MAGNESIUM DEFICIENCY IN LUCERNE

M. R. J. TOXOPEUS and K. J. MCNAUGHT
Ruakura Soil Research Station, Hamilton

Abstract

An experiment was conducted on lucerne (cv. Wairau), growing on a yellow-brown pumice soil low in magnesium. Under a regime of four harvests annually, small but sign&cant yield responses of 4 and 5% were obtained in the third year to additions of 17 and 34 kg/ha Mg, respectively, when the topsoil (0 to 7.5 cm) Mg value in the control plots had fallen to 2 units (advisory scale). Responses were associated with a concentration of 0.09% Mg in herbage cut at the onset of flowering. Foliar symptoms of magnesium deficiency were a chlorosis which increased in severity towards the base of the plant,

INTRODUCTION

MAGNESIUM DEFICIENCY in pastures on pumice soils has been investigated on several occasions (Moody, 1962; McNaught and Darofaeff, 1965; Toxopeus and Gordon, 1971). Its occurrence in soils low in Mg is accentuated by successive hay crops, and by the increasing but necessary use of potassic fertilizers.

With lucerne gaining in importance on these soils in the Central Volcanic Plateau region, it is essential to have information on the magnesium needs of this crop. This paper reports the first documented case of magnesium deficiency in lucerne in New Zealand.

EXPERIMENTAL

A field was selected on Waipahihi sand, a yellow-brown pumice soil formed on Taupo ash colluvium (H. S. Gibbs, pers. comm.), on the basis of low magnesium soil tests. Uniformity tests for the site chosen in this field showed pH values ranging from 5.4 to 5.8 (mean 5.7); Ca, 3 to 5 (mean 3.5); K, 4 to 7 (mean 5); P, 5 to 18 (mean 9); and Mg, 3 to 4 (mean 3.5) in the surface soil (0 to 7.5 cm). These tests were carried out by the procedures used for advisory work (Mountier et al., 1966 (pH, Ca, K, P) ; McNaught and Dorofaeff, 1965 (Mg)) . The ratio of advisory to exchangeable Mg values for this soil type is approximately 17: 1.

The lucerne stand (cv. Wairau) was 1 year old and weed-free, and had been established by the farmer following normal district practice. Its seedbed had been prepared by ploughing in 1 ¼ t/ha agricultural limestone, followed by discing in a further 1 ¼ t/ha. Fertilizer applications made by the farmer at sowing consisted of 625 kg/ha 15% potassic serpentine-superphosphate, 22 kg/ha borax and 11 kg/ha copper sulphate. The seed was inoculated and dusted with 175 g/ha sodium molybdate.

The experiment was started in October, 1969 as a simple randomization of three treatments, replicated eight times. Additions of kieserite ($MgSO_4.H_2O$) at 0, 120 and 240 kg/ha corresponded to nil, 17 and 34 kg/ha Mg. Compensatory sulphate was given as gypsum at 320, 150 and nil kg/ha, respectively. These treatments were repeated once each year, in early spring. Basal fertilizer comprised 45 kg/ha P, as monocalcium phosphate, 250 kg/ha potassium chloride, 22 kg/ha borax, 11 kg/ha copper sulphate, and 175 g/ha sodium molvbdate. Borax was also applied annually.

Maintenance fertilizer was 375 kg/ha 50% potassic superphosphate, applied before each of the four crops grown in a year. Harvests were made at the commencement of flowering, and all herbage was discarded. The site was fenced to exclude grazing.

Soil samples were taken regularly after each cut in the first year, but only once in the second year. In the third year, profile samples were taken to 23 cm after cuts 1 and 3, and to 90 cm shortly after the final harvest.

RESULTS

YIELDS

In the first two years no significant differences in yield were found (Table 1), and the marked variation between years was probably due to variable rainfall. In the third year, although clear visual symptoms of Mg deficiency were observed at all four harvests, significant yield responses to additions of Mg were found only in the last two *cuts.*

Total yield increases in the last year were 4% and 5% for 17 and 34 kg/ha Mg, respectively. By comparison, in an adjacent mowing experiment on pasture, on the same soil type with a similar initial Mg test of 3.6, but without a history of serpentine-superphosphate applications, the total yield increase from 34 kg/ha Mg was 20% in the first year, increasing to 58% in the

TABLE 1: DRY MATTER YIELDS (kg/ha)

Cut	Date-	Mg treatments (kg/ha) 0	17	34	LSD (5%)	CV (%)
1-4	1969-70	9 700 a*	9800a	9 300 a	1000	9.7
5-8	1970-l	15 800a	15 900 a	15 900 a	600	3.2
9	Nov. 30	4350a	4460a	4650a	450	8.9
10	Jan. 17	4 910 a	4 960 a	5 010 a	290	5.2
11	Mar. 13	2 490 b	2 790a	2 680 ab	230	7.8
12	May la	1490 bB	1 560 abAB	1620 aA	90	5.2
	1971-2	13 200 a	13 800 a	14 000 a	800	5.0

"Duncan's lettering (Duncan, 1955) to be compared across the table.

second year. Thus lucerne may be more tolerant of a low Mg status than clovers.

