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## Magnesium supplementation of lactating dairy cows in the summer and autumn

K.A. MACDONALD, J.W. PENNO, G.A. VERKERK, J. JAGO AND B.W. DOW

Dexcel Ltd, Private Bag 3123, Hamilton

### ABSTRACT

A series of three trials were established with 188 lactating dairy cows which were supplemented daily with either 0, 10 or 20 g Magnesium (Mg) during 18 weeks from January to May. Cows in each trial were allocated to treatments randomly in a cross-over design with each treatment lasting 2 weeks. This design was replicated three times during the 18 weeks. There was no treatment effect on serum Mg or milksolids (MS) production, (0.82, 0.82 & 0.83 mmol/l or 0.78, 0.79 & 0.77 kg MS/cow/day for 0, 10 & 20 g Mg, respectively; averaged across all trials) and there were no farmlet-by-treatment interactions. Based on visual assessments of pasture intakes and pasture mineral analysis, mean pasture Mg intakes during all three trials ranged from 23 to 35g Mg/cow/day (SEM 1.14). Urine Mg-creatinine ratio of 50 cows during Trial 3 indicated that the urinary Mg concentration increased linearly with increasing dietary Mg (1.38, 1.87, 2.01 for the 0, 10 and 20 g treatments, respectively; SED 0.175). Trial three results suggest that Mg surplus to requirement was being voided by the cow and that it is unlikely that even at the higher stocking rates, a milk production response to Mg supplementation will occur in the summer/early-autumn period when Mg in diet is >0.18%.

**Keywords:** Magnesium; milksolids; dairy cows; grazing.

### INTRODUCTION

The range of magnesium (Mg) concentration in NZ pastures is wide and this wide range is in part due to the many different soil types and the variations in botanical composition of NZ pastures. Seasonally, pasture Mg levels are lowest in late-winter/ early-spring and higher in the summer and autumn in apparent disharmony with potassium (K) (Roberts, 1987; Roche, 1999). This change is often attributed to increasing amounts of clover in the sward as clover has a higher Mg concentration than ryegrasses.

The uptake of Mg (from the soil) by the plant involves both passive and active mechanisms. There are many factors that affect this uptake and its subsequent availability to the animal. The most important of these is high K concentration, which can reduce either herbage Mg concentration or absorption of Mg by the animal. Both these factors lead to increased risk of metabolic disease (Roberts, 1994).

Magnesium is required for skeletal development as a constituent of bone and it also plays a role in neuromuscular transmission and activity and in many enzyme systems. In mature cattle, about 60% of total body Mg is stored in bones (Rook & Storry, 1962) but these reserves are mobilised very slowly in times of deficit; therefore, abrupt changes in diet and lowered Mg intake can result in hypomagnesaemia. Total dry matter intake (DMI) on a given day can be reduced by inclement weather and by cows grazing pasture with low dry matter (DM) %. Both these factors can lead to reduced Mg intake.

The susceptibility of cattle to Mg deficiency hinges on the fact that the primary site of Mg absorption is the rumen. Generally the absorptive efficiency for Mg by mature ruminants has an upper limit of 35%. Moreover, Mg absorption from a pasture diet is believed to be around 10 to 20%. The exact level of absorption can be influenced by high nitrogen (N) useage or high pasture K concentration (Hemingway, 1999). In an endeavour to match pasture growth with cow demands there has been an increase in the use of N fertiliser in the last 10 years. This could be detrimental, as plasma Mg concentration and Mg absorption

are reduced in cattle grazing pasture fertilised with N (Dalley, 1994). Ammonia levels in the rumen are increased by consumption of N-boosted pasture (Martens *et al.*, 1988) and high clover content in pasture could have a similar effect. The increased use of N could also mean lowered levels of clover in the sward leading to reduced levels of Mg in the diet (McLaren & Cameron, 1990). The loss of clover and hence, lowered Mg levels has been exacerbated by the presence of Clover Root Weevil (*Sitona lepidus*). In the last 5 years Clover Root Weevil and other pests has reduced the level of clover in the sward by 30% on Waikato farms (Harris, 1997).

