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SOME EFFECTS OF TOPDRESSING PASTURE WITH SODIUM CHLORIDE ON PLANT AND ANIMAL NUTRITION

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Abstract

A long term study is being made of the effects of replacing all or part of the fertiliser input of potassium chloride (muriate of potash - KCl) with sodium chloride (common salt - NaCl) on plant and beef animal nutrition. The ryegrass-white clover pasture which is growing on a sodium deficient pumice derived soil (Taupo sandy silt), had received heavy applications of KCl over the preceeding 10 years. Results from the first two years show that because of the already high potassium status of the pasture, neither KCl or NaCl had any effect on pasture dry matter production or species composition, but did effect the chemical composition. Topdressing with NaCl at rates of 100-200 kg/ha/yr significantly increased the herbage sodium concentrations, while similar rates of KCl increased potassium concentrations but decreased sodium concentrations. However, the depressing affects of KCl on sodium concentrations were offset by applying 50 kg/ha/yr of NaCl.

increasing the sodium concentration in the herbage above 0.1% of the dry matter with NaCl had a beneficial effect on the growth of weaner beef animals. However, increasing the sodium intake of beef breeding cows grazing pastures high in potassium had a detrimental effect on the concentration of magnesium in the blood serum. Thus, as a relatively high intake of sodium may induce metabolic problems in breeding cows, topdressing pastures or direct supplementation of animals with NaCl, should not be undertaken without sound evidence of its necessity particularly in areas prone to grass staggers (hypomagnesaemic tetany).

Key Words: animal nutrition, herbage sodium; plant nutrition; potassium chloride; ryegrass-white clover pasture, sodium chloride, serum magnesium.

INTRODUCTION

In contrast to animals, sodium has not been found to be essential for the growth of most plants. Therefore the prospects of using sodium as a fertiliser on pastures depends on whether it can replace some other fertiliser component or improve animal health and/or production. The fertiliser component that sodium is most likely to replace would be potassium, an important plant nutrient. It appears that when potassium is marginally deficient the growth of certain plants can be maintained by sodium substituting for potassium in a number of non-specific physiological processes in the plant (Marschner 1971). However, McNaught & Karlovsky (1964) showed for a grass-clover pasture growing on a marginally potassium deficient soil in New Zealand, that the efficiency of NaCl for stimulating growth was only about 21% of that for the equivalent weight of KCl.

The use of sodium fertilisers to correct sodium deficiencies in grazing animals depends on whether the concentration of sodium can be increased in the leaves of deficient plants. The extent to which sodium is taken up by plants is influenced not only by other nutrients such as potassium but also by the plant species. From a study of 31 pasture species and cultivars grown in New Zealand, Smith *et al* (1978, 1980a) were able to classify plants into two types with examples given in Table 1.

Table 1: SODIUM AND POTASSIUM CONCENTRATIONS (% dry matter) AND POTASSIUM SODIUM RATIOS OF NATROPHI LIC AND NATROPHOBIC PLANTS.

Plant Type	Sodium Leaf	Sodium Root	Potassium Leaf	Potassium Root	Potassium: Sodium Ratios in Leaves
Natrophiles					
Chou Moellier	0.41	0.15	2.4	0.6	5.9
White clover	0.33	0.21	3.5	0.8	10.6
Cocksfoot	0.32	0.20	2.8	0.3	a.8
Perennial ryegrass	0.30	0.14	2.5	0.3	a.3
Natrophobes					
Browntop	0.10	0.23	2.6	0.3	26.0
Kikuyu	0.04	0.22	2.1	0.3	52.5
Paspalum	0.04	0.31	2.2	0.4	55.0
Lucerne	0.04	0.42	3.2	0.7	80.0
Timothy	0.03	0.26	2.8	0.3	93.3
Sainfoin	0.02	0.25	2.8	1.4	140.0

- NATROPHI LES (sodium-loving): Plants which readily absorb sodium from soils and transport it from their roots into their leaves.
- NATROPHOBES (sodium-hating): Plants which have low rates of uptake and accumulate sodium preferentially in their roots and lower stems such that they have very low concentrations in their leaves.

