
THE PROCEEDINGS OF THE
NEW ZEALAND SOCIETY
OF
ANIMAL PRODUCTION
VOLUME 62 2002

Salt supplementation of lactating dairy cows

K.A. MACDONALD[1], J.A. LILE[1], J.A.S. LANCASTER[1], M. COULTER[1] AND M.B. O'CONNOR[2]

[1]Dexcel, Private Bag 3221, Hamilton,

ABSTRACT

Increased intensification of dairy production has contributed to a decrease in the sodium (Na) status of soils throughout New Zealand. This decline has the potential to detrimentally affect animal health and production. A trial was established to determine whether milk production responses would be obtained to sodium supplementation of cows receiving about 0.1% (0.06-0.14%) Na in pasture. The cows were in mid-lactation and were randomly allocated to either the control group or a group receiving 14 g Na/cow/day. Supplementation with 14 g Na did not increase milk yield or affect milk composition and there was no interaction with stocking rate. Serum Ca, Mg, Na, and Cl concentration were not affected by treatment, but serum K concentration decreased with Na supplementation. In summary: 0.1% Na in the diet is sufficient for mid-lactation dairy cows producing 10-12 l milk/cow/day (0.9 kg milksolids/cow/day) and a milk production benefit will not be achieved through Na supplementation.

Keywords: sodium; milksolids; dairy cows; grazing; supplementation.

INTRODUCTION

Sodium (Na) is an essential element for animals but is not required by plants. Soil reserves of sodium are declining in many soils (O'Connor, unpublished data). This decline will reduce pasture Na concentration. High producing dairy cows require approximately 22 g Na/day (Underwood & Suttle, 1989). Supplementation with Na can be either direct (via oral supplements) or indirect through fertiliser. Some plants (e.g., white clover-*Trifolium repens* and ryegrass- *Lolium perenne* L) readily take up sodium, but others like lucerne (*Medicago sativa*), browntop (*Agrostis tenuis*) and kikuyu (*Pennisetum clandestinum*) have low rates of uptake.

In New Zealand, inland soils in particular are low in sodium. This includes the Central Plateau pumice soils of the North Island and the associated volcanic soils of the Waikato/King Country and soils of inland Marlborough, Canterbury, Otago and Southland in the South Island. Increased intensity of dairy production has probably contributed to a decrease in the sodium status of these and other soils throughout New Zealand (O'Connor, unpublished data). Rainfall is the major source of sodium for soils and contributes 30 kg Na/ha/year (1200 mm annual rainfall) at No. 2 dairy, Dexcel. However, leaching losses under intensive dairy management can range from 47-79 kg Na/ha/year (Rajendram *et al*., 1998), indicating a net loss of sodium. Monaghan *et al*. (2000) calculated that a loss of 29 kg Na/ha/yr in Southland is conceivable. This loss combined with the use of potassium-based fertilisers (Morton *et al*., 2000; Roche *et al*., 2001) is likely to greatly reduce the Na concentration in pastures.

Reported responses to Na supplementation vary. O'Connor *et al*. (2000) reported an increase of 12.8% in milksolids (MS) production in New Zealand when cows grazing pastures containing 0.05% Na were supplemented with 15 g Na. Responses were immediate and persisted throughout the trial period (11th November 1999 to 18th February, 2000). Furthermore there was a strong indication that the higher-producing cows responded more to salt supplementation compared with low-producing cows. The increased milksolids production (0.17 kg MS/cow/day) *et al*. (2000) was valued at 77 cents/cow/day (@ $4.50/kg MS). Sodium costs of approximately 1 cent/cow/day resulted in a very economic return. The response obtained in this trial is likely to be at the high end of the scale due to the very low pasture Na status (0.05% Na) compared with the recommended concentration for dairy cows of 0.12% DM (Optigrow, 1998). Joyce *et al*. (1975) obtained responses to Na supplementation of animals grazing lucerne. Chiy *et al*. (1993) have reported milk responses and also grazing behavioural differences in cows fed Na fertilised pasture, whereas Brookes and Wilson (1983) found no response to Na for cows consuming red clover containing 0.065 to 0.075% Na.

The responses obtained by O'Connor *et al*. (2000) were under Na-deficient conditions and would not be regarded as normal in most of the dairying areas of NZ. Nevertheless, the publicity given to this research has seen widespread adoption of Na supplementation. The trial reported here was established at No. 2 dairy Dexcel, to determine whether Na supplementation in mid-lactation would increase milk production when pasture Na concentrations were approximately 0.12% Na.

