Effect of chloride fertilisation on dietary cation-anion difference forage species

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Abstract

The dietary cation and anion difference (DCAD) is an important property when assessing feed for dry cows in order to avoid hypocalcaemia following calving. Low values of DCAD may reduce the risk of milk fever. DCAD is often calculated as the difference between the cations Na^+ and K^+ and the anions Cl^- and S^{2-}. Research has shown that chloride fertilization may reduce DCAD, and that there might be differences in DCAD between commonly used grass species. In a research project in Central Norway the effects on DCAD of different rates of chloride fertiliser application were investigated. Fertilization with 70, 140 or 210 kg Cl per hectare in calcium chloride did significantly reduce DCAD in forage from leys dominated by timothy and meadow fescue. Pure stands of seven grass species were fertilized with either 0 or 140 kg Cl per hectare in spring. The lowest values of DCAD were found in reed canary grass and perennial ryegrass.

Keywords: anions, cations, DCAD, DM yield, mineral difference

Introduction

Milk fever is the second most common production disease in Norwegian dairy production. In the sixties Norwegian scientists showed that anions in the feed could reduce the risk of milk fever (Ender *et al.* 1971). Rations with low values of DCAD activate the homeostatic regulation of calcium and increase intestinal absorption (Martín-Tereso and Martens, 2014). But anionic salts are not very palatable for cattle and it may thus be difficult to get the cows to eat the products. The most common formula of DCAD is: $([Na^+]+[K^+]) - ([Cl^-]+[S^{2-}])$ in mEq kg^{-1} DM. The contents of K and Cl are easier to manipulate than the contents of Na and S. To prevent hypocalcaemia, the DCAD in rations fed to non-lactating dairy cows 3-4 weeks before calving should be around -50 mEq kg^{-1} (Pelletier *et al.*, 2007). Research has shown that chloride fertilization may reduce DCAD, even to negative values, and that there might be differences in DCAD between commonly used grass species (Pelletier *et al.*, 2007). The results indicated an economically optimal rate in the spring between 78 to 123 kg Cl ha^{-1}. The DCAD decreased with advancing stages of development of the grasses. In a research project in Central Norway the effects of chloride fertiliser application on DCAD in different types of grassland were investigated.

Materials and methods

A fertiliser experiment was established in young leys dominated by timothy and meadow fescue at three sites in Central Norway in 2012. The experimental plots (2×7 m) were fertilised with either a 'normal' amount of potassium (according to soil analyses) or half the level of 'normal'. The application of nitrogen and phosphorus in spring was 120 kg and 17 kg per hectare, respectively. At each level of potassium application, the following amounts of Cl were given as calcium chloride in spring, in three replicates: 0, 70, 140 and 210 kg ha^{-1}. The experiments were harvested in 2012 and 2013 at the first cut about two weeks after start of heading of timothy. A similar field experiment was also established in Central Norway in 2013. Instead of four levels of chloride fertilization, the treatments were: 0 kg Cl, 140 kg Cl ha^{-1} in either calcium chloride or magnesium chloride and 210 kg in calcium chloride. This experiment was harvested in two years. In another type of experiment pure stands of seven grass species were established at three sites in 2012, and fertilised and harvested in 2013 and 2014. The species were: timothy (*Phleum pratense* L.), meadow fescue (*Festuca pratensis* L.), cocksfoot (*Dactylis glomerata* L.), smooth bromegrass (*Bromus inermis* Leyss.), reed canary grass (*Phalaris arundinacea* L.), perennial ryegrass (*Lolium perenne* L.) and festulolium (*Festulolium*). The plots were fertilised with either zero or 140 kg Cl in calcium chloride. The first cut was harvested about two weeks after start of heading of timothy for all species, except smooth bromegrass and reed canary grass, which were cut one week later. Grass samples were analysed for content of minerals. Dietary cation-anion difference (DCAD), as mEq kg^{-1} DM, was calculated according the following equation:

$$((Na/22.9+K/39.1) - (Cl/35.5+S \times 2/32.07)) \times 1000.$$

Na, K, Cl and S are in g kg^{-1} DM.

Data from the fertiliser experiment (means for three replicates within year and site) were analysed according to an ANOVA with a split-plot design. The fixed factor potassium fertilization rate was on main plots and the fixed factor chloride application rate on sub-plots. Year (1 and 2) and site (1, 2 and 3) were included as random factors in the model. For the trials comparing different species, means for three replicates within each of three sites in one experimental year were subjected to ANOVA. These data were also analysed as a split-plot, with chloride application rate on main plots and grass species on sub plots. Site was included in the model as a random effect.

Results and discussion

Application of potassium and calcium chloride did not affect the dry matter yield in the fertilisation experiments (Table 1). The DCAD and the contents of K, Na and S were not significantly influenced by the level of potassium fertilisation. Application of chloride did lower the DCAD, and increased the content of K and Cl. The difference in DCAD between 140 and 210 kg Cl ha^{-1} was not significant. There was no effect of chloride type on DCAD. Fertilisation with 280 kg Cl ha^{-1} did not decrease DCAD compared to 140 kg Cl.

There were significant differences in DCAD between the species, but there were no effects of Cl fertilisation on DCAD in the different species on average of three field trials in the first year (Table 2).

