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CLOVER TEST STRIPS FOR IDENTIFICATION OF MOLYBDENUM DEFICIENCY

Jeff D Morton

MortonAg, Christchurch

Abstract

Because of issues such as lack of clover in the spring and interpretation of the results of plant analysis, the concept of applying Mo to a small area and monitoring the vigour and cover of the clover compared to where no Mo had been applied was investigated at 21 sites on the east coasts of both Islands. There was no significant response in clover vigour and cover to 200 g/ha of liquid sodium molybdate at any of the sites as observed 2-3 and 12-15 months after application. Clover Mo and N content were also measured as adequate (> 1 ppm Mo and 4.5% N) at nearly all of the sampling times for each site. Therefore this approach has been shown to be of practical application using GPS to locate a 5x2m strip in 3-5 paddocks with at least 10% clover cover where 500 g/ha of Granular Mo (10% Mo) has been applied in early to mid-spring. If an increase in clover vigour and cover is observed in the test strip compared to the pasture outside then 100 g/ha of Granular Mo or 50 g/ha of sodium molybdate should be added to the fertiliser application.

Rationale & background information

The lack of Mo for legume N fixation and growth was first identified in New Zealand soils in the 1950's (Morton 2022). It was found to be more prevalent on soils of the rolling downs and hill country that were derived from greywacke and Podzols. The lack of Mo was rectified by the application of low rates (50 – 200 g/ha of sodium molybdate (Morton 2022). While on most soils, an increase in soil pH from lime application will remedy a deficiency of Mo, on Sand and Podzol soils there is insufficient inorganic Mo in the soil to be made more plant-available from liming. These soils require Mo application and this is the most viable option where it is uneconomic to transport and aerially apply lime. Initially Mo was applied to pasture based on a broad-scale soil type approach. A laboratory test to analyse clover Mo content was then made available and reference ranges established. Later research established the need for both clover Mo (< 0.1 ppm) and N (< 4.5%) content to be low before a yield response to applied Mo was measured (Morton 2022).

There is currently much debate on the extent of Mo deficiency on New Zealand soils. Plant analysis based on a relatively small proportion of total pasture area would indicate that only a low number of paddocks test as deficient in both Mo and N but a definitive answer is not available. Clover analysis can be time consuming in terms of sampling and interpretation of the results can be difficult where growth is limited by cold and dry conditions at the time of sampling plus sometimes clover N content is not measured in addition to clover Mo content.

Therefore there is the need for an alternative approach to the current method for identifying a deficiency of Mo in clovers. The objective of this project is to test the suitability of applying Mo in a test strip over a small identified area where a deficiency is suspected and comparing clover vigour in the strip with adjacent pasture that has not received Mo.

Methodology

Sites

Sheep and beef farms with mainly Pallic and Brown soils formed from greywacke were selected on the east coast from Hastings to Oamaru. There were three farms in each of the Central Hawkes Bay, Tararua, Wairarapa, North Canterbury, Mid/South Canterbury, North Otago and Central Otago regions chosen which had pure white or red clover already established in a pure sward or present in an older pasture that had not received Mo for at least five years. One representative paddock from each farm had six test strips of 5 x 2 m on a suitable site, randomised with three receiving Mo and three not and the four corners pegged.

Treatment

Each treatment strip had the equivalent of 200 g/ha of sodium molybdate applied as a liquid in early to mid-spring.

Measurements

The following measurements were carried out prior to and within 2-3 and 12-15 months after treatment application on both the test and control strips:

1. Ten bulked 75 mm depth soil cores for pH measurement
2. Fifteen sub-samples of clover tissue for Mo and N analysis, either per plot or bulked for treatment mainly at the 2-3 month post-application visit.
3. An estimate of clover vigour on a 0-10 scale and clover cover as a % of the total area.

Data management and analysis

Analysis of variance using the Jamovi statistical programme (The Jamovi Project 2022) was used to analyse the significance of differences in clover vigour and cover between nil and plus Mo. Where it was not possible to measure clover vigour at some sites on same assessment dates, missing values were used.

Results

The site details, clover Mo and N content and analyses for clover vigour and cover are shown in the tables below.

Table 1 Topography, original vegetation soil pH and date of Mo application for each site.

