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STRATEGIC USE OF SOLUBLE MAGNESIUM FERTILISER TO BOOST SPRING DAIRY PASTURES FOR ANIMAL HEALTH OUTCOMES

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Abstract

Magnesium (Mg) supplementation of spring pastures is imperative for animal health outcomes on dairy farms. Traditionally supplementation via dusting or direct to animal has been used. A small plot trial was used to investigate the use of the soluble Mg fertiliser, kieserite (magnesium sulphate), to boost pasture magnesium contents to animal health levels. Two application timings and three rates of kieserite were applied to autumn saved pasture. Herbage testing was completed monthly during spring to determine uptake of Mg and soil tests were taken to determine changes in soil Mg. Magnesium in the herbage was in the range commonly seen in New Zealand pastures, and magnesium content increased during the trial period from July to November. However, the application of magnesium fertiliser, even at high rates, was not able to increase the magnesium content in the herbage into the animal health range until late spring. This is due to the low soil temperatures experienced during winter and early spring period at Dalkeith farm.

Introduction

Supplementing magnesium (Mg) to dairy cows is imperative for animal health outcomes on dairy farms, especially during calving and early lactation (Schonewille, 2013). In New Zealand, Mg is commonly supplemented via pasture dusting, drenching, water trough treatment, lick blocks and dusting of hay/silage (Grace et al. 2010). Fertiliser Mg is also used to improve soil Mg content and therefore pasture Mg content (Morton and Roberts, 1999). Higher soil Mg contents, over and above what is required for pasture growth (QT Mg 25-30), has been shown to increase the pasture Mg content into the animal health range (> 0.2%) (Edmeades, 2004; Morton and Roberts, 1999). However, variability in herbage throughout the seasons, due to changes in soil temperature and moisture, can lead to low Mg content in the herbage through the winter and early spring period and high Mg content during summer (McNaught *et al*, 1968; Metson and Saunders, 1978) and autumn (McNaught *et al*, 1973). Furthermore, additional dry matter supplementation of dairy cows is often required during this time due to lower pasture growth rates and high demand of calving/lactating animals and depending on the supplement, Mg content can vary. O'Connor et al. (2004) demonstrated in a Northland dairy farm that capital applications of Mg was sufficient to increase the pasture Mg levels into the animal health range over three years. Furthermore, in separate field trials, in Northland and Rotorua, the authors found that the use of kieserite at 25 kg Mg/ha was able to give a short term lift in pasture Mg content. McNaught *et al*. (1968), in Ruakura, found small increases in Mg content of pastures with the application of 50kg Mg/ha applied as kieserite.

A small plot trial was established at Dalkeith Farm, Methven, Canterbury to determine whether a soluble form of Mg fertiliser (kieserite) could be used to boost pasture Mg content during the high demand period in early spring to improve intake of Mg into the dairy cow.

Method

A replicated plot trial was established on July 2019 to determine if the application of kieserite fertiliser (16% Mg, 16% sulphur (S)) could increase Mg content in the herbage for late winter/early spring dairy cow supplementation. The trial was established at Dalkeith Farm, Methven (43˚34’08.3”S, 171˚36’58.7”E), a dryland dairy farm southwest of Christchurch. The soil is a moderately deep well drained silty loam described as a Typic Firm Brown Soil by the New Zealand Soil Classification System (Manaaki Whenua Landcare Research, 2020). Pasture species consisted of ryegrass/white clover sward and the pasture was last grazed early May 2019. Paddock average soil tests were completed to a depth of 75mm in July 2019 with the soil fertility as follows (optimum ranges for pasture growth in brackets): pH: 6.4 (5.8-6.0), Olsen P: 48 (20-30), sulphate-S: 14 (10-12) mg/L, quick test potassium (QT K): 12 MAF units (5-8), quick test calcium (QT Ca): 13 MAF units, quick test magnesium (QT Mg): 14 MAF units (8-10), quick test sodium (QT Na): 3 MAF units (optimum ranges from Roberts and Morton, 1999).

The trial consisted of a control and three application rates of kieserite (25 kg Mg/ha (156 kg kieserite/ha), 50 kg Mg/ha (313kg kieserite/ha) and 100kg Mg/ha (625 kg kieserite/ha). Trial plots measured 4m by 1.5m (6 m^2) with a 0.5 m buffer between plots. The treatments were replicated four times. Treatments were applied at two application dates to determine if the application timing would affect Mg uptake. The applications dates were the 8th July 2019 and 8th of August 2019, these will be referred to as “July application” and “August application” respectively. The treatments were allocated to trial plots using a randomised block design.

