10. Aluminium

Aluminium is not essential for the growth of plants or animals. Aluminium toxicity has not been detected in grazing animals but plant growth, particularly growth of seedlings, can be greatly harmed by high levels of exchangeable soil aluminium.

Aluminium is a major constituent of most soils but only when it moves into soluble or exchangeable form can it affect plants. Exchangeable aluminium values may be high in soils with pH below 5.5 but may occur at pH values as high as 6.0 in heavy-textured soils (Brown and Johnston 1982). The critical soil pH, at which aluminium becomes exchangeable in toxic concentration, depends on many factors, including the predominant clay minerals, organic matter level, concentrations of other cations, anions and total salts as well as the species or cultivar of the plant being considered.

Species differ widely in their tolerance of excess aluminium. Lucerne and phalaris are highly sensitive. Subterranean clover, white clover and perennial ryegrass are moderately tolerant, while cocksfoot is tolerant (Cregan 1980).

10.1 Occurrence of aluminium toxicity in Victoria

High levels of exchangeable aluminium have been found in soils derived from granite and sedimentary rocks in North East Victoria, sandy soils in East Gippsland (Kehoe and Curnow 1963), krasnozems across Victoria and in peaty soils in Western Victoria.

Surface and sub-surface soils with exchangeable aluminium greater than 50 mg/kg (extractant 1M KC1) are shown in figure 10.1. About 25% of all samples tested have had aluminium values greater than 50 mg/kg (Brown and Johnston 1982).

10.2. Signs of aluminium toxicity in plants

The signs of aluminium toxicity may resemble those of phosphorus deficiency (overall stunting; small, abnormally dark green leaves; purpling of stems, leaves and leaf veins; and yellowing and death of leaf tips). Aluminium-injured roots are characteristically stubby and spatulate, while the root tips are thickened and may be brown. The root system as a whole has many stubby lateral roots but lacks fine branching. Aluminium-damaged roots are inefficient in absorbing water and nutrients (Cregan 1980, Mahoney 1982). Their appearance can be easily confused with that of malformed roots growing in compacted soil.

10.3 Diagnosis of aluminium toxicity in plants

The diagnosis of aluminium toxicity from visual signs in plants is unreliable (Pratt 1966), and critical plant concentrations of aluminium are ill-defined. The aluminium concentration in leaves of Lucerne is of little value in determining toxicity (Bouma *et al*. 1981). A value above 150 mg Al/kg DM in sub clover leaves may indicate toxicity (Bouma *et al*. 1981).

Soil exchangeable aluminium concentration is used as a guide to the likelihood of aluminium toxicity in lucerne. Aluminium levels greater than 15 mg/kg may be a problem and above 50 mg/kg toxic, in which case the economics of liming should be considered to overcome this problem (Peverill *et al*. 1980, Mahoney, *et al*. 1981). The soil test has not been adequately correlated in the field for any other plant species in Victoria.

Interstate workers have expressed exchangeable aluminium as percentage saturation of the cation exchange capacity and have correlated their tests with subterranean clover response (Kamprath 1978, Helyar 1979). Tentative critical levels have been suggested for other pasture and crop species (Cregan 1980, Helyar 1979).

10.3.1 Analyses available

Analysis for exchangeable aluminium concentration in soil is available from the State Chemistry Laboratory.

Plant analysis for aluminium is not yet available for diagnostic use.

10.4 Treatment of aluminium toxicity in plants

Broadcast application of lime, when cultivated into the soil, is effective in reducing aluminium toxicity, but only in the surface soil (0-15 cm depth). A guide to lime requirement has been estimated for dryland lucerne in North East Victoria (table 10.1), but no data are available from other parts of the State or for pastures (Peverill *et al*. 1980).

Table 10.1: Lime requirements for dryland lucerne in NE Victoria (Peverill *et al*. 1980)

Exchangeable aluminium (mg/kg)	Lime requirement (t/ha)
0-15	0
15-50	0.5-1.0
50-100	1.0-2.5
100	(Possibly not economic)

Sub-soil levels of aluminium are also important to lucerne. Where exchangeable aluminium exceeds 100 mg/kg in the sub-soil, it is unlikely that lucerne can be grown successfully even where lime is worked into the surface soil, because sufficient lime will not move into the subsoil to significantly reduce the aluminium level (or that of manganese for that matter) (Mahoney *et al*. 1981).

