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Walter Jacob Cox

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Potassium for Pastures

By W. J. Cox, Research Officer
Plant Research Division

Many pastures in the south-west of Western Australia are deficient in potassium or need regular dressings for maximum growth. This article indicates areas and situations in which potassium might be needed, shows how deficiency is diagnosed and gives recommended rates of application.

Large areas of pasture in the south-west of Western Australia need regular applications of potassium fertilisers for maximum growth. Recent research has again emphasised the importance of potassium in maintaining the clover component in pastures, besides enabling us to define broad areas of soil as either adequate or deficient.

Potassium (chemical symbol K) is one of the essential elements needed for growth by plants and animals. Its main role in plant growth is in the functioning of leaf pores (stomata), and as well it is essential for enzyme activity and the transport of sugars. In animals potassium is apparently associated with heart rate and appetite but deficiencies never occur in the field.

The likelihood of potassium deficiency occurring in pastures is mostly determined by available soil potassium, rainfall, and fodder conservation practices.

Soil potassium

Potassium is found in a number of forms in the soil, including water soluble, exchangeable, non-exchangeable but available, and unavailable. Water soluble and exchangeable potassium provide most of the available potassium and are usually measured when soil testing for potassium.

Peaty sands and coarse sands have little or no potassium reserve.

Plate 1—Patchy clover distribution in potassium deficient paddock.

Plate 2—Mt. Barker sub. clover, deficient leaf above, healthy below.

Plate 3—Dinninup sub. clover, deficient leaf above, healthy below.

Plate 4—Deficient Woogenellup sub. clover, marginal leaf chlorosis and pale colour.

Plate 5—Woogenellup sub. clover, very deficient leaf above, healthy below.

Plate 6—Louisiana white clover, healthy leaf above, deficient below.

Plate 7—Strawberry clover, deficient leaf above, healthy below.

Plate 8—Left, no potash, right, 180 kg/ha with increased clover content.

Plate 9—Wimmera rye grass, healthy plant on left, deficient on right.
Even some heavier textured soils (soils 3 and 4) containing 1 to 2 per cent. total potassium have only about 1 per cent. of this in an exchangeable form.

As exchangeable potassium is taken up by plants it is replenished from stocks of non-exchangeable potassium held in clay particles. The size of this reserve determines from stocks of non-exchangeable potassium taken up by plants it is replenished soils (soils 3 and 4) containing 1 to 2 per cent. total potassium have only about 1 per cent. of this in an exchangeable form.

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Especially developed potassium deficiency after the removal of hay or silage for many successive years has seriously depleted the soil's potassium reserves.

Many virgin gravelly and medium textured soils have some potassium reserves, but these are gradually depleted after development.

Soils likely to be potassium deficient are the light textured sandy soils of the higher rainfall areas, particularly the deeper sands on the coastal plain and the peaty sands of the southern coast (Figure 1). Soils with sand overlying clay or gravel may also be deficient, particularly if the surface sand is deeper than 30 cm (12 in.). Some deeper sands in medium and low rainfall areas may also be deficient.

Some heavier soils, particularly the red-brown loams around Donnybrook, Bridgetown and throughout the Blackwood valley to Nannup, are well supplied and have only occasionally developed potassium deficiency after the removal of hay or silage for many successive years has seriously depleted the soil's potassium reserves.

Many virgin gravelly and medium textured soils have some potassium reserves, but these are gradually depleted after development.

Rainfall

Unlike phosphorus, potassium is moderately mobile in soils and can be readily leached beyond the root zone under conditions of high rainfall intensity. This is particularly the case where soils have little clay or organic matter to retain potassium.

**Intensity of land use**

Land use influences the amount of soil potassium removed and thus the need for potassium fertilisers.

**Grazing**

Under grazing, most potassium from plants is returned to the soil through urine (about 80 per cent.) or dung. However, it is returned unevenly and patches are very noticeable on potassium deficient paddocks grazed by cattle. Shifts to camp areas or night paddocks can also occur. Sales of wool, meat or milk result in some small losses of potassium from the farm.

