MOLYBDENUM DEFICIENCY IN CLOVER AND THE IDENTIFICATION OF NUTRIENT DEFICIENCIES IN NEW ZEALAND PASTURES

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Abstract

The lack of clover presence and vigour in pastures can be attributed to several factors such as competition for light from grasses, lack of soil moisture, inappropriate grazing management, insect damage or lack of essential plant nutrients. Often, the last factor is too easily used by farmers and consultants as the prime reason for the poor performance of clover which in many situations is supported by the scientific evidence. To investigate whether the lack of molybdenum (Mo) is a significant factor affecting clover growth, two large national laboratory databases each containing about 8000 paddock sample results for clover Mo and nitrogen (N) from the last ten years were interrogated. One database showed that 12% of the clover samples were deficient in both Mo (< 0.1 ppm) and N (<4.5%) The Tasman and Southland regions had the highest proportion of samples with low levels (18 – 25%) and Marlborough and Taranaki the lowest proportion (1 - 3%). The other laboratory database showed similar overall results with 11% of the total samples being deficient in both Mo and N. These results indicated that a lack of Mo is not currently a major reason for poor clover growth. Identification of nutrient deficiencies in pasture should be carried out using both visual observations of clover vigour and laboratory analysis of soil and pastures or pasture strips receiving the nutrient (eg. Mo). There is a risk of visual observations alone, observation of leaf deficiency symptoms or comparison of clover growth within and outside excreta patches resulting in an incorrect interpretation of what extra nutrients or different rates and forms of existing nutrients are required. Economic analysis on an individual farm basis is also always required for the most correct recommendation of the optimal application rate of phosphorus (P) and potassium (K) in fertiliser.

Introduction

There is a tendency for some consultants and farmers to generalise and attribute poor clover growth throughout New Zealand to the lack of one or more nutrients, such as K and sulphur (S) or Mo and boron. In some cases this is due to pressure on the consultant to come up with a solution or the economics of applying the nutrient not taken into consideration or extrapolating from a small number of farms with a deficiency to a whole industry (eg. K by Edmeades et al. 2016). For K, Morton et al. (2017) showed that most sheep and beef farms that had been soil tested had soil QT K levels either above or within the economically optimal range of 4 – 5. With Mo, there is also a tendency not to consider the clover N content in interpreting the results as found to be necessary from earlier research (Sherrell and Metherell 1985, Morton 2023).

The only objective method of assessing the true extent of a trace element deficiency on a national basis is to use the results of plant analysis. For Mo, this was carried out by examining the clover Mo and N results from two large databases over the last ten years, each of about 8000 samples which are reported in this paper.

Interpretation of Mo deficiency in clovers

There is now empirical evidence that both the Mo and N content of legumes need to be deficient before a definite response in plant yield to Mo can be measured. Theoretically, because Mo is essential for N fixation, a legume cannot lack Mo for this function if the N content is adequate enough to indicate that the plant is fixing sufficient N (During 1984). If N content in the legume is higher than this critical level, despite the Mo content being low, the plant is acquiring sufficient Mo for N assimilation into both legumes and grasses. At two sites in the same paddock on a Manawatu Sand soil, Sherrell and Metherell (1985) reported that both Mo (<0.1 ppm) and N (<4.0%) had to be deficient before a pasture yield response to applied Mo was obtained. The results from a National Series of on-farm trials (Morton and Morrison 1997) at nine sites throughout New Zealand) supported this finding (Table 1) albeit with a higher critical level for N (4.5% cf. 4.0%).

Table 1. Results from National Series of +/- Mo trials (* denotes significance of legume and pasture yield response to 150 g/ha of sodium molybdate at the 5% level of probability)

Site	**Soil Order**	**Initial soil pH**	**Year**	**Average legume Mo content (ppm) from control**	**Average legume N content (%) from control**	**Response in DM yield (%)**	
						Legume	Pasture
Otago Plateau	Pallic	5.4	1	0.11	3.7	69*	25*
			2	0.07	3.9	69*	55*
Eastern Southland	Pallic	5.7	1	1.0	5.0	33*	11*
			2	0.02	4.3	38*	12*
Wairarapa	Pallic	5.6	1	0.04	4.6	11	7
			2	0.10	3.3	26*	11*
Central Plateau	Pumice	5.5	1	0.10	4.6	11	7
			2	0.10	4.3	22*	6*
South Otago	Brown	5.7	1	0.01	5.1	2	2
			2	0.02	5.2	11	1

