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THE MINERAL COMPOSITION OF PASTURE IN SOUTHLAND BASED ON A 5-YEAR MONITORING PROGRAMME

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Abstract

The analysis of mixed pasture species has proven to be a useful guide to plant and animal nutrition. Fourteen or more elements can be analysed in plants and the results used to correct any potential problem. In Southland low Ca, Mg, Co and Se are the main problems in animal nutrition, with low Sand Mo the main deficiencies in plant nutrition.

Most elements in pasture vary with soil temperature in a predictable way and this effect can be used to alert farmers of potential problems with animal nutrition,

Keywords: trace elements, pasture analysis, fertiliser requirements

INTRODUCTION

For several years now the Company has been monitoring the fate of applied fertiliser and trace elements sold in our area and preliminary results presented (Winter 1981) stressed the importance of developing pastures with ideal mineral composition to meet animal requirements rather than for maximum yield, as the end point is animal health and animal products not pasture DM production.

An increased awareness among farmers of the need for nutritionally balanced pastures, i.e. pastures that will not produce metabolic disorders or trace element deficiencies in stock, has led to an increased demand for an accurate and reliable scheme to predict fertiliser and trace element requirements. Work by some authors (Middleton & McNaught 1973; During *et al.* 1981; Morton & Hannagan 1983) has indicated the shortcomings of soil testing under maintenance conditions and many refer to plant analysis for monitoring nutrient status. Our conclusions since starting this work in 1975 is that the analysis of carefully sampled mixed pasture can identify deficiency, adequacy and luxury uptake of nutrients.

If a complete analysis of plants is performed, over 60 elements can be determined and the nutritionally important elements can be divided into two groups:

1. Essential elements.
2. Non essential elements.

Of the essential elements 3 groups occur:

1. Primary plant nutrients: C, H, 0, N, P, K S.
2. Secondary plant nutrients: Ca, Mg, Na, Cl, Si.
3. Trace elements: Mo, Cu, B, Zn, Mn, Fe, including Co, Se and I which are necessary for animal health but are not required for pasture production.

The following discussion assumes that the water supply to plants is adequate at all stages of the year. It should be remembered that plant nutrient imbalances occur for many different reasons, some of which are listed below:

1. Erosion
2. Drought
3. Flood (irrigation)
4. Low natural fertility

5. Leaching
6. Fixing in unavailable forms by the soil
7. Removal in stock to camp sites
8. Removal by crops
9. Removal in animal products
10. Increased productivity
11. Interference with other elements
12. Soil Ph

RESULTS OF INTENSIVE MONITORING OF A SINGLE FARM

A series of samples taken at a maximum. of 3-day intervals from the Company farm for 3-4 months illustrate some of the relationships between plant, animal and climate, using N and P as examples (Fig. 1).

Very high stocking rates for 24 hours results in a major removal of plant material in the order of 70% of the DM originally present. The remaining plant material is mainly stems, emerging leaves and damaged leaves and, as expected, is very low in nutrients. The period to establish normal values after the removal of the animals is around 20 days, a similar time to that observed if pastures are harvested for silage production. Between these periods analysis is quite stable for periods of 3 or 4 days with drifts over longer periods that reflect climatic conditions.

Similar trends are observed for other major elements studied.

As expected for a well-managed farm the nutrient levels in pasture species tend to be high as opposed to our experience with poorly managed or developing farms where nutrient levels are low in the plants. Bearing this in mind wild fluctuations in the nutrient levels would not be expected on well managed farms.

GENERAL CONCLUSIONS EASED ON MONITORING 25 FARMS ON AN 'AS FARMED' BASIS

Magnesium

Mg concentrations are directly related to 9 a.m. soil temperature taken at a depth of 10 cm on a monthly average basis. The seasonal trend is very predictable at approximately 0.01% Mg per degree change in temperature. If soil temperatures are low a Mg supplement needs to be used such as a calcined magnesite (causmag) until soil temperature rises to say 8°C or more (Fig. 2). Similar effects can be seen for many other elements.

Nitrogen

The N content tends to follow the patterns of grazing, decreasing as plant material is removed and increasing again during regrowth. There is evidence, where stock management is poor, that short periods of low pasture N can occur in early spring growth. Where rotations are long and pasture removed during mob-stocking is limited to 50-65%, N supplies are always adequate.

Phosphorus

The concentrations change with topdressing and decrease with time after application. Over the last 5 years there has been a general decline in P levels in plants taken from farms in Otago and Southland reflecting the downturn in fertiliser usage.