MATERIALS AND METHODS

The trial undertaken at No. 2 dairy Dexcel, utilised 188 Friesian cows on 10 farmlets that were part of a multi-year whole farm efficiency study (Macdonald *et al*., 2001). Stocking densities on the 10 farmlets differed and is described in Table 1. No. 2 dairy has three basic soil types ranging from a free-draining volcanic ash soil (Horotui), a poorly drained silt loam (Te Kowhai) and a peaty loam (Te Rapa silt loam). These are evenly distributed across all farmlets.

The cows were randomly allocated to salt supplement or control group (within farmlets), ensuring that there was an even distribution of age, genetic merit and pre-experimental milk and milksolids production. The trial

[2]AgResearch, Ruakura, Private Bag 3123, Hamilton

TABLE 1: Nutritive characteristics and mineral concentration[1] pasture offered to cows at various stocking densities.

Farmlet	Stocking rate	Na	K	Mg	Ca	P	ADF[2]	NDF[3]	CHO[4]	CP[5]	MJ ME[6] /kg DM
1	2.2	0.13	2.16	0.20	0.74	0.30	30.8	50.6	7.5	15.4	7.8
2	2.7	0.08	1.65	0.18	0.40	0.24	33.9	58.4	6.8	14.4	7.7
3	3.1	0.07	3.31	0.18	0.45	0.30	28.8	48.4	6.2	18.7	8.8
4	3.7	0.12	3.39	0.26	0.58	0.35	25.2	43.0	6.2	25.1	9.8
5	4.3	0.14	4.30	0.28	0.52	0.31	23.8	41.0	6.6	25.0	10.0
6	2.2	0.06	3.04	0.18	0.44	0.28	28.7	52.2	5.9	19.4	8.7
7	2.7	0.09	3.07	0.20	0.50	0.28	27.1	48.7	7.1	20.4	9.6
8	3.1	0.13	2.98	0.25	0.53	0.25	26.1	47.5	8.2	19.4	9.6
9	3.7	0.06	4.01	0.20	0.48	0.33	23.8	39.4	7.6	21.6	9.9
10	4.3	0.12	5.47	0.25	0.67	0.30	22.4	34.6	7.6	25.4	10.0

[1] % unless otherwise stated
[2] ADF = Acid detergent fibre
[3] NDF = Neutral detergent fibre
[4] CHO = Soluble Carbohydrate
[5] CP = Crude protein
[6] MJ ME = Megajoules of metabolisable energy

ran from the 31st January to 21st February 2001. The cows were at approximately day 180 of lactation and treated cows received an oral supplement of 14 g Na/cow/day in the form of sodium chloride (35 g /cow/day) at the morning milking.

Milk volume for all cows in each farmlet was measured weekly at successive am and pm milkings and a sub-sample was analysed to determine milkfat, milk protein and lactose concentration using a FT120 (Foss Electric, Hellorod, Denmark). Blood was collected from 54 cows prior to beginning sodium supplementation and following three weeks of Na supplementation. Cows in farmlets 1, 3 & 5 were selected to give a range of stocking rates (Table 1). The blood was collected prior to the am milking by coccygeal venipuncture into a plain vacutainer and analysed for sodium, magnesium, calcium, and potassium concentration.

Pre-grazing pasture samples for each farmlet (to grazing height) were collected (once pre trial and once during the trial) and metabolisable energy (ME), crude protein, NDF, ADF and soluble carbohydrates was estimated by Near Infra-Red Spectrometry (NIR) (Ulyatt *et al.,* 1995). Minerals were analysed by Inductively Coupled Plasma Emission Spectrometry (ICP-ES). The sampler wore plastic gloves to ensure the samples were not contaminated with sweat. Group pasture intakes of the groups were estimated by calibrated eye assessment (O'Donovan, 2000) of pre and post-grazing herbage masses on three occasions per week.

Statistical analysis

The data was analysed using analysis of variance as a farmlet x salt treatment factorial design and including uniformity data within Farmlet as a covariate with GenStat Release 4.22. The milk data for each week was analysed and the means of the three weeks' data for each cow was calculated and then analysed.