In NZ, dairy cows are generally supplemented with Mg several weeks pre-calving until late-spring to overcome the risk of hypomagnesaemia (Young *et al.*, 1981). The use of magnesium supplements has reduced the prevalence of hypomagnesaemia, but it still results in a large economic loss, which was estimated by Towers (1994) to be \$18 million annually in reduced milk production and \$1-10 million in cow deaths. Ellison (1994) reported that there had been a steady increase in the number of herds found to be hypomagnesaemic since 1988. This trend in serum Mg status has been of concern to veterinarians.

There is anecdotal evidence from dairy farmers that Mg supplementation in the summer increases milk production and that cows are less nervous during milking, although in the summer and early-autumn some of the nervousness shown by cows may well be due to ryegrass staggers. Young *et al.* (1979) reported milkfat increases of 10-15% for cows supplemented with magnesium. Blood samples submitted to diagnostic laboratories in the autumn have tended to contain lower Mg concentrations (Ellison, 1994).

The aim of these trials was to measure milksolids (MS) response to magnesium supplementation during the summer and autumn and to determine if serum magnesium concentrations differ in herds managed at different stocking rates. The effect of magnesium supplementation on cow temperament in summer and autumn was also of interest.

## MATERIALS AND METHODS

A series of three trials was superimposed on 188 cows that were already being investigated in a multi-year farmlet comparison of Whole Farm Efficiency (WFE) at the No. 2 dairy of Dexcel (formerly Dairying Research Corporation). The WFE trial had 10 farmlets of Friesian cows (18-20/farmlet) at 5 stocking rates, from 2.2 to 4.3 cows/ha. The design of the WFE trial is such that, in the summer, the cows on the low-stocked farmlets are always fed close to *ad libitum*, while on the higher-stocked farms the intakes may be limited to approximately 10 kg DM/cow/day (66% of cow requirements). No. 2 dairy has three basic soil types ranging from a free-draining volcanic ash soil (Horotiu), a poorly drained silt loam (Te Kowhai) and a peaty loam (Te Rapa silt loam). These are evenly distributed across all farmlets.

In the WFE trial from mid-January onwards, if cow DMI (within any farmlet) is lower than 10 kg DM/cow/day, empty and cull cows (to a maximum of 20% of the herd) were removed from that farmlet. Similarly, when an individual cows body condition score (BCS) is lower than a set level they were dried off (Macdonald & Penno, 1998).

For this project the cows were allocated within farmlets to receive a supplement of either 0, 10 or 20 g Mg supplement/day, in the form of Magnesium Chloride MgCl<sub>2</sub>.6H<sub>2</sub>O. This was prepared as a solution and given to the cows orally (0, 120 or 240 ml solution) at the morning milking.

The cows were randomly allocated to each treatment (within each farmlet) balancing for age, pre-experimental blood Mg concentration and MS production. Each trial consisted of a cross-over design with three 14-day treatment periods. The first trial started on 20<sup>th</sup> January 1999 (Table 1). The summer in 1999 was dry in Waikato leading to reduced pasture growth. In February four farmlets had cows removed from them to reduce the stocking rate. During the second trial whole farmlets were dried off before completion of Trial 2. Thus, data from 10, 10 and 4 farmlets was used in the analysis for Trials 1, 2 and 3 respectively. If a farmlet had pasture silage surplus to winter requirements, this was fed to the cows of that farmlet in an attempt to maintain BCS.

**TABLE 1:** Dates for each 6-week treatment period and average pasture magnesium (Mg) and potassium (K) concentration (% dry matter) in each period and SEM for pasture analysis.

Trial	Dates	Pasture	SEM	Pasture	SEM
		Mg		K	
1	20th January to 2nd March	0.20	0.006	3.41	0.111
2	3rd March to 12th April	0.18	0.005	1.39	0.077
3	13th April to 24th May	0.22	0.009	3.29	0.102

Milk volume for each cow was measured weekly for two successive milkings and a sub-sample was analysed to determine milk fat, milk protein and lactose concentration using a FT120 (Foss Electric, Hellorod, Denmark). On one day at the end of each cross-over period the cows were weighed and BCS recorded after the morning milking. Herds were weighed consecutively and in a random order. On these occasions the behaviour of individual cows was also observed during Trial 1 & 2. To obtain a baseline behaviour score all cows were observed at a weighing before