**Cropping**

As grain contains about 1 per cent. potassium a 1500 kg/ha grain crop removes the equivalent of about 30 kg muriate of potash per hectare.

**Hay or Silage**

Paddocks cut regularly for hay have a large drain placed on the soil reserves. The importance of hay cutting as a cause of potassium deficiency is readily understandable when the quantities of fodder removed and their potassium content are considered. In Table 2 several combinations of yield and potassium content have been used to calculate the amount of potassium that may be removed from a paddock. The range of potassium content covers the possibility of a low potassium hay through to a high potassium hay crop. The table indicates that a reasonable hay crop of 4000 kg/ha will probably remove 60 kg K/ha, equivalent to 120 kg/ha muriate of potash. Much of this is returned in the dung and urine where the hay is fed but not necessarily on the same paddocks from which the hay was cut.

New technology and economic pressures to increase production are likely to increase pressure on soil potassium reserves, and increase the need for additional fertiliser potassium. Irrigation and the use of autumn nitrogen on rye grass are two practices that will make the use of higher rates of potash necessary. A change in farm enterprise from sheep to cattle will also necessitate the use of more potassium fertiliser because of the extra need for hay-making.

**Detection of potassium deficiency**

Although it is evident that large areas of soils are deficient it is important to be able to predict the particular areas where a deficiency of potassium is likely. Prediction methods range from simple observation to the more complicated process of soil testing.

**Pasture appearance**

Severely potassium deficient pastures are usually characterised by their low productivity and declining

<table>
<thead>
<tr>
<th>Texture</th>
<th>Total potassium ppm</th>
<th>Exchangeable potassium ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse sand</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>Fine peaty sand</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>Loam</td>
<td>120</td>
<td>25</td>
</tr>
<tr>
<td>Clay</td>
<td>160</td>
<td>40</td>
</tr>
</tbody>
</table>

| Table 1—Total and available potassium in W.A. soils |

<table>
<thead>
<tr>
<th>No.</th>
<th>Location</th>
<th>Texture</th>
<th>Total potassium %</th>
<th>Exchangeable potassium ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bussleton</td>
<td>Coarse sand</td>
<td>0·02</td>
<td>16</td>
</tr>
<tr>
<td>2</td>
<td>Walpole</td>
<td>Fine peaty sand</td>
<td>0·06</td>
<td>34</td>
</tr>
<tr>
<td>3</td>
<td>Cundinup</td>
<td>Loam</td>
<td>1·8</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>Bridgetown</td>
<td>Clay</td>
<td>1·4</td>
<td>160</td>
</tr>
</tbody>
</table>

| Table 2—Potassium removed by hay crops of varying potassium contents (kg potassium/ha) |

<table>
<thead>
<tr>
<th>Yield kg/ha</th>
<th>Per cent potassium in hay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low (-75%)</td>
</tr>
<tr>
<td>1000</td>
<td>7·5</td>
</tr>
<tr>
<td>2000</td>
<td>15·0</td>
</tr>
<tr>
<td>3000</td>
<td>22·5</td>
</tr>
<tr>
<td>4000</td>
<td>30·0</td>
</tr>
<tr>
<td>5000</td>
<td>37·5</td>
</tr>
<tr>
<td>8000</td>
<td>60·0</td>
</tr>
</tbody>
</table>
Most soils are extremely deficient.

Sandy surfaced soils commonly deficient. Other soils develop deficiency under intensive farming.

Deficiency uncommon except on sandy surfaced soils.

Deficiency spasmodic and only on deep sands.

content of clovers and other legumes. The legume component is replaced by grasses which are more efficient in securing their potassium because of their deeper root system and an inherent ability to extract more potassium from the soil.

In mildly deficient pastures there is still some clover present but it is generally patchy with some areas growing normally while others grow slowly if at all. This uneven appearance (Plate 1) is mainly caused by excreted potassium in urine and dung patches.