Potassium

The K content shows no seasonal trend but does display a marked short term negative correlation with rainfall. Previously high levels reported in spring in Southland have been shown to be the result of the K being applied in spring and in excessive amounts.

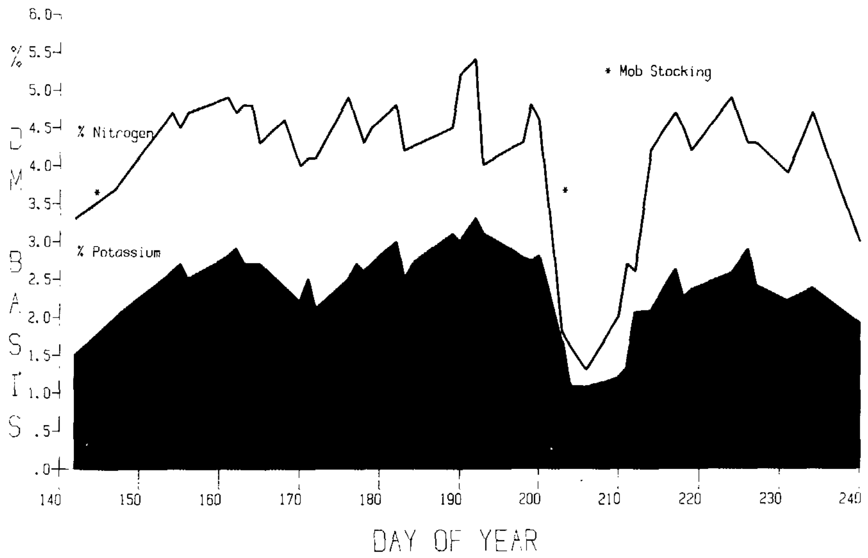

Figure 1: Variation over 3-4 months (May-August) in N and P concentrations (% DM) of an intensively sampled pasture

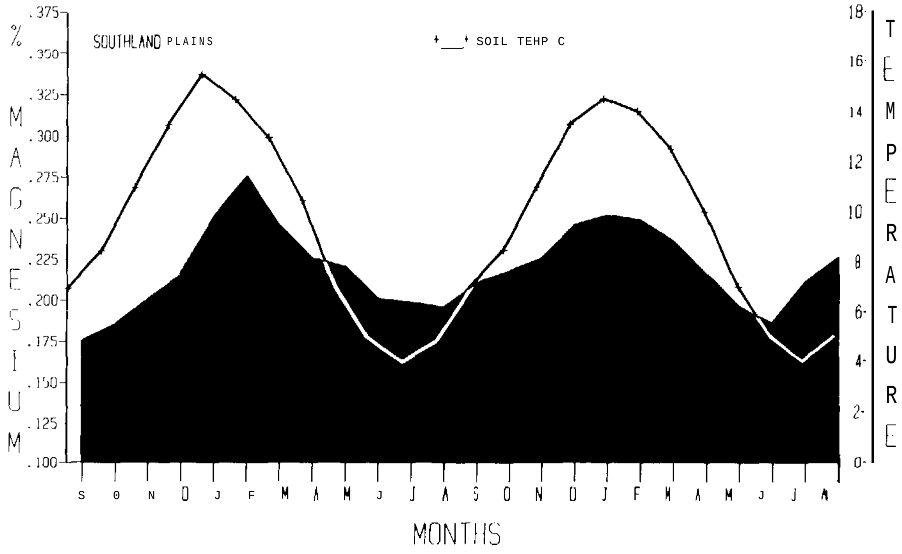

Figure 2. Effect of soil temperature on the Mg content (% DM) of pasture.

Sulphur

Sulphur concentratons, like P, are related to the time of application of superphosphate and can be about 70% of the P level in pastures. Many samples from inland sites show S deficiency as a result of reduced usage of superphosphate and other S-based fertilisers.

