Journal of the Department of Agriculture, Western Australia, Series 4

Volume 25
Number 4 *1984*

Article 4

1-1-1984

The effects on plant growth

W M. Porter

J. S. Yeates

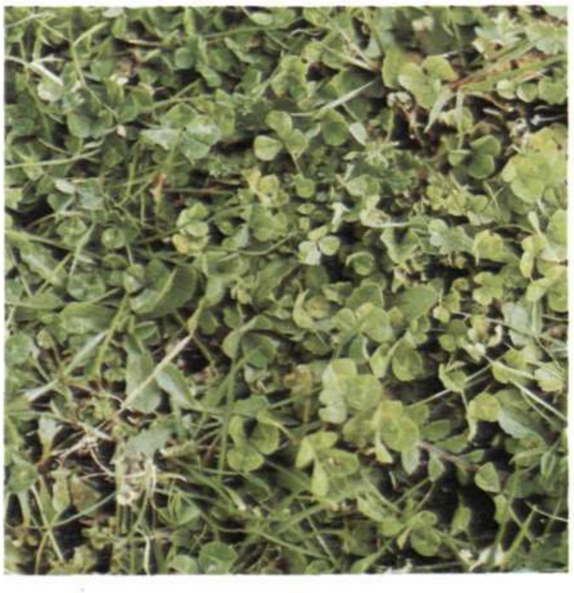
The effects on plant growth

By W. M. Porter, Research Officer, Dryland Research Institute, Merredin and **J. S. Yeates,** Research Officer, Division of Plant Research

The level of acidity of a soil reflects its chemical and sometimes its biological condition. Changes in acidity mean changes in the availability to plants of some soil elements, and modifications to the biological processes in the soil.

Some elements become more available to plants in acid soils, and in some soils particular elements can reach toxic levels. Other elements can be affected in the opposite way: deficiencies can develop in acid conditions.

It is important to realise, however, that the chemical nature of all soils varies. Because of these variations, acidity can affect each soil differently and thus influence plant growth differently.



■ Top: Iron deficiency in clover induced by over-liming a Denmark soil; and (above) manganese deficiency in clover.

Problems of acid soils

Although acidity is usually measured using the pH scale, it is not possible to simply measure the pH and predict which, if any, problems will occur on a particular soil. Similarly liming to reduce acidity may affect soils differently, and in some soils may be detrimental to plant growth (Table 1).

Equally as important is the knowledge that different plant species have different tolerances of acid soil conditions, particularly high levels of soluble aluminium (Table 2).

Lucerne, for example, is poorly adapted to many acid soils, but subterranean clover is tolerant of many problems related to soil acidity. Because most Western Australian soils are slightly to moderately acid in the virgin state, many of the agricultural plants grown here are relatively acid tolerant. Many liming strategies used outside the State, therefore, are not appropriate to local conditions.

The potential effects of soil acidity and liming on plants are shown in Table 1. Research has indicated that aluminium toxicity, molybdenum deficiency and rhizobial growth and nodulation of legumes are significantly affected by acid soils here, but even these problems develop only in specific situations and not on all acid soils.

On some soils, such as the eastern wheatbelt acid sandplain, the levels of aluminium, which is not necessary for plant growth and can be toxic, increase in proportion to increasing acidity. But on the sandy soils of the high rainfall areas even soils of extemely low pH contain little plant available aluminium. These differences in aluminium levels in soils of the same pH illustrate the need for a thorough understanding of particular soil conditions before correcting a soil's acidity.

■ South coastal pasture with manganese deficiency showing up as yellow patches.

Table 1. Restraints to plant and animal production on acid soils and the effects of applying lime.*

Growth restraint	Effects of acidity	Effects of applying lime	Occurrence in Western Australia
Aluminium	Plant availability increases markedly below pH 4.6/5.0, and can be toxic. Damages roots which may limit exploration for water or nutrients. Reduces the ability of roots to take up phosphate.	Reduces availability and can overcome toxicity.	Probably the main cause of reduced root growth in acid, wheatbelt sub-soils. Possibly also important in acid soils of high and medium rainfall zones. But many sandy soils have low levels of aluminium even at low pH.
Manganese	Plant availability increases markedly below pH 5.0/5.5.	Reduces availability.	Toxicities are not known to occur here. Deficiencies have often been induced by applying lime.
Molybdenum	Fertiliser molybdenum is quickly converted to unavailable forms in acid soils.	Increases availability of previously applied molybdenum. Very high levels in pasture can induce copper deficiency in ruminants.	Fertiliser molybdenum has a low residual value in acid soils of the wheatbelt. Deficiency is uncommon in higher rainfall areas after initial application.
Phosphorus	Plant availability can be reduced by effects of aluminium (see above). However effects are variable and can be opposite to above.	Variable. Can increase, decrease or not affect phosphorus availability in different situations.	Factors other than acidity are usually more important in determining availability.
Calcium	Deficiencies can develop because acid soils may contain only small amounts of calcium which are poorly available to plants.	Supplies calcium and increases its availability.	Probably rare.
Magnesium	As for calcium	Deficiency can worsen because calcium from lime reduces the magnesium uptake by plants.	Deficiency occurs in some very acid soils of the eastern wheatbelt. Rare elsewhere.
Zinc and iron	Highly available to plants; no toxicities occur.	Reduces availability and can induce deficiencies on some soils.	Lime induced deficiencies have been observed in the eastern wheatbelt for zinc and on the south coast for iron.
Potassium and copper	Little or no effect.	Little or no effect.	
Organic matter nitrogen, phosphorus and sulphur	Slows the rate of organic matter breakdown because soil microbes are less active in acid soils.	Increases microbial activity and breakdown rate, sometimes releasing nitrogen phosphorus and sulphur. This extra supply of nutrients is usually short-lived.	Some variable occurrence on most acid soils.
Rhizobium spp.	Acidity influences rhizobial survival, ability to form nodules and fix nitrogen. Rhizobia types vary widely in their tolerance of acid soils.	Can improve nodulation if pH is limiting rhizobial growth or legume nodulation.	Medics are limited to high pH soils because their rhizobia cannot tolerate acidity. Sub. clover has problems on unlimed peaty sands in high rainfall areas, and other high rainfall acid pasture soils under certain conditions.

*In this table the first pH measurement given is in dilute calcium chloride solution, the second in water.

Table 2. Tolerance of different plant species to aluminium

Species	Tolerance of aluminium toxicity
Annual medics Lucerne Barley	Extremely sensitive
Phalaris Rapeseed White lupins (*Lupinus albus*) Wheat	Sensitive
Subterranean clover White clover Rose clover Serradella	Moderately tolerant
Narrow leaf lupin (*Lupinus angustifolius*) Ryegrass Oats Triticale	Tolerant
Cereal rye	Extremely tolerant