2. Molybdenum

Molybdenum is an essential element for both plants and animals.

In plants, molybdenum is required for protein synthesis through the metalloenzyme, nitrate reductase. In legumes, molybdenum is also required for the fixation of nitrogen by the *Rhizobium* bacteria in root nodules, and clovers are more often affected by molybdenum deficiency than grasses. Molybdenum toxicity is not thought to be significant in plants.

In animals, molybdenum is a component of several metalloenzymes, in particular xanthine oxidase which catalyses the breakdown of purines to uric acid. A primary molybdenum deficiency has never been reported in livestock (Underwood 1977); however, molybdenum toxicity can occur in the form of a molybdenum-induced copper deficiency (molybdenosis).

2.1 Occurrence of deficiency

Molybdenum deficiency has limited pasture growth and consequently animal production over wide areas of Victoria. The earliest pasture response was recorded late in 1944 on trial strips at Seville, and molybdenum deficiency in pastures became widely identified in the early 1950s. Pasture aspects were extensively reviewed by Savage in 1974 so only major points are repeated here.

Deficiency is restricted to acid soils and occurs most frequently, but not only, in the hilly areas of the State (figure 2.1). Parent rock of these soils may be granite, basalt or sedimentary (sandstones to slates).

Molybdenum toxicity has been diagnosed in livestock grazing pastures on reclaimed coastal swamps, for example South Gippsland, and inland peat swamps in the Western District. These soils are naturally high in molybdenum and are associated with molybdenum concentrations greater than 20 mg/kg DM in the herbage. Molybdenosis has also been caused occasionally by excessive application of molybdenum fertiliser to pasture.

2.2 Signs of molybdenum deficiency

Commonly, the only sign of a molybdenum deficiency in pasture is poor growth despite adequate applications of other fertilisers (Savage 1974). In more severe cases, symptoms of nitrogen deficiency are evident because of the role molybdenum plays in nitrogen fixation and protein synthesis. Grasses suffering from molybdenum deficiency are stunted and pale or yellow-green. Pasture legumes are also stunted with pale green or yellow leaves. Stems and petioles may be reddish-brown. Molybdenum-deficient clover plants may be only 20 mm to 50 mm in diameter at maturity but can still set viable seed.

A molybdenum deficiency does not restrict the initiation of nodules on legume roots, but does affect the functioning of the nodules which, on deficient plants, are smaller and more numerous than on healthy plants. Nodule appearance is not a definitive guide to molybdenum deficiency although the tissue of deficient nodules may be white or green instead of the normal healthy pink color (Savage 1974).

Brassicas are particularly sensitive to molybdenum deficiency, developing "whiptail" leaves, where the leaf is much narrower than usual.

2.3 Diagnosis of molybdenum deficiency

The recommended guide to pasture need for molybdenum is the use of fertiliser test strips. On small strips, up to 20 m in length, the molybdenum is most accurately applied in solution, using 0.5 g ammonium molybdate or sodium molybdate in 4 litres of water to a 20 m x 2 m strip.

Super-molybdenum mixtures can also be used, particularly where large strips are treated using a seed drill. A control strip of plain super applied at the same rate is essential for comparison in this case.

Attempts have been made to diagnose molybdenum deficiency by plant analysis. The concentration of molybdenum in clover in Victoria ranges from less than 0.1 to more than 4 mg/kg DM, with 60% of samples analysed containing 0.5 mg/kg DM or less (Brown 1982). Skene considered that plant molybdenum levels were an unreliable guide to molybdenum response because some "normal sub clover" was found to contain 0.1 mg/kg, which was at the limit of detection (Skene 1964). More recently, Shovelton found that sub clover on responsive sites generally contained molybdenum at 0.1 to 0.2 mg/kg but he also obtained responses at 0.4 and 0.5 mg/kg. No response occurred at sites where molybdenum concentrations in sub clover ranged from 0.3 to 1.7 mg/kg (Shovelton 1982). Savage (1982) found a better correlation for white clover, as most responsive sites contained less than 0.5 mg/ kg. Molybdenum analysis of plant tissue is available from the State Chemistry Laboratory.

Soil analysis has not been a satisfactory method for diagnosis of molybdenum deficiency and is not available from the State Chemistry Laboratory.