The important feature of natrophobic plants is that they are incapable of providing enough sodium for grazing animals even when the soil in which they grow is not deficient or when sodium containing fertilisers have been applied, (Smith *et a/.* 1980b). Consequently animals will need to be directly supplemented with sodium when they graze exclusively on natrophobic plants. For example, Joyce & Brunswick (1975) obtained large increases in liveweight gain, wool growth, and significantly more milk and butterfat by giving NaCl directly to sheep and cattle fed on the natrophobe lucerne *(Medicago sativa* L.). Similar responses have also been obtained in animals grazing sorghum *(Sorghum bicolor* (L.) Monench) (Archer & Wheeler 1978; Wheeler & Hedges 1979). For natrophilic plants additional sodium will only be needed when they are grown on deficient soils. Results from a recent survey have shown that in a number of areas of New Zealand pastures composed of the natrophiles ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.) may contain insufficient sodium to meet the requirements of grazing animals (Smith & Middleton 1978).

The purpose of this study was to examine the long term effects of replacing all or part of the fertiliser input of KCl with NaCl on pasture growth and animal performance on a sodium deficient yellow-brown pumice soil (Taupo sandy silt) at Horohoro near Rotorua. The first two years of the experiment are summarised in this paper.

MATERIALS AND METHODS

One small plot pasture trial and two animal nutrition trials were conducted on a ryegrass-white clover pasture. The pasture had been previously topdressed

with 700 kg/ha of 30% potassic superphosphate-each year as a split dressing for the past 10 years.

Pasture Trial

Beginning in 1980 the treatments in kg/ha/yr were:–

1. Nil (control)
2. 100 KCl
3. 200 KCl
4. 150 KCl + 50 NaCl
5. 100 KCl + 100 NaCl
6. 200 NaCl

A basal dressing of 400 kg/ha of superphosphate plus 30 kg/ha of magnesium (as Mg 0) was applied each year to all plots. Individual plot size was 6 x 1.5m with four replications. In the first year fertilisers were applied in a single application in March, but thereafter as a split dressing in March and October. The plots were mown approximately every month and all clippings returned except for small sub samples which were used for the determination of dry matter yields, botanical composition, and major element composition.

Animal Nutrition Trial

(a) Breeding Cows

Three eight hectare farmlets were established in 1979 with fertiliser treatments as summarised in Table 2. Each farmlet was self contained in terms of feed with the hay fed to the animals confined to the farmlet on which it was made. The farmlets were stocked each year with 32-35 pregnant Aberdeen Angus cows from mid-May until mid-November. Prior to calving cows were fed 5.5kg DM/day as 3 kg pasture DM and 2.5 kg hay DM. From the beginning of August (1-2 weeks before the onset of calving) the cows were fed pasture alone. During the initial 6-7 weeks on pasture the daily ration was restricted to 6.5kg DM/cow, after which the feeding level was progressively increased so that from the beginning of October feeding was *ad libitum* on spring regrowth. Cows were bled after weekly intervals throughout the trial for serum magnesium determinates. Pasture samples were collected daily and hay samples weekly from bulked material from each treatment and analysed for major elements.

(b) Weaners

This trial commenced in March 1980 using the same control and sodium farmlets as for the breeding cows (Table 2.). Weaner beef animals were paired on a liveweight and sex basis and then allocated to treatments on a stratified randomisation basis (32 weaners per treatment). The trial was run from March until May each year. Grazing pressure was very lax with less than 30% of the available herbage being eaten, thus allowing ample scope for selective grazing.

RESULTS

Pasture Trial

Table 3 shows that neither the NaCl nor the KCl treatments had any effect on dry matter production over 2 years, but did effect the chemical composition of the herbage. In addition to increasing the concentration of potassium in the herbage, increasing quantities of KCl decreased sodium concentrations. Thus there was a corresponding increase in the potassium to sodium ratio in the her-

Table 2: FERTILISER TREATMENTS APPLIED TO THE FARMLETS USED IN THE ANIMAL NUTRITION TRIALS

Farmlet	1979 and 1980 Superphosphate	KCl	NaCl	Magnesium (as MgO)	1981 Serpentine Superphosphate	KCl	NaCl	Magnesium
1. Control	500	200	0	30	500	200	0	15
2. Magnesium	500	200	0	125	500	200	0	15
3. Sodium	500	0	200	30	500	0	200	15