Site	Topography	Original vegetation	Soil pH	Date Mo applied
Hurunui, South Canterbury	Hill	Sub/white clover	6.0	28/9/21
Amberley, North Canterbury	Rolling downs	White clover/chicory	5.9	28/9/21
Loburn, North Canterbury	Hill	White clover/grasses	6.3	24/9/21
Kaituna, Central Canterbury	Slight slope	Sub clover/cocksfoot	5.9	7/10/21
Mt Somers, Mid Canterbury	Flat on hill	White clover/grasses	6.0	15/9/21
Springfield, Central Canterbury	Flat	White clover/grasses	6.0	8/10/21

Pareora Gorge, South Canterbury	Hill	Red and white clover/grasses	6.3	30/9/21
Mt Horrible, South Canterbury	Flat on hill	White/red clover	6.2	6/9/21
Cave, South Canterbury	Flat on hill	Ryegrass/white clover	6.5	30/9/21
Palmerston, North Otago	Hill	Grasses/white clover	5.3	18/9/21
Herbert North Otago	Hill	Browntop/white clover	5.2	23/9/21
Waikouaiti, North Otago	Hill	White clover/grasses	5.3	20/10/21
Omakau, Central Otago	Hill	Haresfoot trefoil/Lotus/grasses	5.3	17/9/21
Wedderburn, Central Otago	Hill	Browntop/white clover	5.9	17/9/21
Oturehua, Central Otago	Flat	White clover/grasses	5.8	17/9/21
Martinborough, Wairarapa	Flat	Plantain/clovers	4.5	29/9/21
Ponatahi, Pahiatua	Flat	Ryegrass/clover	5.5	29/9/21
Te Awa Awa, Hawkes Bay	Hill	Plantain/clover	5.1	29/9/21
Pukekara, Hawkes Bay	Flat	White clover	4.9	14/9/21
Poukawa Research Farm, Hawkes Bay	Flat	Ryegrass/white clover	6.8	27/9/21
Waipawa, Hawkes Bay	Flat	Plantain/clover	5.2	13/9/21

The legume at most of the sites was white clover with red clover present at some, associated with grasses and plantain (Table 1). Therefore at most sites, there was a legume present to indicate a response to Mo. Initial soil pH ranged from 4.9 to 6.8.

Clover Mo and N content

Table 2 Clover Mo and N content for each sampling date at each site.

Site	**Sampling date**	**Clover Mo content (ppm)**		**Clover N content (%)**	
		Control	+Mo	Control	+Mo
Hurunui	28/9/21	0.08		4.2	
	22/11/21	0.25	1.23	2.7	2.7
Amberley	22/11/21	0.15	1.01	3.7	4.0
Kaituna	7/10/21	0.31		4.3	
Mt Somers	15/9/21	0.38		4.4	
Springfield	8/10/21	0.63		5.4	
	25/11/21	0.09	0.66	3.2	3.6
Mt Horrible	6/9/21	1.25		4.5	
Cave	30/9/21	1.04		4.5	
	19/11/2021	0.74	5.10	3.5	3.7
Waikouaiti	10/21/21	0.08	0.23	3.3	4.0
Omakau	17/9/21	0.24	2.78	2.8	2.8
Martinborough	29/9/21	1.08	1.45	5.5	5.4
Ponatahi	29/9/21	0.49	1.46	5.3	5.3
Te Awa Awa	29/9/21	0.91	2.50	4.4	4.5
Pukekawa	14/9/21	1.67	1.62	4.9	4.9
Poukawa	21/9/21	0.51	0.63	5.9	5.9
Waipawa	13/9/21	1.17	3.10	4.8	4.8

Most but not all the sites were sampled and analysed for clover Mo and N content at one of the visits. Where clover was not sampled, there was insufficient present in the pasture to collect enough for a meaningful analysis. Where sampling was carried out after Mo was applied there was an increase in clover Mo content. Only at the Hurunui, Springfield (both at one sampling but not the other) and Waikouaiti sites were the Mo and N content below the critical levels of 0.1 ppm and 4.5% respectively (Morton 2022). Clover titanium (Ti) content was also measured (results not shown) and nearly all of the levels were below 50 ppm where contamination with soil and artificially high Mo and N content could occur.