In instances of more severe deficiency the clover plants may be only sparsely scattered throughout the pasture. In such cases the only healthy clover is associated with dung and urine patches from which the plant derives sufficient potassium for normal growth. In cases of severe potassium deficiency grass production is also markedly decreased because of the reduced availability of soil nitrogen previously supplied by the legumes. With extreme deficiency, grass production is further reduced because of a shortage of potassium for the growth of grasses. The result is an extremely poor pasture with a very low carrying capacity.

Deterioration in pasture composition and productivity is not only caused by potassium deficiency. Sulphur or molybdenum deficiency,
and poor grazing management, may cause the same general symptoms on pastures adequately topdressed with superphosphate. Because these symptoms are not specific for potassium deficiency more reliable indicators are needed.

**Specific plant symptoms**

The simplest way to identify potassium deficient pastures is to diagnose deficiency symptoms in individual clover plants—preferably on whole plants in late spring. The symptoms for each cultivar vary to some degree—

Mt. Barker—The leaves pale from the edges and turn a dull yellow. A fine spotting develops on the leaf surface and the spots can join up to form necrotic areas which are often mistaken for insect damage (Plate 2).

Dinninup—Symptoms similar to Mt. Barker except that the spotting is much more prominent (Plate 3).

Woogenellup—Very pronounced marginal leaf scorch with little spotting except under severe deficiency conditions (Plates 4 and 5).

White clover—Leaves become a uniform pale green colour followed by marginal leaf scorch. Some spots develop mainly near the leaf margins (Plate 6).

Strawberry clover—Very pronounced marginal leaf scorch with no spotting (Plate 7).

Rye grass—Yellow-red discolouration starting at the leaf tip and gradually moving down the leaf along the margins (Plate 8).

In all varieties and species the older leaves show the symptoms while the younger leaves appear quite healthy. Although the different varieties show different specific symptoms there is a general reduction in leaf size (Plates 3, 5, 6, 7, 8) and a change in leaf colour from dark green to dull yellow in severely deficient plants. Finally the older leaves scorch completely and die rapidly. Deficient plants generally set a reduced amount of seed or in the more severe cases fail to set seed.

Often symptoms are not clearly defined or are complicated by insect or mite damage or other nutrient deficiencies which make it necessary to follow up with plant analysis to verify or determine the cause of specific symptoms. Plant analysis is also useful in cases of sub-clinical deficiency where there are no gross symptoms but where the addition of potash will result in yield increases.

**Plant analysis**

A more objective way of identifying deficient pastures is by plant analysis or “tissue testing” which quantitatively determines the concentration of an element in part or all of the plant. Knowing the levels of deficiency, sufficiency and excess, as established by calibration trials and experience, it is possible to define the potassium status of the plant. Deficient clover plants up to 8 weeks old generally contain less than 1.5 per cent. potassium and less than 1 per cent. when older than 10 to 12 weeks. Plant analysis is the only way to verify pasture symptoms but it has the drawback of being expensive. An additional problem is that the confirmation is generally received too late for corrective measures to be taken in the same growing season.

**Soil testing**

Analysis of representative soil samples taken from suspect paddocks is the most convenient way of predicting probable pasture deficiency. The analysis tells us that the soil contains a given quantity of extractable potassium and to attach meaning to this we use information obtained from trials relating soil potassium levels with pasture responses to potash. When calibrated with pasture responses, soil testing is a way of predicting the amount of potash fertiliser required on a particular soil type.

In using the potassium soil test it is important to recognise from the start that it will not tell us exactly how much potash should be applied in any one year. Pasture yield response is dependent on many other factors such as rainfall, temperature, earliness of the break-of-season, and the amount of other available nutrients in the soil. However, used sensibly a soil test can help decide the amount of fertiliser potassium to apply.

