MEASURE AND MANAGE

Sulphur in Ontario

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The total amount of Elemental Sulphur (S) in soils can be quite large as much as 1200 to 1600 pounds per acre however elemental S is not available to crops. The oxidized form Sulphate (SO_4^{2-}) is the available form.

The conversion of S to SO_4^2 is accomplished by soil bacteria and oxidation reactions. The cycling of S is very similar to the Nitrogen cycle. There are many forms of S in the soil both organic and inorganic. The transformation of organic S to available sulphate involves mineralization, immobilization oxidation and reduction.

Mineralization is the decomposition of organic matter by bacteria to release organic S to be oxidized to available forms. Immobilization is the opposite process where bacteria incorporate S into their bodies as a source of food and rendering the S unavailable to further breakdown. Reduction occurs in low oxygen or saturated soil conditions where bacteria strip the sulphate of its oxygen and can create the formation of hydrogen sulphide compounds which are phototoxic. These factors run concurrently in the soil and the net difference between mineralization and immobilization places SO_4 into the pool of plant available sulphate.

We have been analyzing soil for Sulphate for the past several years and have found very few samples requiring sulphate additions. Usually soils low in organic matter with sandy texture in the upper slope positions show lower Sulphate values.

Sampling depth seems to be an important factor. The sulphate form much like nitrate nitrogen is mobile in the soil profile. A six inch sample may not be adequate to quantify .the available sulphate. We have run a series of 6 and 12 inch samples for sulphate. There is a much higher amount of sulphate in the 0-12 inch samples than in the 0 - 6 inch depth.

Available Sulphate ppm at 0-6 and 0-12 inch at Milton in a clay soil same field. (April) and the bottom chart a Sandy loam from Ottawa.

Sample #	0-6 inch	0-12 inch
1	21	46
2	37	42
3	15	33
4	27	63
5	18	28
6	30	66
7	14	25
8	15	59
Sample #(sandy)	**0-6 inch**	**0-12 inch**
1	11.3	13
2	12,2	14
3	13.3	14.9
4	6.5	8.5
5	13.38	9.8
6	10.8	12.7
7	11.6	12
8	12	14

The chart from Milton clay clearly shows much higher levels of sulphate in the deeper sample indicating that there is downward movement and accumulation in the lower part of a root zone.
The Ottawa samples being a low organic matter sandy soil are showing much lower Sulphate levels in both 6 and 12 inch samples. All samples would result in a Sulphate fertilizer recommendation.

Our Recommendation Guideline chart for Sulphate applications on a 6 inch sample are as follows.
Adapted from Nebraska

Sulphate Recommendations for soils < 2% Organic Matter (lbs/ acre)

Sulphate ppm	High Demand Crop	Medium Demand Crop	Low Demand Crop		
6	35	30	20		
12	25	20	20		
18	20	15	15		
24	15	10	10		
30	5	5	5		
36	0	0	0		

Sulphate Recommendations for soils > 2% Organic matter (lbs/ acre)

Sulphate ppm	High Demand Crop	Medium Demand Crop	Low Demand Crop		
6	30	25	20		
12	20	20	15		
18	15	10	10		
24	5	5	5		
30	0	0	0		
36	0	0	0		

Crop Demand

High	**Medium**	**Low**
Canola	Sugar Beets	Lettuce
Alfalfa	Tomatoes	Cucumbers
Corn	Onion	Melons
Wheat	Grapes	
Potatoes		
Soybeans		
Barley		
Beans		
Cabbage, cauliflower		

These are recommendation guidelines from the Great Plains where you expect to find S deficiencies care must be taken when interpreting for other jurisdictions. It is always wise to do on farm strip trials to determine response, make sure to leave a zero check so responses can be determined.

The 0-6 inch sample in the Milton chart has 6 samples that would indicate the possible need for sulphur while the 0-12 inch sample has only 2 samples that would result in a sulphate recommendation. In Southern Ontario the response to sulphate has been sporadic or nil. Perhaps the deeper sampling profile is a better sampling depth to predict the need for sulphur in S.W. Ontario.
The Ottawa sampling is lower in Sulphate as expected and would result in a Sulphate recommendation of 20 to 25 lbs / acre. The question then becomes is the early May sampling too early and will more mineralize later when the soil warms up? This is why local calibrations are important.