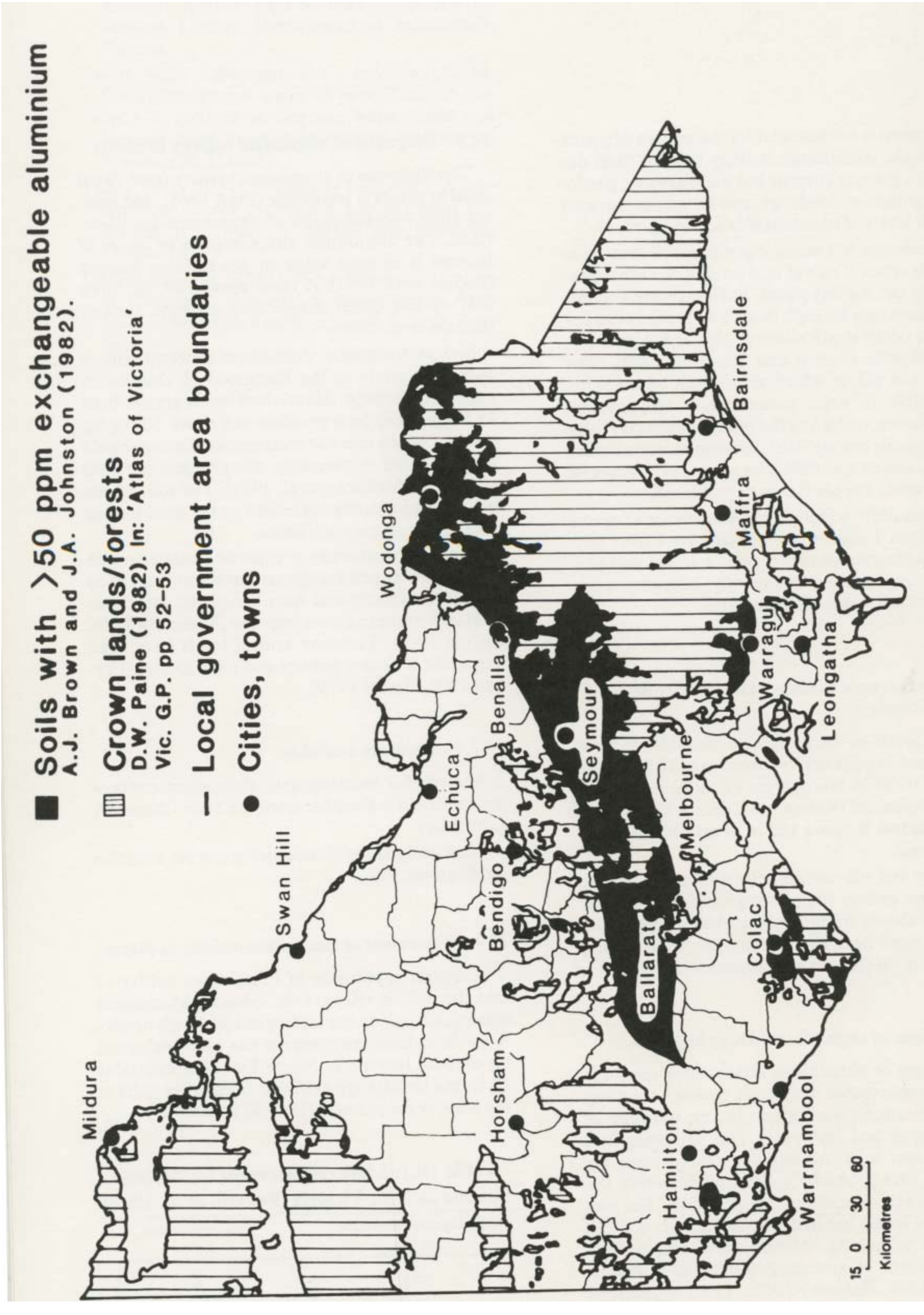

Figure 10.1: Location of Victorian soils with exchangeable aluminium greater than 50 ppm (1M KCl extract) in the surface or sub-surface (Brown and Johnston 1982).

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Two-year-old lucerne at Strathbogie growing well only where limestone was applied to a "high-aluminium" soil.

Good clover growth only occurred where lime was applied to plots on this very acid soil. Lime responses are sometimes due to resulting reductions of toxic levels of aluminium or manganese in soils. In other soils lime mainly helps clover nodulation.

Heavy burdens of internal parasites can lead to an anaemia similar to that caused by inadequate iron intake, and a general illthrift similar to marginal intake of a range of trace elements.

Lucerne leaves showing typical signs of boron deficiency.