The trial was located in a paddock on Dalkeith Farm and was surrounded by a hotwire fence to keep stock out. Fertiliser outside of the treatment applications was spread on the trial plots as per the paddock applications. Applications of fertiliser during the trial was as follows: 4th September 100 kg/ha of Ammo 31N (30.4% nitrogen (N), 13.8% S) and 22nd October 70 kg/ha of Ammo 36 (35.6% N, 9.2% S).

Pasture samples were taken from the July application plots on the 8th of August, 1st September, 1st of October and 11th of November 2019. From the August application plots samples were taken on the 1st September, 10th of October and 11th of November 2019. Within the plots sampling areas were allocated to ensure sampling did not occur in the same area within the plot. This is to replicate what would occur on the farm with animal’s strip grazing paddocks that had grown over winter rather than rotationally grazing through this spring period.

Composite plot soil testing occurred on the 1st of October 2019, after all of the treatments had been applied to determine the change in Mg content in the soil compared to the control.

Climate data was collected from a Harvest© weather station located at 43°34'08.2"S 171°36'57.9"E, approximately 1.2km south of the trial site.

Statistical analysis on herbage testing data was completed using statistical tool for agricultural research (STAR).

Results

Climate

Total rainfall during the trial was 496.8mm (Figure 1) with the majority of the rainfall falling in July (172 mm). Soil temperatures steadily climbed throughout the trial period from 4.5 ºC at the start of the trial and 13.6 ºC at the end of the trial. Soil temperatures ranged from 3 ºC to 16.6 ºC during the trial period with an average of 8 ºC (Figure 2).

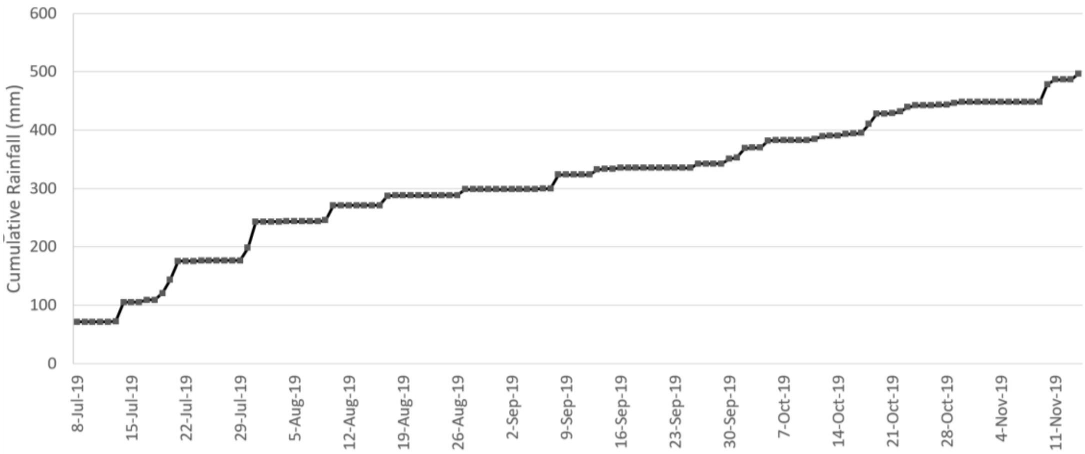

Figure 1: Cumulative rainfall during the trial period (08/07/2019 - 11/11/2019).