RESULTS

Pasture quality was poor as indicated by low ME concentration (7.7–10.0 MJ ME/kg DM) (Table 1). Following a period of low rainfall, pasture quality declined

TABLE 2: Estimated dry matter intake (DMI) and sodium intake of cows at various stocking rates.

Farmlet	Stocking rate	DMI (kg DM/cow/day)	Na intake g/cow/day
1	2.2	18.0	23
2	2.7	14.8	12
3	3.1	15.4	11
4	3.7	14.6	18
5	4.3	11.7	16
6	2.2	18.5	11
7	2.7	12.5	11
8	3.1	12.0	16
9	3.7	13.6	8
10	4.3	9.0	11

TABLE 3: Effect of sodium supplementation on serum mineral concentration (mmol/l) and yield of milk, milkfat, protein and milksolids (kg/day) in mid-lactation.

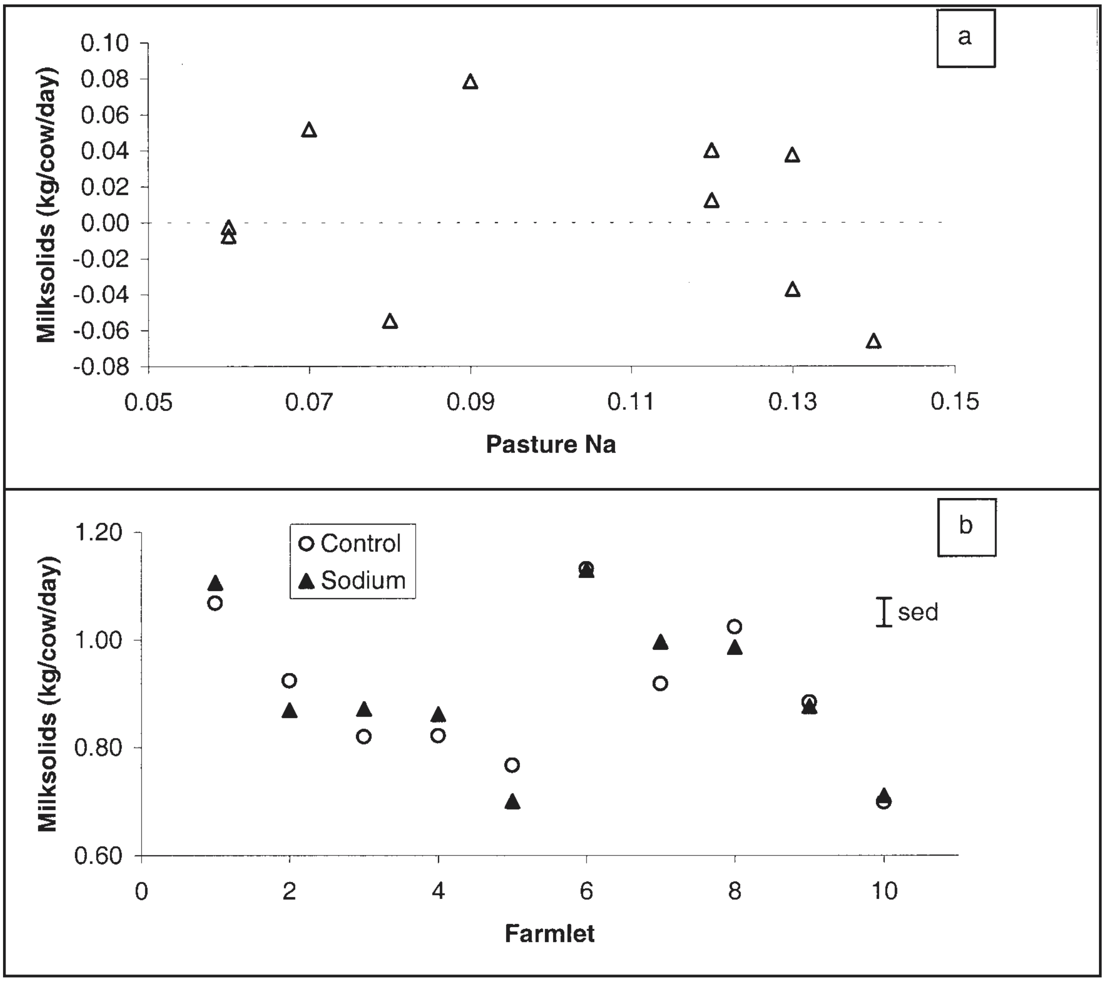
	Control (0 g Na/day)	Treatment (14 g Na/day)	SED
Milk parameters			
Milk	11.1	11.1	0.16
Milkfat	0.53	0.53	0.010
Milk protein	0.38	0.38	0.005
Milksolids	0.91	0.91	0.014
Serum parameters			
Magnesium	0.83	0.82	0.020
Calcium	2.60	2.60	0.026
Chlorine	99	100	0.7
Potassium	4.56	4.23	0.113
Sodium	137	138	0.4

