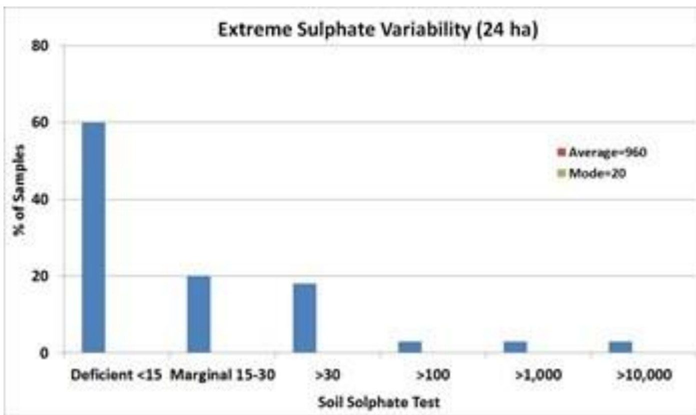
Canola Suphur deficiency

Canola has a higher sulphur (S) requirement than any other major crop grown in Western Canada. Expansion of canola acres, increased yield through improved cultivars and production practices, and tightening rotations have increased S removal from soils to the point where fields or parts of fields that were once well supplied with S are becoming depleted.

Canola generally responded to S fertilizer when the water soluble soil sulphate content to 60 cm (2') soil depth was less than 22 to 34 kg/ha (20 to 30 lb./ac.)

Canola yield response to sulphur (S) fertilizer is dramatic under extreme S deficiency, but canola will also often respond to S fertilizer on soils where a composite soil sample shows S levels to be sufficient. That's because sulphur levels can be highly variable across a field.



For example, Figure 41 shows extreme sulphate variability on a 24 ha (60 ac) solonetzic field near Stettler, Alberta in 1994. Composite samples were taken from each 0.5 ha (acre) and tested separately. The average worked out to be 1,076 kg sulphate/ha (960 lb. sulphate/ac.) in the 60 cm (2') depth, which is excessive from the soil test standpoint. However, the average value is heavily skewed by the few samples with extremely high sulphate values. The "mode," which is the result that occurred most frequently in this field, was just 9 kg sulphate (20 lb. sulphate). This is deficient. The majority of this field would likely respond to S fertilizer.

The Stettler example illustrates that single composite soil samples from fields with high S variability can be difficult to interpret. A soil testing deficient for S is likely deficient (unless underlain by a subsoil sulphate salt layer), while soils testing medium or high for S may have deficient areas that are skewed by areas with excessive S.

For fields testing medium or high for S, a blanket application of 11-22 kg S ha (10-20 lb./ac.) will ensure ample S in low-sulphur areas to meet canola yield expectations. For fields testing low for S, seed yields are usually optimized with application of 15-30 kg S ha (13-26 lb. S/ac.) as sulphate-S at seeding on most soils.

Canola needs 0.5 to 0.6 pounds of sulphur per bushel of yield. A 35 bu./ac. canola crop needs 17-21 pounds per acre of available sulphur. If the 10 to 20 lb./ac. application rate is insufficient to meet a grower's yield expectation, accounting for soil residual levels, then a higher rate will be warranted.

Canola response to S fertilizer varies greatly, depending on:

- soil sulphate levels (amount, spatial and temporal distribution)
- availability of other nutrients (especially N, P and possibly boron)
- soil moisture
- amount, type, and method of S fertilizer applied

The N:S ratio. Research has shown a decrease in canola yield as a result of N application when N was applied alone to S deficient soils. A number of research studies have shown that applying N and S in a ratio of roughly 7:1 can produce yield benefits on soils deficient in both of these nutrients. However, balancing N and S to a fixed ratio is unnecessary and wasteful on canola grown on soils containing sufficient S.

A Saskatchewan study found that optimal yield response for S fertilizer on canola occurred at the 10 kg S per ha rate, while seed quality (oil, protein and S concentration) responded up to the 15 kg S per ha rate.

Some studies have found that sulphate-S applications increase concentration of oil in canola seed while other studies found a decrease or no change.

Application of S has been found to decrease chlorophyll concentration in seed, suggesting that seed quality can be improved by correcting S deficiency in canola.

Sulphur fertilization can increase protein content of the meal, which is desirable, but can also increase glucosinolate contents. Glucosinolates increase with excessively high S fertilizer rates, but are usually well below the standard canola quality limit (currently 30 micromoles per gram).