Clover vigour and cover

There were no significant differences ($P<0.05$) in clover vigour or cover between no and plus Mo treatments at any of the sites or assessment times. Therefore the data was combined over all sites at each assessment time to provide more experimental power (Table 3).

Table 3 Analysis of overall means in clover vigour and cover (%) combined over all sites and assessment times.

	Minus Mo	Plus Mo	P value
Clover vigour	6.98	7.01	0.868
Clover cover	28.8	28.7	0.966

Neither value differed significantly between minus and plus Mo treatments (Table 3).

In addition P values were derived for assessment time, Mo treatment and their interaction (Table 4).

Table 4 Analysis of P values for assessment time and Mo treatment

	Clover vigour	Clover cover
Assessment time	0.438	0.233
Mo treatment	0.838	0.974
Assessment time x Mo treatment	0.762	0.933

There was no significant effect of any of the variables nor their interaction on clover vigour or cover (Table 4).

Discussion

There was a wide range of initial legume cover (6 - 100%) at each of the test strip sites. Only at three of the sites at one sampling each (Table 2) were the Mo and N content of the white clover below the critical range of 0.1 – 0.2 ppm and 4.0 – 4.5% respectively (Morton 2022) and no response in clover vigour and cover was observed. At all the other sites, adequate Mo and N content resulted in no significant difference in clover vigour and cover between the plus and minus Mo plot.

Initial clover vigour ranged from 5 to 9 which indicated that clover was not adversely affected by a nutritional or environmental deficiency. In addition the soil pH at seven of the sites was above 6.0 where a lack of Mo seldom occurs because of the increased availability of soil Mo (Morton 2022). For some sites clover cover decreased from the pre-Mo application assessment in early spring to the 2-3

and 12-15 month-post application assessments. This decline was probably caused by soil moisture being more limited later in the spring.

Conclusion and recommendations

The results from the test plots showed that visual assessment of clover vigour and cover was a feasible method for identifying a lack of Mo.

At nearly all the test plot sites, the lack of response in clover vigour and cover was consistent with adequate clover Mo and N contents.

The following is the recommended protocol that will be available to be used by consultants and farmers to use this pasture test strips technique.

PROTOCOL FOR USING PASTURE TEST STRIPS TO IDENTIFY A LACK OF MOLYBDENUM FOR CLOVER GROWTH

What are the limitations of current methods?

- The main method of detecting a lack of molybdenum (Mo) is to take pasture samples from several paddocks and send them to a laboratory for the clovers to be analysed for Mo and nitrogen (N) content
- The main limitation of this method is there being insufficient clover present in the sward (especially under set-stocking by sheep) to collect enough material for a sample without the leaves being contaminated with soil causing an elevation of Mo and N content
- A second limitation is difficulty in interpreting the results either through insufficient consideration being given to the N content (both Mo (<0.1 ppm) and N (<4.5%) need to be low for a definite response to added N) or being too conservative in recommending Mo. For practical purposes if Mo content of the clovers is less than 0.3 ppm and N content less than 4.5%, then Mo should probably be recommended.

What are pasture test strips?

- A pasture test strip for Mo is a small area that has had Mo applied so that the clover vigour in the strip can be compared with that from outside the strip that has not received Mo

When should I use them?

- When despite good growing conditions and adequate supply of essential plant nutrients, the clover in the pasture lacks vigour
- When a pasture has had Mo applied in the past and the farmer wants to know if they should re-apply it

What do I do?

- Select 3 to 5 paddocks that represent the variation in soil type, farm characteristics and management.
- In an area with reasonable clover cover (at least 10%) in each paddock step out a strip of about 5m long and 2m wide
- GPS the location of the strip and apply the 500 g of Granular Mo (10% Mo) evenly over the area

- The next time you visit the farm in the next 6 to 12 months observe any difference in the vigour of clover both within and outside the strip

How do I act on the results?

- If visually you can see that the clover inside the strip is more vigorous in its growth than the clover outside in a majority of the strips in each paddock then Mo should be added to the next fertiliser mix to be applied
- Use either 100 g of Granular Mo per ha or 50 g/ha of sodium molybdate

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