Because a soil test is the main method by which we can tell in advance whether potassium deficiency is likely to arise, a considerable amount of research is being conducted by the Department in providing a calibration programme for high rainfall pastures. In 1972, 40 rate of potash calibration trials were conducted. Another 40 are in progress this year with a further 21 planned for 1974.

### Table 3—Recommended rates of muriate of potash — kg/ha

<table>
<thead>
<tr>
<th>Soil description</th>
<th>Severity of deficiency</th>
<th>Management during previous year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grazed*</td>
</tr>
<tr>
<td>Sandy textured with clay deeper than 30 cm</td>
<td>Not deficient—maintenance dressing</td>
<td>30–40</td>
</tr>
<tr>
<td></td>
<td>Mildly deficient</td>
<td>60–80</td>
</tr>
<tr>
<td></td>
<td>Severely deficient</td>
<td>150–180</td>
</tr>
<tr>
<td></td>
<td>Not deficient</td>
<td>Nil</td>
</tr>
<tr>
<td></td>
<td>Mildly deficient</td>
<td>30–45</td>
</tr>
</tbody>
</table>

* some variation in rates depending on type of animal enterprise.
† insufficient growth for hay cutting.
Recommendations

Once deficient soils and pastures have been identified we need, of course, to know how much potash to apply to overcome the deficiency and increase production. The optimal fertiliser dressing depends on the soil type and other factors influencing pasture yield response to applied potash, as well as economic considerations.

Recommendations are summarised in Table 3 but it is probable that these will be altered when the calibration programme is completed in 1974.

In cases of severe potassium deficiency where there is no clover in the sward the addition of potash alone will not solve the problem. In such cases it is essential to reseed the pasture with clover using 60 kg/ha of muriate of potash at seeding and an additional 90 kg/ha later in the season. This is in addition to the normal rates of superphosphate used to provide phosphorus and sulphur.

In less severe deficiency cases about 60 kg/ha potash should alleviate any problems. Once the deficiency has been overcome routine maintenance applications of 30 to 40 kg/ha annually will provide adequate potassium for grazed pastures with higher rates for old hay paddocks.

On fertile clay or loam soils there is little likelihood of deficiency and routine topdressing is not warranted. However, if there is any doubt, it may be advisable to run test strips of 50 and 100 kg/ha potash in the hay paddocks (so that any growth differences can be observed) to indicate if benefit may be obtained from topdressing with potash.

The recommended rates give excellent clover responses (Plate 9 and Table 4) and result in additional protein feed for animals as well as a build-up of soil nitrogen which can lead to a subsequent increase in the production and quality of the grass component of the pasture—particularly rye grass.

It is important to remember that it is a waste of time applying potash to improve clover growth if all the pasture is not utilised. On understocked pastures it may pay to use low quantities of both superphosphate and potash.

Time of application

Potassium is readily leached from sandy soils, particularly those which are waterlogged during winter. On such soils a split dressing applying part in autumn and the remainder in spring may be more effective. Provided paddocks can be traversed and there are 6 to 8 weeks of the growing season remaining, a potash application after the winter rains may be worthwhile for spring growth. On these soils, sulphur deficiency is often associated with the potassium deficiency and a mixture of super-potash is suggested. For all other situations autumn topdressing appears to be best.

Alternative sources of potassium

Although muriate of potash is the commonly recommended source of potassium, others are available but they are more expensive (Table 5).

Sulphate of potash is preferred for some crops which are sensitive to chloride. On the basis of price per 100 kg K there is no case for the use of sulphate of potash on pastures.

Langbeinite is a mixed potassium-magnesium sulphate that will shortly be produced at Lake McLeod, north of Carnarvon. As the majority of W.A. soils have adequate magnesium no benefit would derive from this component of the fertiliser but it could be useful as a fertiliser if competitively priced.

Problems regarding the use or need for potash on pastures should be discussed with district advisers of the Department of Agriculture, who can interpret the recommendations to suit particular situations.

Acknowledgments

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Further reading