Table 3: EFFECT OF TOPDRESSING A RYEGRASS WHITE CLOVER PASTURE WITH SODIUM CHLORIDE AND POTASSIUM CHLORIDE ON DRY MATTER YIELDS, SODIUM AND POTASSIUM CONCENTRATIONS, AND POTASSIUM TO SODIUM RATIOS OF HERBAGE

Treatment (kg ha^{-1}yr^{-1})	1980-81 Dry Matter yield (kg ha^{-1} yr^{-1})	Nutrient Concentration (% Dry Matter) K	Na	K:Na	1981-82 Dry Matter yield (kg ha^{-1}yr^{-1})	Nutrient Concentration (% Dry Matter) K	Na	K:Na
Control	14 190	3.76	0.14	26.9	10 940	2.49	0.16	15.6
100 KCl	**14 060**	**4.13**	**0.11**	**37.5**	11 **640**	**3.26**	0.10	**32.6**
200 KCl	14 400	4.01	0.09	44.6	11 800	3.55	0.09	39.4
150 KCl + 50 NaCl	13 850	3.74	0.14	26.7	11335	**3.20**	**0.15**	**21.3**
100 KCl t **100** NaCl	14 060	**3.71**	**0.16**	**23.2**	**11790**	3.37	0.18	18.7
200 NaCl	13480	3.53	0.23	15.3	**11400**	2.73	0.41	6.7
SEM	**1 171**	**0.66**	**0.04**	**10.8**	**1 327**	**0.55**	**0.08**	**10.0**

SEM = standard error of mean

bage. For all treatments there was a decline in the concentration of potassium in the second year due mainly to removals of herbage samples. However, this decline was unlikely to have affected pasture growth as potassium concentrations were sufficient for optimum growth (i.e.> 2.0% dry matter, McNaught 1980).

Applying NaCl significantly increased sodium concentrations in the herbage, particularly at the highest rate. Sodium on the other hand had no consistent effect on potassium concentrations which remained at a relatively high level. The depressing effects of KCl on sodium concentrations were offset by applying 50 kg NaCl/ha/yr.

Botanical composition of the pasture remained remarkably constant throughout the trial with little effect from the fertiliser treatments.

Table 4: THE EFFECTS OF SODIUM CHLORIDE AND MAGNESIUM OXIDE APPLIED IN FERTILISER ON SODIUM, POTASSIUM, AND MAGNESIUM CONCENTRATIONS IN HERBAGE, AND MEAN SERUM MAGNESIUM CONCENTRATIONS AND INCIDENCE OF GRASS STAGGERS IN BEEF BREEDING COWS.

Year	Fertiliser Treatment (see Table 2)	Nutrient Con. (% dry matter) Na	K	Mg	Serum Mg (Mg %)	Grass Staggers (% incidence)
1980	Control	0.09	3.47	0.19	1.05	23
	Sodium chloride	0.16	3.39	0.19	0.96	20
	Magnesium oxide	0.08	3.42	0.28	1.28	3
1981	Control	0.08	3.71	0.19	1.08	39
	Sodium chloride	0.21	3.58	0.18	0.95	22
	Magnesium oxide	0.09	3.49	0.28	1.53	0

Breeding Cow Trial

Increasing the sodium intake of cows grazing pasture high in potassium by topdressing with NaCl was found to decrease the already low serum magnesium concentrations in these animals (Table 4.) but had no effect on cow liveweight or on birth weights of the calves. The adverse effect on serum magnesium concentrations was most noticeable ($P>0.01$) prior to calving when the cows were on a restricted ration.

The incidence of grass staggers (hypomagnesaemic tetany) was very high in both the control and sodium groups during these two years. The slightly lower incidence in the sodium group is more likely due to chance effects than to any genuine reduction caused by the higher sodium intake. Previous data from Horohoro over a 10 year period has shown that factors which induce lower serum magnesium concentrations in cattle invariably increase the incidence of grass staggers in the long term. The substantial increases in the serum magnesium concentrations and accompanying reductions in the incidence of grass staggers of the cows grazing the pastures topdressed with a high rate of magnesium oxide can be directly attributed to the high concentrations of magnesium in the herbage. It should also be noted that NaCl had no effect on the concentration of magnesium in the herbage.

