LABORATORY TESTS FOR SOIL SULPHUR IN PASTORAL SOILS

This technical note describes the three commonly requested tests for soil-sulphur, outlining their uses and limitations. Traditional soil tests for sulphur include sulphate-S (SO4-S) and extractable Organic S (OS) as measures of immediately plant-available and medium term plant-available sulphur respectively. Both tests have some limitations however, and recent research has shown a superior soil test for assessing sulphur needs of pastures to be the Total Sulphur (tS) test.

Why test for S?

Sulphur (S) is an essential element for growing plants, being a component of plant-proteins and having an important role in the synthesis of chlorophyll. It is also essential for animal health in the formation of proteins that make up skin, hair & wool. S deficiency in plants manifests itself as pale, yellow leaves; similar symptoms to those found in nitrogen deficiency - the difference being with S deficiency the symptoms appear in the youngest leaves rather than the oldest.

Sulphur testing is important where low sulphur or sulphur-free fertilisers are used, such as high analysis NPK fertilisers. Retention of sulphate-sulphur by the soil is related to its phosphate retention or anion storage capacity (ASC); with high leaching losses of the sulphate anion being associated with low phosphate retention soils (low ASC). This should also be taken into account when considering sulphur fertiliser options.

It is understood that Sulphur(S) exists in the soil predominantly as bound organic S with small amounts existing in quasi-equilibrium as sulphate-S (SO4-S) and extractable organic S (OS).

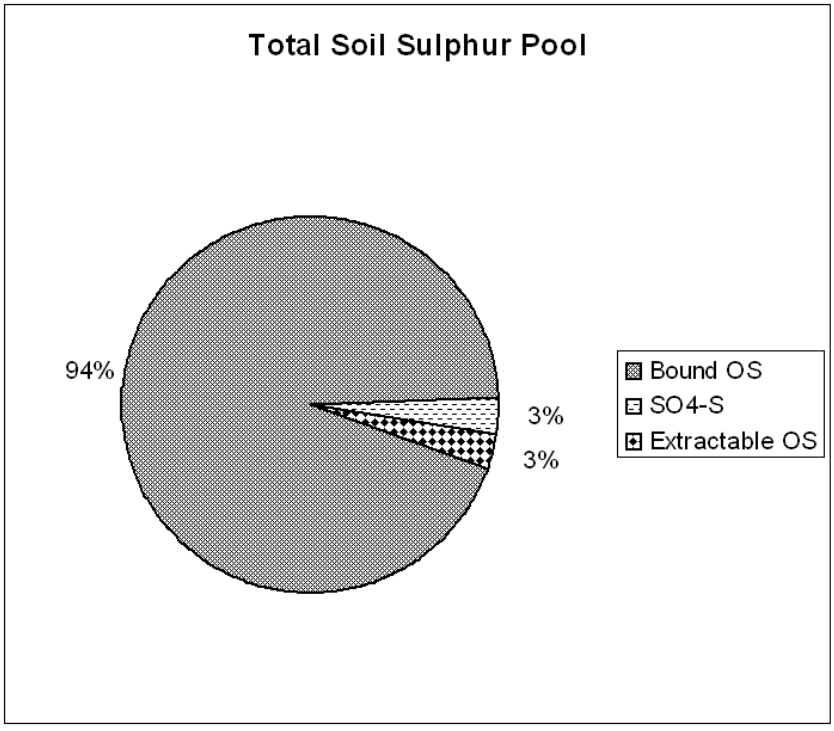

Fig 1. Model showing relative distribution of forms of S in the soil.

Sulphate S (SO4-S) Test

This test measures readily available sulphur in the form of dissolved plus adsorbed sulphate. SO4-S is measured from either Calcium or Potassium Phosphate extracts using an ion-chromatography (IC) technique[1].

The SO4-S in the soil at any one time is influenced by mineralisation and as such is highly variable; particularly as soil temperature and moisture levels alter. Sulphate-S is prone to wide fluctuations as it is such a mobile anion; researchers[2] have found typical levels of 40-70kg/ha leached on dairy farms. Also, SO4-S occurs as hot-spots in dung and urine patches, calculated at 35 and 100kgS/ha respectively. Table 1 shows typical interpretive ranges for SO4-S in the soil.