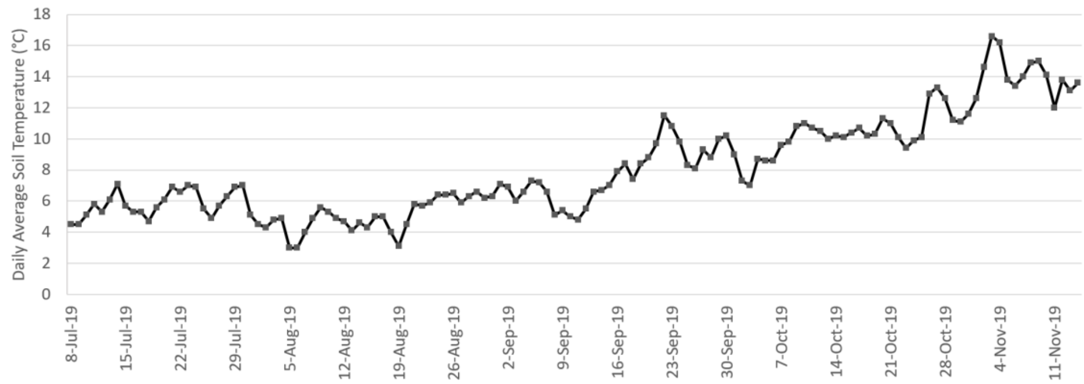

Figure 2: Average soil temperature during the trial period (08/07/2019 - 11/11/2019).

Magnesium in Herbage

Effect of Kieserite application rate

For the July application, the application of kieserite did not significantly increase the Mg content of the pasture compared to the control across all four sampling dates (Table 1). Furthermore, majority of the samples remained in the deficient range for pasture (<0.15 %) until soil temperatures warmed in early October where kieserite was applied, and in mid-November in the control (Figure 2). The application of kieserite, even at high rates, was unable to increase the herbage into the animal health range (>0.2 %) (Edmeades, 2004) across the July application trial.

In the August application the application rate of kieserite did significantly increase the Mg content in the herbage compared to the control (Table 2). Across all sampling dates, the 100 kg Mg/ha treatment significantly increasing the Mg content compared to the control. In contrast, the 25 kg Mg/ha and 50 kg Mg/ha treatment was not sufficient to increase the Mg content compared to the control.

Table 1: Effect of July and August application (application date 8th July and 8th of August, respectively) of different kieserite rates on the Mg content (%) of herbage. Same letters are not significant (P = 0.05).

Application Rate (kg Mg/ha)	July Application				August Application		
	8 Aug	**2 Sept**	**1 Oct**	**11 Nov**	**2 Sept**	**1 Oct**	**11 Nov**
0	0.115	0.118	0.140	0.168	0.118^{b}	0.138^{c}	0.170^{bc}
25	0.130	0.140	0.155	0.182	0.120^{b}	0.138^{c}	0.168^{c}
50	0.135	0.138	0.175	0.190	0.132^{b}	0.160^{b}	0.188^{ab}
100	0.132	0.135	0.150	0.182	0.158^{a}	0.192^{a}	0.200^{a}
ANOVA *P*-value	NS	NS	NS	NS	0.0041	<0.0001	0.013
LSD$_{0.05}$	-	-	-	-	0.019	0.014	0.019
CV (%)	10.43	12.06	12.35	10.37	9.14	5.65	6.69

Only the 100kg Mg/ha treatment was able to increase the herbage Mg into the pasture optimum range (>0.15%) across all of the sampling dates (Table 2). By October, the 50kg Mg/ha treatment had increased into the optimum range and by November all treatments including the control had increased into the pasture optimum range. All treatments and sampling dates did not increase the Mg content of the herbage into the animal health range (>0.2%).

Effect of sampling month

Magnesium content in the herbage increased over the sampling months for both the July application and the August application (Figure 3 and Figure 4).