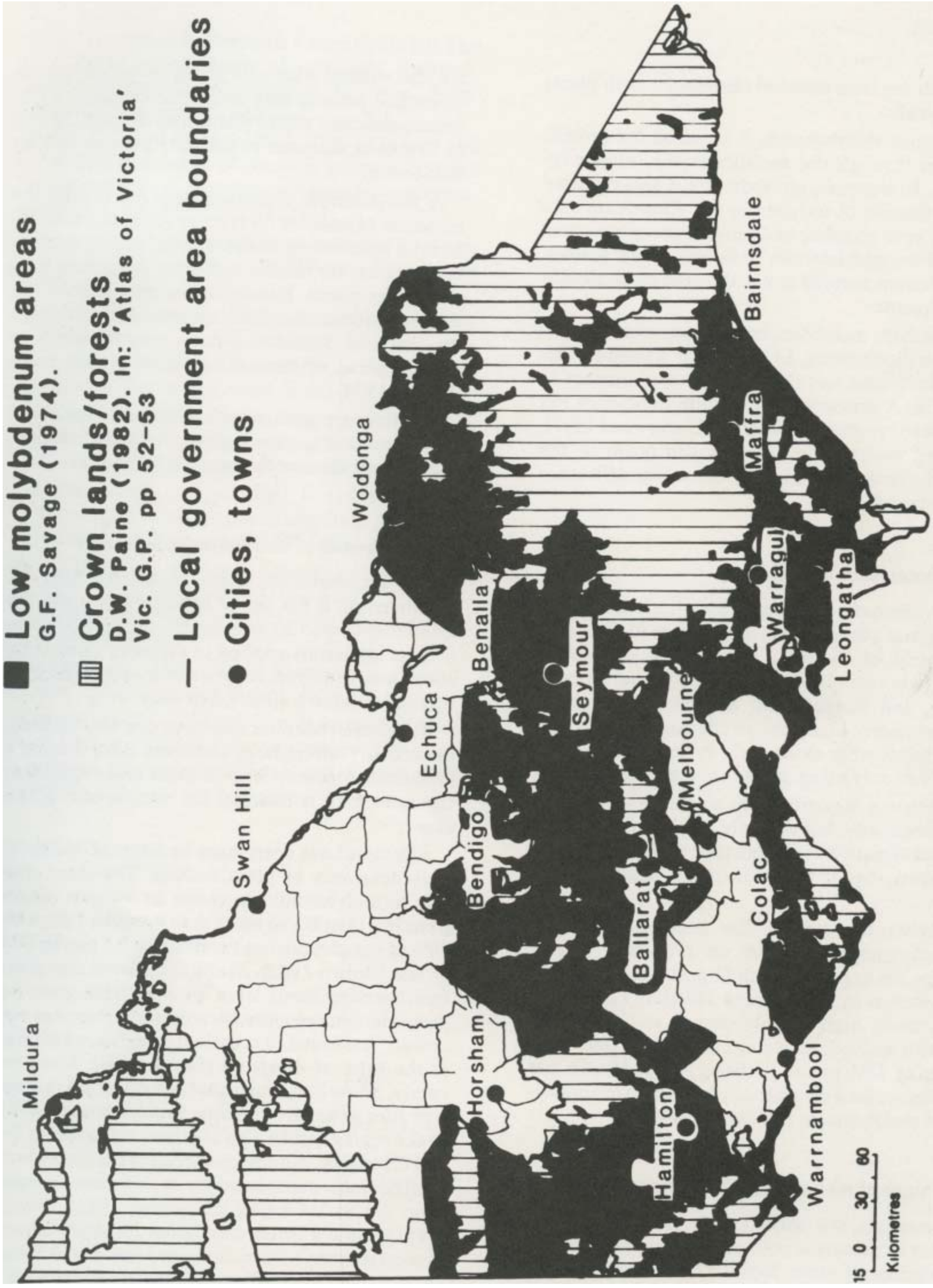

Figure 2.1: Areas where there have been pasture responses to molybdenum in Victoria, based on the data published by Savage (1974). Molybdenum has been widely applied in these areas.

2.4 Treatment of molybdenum deficiency

Molybdenum deficiency in pastures is treated by applying molybdenum compounds, ready-mixed in fertilisers, at 50-60 g of elemental Mo per hectare (Savage 1974). Molybdenum and superphosphate mixtures, for example, are currently available with molybdenum contents of 0.10, 0.05, 0.025 or 0.015%. The molybdenum concentration chosen depends on the desired application rate of other nutrients in the mixture.

