Greater dispersion and contact with microorganisms should hasten oxidation
MicroEssentials S15 by Mosaic

13 – 33 – 0 – 15

- Ammonium Phosphate
- Ammonium Sulphate
- Elemental S

- \( \frac{1}{2} S \) in sulphate form (plant available)
- \( \frac{1}{2} S \) in elemental form (requires conversion)
Advantages of MicroEssentials S15

• Lower salt index than a blend of MAP and AS
  – Improved seed safety
• Better distribution of P and sulphate in the seed-row
• Co-granulation of AS and MAP may improve P uptake
• Conversion of elemental to sulphate does not appear to be hastened

-Only count on $\frac{1}{2}$ of the S being available since elemental S will not convert rapidly
Availability of S15 was Intermediate Between Elemental and Sulphate Source

S Uptake

Plant Yield

(U of M thesis by Kroeker 1995)
MicroEssentials S15 and RRS had lower seedling toxicity than ammonium sulphate.
Weather Can Affect S Deficiency
Sulphur Deficiencies in Canola are More Frequent After Wet Years - 1999, 2010 and 2011
Leaching in Wet Years or Field Areas Increases Risk of Deficiency
Strong S Response Occurred in 2010

Be particularly alert for S deficiencies after a wet year that promoted leaching.
Do Hybrid Cultivars need More Sulphur?

- Most cultivars grown in Canada are hybrids
- Yield potential is substantially higher than older OP varieties
- Removal of S over time will be greater with higher yield
- Hybrids appear to have higher root activity and greater ability to extract S from the soil than OP cultivars
- Hybrids produce more yield at a given S level than OP
Yield of OP or Hybrid Canola as a function of N application with or without 40 kg S ha$^{-1}$

- Hybrid cultivars produced higher seed yield than OP lines but did not require additional S.
Adding N without S Can Depress Canola Yield on an S-deficient soil

Increasing N with No S

Increasing N with S

Led to the idea that a specific N:S ratio was needed – between 5 and 7 N to 1 S
Adequate S is Needed, But Specific N:S Ratio May Not Be That Important

• High N:S ratio can indicate an S deficiency
• However, once a S deficiency is corrected there is little or no response to adding more S with increasing N rate.
• Worry about supplying the required S rather than about a precise N:S ratio
Sulphur Fertilization and Protein Content

- Bread-making quality requires protein quantity and quality.
- Protein premiums for wheat reflect the importance of protein in crop quality.
- Nitrogen and sulphur are both required for protein production.
- S-containing amino acids are important for bread-making.
Effect of S Fertilizer in Wheat on Loaf Height Occurred at Sites where Yield Response Occurred as Well

Loaf Height (mm)

Athabasca  Erickson  Melfort
0 lb S/ac  18 lb S/ac

Unger
Sulphur has a Small Effect on Protein Compared to Nitrogen

% Protein in Wheat

- No N
- N Only
- N+S

<table>
<thead>
<tr>
<th>Variety</th>
<th>No N</th>
<th>N Only</th>
<th>N+S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enchant</td>
<td>192</td>
<td>17</td>
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<td>Airdrie</td>
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<tr>
<td>Red Deer</td>
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<tr>
<td>Ft Sask</td>
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<tr>
<td>Swift Current</td>
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• Traditional principles still apply
  – Plants take up sulphate
  – Elemental must convert to sulphate
  – Conversion of elemental is slow in prairie soils

• Conversion of elemental in new products isn’t rapid enough to supply S in year of application
  – May be other benefits in seed safety or distribution

• Hybrids extract S efficiently from soil and may not initially need more S than OP
  – May increase depletion on poorly buffered soils
• Recognise S variability across field and within soil profile
• Don’t worry too much about specific N:S ratios
  – High N:S ratio can indicate an S deficiency
  – Correct the S deficiency
• Effects on protein content and quality are only likely where S is low enough to reduce yield
• Very wet conditions can lead to leaching and increase the risk of S deficiencies
  – Keep alert for S problems in wet years
Thank You for Your Attention