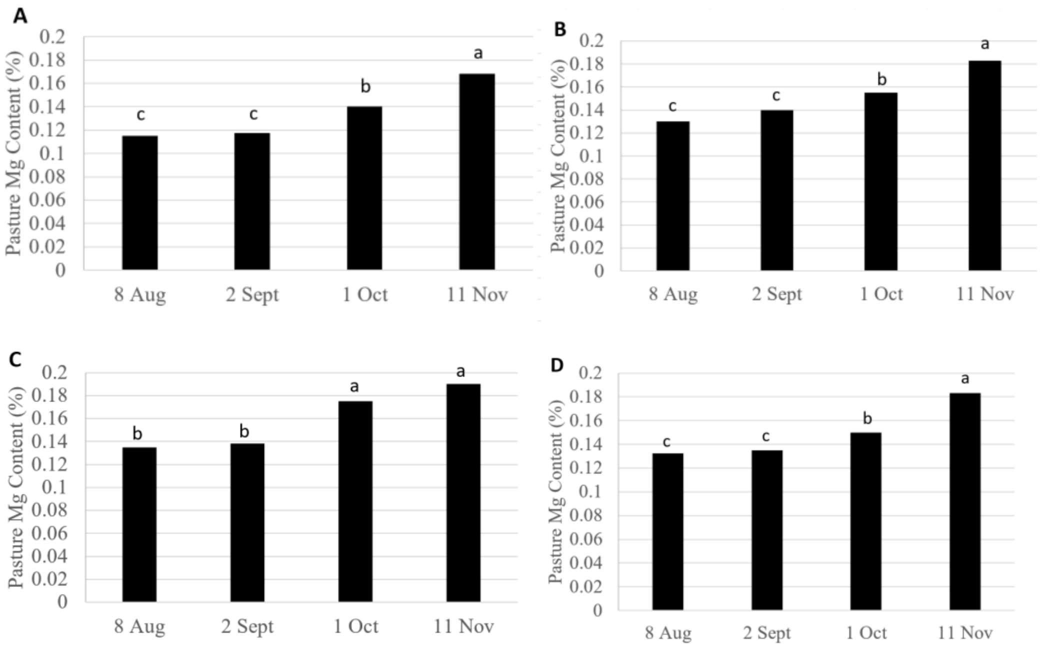

Figure 3: Effect of sampling date on Mg content (%) of the herbage for the July application (application date 8th July). A = control, B = 25 kg Mg/ha, C = 50kg Mg/ha and D = 100kg Mg/ha. Same letters above bar are not significant (P = 0.05). Least significant difference (LSD$_{0.05}$ = 0.0146).

For the July application, only the October and November samplings had significantly higher Mg content compared to the August and September sampling across all Mg application rates (Figure 3). In contrast, in the August application, the Mg content significantly increased in all sampling months across all Mg application rates (Figure 4).

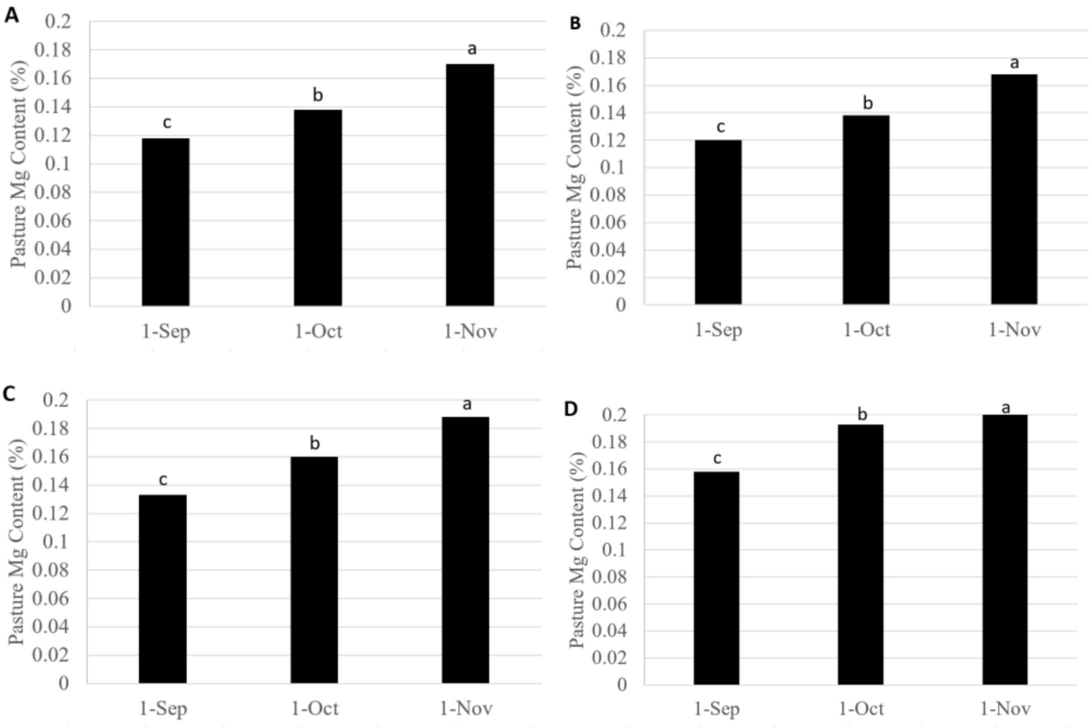

Figure 4: Effect of sampling date on Mg content (%) of the herbage for the August application (application date 8th July). A = control, B = 25 kg Mg/ha, C = 50kg Mg/ha and D = 100kg Mg/ha. Same letters above bar are not significant (P = 0.05). Least significant difference ($LSD_{0.05}$ = 0.0146).

