Soil acidity on high rainfall pastures

J.S. Yeates
D.A. McGhie
I.R. Wilson

Follow this and additional works at: https://researchlibrary.agric.wa.gov.au/journal_agriculture4

Part of the Agronomy and Crop Sciences Commons, Environmental Chemistry Commons, and the Soil Science Commons

Recommended Citation
Available at: https://researchlibrary.agric.wa.gov.au/journal_agriculture4/vol25/iss4/9

This article is brought to you for free and open access by Research Library. It has been accepted for inclusion in Journal of the Department of Agriculture, Western Australia, Series 4 by an authorized administrator of Research Library. For more information, please contact jennifer.heathcote@agric.wa.gov.au, sandra.papenfus@agric.wa.gov.au.
IMPORTANT DISCLAIMER

This document has been obtained from DAFWA's research library website (researchlibrary.agric.wa.gov.au) which hosts DAFWA's archival research publications. Although reasonable care was taken to make the information in the document accurate at the time it was first published, DAFWA does not make any representations or warranties about its accuracy, reliability, currency, completeness or suitability for any particular purpose. It may be out of date, inaccurate or misleading or conflict with current laws, polices or practices. DAFWA has not reviewed or revised the information before making the document available from its research library website. Before using the information, you should carefully evaluate its accuracy, currency, completeness and relevance for your purposes. We recommend you also search for more recent information on DAFWA's research library website, DAFWA's main website (https://www.agric.wa.gov.au) and other appropriate websites and sources.

Information in, or referred to in, documents on DAFWA's research library website is not tailored to the circumstances of individual farms, people or businesses, and does not constitute legal, business, scientific, agricultural or farm management advice. We recommend before making any significant decisions, you obtain advice from appropriate professionals who have taken into account your individual circumstances and objectives.

The Chief Executive Officer of the Department of Agriculture and Food and the State of Western Australia and their employees and agents (collectively and individually referred to below as DAFWA) accept no liability whatsoever, by reason of negligence or otherwise, arising from any use or release of information in, or referred to in, this document, or any error, inaccuracy or omission in the information.
Most of the soils of the high rainfall area of south-western Western Australia are naturally acid. The most acid group of soils, the peaty sands, have been routinely limed before subterranean clover pastures were established since research in the 1950s showed that poor Rhizobium nodulation could be overcome with the application of about 2 tonnes per hectare of coastal limesand.

Later work on the Coolup sands of the Swan coastal plain in the mid 1960s showed pasture responses to liming which were attributed to the breakdown of organic matter, and possibly legume nodulation effects in a mixed legume-grass pasture. This research also showed that the pH of the Coolup sands was related to the number of years since clearing for pasture production. Pastures older than 10 years had a pH of between 0.5 and 1.0 unit lower than new land.

In recent years farmers have increasingly reported so-called 'pasture deterioration' problems in the south-west of the State. Although there may be a number of causes of pasture decline (Gillespie, 1983), soil acidity could possibly be one of them. The lack of detailed information on soil pH of most of the area led in 1981 to the establishment of a soil acidity research programme in the high rainfall, permanent pasture areas.

Research programme

The research programme aims:
- To determine the present pH of cultivated soils, and the extent to which pH has altered since clearing.
- To examine the responsiveness of old land pastures with low pH levels to applied lime.
- To relate the responsiveness of pastures to measurable soil properties—that is to develop a test to predict the soil's need for lime.

Research work on the project was divided into three stages:
- Soil pH surveys of the high rainfall pasture areas to determine the type, distribution and extent of very acid soils.
- Field experimental work to identify lime responsive soils, and to investigate the possible use of soil tests to predict responses.

\[\text{Spreading lime on pastures. The indiscriminate use of lime can cause more plant growth problems.}\]
on high rainfall pastures

• Detailed glasshouse studies to determine the precise reasons for soil responses to lime. These will add to field information useful in the development of a test for liming soils.

The first stage of the work has finished. The second stage started in 1981 and the third in 1984.

Soil acidity surveys

Soils were sampled from farmers' paddocks and taken back to the laboratory for pH measurement. Where possible paired samples from developed and undeveloped (virgin bush) land were taken to attempt to estimate the reduction in pH since clearing. Comparisons were made only at those sites with uniform soils between cleared and uncleared areas. Because there was no adequate paddock history for most sites, the effect of age since clearing, or other factors affecting pH change, could not be assessed from the data. It is possible that lime had been applied to some developed sites.

Many of the high rainfall pasture soils were moderately to strongly acid. About half of the 920 samples collected had pH measurements of less than pH 4.8/5.5° and 10 percent were less than pH 4.3/5.0.