MAGNESIUM IN SOIL

The results in Table 2 show highly significant differences in Mg levels in the surface soil between the three treatments, and a gradual decline in Mg status in all treatments as harvesting proceeded.

Magnesium levels in the topsoil in the control plots fell from a mean value of 3.7 in the first year to 2.0 in the second, and to 1.9 in the third year. Although the level in the top 7.5 cm of soil remained at approximately 2 units in the last two years of the experiments, the level below 7.5 cm fell in the final year when yield responses were found. For practical purposes the results suggest a critical soil Mg level of approximately 2 units in the top 7.5 cm layer.

NUTRIENT ELEMENTS IN HERBAGE

Analysis of the herbage from each cut (Table 3) showed highly significant differences in Mg concentrations between treatments from the end of the first year onward, and a general decline in Mg status with successive cuts, especially in the control treatment.

The concentration of Ca in successive crops tended to decline also, from an overall mean value of 1.26% at cut 1 to 1.04% at cut 12, but was adequate for plant growth, Mean Ca values differed significantly between Mg treatments, and were 1.24% at nil, 1.16% at 17 and 1.08% at 34 kg/ha of magnesium.

Other element concentrations showed no important differences between treatments. Variations between cuts were greater, with

TABLE 2: MAGNESIUM STATUS IN SOIL (ADVISORY TESTS*)

Cut	*Depth (cm)*	*Mg Treatments* 0	17	34	*CV (%)*
1969-70 (mean)	0-7.5	3.7 cc	6.0 bB	10.3 aA	
5	o-7.5	2.0 cc	5.1 bB	9.4 aA	12.6
	7.5-15	2.1 cB	2.9 bB	4.9 aA	15.5
9	0-7.5	2.0 cc	4.8 bB	8.4 aA	24.3
	7.5-15	1.1 cc	2.0 bB	3.5 aA	22.9
	15-23	1.1 bB	1.5 bAB	2.1 aA	27.1
11	o-7.5	2.0 bB	2.9 bB	4.8 aA	26.9
	7.5-15	1.9 bB	2.5 abAB	3.4 aA	33.1
	15-23	1.4 a	1.6 a	2.3 a	45.2 (LSD 0.9)
12	o-7.5	1.7 cB	2.8 bA	3.7 aA	24.8
	7.5-15	1.3 cB	2.0 bB	3.0 aA	21.6
	15-23	1.3 b	1.5 b	2.1 a	32.9
	23-28	0.9 bB	0.9 bB	1.3 aA	22.3
	38-61	0.7 bB	0.8 bB	1.1 aA	20.6
	61-90	0.7 bB	0.8 bB	1.1 aA	16.9

*The ratio of advisory to exchangeable Mg values for this soil is approximately 17: 1.

TABLE 3: MAGNESIUM CONCENTRATION IN HERBAGE DRY MATTER (%)

cut	*Date*	*Mg Treatments (kg/ha)* 0	17	34	*CV (%)*
1	Nov. 24	0.151 bB	0.160 abAB	0.174 aA	9.0
2	Jan. 13	0.151 bB	0.165 bB	0.195 aA	10.1
3	Feb. 17	0.165 cB	0.179 bB	0.207 aA	6.7
4	Apr. 23	0.130 cc	0.148 bB	0.179 aA	4.1
Mean	(1969-70)	0.149	0.163	0.189	
5	Nov. 24	0.115 cC	0.167 bB	0.199 aA	6.8
6	Jan. 6	0.101 cB	0.143 bA	0.163 aA	12.2
7	Feb. 18	0.098 cC	0.134 bB	0.161 aA	8.1
8	Apr. 21	0.093 cc	0.122 bB	0.147 aA	10.5
Mean	(1970-l)	0.102	0.142	0.168	
9	Nov. 30	0.095 cc	0.154 bB	0.179 aA	8.2
10	Jan. 17	0.079 cc	0.127 bB	0.167 aA	10.4
11	Mar. 13	0.068 cc	0.110 bB	0.158 aA	10.0
12	May 10	0.086 cc	0.131 bB	0.162 aA	7.1
Mean	(1971-2)	0.082	0.131	0.167	

a range of values of N, 3.03-4.30%; P, 0.246-0.359%; and K, 2.3 1-3.38%. Trace element concentrations were determined on herbage from cut 3 and also found to be adequate at Mn, 76; Zn, 92; Cu, 7.2; Fe, 113; and B, 52 ppm.