Tarras (Central Otago)	Semi-arid	5.3	1	0.01	5.1	6	1
			2	0.02	5.1	-10	0
Te Anau	Allophanic	5.7	1	0.30	4.3	0	3
			2	0.50	4.5	3	1
Northland	Brown	6.0	1	0.30	5.4	0	3
			2	0.10	5.3	-2	1
Hawea Flat (Central Otago)	Pallic	5.9	1	1.10	4.0	2 (Lucerne)	2
			2	0.5	3.7	3	3

Significant responses in legume and total yield to Mo ($P<0.05$) were measured at the Inland Otago and Eastern Southland sites in both years and the Wairarapa and Central Plateau sites in Year 2. At all of the other five sites, there was no significant response in legume or total pasture yield to Mo. The general overall pattern from most of these sites was a significant legume and pasture yield response ($P < 0.05$) to applied Mo when legume Mo and N content for most sites was 0.1 ppm and 4.5% or less respectively. There was no significant response in yield ($P > 0.05$) when either clover Mo content was less than 0.1 ppm and clover N content above 4.5% as at South Otago, Tarras and Northland in Year 2 There was also no significant yield response to Mo when both clover Mo and N were above 0.1 ppm and 4.5% respectively as at the Wairarapa, Central Plateau and Northland sites in Year 1 and Hawea Flat in both years. At the Te Anau site, clover Mo content was adequate and the low to marginal N content was caused by other limiting factors. Rolt (1968) reported that maximum white clover yield was achieved when the N content was high and Mo content ranged from 0.1 to 4.7 ppm.

Overall, these results show that both Mo and N content of legumes needs to be below the critical level to justify the application of Mo.

Laboratory databases

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The proportion of clover samples with Mo content below 0.1 ppm and N content below 4.5% for each region over the last ten years and the average for New Zealand are shown in Table 2. There were 8024 clover samples in the database.

Table 2. The proportion of paddock clover samples (%) with deficient Mo (<0.1 ppm) and N (<4.5%) content

Region	Proportion
Northland	22
Auckland	6
Waikato	8

Bay of Plenty	10
Taranaki	1
Manawatu/Wanganui	11
Poverty Bay	9
Hawkes Bay	9
Wairarapa	12
Tasman	19
Marlborough	3
West Coast	16
Canterbury	8
Otago	12
Southland	18
Average	12

The higher proportion of deficiency in Northland could have been expected because of the presence of more strongly weathered soils such as Podzols and Ultic. Soils of the Tasman and West Coast region also contain Podzols and more strongly weathered Brown soils. Pallic and Brown soils that tend to be more responsive than other soil orders predominate in Southland which had a higher proportion of Mo and N-deficient samples (18%). Regions with a higher proportion of hill country such as Hawkes Bay, Poverty Bay and Wairarapa also with Pallic and Brown soils had proportions of Mo and N-deficient samples (9 -12%) around the national average. These soil orders are also present in Marlborough which despite this only had 3% of Mo deficient farms. In contrast regions with mainly Allophanic soils which can supply Mo such as Taranaki and Waikato had lower proportions of samples with Mo and N in the deficient range (1 and 8%).

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This database which contained 7933 paddock clover samples analysed in the last ten years had 11% in the deficient ranges for Mo and N. It was not possible to identify the regional distribution of deficiency.

Discussion

There may be several reasons for the current low incidence of Mo deficiency in clovers including awareness to apply it when required and the greater use of lime on the hill country of sheep and beef farms elevating the soil pH and increasing the plant-availability of Mo. In two surveys of 80 - 120 farms each in the lower South Island (Morton 1994) and the lower North Island and South Island, Morton (1994, 1995) there was an average 6% of sheep and beef farms with clover Mo content less than 0.1 ppm and clover N content less than 4.5%. Therefore, the results of these two surveys and the reported databases indicate a doubling of Mo-deficient sheep and beef farms over nearly thirty years.

Nevertheless the results from the laboratory databases show that there is a continuing need for farmers to check the adequacy of Mo in their pasture legumes. Chemical analysis of Mo and N content, as used in the reported measurements is the current method of the identification of Mo deficiency but this method relies on the collection of clover samples in late-spring and summer when soil moisture can be restricting the growth of legumes. If the proportion of clover is already low because of lack of Mo or other limiting factors it can be difficult to collect a sufficient clover sample. An alternative method is to apply granular Mo to a small strip and compare any difference in legume vigour within that strip and the outside area that has not received Mo (Morton 2022).