Generally the sandy soils had lower pH levels (were more acid) and the heavier forest soils had higher pH levels (less acid). Soils in the Albany-Walpole area had the lowest average pH levels (see table).

Estimates of the fall in pH after development for agriculture varied, but on average there was a drop of about one-third of a pH unit.

Conclusions

Most of the soils of the high rainfall area were acid, and have become more so as a result of agricultural development. However as most common pasture species, particularly subterranean clover, are tolerant of acid soils, it cannot be automatically assumed that liming these soils is necessary.

Because of the complex nature of the effects of acidity, soil tests are needed which will predict where liming responses are likely and where acidity is not affecting pasture growth, even though soil pH may be low.

Liming trials

The only practical way to reduce soil acidity is to apply lime. By applying lime, those sites on which acidity restricts pasture growth can be identified. The reasons for responses to lime can be ascertained by soil analysis and other techniques, and soil tests developed to predict other lime responsive sites.

Since 1980, there have been more than 60 field trials in the high rainfall area. The sites were selected because they were all strongly acid. They included a range of soil types from deep grey sands and peats to heavy clays and gravels. In some trials comparisons were made between lime topdressed on the surface of pastures, and lime incorporated into the topsoil using a rotary hoe. Molybdenum and magnesium were also applied as deficiencies of these nutrients can sometimes be overcome by liming.

All trials have been or will be continued for at least three years to check for delayed responses to lime. Pasture measurements are taken at least twice per season on each site.

Results

Until early 1984, pastures had responded to lime on only 28 of the 53 sites which have yielded useful results. On a number of the 28 sites, responses were small, or appeared over only part of the three-year period. There were no responses to applied molybdenum or magnesium on old land pastures. It should be remembered that the trial sites were selected because they were more acid than most paddocks.

The responses to lime were mainly restricted to soils with pH less than 4.2/4.9, but not all soils with below this figure responded to lime.

On the most acid soils (predominantly the peaty sands), subterranean clover invariably responded to lime applied to new land, or cultivated old land, but not on old uncultivated pasture. Responses to lime also occurred on other cultivated soils if the pH was less than 4.2/4.9, but responses were less predictable, and apparently dependent on cultivation techniques and pasture history. A few responses occurred at higher pH levels, but were generally transient and small.

Generally in the trials, the greatest responses to lime were on the very acid soils. On the peaty sands (pH often less than 3.5/4.5) subterranean clover yields on new or cultivated paddocks were increased tenfold by liming. Responses on other soils, all with higher pH than the peaty sands, were usually 30 per cent or less.

Responses to lime on the less acid soils may be associated with the increased soil moisture retention and reduced water repellancy influencing pasture germination and establishment. In some cases lime may also temporarily increase the amount of nitrogen available from soil organic matter.

Most of the lime responsive heavier soils (gravels, clays) had high levels of extractable aluminium which were initially believed to be partly responsible for the growth responses in subterranean clover.

*In this article the first pH measurement given is in dilute calcium chloride solution, the second in water.
However recent glasshouse experiments have indicated this may not be so. Field responses to lime on these and other soils of pH less than 4.2/4.9 are probably mainly due to improved rhizobial nodulation of subterranean clover following liming.

The influence of cultivation on lime responses on old land is believed to be due to the effects of the build-up of layers of soil rich in organic matter on the top few centimetres of permanent pasture.

On acid soils, this layer has a pH often half a unit higher than the rest of the top 10 cm of soil. Unlike the bulk soil, it is usually favourable for rhizobia survival and growth, and nodulation of the near-surface roots (Figure 1).

During pasture re-seeding or cropping operations, this higher pH surface layer is destroyed, resulting in rhizobia death or inactivation and poor plant nodulation. However clods of soil still containing active rhizobia may allow patchy nodulation, or variable responses to liming, especially at marginal soil pH levels.

Although nodulation of only the near-surface roots may restrict plant growth in dry areas, this does not appear a problem in the acid soils of the higher rainfall area, many of which remain wet or even waterlogged for much of the growing season. Sampling of subterranean clover growing in these areas has shown that 80 per cent or more of the plant’s root mass on permanent pastures is in the top 5 cm of soil, and 60 per cent commonly in the top 2.5 cm, even on non-acid soils.

Although the work so far has concentrated on subterranean clover, the same principles apply to other legumes which usually have higher pH requirements. Non-leguminous plants, such as grasses and weeds, may be sensitive to aluminium levels on the heavier acid soils, although this was not apparent in field experiments. Further work is planned with these species.

**Rates of lime**

The rate of lime needed for maximum plant growth on responsive soils depends on:
- The initial pH of the soil.
- The soil’s capacity to resist pH change (its buffering capacity).
- The final pH required, which depends on the soil type and the plant species to be grown.