Table 5: EFFECT OF TOPDRESSING A RYEGRASS-WHITE CLOVER PASTURE WITH SODIUM CHLORIDE ON SODIUM AND POTASSIUM CONCENTRATIONS IN HERBAGE, AND ON LIVEWEIGHT GAIN OF WEANER BEEF ANIMALS.

Year	Duration of trial (weeks)	Fertiliser Treatment (ha^{-1} yr^{-1})	Nutrient Concen. (% dry matter) Na	K	Fasted liveweight gain (kg weaner^{-1})
1980	7	Control	0.11	3.82	23.25
		200 NaCl	0.17***	3.41***	22.00 n.s.
1981	8	Control	0.08	4.53	21.25
		200 NaCl	0.32""	3.99***	27.00""

*** significantly different from Control treatment ($P<0.001$)
** significantly different from Control treatment ($P<0.01$)
n.s. not significantly different

Weaner Trial

Topdressing pastures with 200 kg/ha/yr of NaCl had no significant effect on the growth of animals in the first year but gave significant liveweight gains in the second year (Table 5.) The lack of any animal responses in the first year was most likely due to the higher sodium concentrations in the herbage of the control pastures in that year. The sodium concentrations for the first and second years being 0.11 and 0.08% of the dry matter respectively. As in the pasture trial NaCl at rates of 200 kg/ha/yr significantly increased the sodium concentration in the herbage. By contrast, potassium concentrations were reduced by NaCl although they still remained at a relatively high level despite withholding potassic fertilisers over the two years of the trial.

DISCUSSION

This study supports previous findings that the concentration of sodium in the herbage of natrophilic pasture species such as ryegrass and white clover can be increased by topdressing with NaCl (McNaught & Karlovsky 1964; Smith et *al.* 1978; 1980b; Schultz et *al.* 1979). Because of the high potassium status of the pastures in the present study it was not possible to compare the efficiency of NaCl with KCl for promoting pasture growth as both fertilisers had little effect on either botanical composition or pasture dry matter production. However it should be noted that the potassium concentrations found in this study are similar to those typically found in many topdressed pastures thoughout New Zealand (Smith & Middleton 1978). While excessively high potassium concentrations are a common feature of pastures in this country, withholding potassic fertiliser can have a serious effect on pasture production. For example, on some high producing Waikato dairy farms reductions in pasture production were noted after one year of withholding potassium (O'Connor & Smith 1982).

Increasing the sodium concentration of deficient herbage above 0.1% of the dry matter by topdressing with NaCl can have a beneficial effect on the growth of weaner beef animals (Table 5.) A similar sodium concentration has been suggested by the Agricultural Research Council as being required for such animals

(ARC 1980). However for pregnant beef cows (and possibly dairy cows) increasing their sodium intake by topdressing pastures high in potassium with NaCl reduced the magnesium concentration in their blood serum (Table 4). Similar results have also been obtained by Young (1976) at Horohoro by giving NaCl directly to pregnant beef animals. These results suggest that when sodium containing fertilisers or sodium supplements are used in areas with a high potassium status and prone to grass staggers there will be a greater need for a magnesium supplementation programme.

In view of the possible adverse effect which a relatively high intake of sodium may have on animal health, topdressing pastures or direct supplementation of animals with NaCl should not be undertaken without sound evidence of its necessity. Possibly the best method for diagnosing sodium deficiency in grazing animals is to measure the proportion of sodium and potassium in the parotid saliva. Recent studies at Ruakura (N.R. Towers & G.S.Smith, unpublished) suggest that a linear relationship exists between sodium intake and the sodium to potassium ratio of the saliva such that reductions in the sodium intake result in approximately equal reductions in the mean sodium to potassium ratio. An avid consumption of sodium salts on the other hand, reflects a sodium appetite common to all ruminants irrespective of need and therefore does not necessarily indicate sodium deficiency. Where sodium deficiency has been diagnosed, however, direct supplementation such as the addition of sodium to drinking water or as salt licks is the preferred method over pasture topdressing with NaCl. Direct supplementation has the advantage of allowing sodium to be withheld from animals during the critical periods such as pre and post calving. Finally this study highlights the complex nature of the grass staggers syndrome, and the need for more research into the requirements and effects of NaCl on other classes of stock in New Zealand.

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