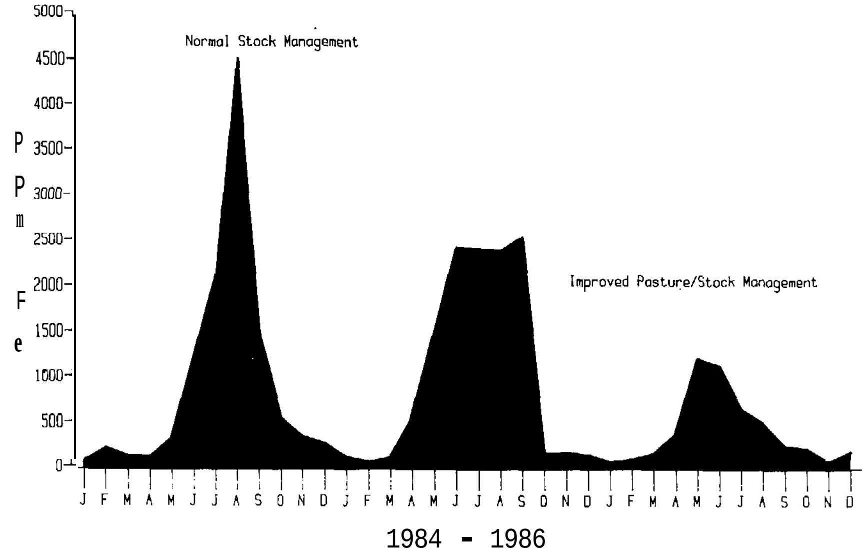

Figure 3: Effect of soil contamination on pasture Fe concentrations.

Calcium

The Ca content has been observed to be directly related to soil temperature, for -example in clover the change is about 0.05% per one degree change in temperature.

Iron

As the Fe content of soil is high soil contamination can elevate pasture Fe values (see Fig. 3). A clean pasture sample will contain 50-100 ppm Fe. The Fe content of 'soil-free' pasture appears to be related to soil temperature.

High Fe intakes can have a detrimental effect on animal health as dairy and beef animals become Cu deficient if high intakes of Fe occur for prolonged periods, even if Cu intakes are normal. This induced copper deficiency could normally be controlled by better pasture management in autumn and winter.

Manganese

The Mn content of pasture behaves similarly to Fe with clean pasture having levels around 50 ppm. High intakes of Mn, over 400 ppm, will cause poor weight gains in lambs (Grace 1973). Liming to pH 5.5-6.0 will normally prevent this problem, as the plant uptake of Mn is reduced as the soil becomes less acidic.

Zinc and Copper

Both Zn and Cu concentrations in pasture also appear to be related to soil temperature and change by 0.5-0.7 ppm per one degree change in temperature. Topdressing pasture with copper sulphate (5 kg/ha) is a method for correcting Cu deficiency, as the Cu content of pastures low in Cu (3-5 mg/kg DM) can be increased to 6-l 0 mg Cu/kg DM. These increased Cu levels will ensure adequate Cu intakes for sheep if the pasture Mo and Fe concentrations do not exceed 2 and 500 µg/kg DM respectively, as Mo and Fe impair the absorption of Cu.

The temperature effects observed on pasture Cu levels in the field are remarkably similar to those seen in the greenhouse by Hogg 8 Moore (1976) while the seasonal trends are similar to those reported in the North Island by Metson 8 Saunders et al. (1978, 1979).

Selenium

Selenium deficiency occurs in grazing animals when pastures contain less than 30 µg Se/kg DM.

Selenium when required can be applied as a prill, either with fertiliser or on its own. The rate of 1% selenium prills is 1 kg/ha. This is a very effective method of combating deficiency. Diagnosis of Se deficiency is best assessed on the Se levels of tissues rather than soil or plant samples.

Cobalt

Cobalt deficiency in lambs is observed when pastures contain less than 0.09 mg Co/kg DM.

When required Co can be applied to pasture as cobalt sulphate at 375 g/ha, usually in October/November. Serum vitamin B_{12} levels or the urinary FIGLU assay is preferable to soil or plant analysis for predicting Co deficiency.

Recent research has shown that very few farms in Southland and Otago have trace element problems other than Se and Co.

AN EVALUATION OF PASTURES TO MEET THE MINERAL REQUIREMENTS OF THE GRAZING RUMINANT

If animal performance is poor when pasture allowances are adequate and diseases, including internal parasites, are absent, then a mineral deficiency can be suspected. Many of the signs of mineral deficiencies are non-specific and are associated with poor growth rates, reduced fertility, low milk yields and a lower resistance to diseases. The mineral composition of the pasture can be used to investigate the adequacy of the pasture to meet the mineral requirements of livestock. The mineral requirements for sheep and cattle are expressed on a dietary basis so that the mineral levels in the pasture can be compared directly with the requirements.