Magnesium in Soil

Initial soil tests taken across the paddock determined that the average Mg content was QT Mg 14. This is well above the optimum range of QT Mg 8-10 required for pasture growth, but not in the animal health range (QT Mg 25-30) (Morton and Roberts, 1999). Soil testing completed in October 2019 (Figure 5) shows the control soil Mg content had increased to 16 from the paddock average taken in July 2019.

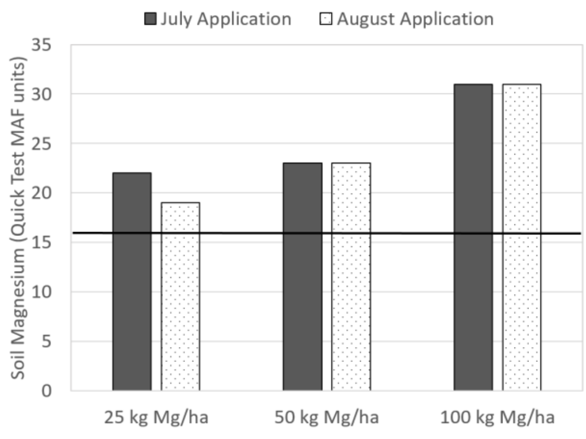

Figure 5: Soil magnesium levels tested to a depth of 75mm. Composite samples were taken from each of the treatment plots. Control Mg level is indicated by the black line.

Magnesium applications, regardless of application date, increased the Mg content of the soil, with the 25kg Mg/ha, 50kg Mg/ha and 100kg Mg/ha increasing the soil tests to an average of 21, 23 and 31 respectively.

Discussion

The application of kieserite in late winter was not able to increase Mg content in the herbage into the animal health range of >0.2% even at high application rates. This is in contrast to what was found by O'Connor *et al*. (2004) and McNaught *et al*. (1968) at North Island sites. The difference in results between trials demonstrates the effect of climatic factors on Mg uptake by pasture. Metson and Saunders (1978) and McNaught *et al*. (1968) found that Mg content in pastures were lowest in winter and highest in the summer in sites across the North Island. McNaught et al. (1968), in Ruakura, recorded soil temperatures of 11.2ºC in late June. Dalkeith's farm is located in Methven, at the base of Mt Hutt which is prone to low soil temperatures during winter and early spring. This was shown in the soil temperature data where soil temperatures only reached >10ºC consistently from October onwards (Figure 2). This indicates the importance of soil temperature on Mg uptake by pasture in early spring. In addition, warmer soil temperatures promote clover growth often increasing the proportion of clover in the pasture sward. Clover has been shown to have a higher Mg content, especially during cooler temperatures, than ryegrass plants (McNaught *et al.* 1968; McNaught *et al.* 1978; Metson and Saunders, 1978). A higher proportion of clover in the sward with warmer temperatures as well as increased Mg uptake by overall pasture could lead to higher Mg content. Mixed pasture samples were taken during the trial period, pasture composition was not measured, but reduced clover due to cooler temperatures could have contributed to lower Mg uptake at Dalkeith farm.

For all of the treatments and sampling dates the Mg content of the pasture was in the range of Mg concentrations commonly seen in New Zealand pastures (0.1-0.6%) (Table 1 and 2) (Smith and Cornforth, 1982). However, not all samples were above the deficiency range (0.15%) for mixed pastures (Morton and Roberts, 1999) even though the Mg content in the soil was in the optimum range (Figure 3). This reflects the value of having both a soil tests and herbage test when identifying limiting factors to pasture growth, especially with seasonal changes to nutrient uptake.

Initial soil tests of the trial site indicated that the QT Mg was 14. However further testing in October identified that the control plots had a QT Mg value of 16. Variability in Mg soil tests between the initial paddock soil test and the control composite soil test could have been caused by changes in testing date (Robert, 1987), area tested or just inherent natural variability within the paddock. Edmeades *et al.* (1985) found that Mg content within the soil could vary 10-15%. The application of kieserite increased the soil Mg by 5-7 kg Mg/ha per QT Mg MAF unit increase (Figure 5). This aligns with what is described in Morton and Roberts (1999) and demonstrates the value of capital Mg to increase soil tests to animal health ranges.