Molybdenum does not need to be applied every year. Usually once every eight to 10 years is sufficient except in very high rainfall areas (above 1000 mm annually) or on high phosphorus-fixing soils, for example, red clay loams of the Krasnozem type. In these special situations molybdenum is repeated after five or six years although responses have been occasionally observed two and three years after application of the normal rate (Savage 1974). Test strips should be used as a guide to the need for a repeat application.

Too frequent application or excessive rates of molybdenum can induce plant levels of Mo that may be harmful to stock, so care must be exercised. The application of molybdenum to only part of the farm in any one year, together with appropriate control of grazing, reduces the possibility of problems due to high molybdenum concentration in the herbage. Alternatively, the application rate may be halved and the half rate applied every four—five years.

Where copper deficiency has occurred in live-stock, or could be induced by molybdenum fertilisers, it is advisable to include copper with the application of molybdenum.

Liming to alleviate soil acidity increases the availability of molybdenum to plants (Savage 1974)) and has been associated with molybdenosis in grazing ruminants in south-east South Australia.

2.5 Molybdenum toxicity in animals (molybdenosis)

Molybdenum combines with sulfur in the rumen to form Cu-Mo-S complexes (copper-thiomolybdates) which reduce the availability of copper to animals and the activity of copper enzymes in tissues (Underwood 1977). As the concentration of molybdenum in herbage increases, higher concentrations of copper in herbage are needed by the animal to compensate (see Copper section).

Infertility has been associated with severe copper deficiency, but the evidence has rarely been conclusive. Recent studies in Scotland have clarified some of the confusion surrounding the association of high molybdenum intake, low copper status, and poor growth and infertility in cattle (Philippo *et al*. 1985).

Low copper status (low plasma and liver copper) was produced in heifers by feeding high intakes of molybdenum (5 mg/kg DM) or iron (500 mg/kg DM). Where the low copper status was caused by high iron intake, there was no effect on the growth or fertility of the heifers; but where high molybdenum intake was the cause, the heifers exhibited delayed puberty, low growth rates and poor conception rates. It was postulated that molybdenum directly interferes with normal hormonal control of reproduction.

It is not known if molybdenum can have this effect on fertility in cattle when copper status is apparently normal, but studies are in progress to test this hypothesis. The finding of low copper status alone is not a guarantee that there will be growth responses and improvements in fertility after copper supplementation, unless molybdenum intake is high.

It should be emphasised that the risk of inducing copper deficiency using **recommended** molybdenum fertiliser application rates is slight. The production gains to be made from the application of molybdenum to deficient areas greatly exceeds the potential hazards from induced copper deficiency.

References

Brown, A.J. (1982) Total molybdenum in pasture and lucerne. In "Trace Element Review papers, 1982". Agricultural Services Library, Department of Agriculture, Victoria.

Philippo, M., Humphries, W.R., Bremner, I., Atkinson, T.G. and Henderson, G. (1985) Molybdenum induced infertility in cattle. In "Trace Element Metabolism in Man and Animals, 5". Proceedings of International Symposium. In press.

Savage, G.F.J. (1974) The role of copper and molybdenum top dressing in pasture improvement in Victoria, and their effect on herbage copper and molybdenum (many references). In "Copper and Associated Elements Affecting Pastures and Animals in Victoria". Proceedings of Seminar. Department of Agriculture, Victoria, November 1974.

Savage, G. (1982) Trace element investigations—Warragul and Leongatha Districts, 1979: Effect of applied molybdenum on herbage molybdenum levels in "Trace Element Review papers, 1982". Agricultural Services Library, Department of Agriculture, Victoria.

Shovelton, J. (1982) Trace element studies in the Wodonga District. In "Trace Element Review papers, 1982". Agricultural Services Library, Department of Agriculture, Victoria.

Skene, J.K.M. (1964) Uptake of copper and molybdenum by pasture herbage. Unpublished Report. In "Trace Element Review papers, 1982". Agricultural Services Library, Department of Agriculture, Victoria.

Underwood, E.J. (1977) "Trace Elements in Human and Animal Nutrition. 4th Edition. Academic Press, London, New York.

Responses to molybdenum fertiliser can be this dramatic: pale green subterranean clover is typical of molybdenum deficiency.

White bands in black wool due to periodic copper deficiency. High intakes of molybdenum can have identical signs.

Lamb suffering the ataxia (swayback) characteristic of copper deficiency.

Pale coat color and diarrhoea in these cattle responded to a copper supplement.