DISCUSSION

VISUAL SYMPTOMS

Chlorosis, associated with magnesium deficiency, was first observed a month before the first harvest in the third year, and was more pronounced toward the base of the plant. The intensity of the yellow discoloration showed a progression, from a pale yellow-green leaf, with normal midrib and base, to a marked interveinal chlorosis, turning to marginal bronzing and necrosis. This is in accord with Millikan's (1958) colour illustration of Mg deficiency in his work with nutrient solution cultures.

Magnesium deficiency may be distinguished from acute potassium deficiency because the chlorosis does not develop on the leaf margins initially, and from nitrogen and boron deficiency because the chlorosis is not as pronounced in the younger leaves.

UPTAKE OF MG

In Table 2 the data from the 90 cm soil profile suggest that the uptake of Mg by roots did not extend below 23 cm.

The removal of Mg from the soil by the crop was apparently offset by the addition of 17 kg/ha Mg. With 34 kg/ha, however, the soil was enriched, with subsequent considerable downward movement of Mg, no doubt aided by Cl-ions from liberal KC1 topdressings (Hogg, 1960) .

Apparent recovery of Mg in herbage was low (Table 4). Although more K was removed than was applied, the levels of K in the herbage remained more than adequate throughout (McNaught, 1970).

TABLE 4: TOTAL UPTAKE IN HERBAGE (kg/ha)

	Magnesium *Mg Treatments (kg/ha)*			*Potassium*
	0	17	34	(mean)
Total (1969-72) *	40.7	55.3	65.6	1123
Less "control"	—	14.6	24.9	.
Added	—	51.0	102.0	915
Recovered in herbage	—	29%	24%	123%

*The values shown were calculated from individual cuts.

The present district fertilizer recommendation for lucerne is to apply a total of 1 t/ha of 50% potassic serpentine-superphosphate each year, in three dressings. In this, the total addition of Mg approximates 25 kg/ha of which only about two-thirds is available (Hogg and Karlovsky, 1968). This is possibly insufficient if lucerne is exclusively grown for conserved fodder, and additional Mg, as kieserite or MgO, may be necessary on soils low in Mg. Under conditions of occasional grazing, however, the return of Mg in dung should compensate to some extent. Also, an allowance must be made for the contribution of Mg as an impurity in lime applications (Kitt, 1962).

HERBAGE MG STATUS

The mean Mg concentration in herbage from the control plots fell from 0.149% in the first year to 0.102% in the second year, and to 0.082% in the third year. In this last year a significant yield response of 12% to 17 kg/ha Mg was obtained when the concentration in the herbage from control was 0.068% Mg and a 5 % response at 0.086%. Although yields were only slightly reduced by Mg deficiency, a critical concentration, for 95% maximum yield, of about 0.09% Mg is indicated.

ACKNOWLEDGEMENTS

We are indebted to the farmer, B. E. Lane, for his co-operation, and to Mrs E. Viggers (statistical analysis), F. D. Dorofaeff (herbage analysis), G. A. C. Oomen (soil analysis), and to Ruakura staff for assistance with field work.

REFERENCES

Duncan, D. B., 1955: *Biometrics,* II: l-42.
Hogg, D. E., 1960: *N.Z. Journal* of *Agricultural Research, 3: 377-83.*
Hogg, D. E.; Karlovsky, J., *1968: N.Z. Journal of Agricultural Research, 11*: 171-83.
Kitt, W., *1962: Department of Scientific and Industrial Research Report D.L. 2060:* 76 pp.
McNaught, K. J., *1970: Proceedings of the XI International Grassland Congress:* 334-8 (M. J. T. Norman, Editor). Queensland University Press, St. Lucia.
McNaught, K. J.; Dorofaeff, F. D., *1965: N.Z. Journal of Agricultural Research, 8: 555-72.*
Millikan, *C.* R., 1958: *Journal of Agriculture, Victoria, 56:* 511-31.
Moody, R. W., 1962: *Proceedings of the N.Z. Grassland Association, 24:* 151-S.
Mountier, N. S.; Grigg, J. L.; Oomen, G. A. C., 1966: *N.Z. Journal of Agricultural Research, 9: 328-38.*
Toxopeus, M. R. J.; Gordon, R. *B.,* 1971: *Proceedings* of *the N.Z. Grassland Association, 33: 35-41.*