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HOW IMPORTANT IS SULPHUR FOR PASTURES?

With the introduction of low sulphur compound and concentrated fertilisers, a new look is required at the sulphur status of West Australian soils, and the sulphur requirement of pasture. In this article the functions of sulphur, deficiency symptoms and potential problem soils are described. Current recommendations and plans for future research work are outlined.

R. N. GLENROSS and W. J. COX, Research Officers, Plant Research Division.

FOR many years sulphur deficiency in various soils in Western Australia has been obscured by the general use of superphosphate as a sulphur-containing phosphatic fertiliser. Only in the last few years has sulphur been shown to be important in stimulating legumes, and so increasing pasture production.

This new interest in sulphur has arisen from the introduction of low-sulphur and sulphur-free concentrated fertilisers, and the fact that on old land the need for sulphur may be higher than the need for phosphorus.

The function of sulphur

Sulphur is an essential plant nutrient and is a constituent of a number of essential plant compounds. The most important of these are the proteins which contain the amino acids cystine (27 per cent. sulphur) and methionine (21.5 per cent. sulphur).

Amounts of sulphur in soils

The total sulphur in West Australian soils ranges from a very low 0.003 per cent. on virgin grey white sands in the high rainfall areas to 0.3 per cent. and higher on salmon gum-gimlet country. Soils adjoining salt lakes in the eastern wheat-belt can contain considerably higher amounts.

Most of the sulphur in topsoils is in organic combination, derived from plant and animal residues. This is a reserve not available for uptake by plant roots until it is broken down in the soil.

Sources of sulphur available to plants

Plants obtain sulphur from four main sources—the soil, fertilisers, rain and the atmosphere. In the soil, the sulphur available to plants results from the breakdown of rock material and decomposition of organic matter.

The main fertiliser source of sulphur in Western Australia is the calcium sulphate contained in superphosphate. Superphosphate contains about 12 per cent. sulphur, compared with about 10 per cent. phosphorus. Some sulphur is also applied in double superphosphate (2 to 5 per cent. sulphur), sulphate of ammonia (24 per cent.) and gypsum (17 per cent.).

In Western Australia the rainfall provides very little sulphur—commonly as little as one to two pounds an acre, but slightly more near the coast.

Plants can absorb sulphur dioxide from the atmosphere through their leaves. In industrial countries where the level of sulphur dioxide in the atmosphere is high they may get nearly a third of their sulphur from this source. This would be unimportant in most of Western Australia.

Losses of sulphur from soils

Sulphur is removed from soils by two main methods: It may be taken up by the plants or leached through the soil. Legumes generally need more sulphur than cereals or grasses as illustrated by Table 1.
Table 1. — Sulphur uptake by plants

<table>
<thead>
<tr>
<th>crop</th>
<th>yield lb./ac.</th>
<th>sulphur uptake lb./ac.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clover</td>
<td>3600</td>
<td>17</td>
</tr>
<tr>
<td>Lucerne</td>
<td>3600</td>
<td>20</td>
</tr>
<tr>
<td>Wheat</td>
<td>1200</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Although grazing returns a large percentage of "plant" sulphur to the soil through the urine some of this in turn, can be lost by leaching. Adequate sulphur must therefore be regularly supplied to the soil to replace that lost in plant and animal products and that lost by leaching out of the root zone.

Table 2. — Sulphur removed by animal products

| Fleece (10 lb.) | 0.3 lb. sulphur |
| Fat lamb       | 0.5 lb. sulphur |
| 250 gal. milk  | 1.5 lb. sulphur |

On many soils sulphur applied as a component of superphosphate at topdressing time (autumn) may be rapidly leached from the soils during winter. This loss occurs when plant growth is slowest. In spring, when growth is most rapid, sulphur may then become limiting. This was demonstrated on a red-brown sandy loam at Chapman Research Station, when the seasonal sulphate sulphur levels were followed during 1967-68. When 82 lb. per acre of gypsum (containing the same amount of sulphur as 115 lb. of superphosphate) was applied in mid-May the sulphur level in the surface soil fell rapidly during the following three months, although there was no loss from lower levels. The soil had received about 2,150 lb. of superphosphate since 1920.

On many coarse-textured soils the residual value of the applied sulphate is much lower than that of the phosphate applied in superphosphate. The soils are therefore changing from the virgin state in which phosphorus limited growth to a stage where sulphur is more important. On many of these soils superphosphate applications can be reduced or used less frequently, so that sources of sulphate are needed. On fine textured soils and those with much ironstone gravel present close to the surface the soils are able to retain sulphate and sulphur leaching is less.

Symptoms of deficiency

Deficiency symptoms appear first in legumes in the pasture. In subclover the symptoms are:

Root nodules

Root nodules are small scattered and unbranched, with greenish pigmentation near their base.
Leaves
The leaves of affected plants exhibit a pale yellow-green chlorosis in the early stages, which subsequently changes to lemon yellow. Associated with this symptom is a bright red anthocyanin coloration along the leaf veins.