from an average of 10.7±0.5 MJ ME during the pre-experimental period

The nutritive characteristics and mineral concentrations of the pasture offered are presented in Table 1. Herbage sodium concentrations varied within farmlets (0.10% Na ±0.04). Pasture K averaged 3.34% DM and ranged from 1.65 to 5.47 % DM (Table 1). Calculated pasture Na consumed ranged from 8 to 23 g/cow/day (Table 2)

Supplementation with Na had no significant affect on milk yield, milkfat, milk protein (Table 3) or milksolids yields (Figure 1a). There was no significant interaction of farmlet with salt treatment (Figure 1b).

FIGURE 1. Milksolids response to sodium supplementation on pastures with different sodium concentrations (a) and the milksolids response to sodium supplementation of cows on farmlets with different stocking rates (b)



The serum concentration of magnesium, calcium, chlorine and sodium were unaffected by treatment (Table 3). However, supplementation decreased ($P< 0.01$) blood potassium concentration.

DISCUSSION

The design of the WFE trial was such that, in the summer, the cows on the low-stocked farmlets were fed close to *ad libitum*, while on the higher-stocked farms the intakes may have been limited to approximately 10 kg DM/cow/day (66% of cow requirements). The lack of a milk production response to Na supplementation suggests that Na intake (pasture Na concentration) was sufficient for the level of production. Pasture energy concentration declined to an average of 9.2 MJ ME/kg DM (Table 1), which was not sufficient energy to maintain high levels of milk production (<11 litres/cow/day). O'Connor *et al.* (2000) reported that there was a strong indication that the higher-producing cows responded better to salt supplementation than low-producing cows. This is not supported by data reported here as there was no treatment by stocking rate or treatment by level of MS production interactions (Figures 1a & 1b).

The decline in serum K concentration in the experiment reported here was unexpected. Martens *et al.* (1987) found increased concentration of K in saliva and rumen fluid which would presumably result in lower blood K when cows were deficient in Na. A decrease in serum K with Na supplement was unexpected and the reason for this decline remains enigmatic.

Generally, sodium supplementation is either given orally (in drenches) or in fertiliser form. Direct supplementation of Na has the advantage over topdressing in enabling the supply of exact Na requirements. Due to the relatively low cost of Na, it is often suggested as an additive to bloat drenches. However there can be problems in oral supplementation of Na. In some cows sodium chloride can cause contraction of the reticular (oesophageal) groove (Carruthers *et al.*, 1994; McLeay *et al.,* 2002) and the Na and animal health product is directed into the abomasum instead of the rumen. This could have negative ramifications if the health product is required in the rumen (e.g., bloat oil).

Furthermore researchers (e.g., Chiy & Phillips) have reported significant benefits in milk production to Na supplementation through pasture fertilisation. They hypothesise that effects of this are due to reasons other than Na deficiency per se. e.g., herbage digestibilty and palatability. Little work has been done on these aspects in New Zealand although O'Connor (unpublished) found increased herbage palatability through sodium fertilisation. Although the results presented here do not support oral supplementation of Na when >0.1% Na in the diet, they do not provide an insight into Na supplementation by other means.

O'Connor *et al*. (1989) suggested that there may be a 40-100% fluctuation in pasture Na concentration on trial sites and concluded that it is likely to be bigger with paddock sampling due to within-paddock variation. These results are supported by data from No. 2 dairy (Macdonald, unpublished data). Although herbage Na was found to vary between farmlets (0.1% DM ±0.04), there was no interaction between Na supplement and farmlet in this study.

CONCLUSION

No evidence was obtained to indicate that cows in mid-lactation grazing pastures containing 0.06-0.14% Na required sodium supplementation.

ACKNOWLEDGEMENTS

The authors greatly acknowledge the staff of Dexcel's No. 2 dairy for their assistance and Barbara Dow for the statistical analysis.

