Effect of soil moisture on the response of subterranean clover to lime

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Summary A pot experiment was carried out using a soil high in aluminium to investigate the relationship between the dry matter responses of subterranean clover to lime at two soil moisture levels. Subterranean clover, which is reputed to be tolerant to high aluminium levels in the soil, showed an increase in the dry weight of plant tops of 50% when lime was added on the low moisture treatments. By contrast the response on the high moisture treatment was only 5.6%.

Introduction

Subterranean clover is thought to be relatively tolerant to aluminium\(^5\). The evidence for this conclusion largely derives from pot experiments using acid soils high in exchangeable aluminium, and solution culture experiments. However there is evidence (Horsnell unpublished data) that subterranean clover is responsive to lime on similar soils in the field. The reason for this difference in response between glasshouse and field studies is unknown. However, since aluminium affects root growth and the efficiency of water and nutrient uptake\(^2,4\) the explanation may lie in differences in the supply of soil water and nutrients between the field and the pots. In pot and nutrient solution experiments, water and nutrients are usually non-limiting; this could conceivably mitigate effects of aluminium on root growth and efficiency. The work described here explored the possibility of a lime/soil water status interaction affecting the response by subterranean clover to high soil aluminium levels.

Materials and methods

An acid fine sandy loam soil developed on sedimentary rocks with a pH ranging from 4.60–5.15 (1/5 soil:water) and soil aluminium levels (extracted with 0.01 \(M\) \(CaCl_2\)) of 13.2–22.4 \(\mu g\) \(Al/g\) soil was used. It was taken from a site 80 km north of Canberra near Grabben Gullen, NSW, Australia. The soil was sieved through a 2 mm sieve and 1200 gm of soil from the 5–10 cm layer was placed in a polythene bag in an enamel pot diameter 12 cm, depth 12 cm. The treatments applied were lime at 0 or 3.6 gm/pot, and moisture levels of 100% and 70% of field capacity. There were four replicates of each treatment. Field capacity was determined on a moisture tension plate at 125 cm of water tension and by gravimetric method after 48 hours of draining. Good agreement between both methods gave field capacity to be 25% by weight of the oven dried soil.

Basal molybdenum (0.02% Mo) fortified superphosphate equivalent to 625 kg ha\(^{-1}\) and, where appropriate, the lime treatment were mixed throughout the pot. (Borax (15.4 kg ha\(^{-1}\), potassium sulphate (185 kg ha\(^{-1}\)) and zinc chloride (7.2 kg ha\(^{-1}\)) were applied in solution to the soil surface. The lime and superphosphate treatments were allowed to equilibrate for one week before the seed was sown. To promote nodulation and nitrogen fixation the seed (\textit{Trifolium subterraneum} cv Woogenellup) was inoculated, lime-pelleted and sown in two rows

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Table 1. Effect of soil moisture level and lime on the growth and chemical composition of subterranean clover

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Soil moisture % of field capacity</th>
<th>Dry weight tops gms/pot</th>
<th>Plant tops aluminium ppm (0.01 M CaCl₂)</th>
<th>Soil aluminium ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lime g/pot</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>70</td>
<td>1.62 (0.20)</td>
<td>147.5</td>
<td>15.8</td>
</tr>
<tr>
<td>3.6</td>
<td>70</td>
<td>2.43 (0.39)</td>
<td>55.5</td>
<td>1.3</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
<td>3.22 (0.51)</td>
<td>128.3</td>
<td>16.7</td>
</tr>
<tr>
<td>3.6</td>
<td>100</td>
<td>3.40 (0.53)</td>
<td>41.8</td>
<td>1.2</td>
</tr>
<tr>
<td>LSD 5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Analysis of variance

Lime 10.1*** 73.8*** 1087.0***
Moisture 48.9*** NS NS
L x M 6.4* NS NS

(figures in brackets are (log values)).
NS = not statistically significant.

across the pot in which the equivalent of 375 kg ha⁻¹ of lime: superphosphate in equal proportions had already been placed¹. Plants were sown on 1st November 1983. The pots were watered to field capacity after sowing and this was maintained until germination. After germination all pots were allowed to dry to 70% of field capacity and when the low moisture treatments reached 70% of field capacity the high moisture treatments were watered to field capacity. Pots were watered thereafter daily to weight. The pots were thinned to 8 plants/pot 14 days after sowing and harvested 51 days after sowing. At harvesting plants were acid washed in preparation for aluminium analysis¹ then oven dried at 70°C and weighed. Plant aluminium was determined by X-ray spectrometry⁴, soil aluminium by the aluminon method⁵, after 16 hours of shaking in 0.01 M CaCl₂ (1/2 soil solution ratio). Soil pH was measured as before. Analysis of variance were done on the dry weights, plant aluminium and soil aluminium data to determine the effect of lime, soil moisture and their interaction. Dry weight data was log transformed.

Results and discussion

Lime had a small effect on subterranean clover yield in the high moisture regime but a very marked effect (50% increase in yield) in the low moisture regime (Table 1). The lime x moisture interaction interaction was significant (P > 0.05) on the transformed data. Reducing the moisture supply reduced yields by 29% on the limed soil and by nearly 50% on the unlimed soil.

Lime decreased soil aluminium levels considerably, and, probably as a result, also plant aluminium; soil moisture levels had little effect. Thus although high levels of aluminium were found in plant tissue on the low lime treatments, growth was reduced only where the soil moisture regime was also low. The plant aluminium levels were above the threshold values of 120 ppm which produced growth depression of subterranean clover⁷ and within the toxic range suggested by Bouma². The lime x moisture interactions for plant and soil aluminium were not significant.

The present results suggest that aluminium, in addition to its well known harmful effect on size and function of the root system⁵,⁴, may have an additional and more indirect effect on