Table 1. Dietary cation-anion difference (DCAD), content of minerals and dry matter (DM) yield at first cut. Effects of chloride and potassium fertilisation on leys dominated by timothy and meadow fescue. Average of three field trials in two years.

K fertilisation	Cl fertilisation	DM yield (Mg ha^{-1})	DCAD (mEq kg^{-1} DM)	K (g kg^{-1} DM)	Na (g kg^{-1} DM)	Cl (g kg^{-1} DM)	S (g kg^{-1} DM)
Low	0	7.3	151	16.7	0.51	7.5	1.4
	70 kg Cl ha^{-1}	7.3	83	18.2	0.74	11.6	1.4
	140 kg Cl ha^{-1}	7.1	52	18.9	0.72	13.4	1.3
	210 kg Cl ha^{-1}	7.2	43	18.4	0.78	13.3	1.4
Normal	0	7.2	134	19.3	0.48	10.5	1.4
	70 kg Cl ha^{-1}	7.1	110	21.6	0.64	13.5	1.4
	140 kg Cl ha^{-1}	7.3	81	21.2	0.46	14.1	1.4
	210 kg Cl ha^{-1}	6.9	64	21.7	0.48	15.0	1.4
P potassium fertilisation		ns[1]	ns	ns	ns	0.01	ns
P chloride fertilisation		ns	0.00	0.05	ns	0.00	ns
P Cl fertilisation × K fertilisation		ns	ns	ns	ns	ns	ns

[1] ns = not significant.

Table 2. Dietary cation-anion difference (DCAD), content of minerals and dry matter yield at first cut. Effects of chloride fertilisation on different species. Average of three field trials in one year.

Cl fertilisation		DM yield ($Mg\ ha^{-1}$)	DCAD ($mEq\ kg^{-1}$ DM)	K ($g\ kg^{-1}$ DM)	Na ($g\ kg^{-1}$ DM)	Cl ($g\ kg^{-1}$ DM)	S ($g\ kg^{-1}$ DM)
No Cl	timothy	7.2	235	19.3	0.15	6.8	1.2
	mead. fescue	6.5	229	23.1	0.27	9.9	1.6
	cocksfoot	5.9	347	23.9	0.88	7.8	1.5
	smooth bromegrass	7.4	213	16.8	0.27	5.8	1.1
	reed c. grass	6.4	180	19.4	0.20	8.1	1.4
	ryegrass	6.2	268	21.1	1.58	8.9	1.6
	festulolium	6.4	312	25.2	1.10	9.1	1.7
140 kg Cl ha^{-1}	timothy	7.0	110	19.9	0.17	12.3	1.1
	mead. fescue	6.7	154	24.6	0.22	14.4	1.6
	cocksfoot	5.4	156	28.0	1.15	18.3	1.5
	smooth bromegrass	7.0	154	18.7	0.20	10.1	1.1
	reed c. grass	6.9	36	20.4	0.28	13.9	1.5
	ryegrass	6.5	69	23.6	2.25	19.6	1.6
	festulolium	6.6	119	27.2	0.95	17.7	1.6
P chloride fertilisation		ns[1]	ns	ns	ns	ns	ns
P species		ns	0.00	0.00	0.00	0.00	0.00
P chloride fertilisation × species		ns	ns	ns	ns	0.00	ns

[1] ns = not significant.

Without Cl application the DCAD varied from 180 in reed canary grass to 347 in cocksfoot. When Cl was applied the DCAD was about 150 in meadow fescue, cocksfoot and smooth bromegrass. The lowest values were found in perennial ryegrass (69) and reed canary grass (36). In the second year the contents of minerals were analysed only for the treatment with 140 kg Cl ha^{-1}. The differences in DCAD between the species were similar to those of the first year. The grasses timothy, meadow fescue, cocksfoot and smooth brome grass had a DCAD of about 115. The values of perennial ryegrass, festulolium and reed canary grass were 83, 74 and 48, respectively. The differences in DCAD between species may partly be explained by differences in DM yield and time of heading in the first cut.

Conclusions

Chloride fertilisation decreased DCAD in forage significantly to a level suitable for feeding dry cows prior to calving. Although there were differences in DCAD between species, it may be difficult to achieve a sufficiently low DCAD by selecting only species with a low DCAD.

References

Ender F., Dishington I.W. and Helge-Bostad A. (1971) Calcium balance studies in dairy cows under experimental induction and prevention of hypo-calcaemic paresis puerperalis. The solution of the aetiology and the prevention of milk fever by dietary means. *Zeitung fur Tierphysiologie. Tierernährung und Futtermittelkunde* 28(5), 233-256.

Martín-Tereso J. and Martens H. (2014) Calcium and magnesium physiology and nutrition in relation to the prevention of milk fever and tetany (dietary management of macrominerals in preventing disease). *Veterinary Clinics of North America: Food Animal Practice* 30(3), 643-670.

Pelletier S., Belanger G., Tremblay G.F., Seguin P., Drapeau R. and Allard G. (2007) Dietary cation-anion difference of Timothy (*Phleum pratense* L.) as influenced by application of chloride and nitrogen fertilizer. *Grass and Forage Science* 62, 66-77.