Trial 1 commenced. Cows were observed from the time the rear gate of the weigh scale closed behind them until they walked off the platform. A score from (0-5) was given as follows:

- 0 Calm, stood completely still throughout weighing
- 1 Displayed **one** of the following: Moved her leg off the platform to reposition > 2 times; lifted her head in a jerky and rapid manner in a vertical direction; lost her footing while exiting the scale platform
- 2 Performed **two** of the behaviours described for score 1
- 3 Performed all **three** of the behaviours described for score 1
- 4 Was very unstable and leant on the sides of the weigh crate for support, shaky
- 5 Fell down during weighing and was unable to stand

At the end of each cross-over period (before the morning milking) a blood sample was collected from all cows by coccygeal venipuncture, serum extracted and serum Mg concentrations determined. Urine samples were collected once from 50 randomly selected cows during Trial 3 and the sample analysed for Mg and creatinine. Urinary Mg is expressed as a ratio to creatinine concentration to give Corrected Urinary Mg (CUMg), to overcome variations in urine volume between animals (Towers, 1982; Roche, 1999).

Pre-grazing pasture samples (to grazing height) were collected during each cross-over period and analysed for metabolisable energy (ME), crude protein and carbohydrates by Near Infra-Red Spectrometry (NIR) (Ulyatt *et al.*, 1995). Minerals were analysed by Plasma Emission Spectrometry. The timing was such that these samplings were collected on pasture grazed by the cows on the day before the blood samples were collected. Average pasture Mg was 0.20, 0.18 & 0.22 and pasture K was 3.41, 1.39 and 3.29 % DM for Trials 1, 2 and 3 respectively (Table 1). Pasture intakes of the groups were also assessed on three occasions per week from pre-grazing and post-grazing herbage mass estimated by calibrated eye assessment (O'Donovan, 2000).

### Statistical Analysis

Urine and animal behaviour data were analysed using ANOVA. Serum magnesium and milk data were analysed with residual minimum likelihood (REML) in Genstat 5 Release 4.2 statistical package.

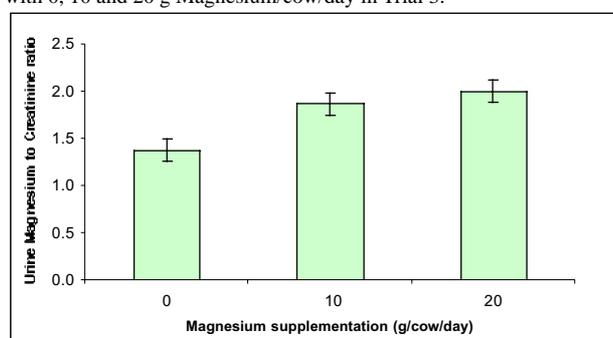
## RESULTS

The mean serum Mg concentration across all farmlets was 0.83 mmol/l. There were no significant treatment effects on serum Mg during any of the three trials (Table 2). Similarly the supplementation of Mg had no effect on milk yield, milk fat or milk protein (Table 2) and there were no farmlet-by-treatment interactions.

Urine samples collected from 50 cows indicated that there was an increase in CUMg with increasing level of supplementation (P<0.001) for the 0, 10 and 20 g treatments, respectively (SED 0.175) (Figure 1). Mean estimated group pasture intakes during Trial 1 were 12 - 13 kg DM/cow/day. In Trial 2, low cow DM intakes and low BCS meant that some of the farmlets had all the cows dried off before completion of the trial. Production during Trial 3 were

**TABLE 2:** Serum magnesium concentration and yield of milk, milk fat and milk protein for cows treated with differing levels of magnesium supplementation.