The average uptake of Sulphate by most crops is in the 10- 30 pound per acre range. The average deposition of sulphur from air pollution is thought to be in the 20 to 25 pound per acre range. Therefore it seems that the need for supplemental S is low.

When we do see apparent S deficiency it is usually in early spring under cool growing conditions the conversion of S to SO_4 is slow and root growth is limited. As the soil and air temperature warms up the conversion speeds up and root growth increases to take advantage of Sulphate in the lower part of the root zone.

Sulphur in Plants

The amount of S in plants is similar that of P ranging from 0.1 to 0.8 %. Plants with a higher Sulphur content are cabbage, cauliflower, turnip, radish, onions, and asparagus. Sulphur compounds such as mustard oil glycosides in these plants are responsible for the distinctive flavour. Sulphur is also necessary for the formation of S containing amino acids of methionine, cystine and cystiene. These amino acids are necessary for animal nutrition and impart baking quality to wheat flower. Really stinky canola indicates adequate S uptake.

Sulphur Deficiency Symptoms

In general a pale green colour develops much like N with the exception that the entire plant is pale green whereas N deficiency is in the lower part. S deficient plants may be shorter, reduced leaf area, lack vigour and maturity. The stems often become woody in texture. Leaf cupping, yellowing between the veins early in the season and reddish discolouration later on is evident in the canopy.

In S.W.Ontario the crop of greatest concern has been canola generally most plants contain an N:S ratio of 8:1 or 10:1. It has been a practice to apply a pound of S for every 8 pounds of N to assure sufficient S uptake for oil formation. Numerous field trials have been inconsistent in Sulphur response on canola. This may be due in part to spatial variability of S in the landscape (low in the upper slopes), weather conditions affecting mineralization, root growth or seasonal difference in deposition or adequate soil levels.

One of the conditions that may develop on canola after harvest is the formation of **new buds and regrowth on the cut stubble**.(do not confuse with volunteer canola from seeds) One of the conditions of S deficiency is delayed senescence it may be worth noting where in the field this occurs and make a map for future reference and variable rate applications of Sulphur. Plants with adequate S will not regrow and the stubble will be dead.

Sources of Sulphate Sulphur

The plant available form is the sulphate form not elemental S. Elemental S must be broken down into sulphate. The main commercial sources are ammonium sulphate 21%N and 24% sulphate, ammonia thiosulphate 12% N and 26% sulphate (liquid), sulphate of potash 50% K and 17% sulphate, KMag 22% K, 11% Mg and 22% sulphate.

If sulphur is determined to be necessary early applications of a sulphate form incorporated prior to planting is desired. Late rescue treatments before bolting in canola

are possible but yield loss may already have occurred. In many horticulture crops the use of sulphate of potash (SOP) as a K source already provides a significant level of available sulphate to crops with the highest requirements. Applying 200 pounds of actual K from SOP provides 68 pounds of sulphate.

Lowering Soil pH

Elemental Sulphur (S) can be used as a soil amendment to lower soil pH. However it may take several large applications to effectively lower the soil pH in highly buffered calcareous soils. The conversion of S to Sulphate provides the necessary Hydrogen ion activity to lower the pH.

To lower the pH from 7.0 to pH 5.0 would require 2 annual applications of S at a rate of 2000 pounds per acre for a total application of 4000 pounds on a loam soil.

A formula for calculating a more precise rate is as follows.

Lbs of S = %base saturation now- %base saturated needed x CEC x 16x 17.8

Example a soil with a CEC of 20 and a base saturation of 90% and a target base saturation of 60 is desired.

Lbs of S = (.90-.60) x 20 x 16 x 17.8

=1708 lbs per acre of elemental S in a 6 inch plow layer

This soil amending practice is limited to specialized cropping situations.

Starter Fertilizers

The addition of S to starter bands along with mono- ammonium phosphate and ammonium sulphate will help to maintain and extent the acidifying affect of starter fertilizers to benefit the availability of micronutrients especially manganese.

Summary

In our lab analyzing for Sulphate is an option rather than a standard we believe that with few exceptions such as low organic matter sands that we are more than sufficiently supplied with sulphur. Northern Ontario is the only place where consistently low levels persist and therefore we recommend farmers from there choose a Sulphate test as an option on the standard packages. We further believe that a sulphate test should be done on a 12 inch sample not a 6 inch sample and could be done with the nitrate soil test. Agri-Food Laboratories will be doing further testing in this area.