Canola yield response to the first 10-20 lb./ac. of applied S can be dramatic, especially for parts of the field where S is deficient. These areas will need S in order to generate an economic gain from any amount of N fertilizer. But once a baseline amount of soil sulphate S is reached, the economic return for subsequent fertilizer will be much higher for N than for S.

The organic portion of the sulphur cycle in soil is closely tied to N due to their association in protein. Each undergoes mineralization from organic matter, immobilization, oxidation and reduction of inorganic compounds.

Like N, the main S reserve in soil is in organic matter (OM). Growers can expect roughly 2-3 pounds per acre of available sulphur for each percentage point of OM. Soil with 4% OM could provide 8-12 pounds of available S to the crop.

However, the S mineralization rate is quite slow, and cannot match the uptake rate of growing plants.

In many western Canadian soils, there is a subsoil salt (gypsum) and/or lime (calcium carbonate) layer. This subsoil layer contains considerable sulphate, often as co-precipitates with lime. Although this subsoil sulphate solubility is reduced, it still can contribute to plant needs if it exists within the rooting zone. However, the length of time that canola grows in S-deficient topsoil before rooting to the subsoil S will affect the yield response to fertilizer S. Also, the depth to subsoil S tends to vary greatly across the field. Total S amounts (organic and sulphate) generally increase from upper to lower slope positions.

In most Prairie soils, sulphate is not held by organic matter and clay particles since they are both negatively charged. Therefore, sulphate is vulnerable to leaching losses.

<

Sulphur deficiencies look like:

- Top leaves are small and narrow, and are often cupped.
- Pale yellow leaves
- Prolonged flowering if the crop is having trouble setting seed.
- Small flowers with very pale yellow colouration.
- Short pods with little or no seed set.
- Patchy look to the field. Sulphur is highly variable across a field, so deficiencies will usually show up in patches.
- Sulphur deficiency is more typical in sandy soil with low organic matter.

Sulphur has several effects on canola growth. Since chlorophyll synthesis requires S, sulphur deficiency will affect visible leaf colour and photosynthesis. Protein synthesis requires S containing amino acids, and, therefore, S deficiency affects rapidly growing parts, especially reproductive structures.

Mild S deficiency often does not result in noticeable symptoms, but still can reduce yield. Medium deficiencies do not show symptoms until bolting, flowering and podding. Under severe deficiency, symptoms show up about two weeks after germination.

By the bolting stage, S deficiency begins to affect yield parameters such as branches per plant, fertile flowers per plant, seeds per pod and individual seed weight. Under mild to moderate S deficiency, the thousand-kernel weight is normally not significantly affected since plants compensate by reducing the seed number per pod. Nitrogen deficiency affects pods per plant more than S deficiency, while S deficiency reduces the seeds per pod.

Sulphur deficiency symptoms vary depending upon the severity and timing of the deficiency relative to crop growth stage. In the vegetative stage, foliar symptoms show up under severe S deficiency. Since S has a low mobility within the plant, symptoms are observed more readily on the youngest leaves, which are greenish-yellow compared to the normal bluish-green in B. napus. The yellowing (chlorosis) starts from the leaf edges and the tissue around leaf veins remains green. Subsequently, the leaf edges and bottoms may turn purple. Besides the leaf colour, S deficiency in young plants causes smaller leaves as well as upward cupped leaves.

By the bolting stage, new leaves of S-deficient plants show chlorosis, purpling and spoon-like leaf cupping. The purple colour is caused by enhanced pigment (anthocyanin) synthesis due to sugar accumulation resulting from S limited amino acid and protein synthesis. The degree of leaf cupping is highly dependent on the timing of the S deficiency. There is significant cupping when S deficiency occurs before half of the leaf weight is attained.

By flowering, S-deficiency symptoms can show up in the petals — they are smaller and lighter yellow. If severe S deficiency occurred in the vegetative stage, symptoms can be found both in foliage and flowers. However, if S deficiency occurs around flowering, leaf symptoms may not be obvious, but flower petals may become paler. Yellow and white petals may even exist side by side on a single flower.