	Trial	Magnesium g /cow/day			SED
		0	10	20	
Serum Magnesium (mmol/l)	1	0.81	0.81	0.82	0.005
	2	0.82	0.81	0.82	0.007
	3	0.82	0.83	0.84	0.018
Milk (kg/cow/day)	1	11.3	11.3	11.2	0.092
	2	6.3	6.5	6.3	0.111
	3	8.1	8.4	8.1	0.220
Milk fat (kg/cow/day)	1	0.39	0.40	0.39	0.003
	2	0.25	0.26	0.25	0.004
	3	0.32	0.33	0.33	0.008
Milk Protein (kg /cow/day)	1	0.39	0.40	0.39	0.003
	2	0.25	0.26	0.25	0.004
	3	0.32	0.33	0.33	0.008

**FIGURE 1:** Urine magnesium to creatinine ratio for cows supplemented with 0, 10 and 20 g Magnesium/cow/day in Trial 3.

higher than that for Trial 2 because only the highest producing cows in the low-stocked farmlets were still being milked (Table 2).

Estimated mean group DM intakes of the cows ranged from 12.2 to 17.1 kg DM/cow/day (Table 3). Based on mean group pasture intakes, pasture Mg intakes (g Mg/cow/day) were calculated to range from 23 to 35 g Mg/cow/day (SEM 1.14).

**TABLE 3:** Calculated average dry matter intakes (DMI) from pasture and pasture silage and magnesium intake for Trials 1, 2 & 3.

Farmlet	DMI (kg DM/cow/day)	g Mg /cow/day
1	16.8	35
2	16.3	32
3	14.8	33
4	13.3	29
5	12.2	31
6	15.1	27
7	17.1	24
8	15.3	31
9	13.2	23
10	13.7	30

**TABLE 4:** Mean behaviour score during weighing for treatments 0, 10 & 20 g Mg/cow/day in Trial 1 and 2.

	Treatment (g Mg/cow/day)			sed	P
	0	10	20		
Trial 1	0.32	0.36	0.33	0.049	n.s
Trial 2	0.29	0.26	0.31	0.044	n.s

In the behaviour study the majority of cows scored either 0 or 1 throughout the trial (62.4% and 17.2% of scores were 0 and 1, respectively). Only two animals scored 4 and no

animals recorded a score of 5. Treatment had no significant effect on behaviour score during weighing in either Trial 1 or 2 (Table 4).

## DISCUSSION

This series of trials has investigated whether Mg supplementation in summer/autumn can increase milk production. Within the range of Mg intakes of the cows there was no effect of supplementation on production. Even at a blood concentration of 0.75 mmol/l (the lowest measured mean for any of the farmlets) a cow would not be considered to be clinically Mg deficient. The effect of additional Mg supplied to the cows could have been negated by a high pasture K concentration (Trial 3 mean: 3.29 % DM, SEM 0.102) which has been shown to reduce Mg absorption in the rumen (Schoneville *et al.*, 1999). The drop in pasture K of 3.41 to 1.39% between Trial 1 and 2 (Table 1) is probably due to the reduced uptake by the plant in a lowered growth period.

The design of the Whole Farm Efficiency Trial is such that there are large differences in pasture DMI between farmlets by virtue of the extreme differences in stocking rate. The fact that there was no farmlet-by-treatment interaction suggests that even at low levels of pasture intake, the higher-stocked cows were still consuming enough Mg. In the autumn (Trial 3), when pasture growth had increased following autumn rains and nitrogen applications, there was no treatment response and pasture Mg concentration was similar with those recorded in Trials 1 & 2.

Cows that are hypomagnesaemic are often much more alert and exhibit nervousness when exposed to unusual situations, such as upon entering a weigh platform. Supplementation with Mg had no effect on cow behaviour at weighings.

If Mg deficiency were to occur it would be expected to be greatest in the higher-stocked farmlets. When pasture Mg concentration was approximately 0.2% DM, Mg intakes were about 20 g/cow/day. The heaviest group of cows weighed approximately 500 kg and were producing 14 kg milk/day. Their dietary Mg requirements were calculated as 17.5g Mg/day (Holmes *et al.*, 1987). In all three trials the estimated dietary Mg intake was above this level so any response to supplementation was unlikely to occur. The fact that at 0g Mg, the minimum calculated intake was 23 g Mg/cow/day and that the Mg excreted in the urine increased with the level of supplementation supports the argument that the cows had sufficient Mg in their diet.

These results suggest that production responses to Mg supplementation in the summer and autumn are unlikely. Even at high stocking rates and subsequently low pasture intakes, Mg supplementation did not elevate serum Mg concentration or affect milksolids production.

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