On most responsive soils, two to four t/ha of lime was sufficient to achieve maximum subterranean clover growth. The pH of the top 10 cm of most soils increased by only 0.1 to 0.2 of a pH unit per tonne of first grade agricultural limestone applied.

**Figure 1. Changes in pH with depth on undisturbed, old land pastures.**

Lime applied to the soil surface increased the pH of only the top few centimetres of many soils for up to three years after application. On a few soils however, pH rapidly increased to depths of 10 cm or more. Why the soils behaved differently, and how individual soils would be expected to behave, is not yet clear.

Lime applied to the soil surface of new or disturbed peaty sand sites was about four times as effective for subterranean clover growth as the same amount of lime incorporated into the top 10 cm of soil. Nodulation and growth improved greatly, even at very low rates of topdressed lime.

**Recommendations**

Recommendations for the use of lime on high rainfall pastures are still incomplete. Sites likely to respond cannot be predicted with certainty, and the economics of using lime on responsive sites is not clear.

Subterranean clover is likely to respond to lime at the pasture development stage or after cultivation of soils of pH less than 4.2/4.9, but not on soils which are under permanent pasture. On the wetter soils such as the peaty sands, lime should not be worked into the soil unless perennial legumes are to be sown. If lime is to be incorporated, much higher rates are required.

How long a single lime application will last depends on the rate at which it is applied, the soil type, and the rate of soil acidification. At normal rates of lime, most soils will not need further applications within 10 years. Single lime applications appear to last much longer on peaty sands. However, more research is needed as most agricultural soils probably acidity with time.
Soil testing and lime test strips

Because of the initial cost and the potential problems caused by overliming—manganese, iron and possibly zinc deficiency in plants on some Western Australian soils and molybdenum toxicity in animals—farmers should test the soil for pH before applying lime.

Routine liming is recommended on new or recultivated peaty sands. On other soils farmers should apply lime test strips to pastures if the soil pH is 4.2/4.9 or less.

Subterranean clover based pastures on soils above pH 4.2/4.9 are unlikely to respond to lime, though transient responses may develop on some soils between pH 4.2/4.9 and 4.8/5.5. These responses will probably not be economic.

Test strips of lime should be applied to pastures on which observations or measurements can be made for at least two years. Unlimed adjacent strips should be left in the same paddock and treated in the same way as the limed strips. Hay paddocks are best because any growth responses to liming can easily be seen in spring.

If applied properly, test strips can avoid money being wasted on unnecessary lime, and the costly nutritional problems of overliming. Soil tests, when developed, will help improve the accuracy of lime recommendations in the high rainfall areas.

Acknowledgements

This project is funded by the Australian Meat Research Committee. Field work was conducted by Messrs. D. Tooke and M. Clarke of the Department of Agriculture’s Bunbury and Albany offices respectively.

Bibliography


Soil pH in the top 10 cm of soil on developed land in the high rainfall areas of south-west Western Australia

<table>
<thead>
<tr>
<th>Area surveyed</th>
<th>Total number of soil samples</th>
<th>Current pH Soils with pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;5.5 %</td>
</tr>
<tr>
<td>Swan coastal plain</td>
<td>390</td>
<td>161 (41) 26 (7)</td>
</tr>
<tr>
<td>Dennybrook (Jarrah forest soils)</td>
<td>112</td>
<td>25 (22) 2 (2)</td>
</tr>
<tr>
<td>Leeuwin-Naturaliste</td>
<td>159</td>
<td>77 (48) 12 (8)</td>
</tr>
<tr>
<td>Manjimup (Karri forest soils)</td>
<td>62</td>
<td>13 (21) 1 (2)</td>
</tr>
<tr>
<td>South coastal area</td>
<td>197</td>
<td>150 (76) 53 (27)</td>
</tr>
<tr>
<td>All areas</td>
<td>920</td>
<td>426 (46) 94 (10)</td>
</tr>
</tbody>
</table>

Change in pH since clearing

Number Reduction of comparisons in soil pH

<table>
<thead>
<tr>
<th></th>
<th>Number Reduction of comparisons in soil pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swan coastal plain</td>
<td>39 (0.37)</td>
</tr>
<tr>
<td>Dennybrook (Jarrah forest soils)</td>
<td>29 (0.28)</td>
</tr>
<tr>
<td>Leeuwin-Naturaliste</td>
<td>52 (0.46)</td>
</tr>
<tr>
<td>Manjimup (Karri forest soils)</td>
<td>22 (0.22)</td>
</tr>
<tr>
<td>South coastal area</td>
<td>142 (0.33)</td>
</tr>
<tr>
<td>All areas</td>
<td></td>
</tr>
</tbody>
</table>