The life span of S-deficient petals is shortened to one day from two or three, and pollen production is greatly reduced. In addition, S-deficient petals are egg shaped compared to more round petals on sufficient S plants. Flowering is often delayed and prolonged. Reports suggest that S-deficient plants do not attract honey bees, perhaps due to lack of pollen. By podding, S deficiency becomes more distinctive. Pod number and size, and seed number per pod are reduced significantly. Pods may be pale green, often with purpling and can be compressed or flattened.

Proper diagnosis of nutrient deficiency should use the following assessments:

1. **Soil test.** Are any obvious shortages evident? Consider soil quality variation within the field. Does symptom severity follow a pattern consistent with typical differences in soil S levels (e.g. less S on hilltops leading to more severe symptoms)?

2. **Fertilizer history.** In past years, what rates and source products have been applied on that field? Include crop yields and consider whether rates have been adequate to match removal.

3. **Tissue test.** Use in conjunction with other tests. Consider that different cultivars may have considerably different critical levels at which S deficiency is observed. A comparative test between healthy looking and deficient looking plants in the field is always more preferable. Make sure to record growth stage as criteria change with stage.

4. **Environment.** Cold, wet, hot and dry can all stress canola plants, creating symptoms that may look like nutrient deficiencies. If neighbors have similar symptoms, the cause is probably environmental — frost, excess moisture, etc.

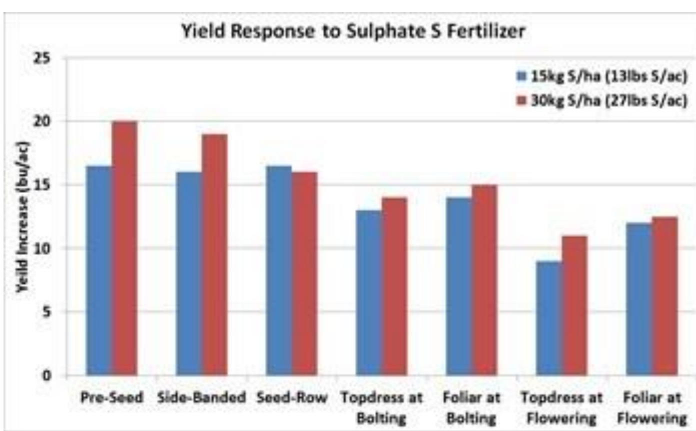
5. **History of the land.** Recently broken forage land is likely to be depleted in a lot of nutrients. For example, alfalfa uses significant quantities of S, so if the field has been baled removing all top growth over many years S levels could be very depleted.

6. **Look at other fields for similar symptoms.** When diagnosing for a specific nutrient, target the crop that tends to be most sensitive to that nutrient. Canola is more sensitive to low sulphur levels than cereal crops are.

Applying higher rates of ammonium sulphate in the seed row along with monoammonium phosphate can increase seeding toxicity and reduce final seed yield. Phosphate should be the top priority for seed row placement, because unlike S it has demonstrated crop response benefits from this type of placement at safe seed-placed rates.

Only limited amounts of sulphate S fertilizer can be safely applied near the seed. The safe amount will vary with the degree of seedbed utilization, moisture conditions, soil type and amounts of other fertilizer nutrients. Until research has determined the safe amount of seed row S fertilizer under various combinations of the above factors, limit seed-placed ammonium sulphate to no more than 12 kg sulphate/ha (10 lb./ac.). Include N amounts in sulphate fertilizer when calculating total N fertilizer amounts to be safely seed-placed.

The best yield response to sulphate S fertilizer is at or before seeding, as illustrated in Figure 43 from six site-years of recent research at AAFC's research centre in Melfort, Saskatchewan. This research also showed that side banding or pre-seed incorporation increased yield more than seed row placement of 30 kg sulphate/ha (27 lb./ac.), probably due to seedling toxicity.



Under average to good moisture conditions, sulphate fertilizer can be broadcast-incorporated in the spring with good results. Under dry spring conditions, broadcast sulphate fertilizer can be stranded and result in poor uptake. However, under such dry conditions, canola germination and establishment will also be severely affected.

Applications at seeding are generally more effective than at bolting and early flowering stages, but in-crop applications can correct S deficiencies. An AAFC found that in-crop applications of S can restore seed yield substantially at bolting and moderately at early flowering. The AAFC study applied S in-crop at sulphate rates of 15 kg/ha (13 lb./ac.) and 30 kg/ha (26 lb./ac.). The results are in the table below. Topdressing, in this case, is applying granular potassium sulphate at the S rates listed. Foliar application, in this case, is a liquid potassium sulphate solution at 200 L/ha (20 gal/ac.)