Thought needs to be given to the whole supplementation of the animal and the Mg content present in all forms of feed. O'Connor et al. (2004) found that where lower Mg feed was fed as a higher proportion of the diet due to wet weather events or poor pasture utilisation that Mg serum levels in the animal dropped. Indicating the importance of understanding the Mg content of all feed types. High Mg content during summer could be conserved or cut for supplements to be fed during the low Mg spring (McNaught *et al.* 1968)

Potassium (K) and nitrogen (N) application has been found to interact with Mg uptake of pasture (Schonewille, 2013). Soil tests at Dalkeith Farms showed a QT K of 12, above the optimum level of 6-8. Potassium uptake by the pasture during spring could have decreased Mg content in the herbage during this time. However, McNaught *et al.* (1968) found that seasonal changes in Mg content were not due to fluctuations in K herbage levels, but were rather due to climatic changes and N uptake. McNaught *et al*. (1973) found when there was a significant yield response to added K there was a decrease in Mg concentrations in the herbage. No potassium fertiliser was added during the trial period and although high levels of K found in the soil may have interacted with Mg uptake, they would have influenced all plots similarly.

Conclusion

The application of kieserite to Dalkeith Farms was not able to increase pasture Mg content into the animal health range during the early spring period when animal demand for the nutrient is high. This is due to cooler soil temperatures during this time effecting Mg uptake and potentially clover content in the sward.

Opportunities for future work

Further research needs to assess the impact of cool climates on Mg uptake by pasture and the impact of potassium soil test levels, all of the research referenced in this paper was North Island focused. Autumn applications of kieserite, when soil temperatures are warmer, could increase Mg content in autumn conserved pasture for spring grazing. Further research needs to be conducted in this area to fully understand if kieserite could be used to boost spring pastures.

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Reference

Edmeades, D.C., Cornforth, I.S., Wheeler, D.M. (1985). Getting maximum benefit from soil testing. *New Zealand Fertiliser Journal*. 67: 16-17.

Grace, N., Knowles, S. and Sykes, A. (2010) Managing mineral deficiencies in grazing livestock. *Occasional Publication No. 15 – New Zealand Society of Animal Production.*

McNaught, K. J., Dorofaeff, F. D. and Karlovsky, J. (1968). Effect of magnesium fertilisers and season on levels of inorganic nutrients in a pasture on Hamilton clay loam. I. Magnesium and Calcium. *New Zealand Journal of Agricultural Research,* 11: 533-550.

McNaught, K. J., Dorofaeff, F. D., Ludecke, T.E. and Cottier, K. (1973). Effect of potassium fertiliser, soil magnesium status and soil type on uptake of magnesium by pasture plants from magnesium fertilisers. *New Zealand Journal of Experimental Agriculture* 1 (4): 329-347.

Metson, A.J. and Saunders, W. M. H. (1978). Seasonal variations in chemical composition of pasture. *New Zealand Journal of Agricultural Research*. 21 (2): 341-353.

Morton, A. and Roberts, J. (1999). Fertiliser use on New Zealand Dairy Farms. Published by the Fertiliser Association of New Zealand, Wellington, New Zealand.

O'Connor, M.B.O., Hawke, M.F., Hunt, B.J., Alexander, K. and Roberts, A.H.C. (2004). Magnesium supplementation of the dairy herd: a case study in Northland and a comparison of two magnesium fertilisers; kieserite and magnesium oxide. *Proceedings of the New Zealand Grasslands Association*. 66: 245-249.

Roberts, A. (1987). Seasonal variation in soil tests and nutrient content of pasture at two sites in Taranaki. *New Zealand Journal of Experimental Agriculture*. 15: 283-294.

Schonewille, J.T. (2013). Magnesium in dairy cow nutrition: an overview. *Plant and Soil*. 368: 167-178.

Smith, G.S. and Cornforth, I.S. (1982). Concentrations of nitrogen, phosphorus, sulphur magnesium and calcium in North Island pastures in relation to plant and animal nutrition. *New Zealand Journal of Agricultural Research.* 25: 373-387.