Test	**SO4-S (mg/kg)**
Very low	<4
Low	4-10
Medium	10-20
High	20-50

Table 1. Typical interpretive ranges for soil Sulphate-Sulphur

Organic S (OS) Test

As stated earlier, most of the soil's sulphur (97%) is in organic forms. This pool of S is in a slow equilibrium with the plant available, inorganic form of sulphate-S. Being a natural source of S, it is useful to have a means of assessing this component, especially where the SO4-S test indicates low levels of the readily plant available form. The OS test measures the readily soluble fraction of the organic S pool and is a measure of the medium-term available S.

In 1995, Dr John Watkinson (AgResearch) established[3] that the same extract used for the SO4-S test could be run through another instrument known as ICP-OES, providing a measure called Total Extractable S (TES). The difference between the TES and the SO4-S gives the Extractable Organic S (OS as it is provided on your soil reports). Researchers showed that OS is a more robust test than using SO4-S alone, as it is a more stable S-fraction. While the OS test has been widely adopted and is seen by many to be a reliable measure of S supply in the medium term, its main problem is that it requires two analyses and can only be measured by difference – any variation in one or the other measures will impact on the OS value calculated. Table 2 shows typical interpretive ranges for OS in the soil.

Test	**(Extractable) OS (mg/kg)**
Very low	<5
Low	5-11
Medium	12-20
High	>20

Table 2. Typical interpretive ranges for soil Organic Sulphur

Total S (TS) Test

The latest S test recommended for pasture soils is the 'new' Total S test. This test is a measure of the total pool of all forms of S and is determined by boiling a soil sample in nitric/hydrochloric acids and analysing the extract by ICP-OES. In fact it is not entirely a 'new' test – various acid digestions for total elements have long been in use.

What is new is the field-calibration for interpretation of the test. AgResearch have investigated soils from a series of 43 field trials and shown the TS test to give a better correlation[4] to pasture response than the OS or SO4-S tests. The trials showed that for all soil types (excluding raw peat as not included in trial work, maximum pasture yield requires TS >900 mg/kg, whereas S deficiency would likely be a factor when TS <600mg/kg.

The TS test is less prone to spatial and seasonal variability and is less affected by dung and urine patches. It does not give any information on immediately available S however. Table 3 shows the interpretive ranges for the TS test for pastoral soils.

Test	TS (mg/kg)	Response to Applied S
Very low	<400	High response
Low	400-600	Medium response
Medium	600-1000	Unlikely response
High	>1000	No response

Table 3. Interpretive ranges for Total Sulphur in pastoral soils (excluding raw peat).

Conclusion

The SO4-S test is still highly recommended as the plant-available S test, but for pasture soils it may well be complemented by the less variable TS test. Interpretation of the SO4-S test should consider soil factors such as anion storage capacity, organic matter content and texture. Climate will have a large influence also e.g. accumulation in dry periods and leaching in wet periods. While the extractable OS test is more stable than the SO4-S test, it requires two tests in the laboratory and therefore can have reasonably high error associated with it. The TS test is considered to be particularly useful in conjunction with the SO4-S test to identify inherent S deficiency or adequacy. It is also thought to provide a measure of the long-term S status of those soils prone to leaching i.e. pumice and low ASC sedimentary soils. The TS test should not be used on raw peat soils however, as interpretation is not available currently.

References

1. Searle, P.L. (1988). The determination of phosphate-extractable sulphate in soil with an anion-exchange membrane. Comm. Soil Sci. and Pl. Anal. 19(13), 1477-1493.

2. Rajendram,G., Ledgard, S., Monaghan, R., Sprosen, M. and Ouyang, L. (1998) Effect of rate of nitrogen fertiliser on cation and anion leaching under intensively grazed dairy pasture. In occasional report No. 11. Ed LD Currrie & P Loganathan. P67-73. FLRC , Massey University, Palmerston North, NZ.

3. J.H. Watkinson & K.W. Perrott (1990). A New Soil Test for Sulphate and Mineralisable Organic Sulphur. Proceedings of the NZFMRA Conference. p188-198.

4. Rajendram, G., Ghani, A., Waller, J., Kear, M., Watkinson, J., Benge, K. and Wheeler, D. (2008) Total Sulphur: A Better Predictor of Sulphur Deficiency in Pastoral Soils. In Occasional Report No.21. Ed LD Currie & LJ Yates. FLRC, Massey University, Palmerston North, NZ.