Treatment	**S rate (kg/ha)**	**Yield (kg/ha) Mean of 6 sites**
No Fertilizer	0	406
S sidebanded at seeding	30	779
N + S incorporated at seeding	15	1074
	30	1228
N + S sidebanded at seeding	15	1064
	30	1208
N + S seedrow placed at seeding	15	1083
	30	1156
N + S topdressed at bolting	15	823
	30	937
N + S foliar applied at bolting	15	910
	30	1002
N + S topdressed at flowering	15	646
	30	766
N + S foliar applied at flowering	15	788
	30	813

Elemental sulphur is not a good choice for in-crop application since its slow conversion to sulphate means the S may not be available to the crop soon enough. Elemental sulphur is better for long-term maintenance.

When doing an in-crop application, growers could target only those areas — such as hill tops — that tend to be sulphur deficient.

An in-crop application can make financial sense for canola if:

- Growers could not put the desired rate on at seeding.
- Yield potential improved and growers want to add sulphur to their nitrogen top up. If field conditions have been excessively moist, sulphur may have moved lower in the soil profile. As canola plants grow, their roots will extend into these reserves. For that reason, growers who have been applying recommended rates of sulphur may not see as much economic return from a sulphur top up compared to a grower who has cut sulphur rates in recent years.
- Canola shows signs of sulphur deficiency. (See the symptoms in section 3.5.3 above.)

Application technique:Application prior or during rainfall is best. Surface applied ammonium sulphate requires rain to move it into the root zone. Sulphur is not volatile like nitrogen fertilizer, so losses will be minimal if rain is not immediately forecast.

If dribbling on liquid ammonium sulphate (8-0-0-9) or ammonium thiosulphate (12-0-0-26), damage from leaf burn tends to be more severe when canola is smaller than the 5-leaf stage.

Applying sulphate fertilizer in a tank mix with herbicide/fungicide may not provide enough sulphur to provide a benefit to the crop. Also, flat fan sprays that cover the leaf are far more toxic to the crop than fertilizer dribbled on the soil surface. Plus, the crop can't take up much fertilizer through the leaves.

Fall broadcast elemental S fertilizer left on the surface until incorporation next spring will improve the oxidation and canola yield response compared to spring broadcast. However, this practice should still be initiated two years ahead of the canola crop to ensure consistent response, and is unlikely to match the availability of spring applied sulphate fertilizer.

Spring, before or at seeding, tends to be the best time to apply sulphate fertilizer. Highest fertilizer use efficiency generally results when sulphate fertilizer is placed near roots for easy access, and just before the period of plant uptake. Under dry spring conditions, broadcast sulphate fertilizer can be stranded and result in poor uptake. However, under such dry conditions, canola germination and establishment will also be severely affected. Under average to good moisture conditions, sulphate fertilizer can be broadcast-incorporated in the spring with good results. On sandy soils, sulphate leaching can occur during wet periods.

Table 7. Effect of S Fertilizer Form and Placement on Canola Yield

Treatment	**Yield (bu/ac)**		
	1996	**1997***	**1998***
Check	21	16	11
Spring broadcast Tiger 90	18	12	25
Spring broadcast elemental S (99%)	23	6	11

Table 7. Effect of S Fertilizer Form and Placement on Canola Yield

Treatment	Yield (bu/ac)		
	1996	**1997***	**1998***
Spring broadcast ammonium sulphate	37	31	24
Spring dribbled ammonium thiosulphate	34	31	26
Spring pre-plant banded Tiger 90	16	7	12
Spring pre-plant banded ammonium sulphate	36	31	28
Seed-placed Tiger 90	21	10	18
Seed-placed ammonium sulphate	37	10	26

Many different sulphur fertilizers are available, and each requires a different management system to maximize the nutrient potential. Sulphates are the best choice to meet immediate needs of the crop.

Sulphate S. Sulphate fertilizer forms should be used when canola needs S for immediate crop uptake. Choices:

- Dry ammonium sulphate (20.5-0-0-24 granular and 21-0-0-24 crystalline)
- Liquid ammonium thiosulphate (12-0-0-26). This requires a short time period for oxidation to sulphate.

Fertilizer use efficiency is highest when sulphate fertilizer is placed near roots for easy access, and just before the period of plant uptake.