9. Manganese

Manganese is required for healthy growth of plants and animals.

In animals, manganese is required for carbohydrate and lipid metabolism and for growth, reproduction and skeletal development (Underwood 1981).

In plants, manganese is involved in chlorophyll synthesis and the activity of oxidase enzymes. Concentrations of manganese required for optimal growth of pasture species are in general higher than the dietary requirements of animals. Therefore, although manganese deficiency has been recognised in plants growing in many areas of the world, manganese deficiency in grazing animals is generally regarded as a rare occurrence (Underwood 1981).

Manganese toxicity is a significant problem for both plants and animals in Victoria.

9.1 Occurrence of manganese deficiency in Victoria

Plant deficiency of manganese is confined to neutral and alkaline soils, but can be induced by excessive liming of acid soils. In Victoria, there is no evidence of manganese deficiency affecting pasture growth despite considerable field experimentation.

There have been no confirmed cases of manganese deficiency in grazing animals in Victoria. In general, manganese concentrations in herbage are not low enough, that is, not less than 25 mg/kg DM, to indicate potential animal deficiency. Less than 1% of ingested manganese is normally absorbed by cows. Overseas studies have suggested that high dietary concentrations of calcium, phosphorus and iron reduce the availability of ingested manganese, and may contribute to a "conditioned" manganese deficiency in livestock (Underwood 1981).

9.2 Signs of manganese deficiency

Decreased growth of subterranean clover occurs with manganese deficiency, and stunting is more apparent in the roots than the tops. The leaves develop interveinal yellowing followed by brownish-grey necrotic spots. These signs develop first near the petiole, then expand out towards the leaf margin. The younger leaves fail to develop and are severely necrotic (Millikan 1953, Tyson 1954). Similar signs are seen in white clover and lucerne (Millikan 1958).

Oats are particularly sensitive to manganese deficiency, which causes the condition commonly known as "grey speck" due to grey spots on the leaves. Deficiency is also apparent as a kinking of the leaf near its base while the top is still green, followed by failure to flower and seed (Leeper 1970). In rape, manganese-deficient interveinal chlorosis develops particularly in the older leaves (Mason and Gartrell 1972).

In livestock, manganese deficiency has been associated with signs of impaired growth and bone development, gait abnormalities in newborn calves and lambs, and failure of conception in ewes and cows (Underwood 1981).

9.3 Diagnosis of manganese deficiency

9.3.1 Plants

Plant levels of manganese in Victoria have ranged from 13 to 19100 mg/kg DM, with mean values ranging from 120 to 200 for pasture plants and most field crops but 440 for sunflowers and 5200 for lupins (Brown 1982). A critical concentration of 25 mg/kg DM has been suggested as the mini-mum amount of manganese for healthy growth of flowering subterranean clover (Tyson 1954) but this has not been confirmed in Victoria. For species particularly sensitive to manganese deficiency, such as Algerian oats, the critical concentrations appear to be in the range of 10 to 15 mg Mn/kg DM (Leeper 1970).

9.3.2 Livestock

The manganese concentration in the diet provides the most useful means of detecting deficiency in animals. Diets containing 40 mg/kg DM are considered adequate (Underwood 1981), and many suspected deficiencies can be eliminated using this criterion. Where dietary concentration is below this, direct measurement of actual animal status is preferred.

Manganese concentrations in the liver of sheep are related to dietary manganese concentrations over the range from deficiency to toxicity (Paynter 1983); where the concentration is less than 100 umol/kg (6 mg/kg) DM, supplementation trials are indicated (Egan 1975). It should be noted that lambs normally have higher liver manganese concentrations than adult sheep (Paynter and Caple 1984).

The manganese concentration in blood declines in animals fed low manganese diets (Underwood 1981), but this is not a good diagnostic criterion. Very low concentrations of manganese are normally present in the blood of sheep and cattle, less than 0.1 umol/l, making sampling highly susceptible to contamination from collection vessels. Specialised techniques are also required to measure these low concentrations (Paynter 1979). Similarly, wool manganese is of limited value in the assessment of manganese status of sheep (Egan 1975), because of its insensitivity to dietary manganese changes and because of problems due to sample contamination (Paynter 1982).

9.3.3 Soils

Soil analysis is not regarded as a satisfactory diagnostic approach to assessment of the manganese nutrition of plants or animals, due to the complexity of the soil chemistry of manganese. For example, available manganese concentrations in soil change considerably when moist soil samples dry out (Leeper 1970).

9.4 Treatment of manganese deficiency

In the Netherlands, manganese sulphate top-dressing at 15 kg/ha has been used effectively to overcome a manganese deficiency in plants (Underwood 1981). This rate was commonly used in pasture field trials conducted by the Department of Agriculture during the 1950s and 1960s when the trace element status of Victorian pastures was being assessed. No responses to manganese were observed at any of the sites tested in Victoria.

For animals, supplementation of the feed with manganese sulphate at 4 g/cow, 2 g/heifer or 1 g/calf, daily, will prevent manganese deficiency (Underwood 1981).

9.5 Occurrence of manganese toxicity in Victoria

Manganese toxicity in plants is of importance in Victoria (Millikan 1958). Toxicity is confined to acid soils inherently high in manganese, and has been recognised in pastures (Cameron 1963) and lucerne (Avery 1963, Mahoney 1982) in north-eastern Victoria, and in rape in the Ballarat area (Newman 1963).