Petioles and stems
Petioles and stems are heavily pigmented and brownish red in colour, compared with the normal green colour which becomes partly obscured by a light reddish brown pigmentation with age.

Pasture responses to sulphur
Under 20 inch rainfall areas
In the lower rainfall areas, pasture growth responses to sulphur have generally been obtained on the sandy soils with low organic matter when double-superphosphate was used as the source of phosphorus. On sandy soils of low super history sulphur responses occurred in the first year, while on soils with a medium to high super history responses were not evident until the second or third year.

On the red-brown clays which carry salmon gum and gimlet, there was no response to sulphur after three years.

The importance of annual application of superphosphate and hence sulphur on most soils is evident from Table 3. Topdressing every second year gives reduced yields because sulphur is limiting in the “off” years. In a case such as this topdressing every second year with sulphur-fortified superphosphate could be advantageous.

<table>
<thead>
<tr>
<th>Superphosphate lb. per acre</th>
<th>Pasture yield cwt./ac. D.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>40 every year</td>
<td>30.7</td>
</tr>
<tr>
<td>80 every second year</td>
<td>25.0</td>
</tr>
<tr>
<td>80 every second year with 52 lb. gypsum in the “off” year</td>
<td>31.1</td>
</tr>
</tbody>
</table>

Table 3.—Dry matter production in “off” year

Location of sulphur trials

Cereal trials
Pasture trials

Location of sulphur trials

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Over 20 inch rainfall areas

In areas with over 30 inch annual rainfall, clover growth increases following sulphur application are common on coarse textured grey soils, especially on old pastures. These always occur when sulphur-free or low sulphur phosphate fertilisers are used. On some soils in some years more sulphur is required than can be supplied in a normal autumn dressing of superphosphate. (See Table 4).

Table 4.—Time of application—gypsum sulphur total dry matter yield 1964

<table>
<thead>
<tr>
<th>1964 Treatment</th>
<th>Redmond cwt./ac</th>
<th>Boyanup cwt./ac</th>
<th>Capel cwt./ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Sulphur</td>
<td>18.5</td>
<td>31.4</td>
<td>30.8</td>
</tr>
<tr>
<td>Gypsum sulphur April</td>
<td>23.6</td>
<td>40.7</td>
<td>32.6</td>
</tr>
<tr>
<td>Gypsum sulphur August</td>
<td>26.2</td>
<td>48.8</td>
<td>45.2</td>
</tr>
<tr>
<td>Gypsum sulphur August and April</td>
<td>26.0</td>
<td>45.8</td>
<td>45.0</td>
</tr>
</tbody>
</table>

It is now evident that in such cases, the gypsum form of sulphur is too soluble and leaches out of the plant root zone over the winter period. More sulphur is needed after the heavy winter rains.

On clays, red brown loams, and gravelly soils in this heavy rainfall area, sulphur deficiency is not common on old land in the first year that sulphur-free phosphate fertiliser is used.

Sulphur responses in the 20 to 30 inch rainfall zone are less common. Most of the soils in this area are mainly ironstone gravelly soils. Coarse textured soils such as spillway sands, or coarse grey brown loamy sands formed over country rock have shown large responses to sulphur in some years. Any requirement over and above that provided by normal super appears to be small and varies with season.

Current research

The main aim of current research is to define sulphur deficient soils and their requirements. At the same time the two main sources of sulphur—gypsum and mineral sulphur—are being evaluated, using a range of particle sizes on a number of sub. clover pastures.

Accurate assessment of the sulphur requirement for pasture on a particular soil type is very difficult because of the valuable contribution of animal returns and variable seasonal conditions. However, a plant test for determining sulphur deficiency is being investigated.
Current work will assess the sulphur requirements and most efficient sulphur source on four soil types in the over 30 inch zone, four in the 20 to 30 inch rainfall zone and three in the low rainfall areas. All trials are under a grazed situation to include animal returns.

Results from this programme should indicate the rate, source and application time of sulphur fertilisers.

**Recommendations—low rainfall**

At present we cannot recommend that farmers use sulphur (either as gypsum or mineral sulphur). As long as the recommended rates of superphosphate are applied it is unlikely that sulphur deficiency will occur in normal seasons.

**Recommendations—high rainfall**

20 inch to 30 inch Zone: At present we cannot recommend that farmers should use gypsum or elemental sulphur over and above superphosphate (10 per cent. phosphorus, 12 per cent. sulphur).

Over 30 inch zone: On grey surfaced soils (over 12 inches to a subsoil layer) and particularly on winter wet sands, a sulphur fertiliser, super or gypsum, is needed for maximum growth. Although phosphorus is needed in autumn, and potash is usually essential on such soils, sulphur fertilisers are required following winter rains.

Normal super dressing on most red brown loams and gravels of the higher rainfall areas supply adequate sulphur for total production.

**Acknowledgments**

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