There is a requirement for P and S for pasture growth on most New Zealand soils. Potassium is usually required on most dairy farms and to replace what has been removed in conserved feed. More weathered soil orders such as Brown and Podzol soils can require K on sheep and beef farms, especially where there is a greater than 50:50 cattle:sheep ratio under average annual rainfall of greater than 1500 mm (cattle recycle urine K less efficiently than sheep). Molybdenum is also required on Pallic and Brown soils (Morton 2024) and Podzols which also require copper (Cu) for optimal pasture growth (Morton, unpublished). Therefore, to confirm a requirement for K and Cu, application of muriate of potash and copper sulphate to separate pasture strips could also be worthwhile.

To be credible in advising farmers of the probable reason for poor clover growth, it is important that the consultant rules out the factors that can be more easily measured and verified such as soil or plant nutrient status. It is relatively easy but can be misleading for them to attribute this poor growth to a nutrient deficiency based on visual assessment of the pasture sward. Visual symptoms of nutrient deficiency on the leaf can often be confused with symptoms of various fungal and other diseases. Also the visual symptoms on the leaf for one deficiency can be mistaken for another such as yellowing of the grass leaf for both S and N. The best option for detection is a combination of soil and plant analysis or a strip with Mo or other nutrients applied combined with the visual assessment of vigour and growth.

Some consultants prefer to identify a nutrient deficiency such as K or S based on leaf symptoms of deficiency or the difference between clover growth in excreta patches compared with the pasture outside them. These methods are viable only if supported by soil and/or leaf analysis. Potassium deficiency on clover leaves is marked by pink mottles over the whole leaf or around the margins of the leaf. It is important not to confuse the mottles around the leaf margins with leaf burn from the ammonia in a urine patch during hot, dry weather conditions. There also needs to be at least 10- 20% of the clover leaves affected by visual symptoms of deficiency before it can be considered to be significant.

About 90% of the excreted K is contained in the urine so a difference in clover vigour or growth both inside an outside a urine patch could well indicate a lack of K. But cattle can also defaecate at the same time as urinating. Therefore it is important to determine whether the better clover growth in the excreta patch is caused by the addition of K from urine rather than the cattle avoiding grazing the odourous pasture around the fresh dung patch and allowing more clover growth.

A lack of S for clover growth is indicated by a yellowing of the leaf. About 50% of the excreted S is in urine in an immediately plant-available form and 50% in dung in a slowly-available form. Therefore it can be difficult to ascertain whether a greater proportion of clover in the cattle urine patch is caused by a lack of S or K or both nutrients.

The recommended rate of nutrient application should always be based on economics with the cost of the fertiliser nutrient compared with the financial return from pasture and animal production. This can be carried out using the Overseer econometric model or other financial analysis. On sheep and beef farms, only those with very high financial performance (gross margin/ha greater than $800) can soil test levels for near maximum production of greater than an Olsen P of 20 or QT K of 5 be justified from an economic aspect (Morton and Roberts 2024).

With the short and probable long-term increase in fertiliser nutrient prices, it is essential that the advice given to farmers is based on objective measurements and observations by an experienced advisor rather than ad-hoc methods used to come up with a hasty and non-scientifically derived solution to the issue.

Conclusions

1. Two large databases each of about 8000 paddock samples of clover collected over the last ten years have shown that 11-12% of them are deficient in Mo as defined by Mo content less than 0.1 ppm and N content less than 4.5%.
2. In one database, the Northland, Tasman and West Coast regions with the greatest area of Podzols had the highest proportion (16 – 22%) of Mo and N-deficient samples while Taranaki and Marlborough had the lowest proportion (1 – 3%) of Mo and N-deficient samples.
3. Ideally nutrient deficiencies in pasture should be identified using a combination of observation of pasture vigour by an experienced advisor and analysis of soil and/or pasture samples.
4. Alternatively small pasture strips can have K, S, Mo or Cu applied and growth compared with the pasture outside the strip to identify a deficiency.
5. Using visual leaf symptoms of deficiency or differences in clover growth between within or outside excreta patches can lead to miss-diagnosis of the problem and extra cost to the farmer.
6. The recommended rate of fertiliser nutrient application should always be based on economic optimisation instead of aiming for near-maximum pasture production.

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