REFERENCES

Brookes, I.M.; Wilson, G.F. 1983: Milk production by dairy cows grazing 2 red clover cultivars with and without sodium supplementation. *New Zealand journal of experimental agriculture 11*: 137-140

Carruthers, V.R.; Phipps, D.E.; Bakker, R.J. 1994: The effect on oesphageal groove closure of water and mineral solutions drenched to cows. *Proceedings of the New Zealand Society of Animal Production 54*: 23-25

Chiy, P.C.; Phillips, C.J.C.; Bello, M.R. 1993: Sodium fertiliser application to pasture. 2. Effects on dairy cow production and behaviour. *Grass and forage science : 48*. 203-212

GenStat (2000): GenStat for Windows. Release 4.22. Fifth Edition. VSN International Ltd., Oxford

Joyce, J.P.; Brunswick, L.C.F. 1975: Sodium supplementation of sheep and cattle fed lucerne. *New Zealand journal of experimental agriculture 3*: 299-304

Macdonald, K.A.; Penno, J.W.; Nicholas, P.K.; Lile, J.A.; Coulter, M.; Lanacaster, J.A.S. 2001: Farm systems – Impact of stocking rate on dairy farm efficiency. *Proceedings of the New Zealand Grasssland Association 63*: 223-227

Martens, H.; Kubel, O.W.; Gabel, G.; Honig, H. 1987: Effects of low sodium uptake on magnesium metabolism of sheep. *Journal of agricultural science, Cambridge 108*: 237-243

McLeay, L.M.; Waller, J.E.; O'Connor, M.B.; Hobson, B.L. 2002: Reticular groove contraction in dairy cattle following drenching with anti-bloat and a mixture of anti-bloat and NaCl. *New Zealand veterinary journal. (In Press)*

Monaghan, R.M.; Paton, R.J.; Smith, L.C.; Binet, C. 2000: Nutrient losses in drainage and surface runoff from a cattle-grazed pasture in Southland. *Proceedings of the New Zealand Grassland Association 62*: 99-104

Morton, J.D.; Smith, L.C.; Roberts, A.H.C.; O'Connor, M.B.; Hunt, B.J. 2000: Effect of K and N on minerals required by dairy cows. In Soil Research: A knowledge industry for land-based exporters. (Eds. L.D. Currie and P. Loganathan). Occasional Report No. 13. *Fertiliser and Lime Research Centre, Massey University, Palmerston North. (In press)*

O'Connor, M.B.; Addison, B.; Miller, A.D. 1989: The effects of topdressing pastures in the Waikato with sodium chloride. *Proceedings of the New Zealand Grassland Association 50*: 83-87

O'Connor, MB.; Hawke M.F.; Waller, J.E.; Rotherham, J.R.; Coulter, S.P. 2000: Salt supplementation of dairy cows. *Proceedings of the New Zealand Grassland Association 62*: 49-53

O'Donovan, M. 2000: The relationship between the performance of Irish Dairy cows and grassland management practise on intensive dairy farms in Ireland. *PhD Thesis, National University of Ireland, 366 pages*

Optigrow, 1988: Animal health profiles - a guide to veterinarians. Ministry of Agriculture and Fisheries

Rajendram, G.S.; Ledgard, S.F.; Monaghan, R.; Penno, J.W.; Sprosen, M.; Ouyang, L. 1998: Effect of rate of nitrogen fertiliser on cation and anion leaching under intensively grazed dairy pasture. In long-term nutrient needs for New Zealand's primary industries: global supply, production requirements and environmental constraints. (Eds L.D. Currie and P. Loganathan). Occasional Report No. 11. *Fertiliser and Lime Research Centre, Massey University, Palmerston North* Pp. 67-74

Roche, J.R.; Kolver, E.S.; Roberts, A.; Morton, J. 2001: Dietary potassium does not negatively affect blood calcium in preparturient cows fed pasture. *Proceedings 11th international conference on production diseases in farm animals. 12-16 August*, *Copenhagen* Pp 101

Ulyatt, M.J.; Lee, J.; Corson, D. 1995: Assessing feed quality. *Proceedings of the Ruakura farmers' conference 47*: 59-62

Underwood, E.J.; Shuttle, N.F. 1989: The Mineral Nutrition of Livestock. 3rd Edition. CABI Publishing. Oxon. UK