Plants absorb manganese in the reduced or divalent form, the formation of which is favored by low soil pH and by inadequate soil aeration. Inadequate soil aeration can result from poor drainage, that is, waterlogging, or soil compaction, and can lead to manganese toxicity even in only slightly acid soils. Apple and pear trees suffered from manganese toxicity on soils of pH 6 after a very wet year in the Goulburn Valley (Leeper 1970). Hot dry conditions have also been shown to increase the availability of the divalent form of manganese, even with quite high soil pH (Leeper 1970). It is evident that "pulse" releases of available soil manganese due to environmental conditions may be a problem at particular times, but may not be a problem during the remainder of the year (Cregan 1980).

Manganese toxicity may occur in conjunction with aluminium toxicity in very acid soils (Cregan 1980, Mahoney *et al*. 1981). However, it is possible to have manganese toxicity at a soil pH which is too high for aluminium toxicity to affect plant growth.

Manganese toxicity can occur in grazing animals in Victoria. Toxicity may be associated with the grazing of lupins, particularly *Lupinus albus,* which accumulate high concentrations of manganese in the herbage and grain (Smith 1982, Brown 1982). Manganese toxicity in most pasture species is observed at plant concentrations of 500 to 1000 mg/kg DM (see section 3.1). In contrast, sheep body weight and wool growth are unaffected at up to 2500 mg/kg dietary dry matter (Paynter 1983).

9.6 Signs of manganese toxicity

Plant species differ in their tolerance of high soil levels of available manganese (Cregan 1980, Andrew and Hegarty 1969). Lucerne, annual medics, strawberry clover and crucifers are highly sensitive (Cregan 1980). Subterranean clover is less sensitive, while ryegrass is highly tolerant. Plant varieties within a species also differ in tolerance; such differences have been reported in lucerne and wheat (Cregan 1980). Lucerne seedlings are more susceptible than mature plants, particularly following hot, dry weather.

Plants suffering from manganese toxicity usually show a chlorosis of leaves and stunted growth. In lucerne, there is a marked yellowing of the distal margins of the oldest leaves. Dark brown, necrotic spots may occur in the yellow areas (Millikan 1958).

In subterranean clover, signs of manganese toxicity appear in late autumn, initially as a light-brown discoloration of the leaf margins which later change to a reddish color. Youngest leaves may become yellow. With severe toxicity marginal necrosis may be seen in the youngest leaves and severe stunting and even death of plants may occur (Millikan 1953). Signs of manganese toxicity in subterranean clover can be easily confused with those of water-logging or root rot; plant manganese analysis should be used for a differential diagnosis. Combined infections of root rot fungi and manganese toxicity have affected subterranean clover in north eastern Victoria (Cameron 1963).

Although manganese toxicity may affect root growth (Millikan 1953, 1958), the effects are far less apparent than those observed with aluminium toxicity. In severe cases of manganese toxicity, browning of the roots becomes apparent after visible foliar damage.

9.7 Diagnosis of manganese toxicity

9.7.1 Plants

Toxic concentrations of manganese in plants are not well defined, and can vary with both cultivar and the environment (Cregan 1980). Suggested toxic concentrations are within the range of 200 to 400 mg/kg DM for most annual medics, 400 to 500 mg/kg DM for lucerne seedlings, strawberry clover and barrel medic, 500 to 1500 mg/kg DM for white and subterranean clover, oats and wheat, and 1500 mg/kg DM for most other pasture species (Cregan 1980). The considerable sensitivity of medics and fodder rape to high levels of manganese can assist in identifying problem soils.

Smith *et al* (1983) in New Zealand have established concentrations of manganese at which growth was reduced by 10% of 340, 570 and 1110 mg/kg DM for lucerne (cv. Wairau), white clover (cv. Grasslands Pitau) and ryegrass (cv. Grasslands Nui) respectively.

9.7.2 Livestock

Toxicity in animals, as well as deficiency, can be assessed from either dietary or liver concentrations of manganese. Dietary concentrations of greater than 4000 mg Mn/kg DM and liver concentrations greater than 200 umol/kg wet weight have been associated with toxicity (Smith 1982).

9.7.3 Soils

Soil analysis is not regarded as a satisfactory diagnostic approach to assessment of the manganese nutrition of plants or animals, due to the complexity of the soil chemistry of manganese.

9.8 **Treatment of manganese toxicity**

Where manganese toxicity is a problem the application of lime worked into the soil to a depth of 100 to 150 mm should be considered. The amount of lime required varies with the pH of the soil, its texture and its content of organic matter (Mahoney et al. 1981). In New South Wales, the aim of treatment is to raise the pH (of a mixture of one part soil to two parts water) above pH 5.6 (Cregan 1980). As several tonnes/ha of lime may have to be used, the economics of the practice must be assessed carefully. A reduction in waterlogging or heavy phosphorus fertiliser application can also alleviate manganese toxicity, but liming is usually the preferred approach.

Where manganese toxicity is threatening the survival of lucerne seedlings, removal of the leaves by grazing or mowing at that time can alleviate the problem and allow establishment (Mahoney 1977).

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