For example pastures must contain 0.03 mg Se/kg DM to meet the Se requirements of sheep and cattle, and if the pasture under investigation has a Se concentration of 0.02 mg/kg DM then Se deficiency is most likely to be the problem. This diagnosis should be checked by determining the blood Se levels in groups of

Table 1: Mineral composition of pasture (clean, actively growing herbage) producing good animal performance

	Mean	Range	
	% DM		
N	4.50	4.00	5.00
P	0.45	0.42	0.48
K	2.80	2.50	3.20
s	0.30	0.28	0.40
Ca	0.80	0.50	1.00
Mg	0.22	0.18	0.30
Na	0.20	0.15	0.35
Si	0.80	0.50	1.50
Si	0.80	0.50	1.50
Cl	1.30	1.00	1.70
	µg/kg DM		
Fe	150	100	250
Mn	SO	50	150
Zn	25	20	40
Cu	10	8	12
B	12	10	20
Al	20	0	25
MO	1	0.5	2.5

young sheep. Selenium deficiency is also characterised by white muscle disease and infertility in ewes, and can be prevented by oral dosing or subcutaneous injections of Se as well as topdressing with Se at 10 g/ha/year.

Table 1 reports the pasture mineral composition of a high producing Southland sheep farm with no animal performance problems. This can be used as a guide for evaluating analysis results from mixed pasture samples.

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EFFECT OF CONTROLLED-RELEASE SELENIUM GRANULES APPLIED WITH FERTILISER ON BLOOD LEVELS OF GRAZING SHEEP

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Abstract

Two sheep grazing trials, at Awarua, Southland, and at Wairakei, central North Island, on selenium (%)-deficient and Se-retentive soils under a rainfall of about 1000 mm were used to test the duration of effectiveness of a mixture of standard and controlled-release Selcote® Se granules applied at 0.5 kg/ha each. Selenium concentrations in blood of ewes and lambs were maintained above deficiency levels for 2 years in both trials. Peak values were observed or inferred from both rapid-release and slow-release granules. The pattern of pasture Se was consistent with blood Se values where sampling was sufficiently intensive to allow for the low rate of granule application.

Keywords: Pasture. ewes. lambs, yellow-brown pumice soil?,, lowland yellow-brown earths, Selcote.

INTRODUCTION

Selenium (Se) granules were approved as a topdressing in 1982 for prevention of deficiency in grazing stock (Watkinson 1983). Since then they have been demonstrated to be long lasting, safe, economical, and flexible in timing and method of application. At the application rate of 1 kg/ha granules, equivalent to 10 g/ha Se as selenate, they can be either mixed with fertiliser or applied on their own at any time of the year.

Selenium is released quickly from the granule under moist conditions and uptake into the plant is rapid, reaching a peak within a week or two. Pasture Se then declines slowly, returning to the original level within 6-9 months on severely deficient soils (e.g. pumice soils), or after 20 to 24 months on marginally deficient soils (e.g. dryland Canterbury soils). Stock grazing from the time of application are fully protected for at least 12 months because of body storage of Se, but stock brought in and grazed on pasture 6 to 9 months after application on pumice soils have little protection until the next application of Se (Watkinson 1983, 1987). Up to 15% of applied selenate is taken up by the pasture, leaving at least 85% of the selenate in the soil (Watkinson 1983), which is reduced to selenite sometimes within a few weeks (Watkinson, unpublished information), lowering its availability. There is therefore a need for a slow-release formulation to protect the selenate against reduction and spread the time interval for which Se is available to pasture plants so that stock are protected at all times over a 12- to perhaps a 24-month period.

METHODS

In joint work with Agtech Developments (NZ) Ltd, testing of slow-release products using field plot trials led to the development of a formulation which could release most of the Se at about 6 months after application. Two sheep grazing trials were carried out, under contract to Agtech Developments, on soils under a rainfall of over 1000 mm that would give low residual pasture Se (through microbial reduction and soil retention) under different climates. One trial was in Southland at Awarua on

Tisbury silt loam while the other was on a pumice soil at Wairakei. A mixture comprising 0.5 kg/ha standard Selcote® granules and 0.5 kg/ha controlled-release Selcote granules was used, the standard product to give immediate protection and the controlled-release formulation longer protection. Lambs and ewes were used because the blood levels of growing animals are lower than those of mature adults because of their increased requirement for growth under decreasing pasture Se concentrations (Watkinson 1983).

Control treatments and Se topdressing replicates were not included because Se topdressing on deficient areas increases natural baseline Se values of pasture and blood by up to about 50 times, so that treatment effects are always significant. In addition, most control animals would be unlikely to survive the 2 years of the trial, and therefore blood Se values at the end of the trial are compared with the initial values. Critical blood values for Se deficiency are 1 O-20 μg/l Se. Further, it is difficult to find animals for trial work in a deficient area that have not been already treated with Se, but as the effect of a Se drench on blood Se disappears within about 3 months, these animals are suitable for experimental work

Awarua Trial

This trial was run by the Southland Co-operative Phosphate Co. on their property at Awarua on Tisbury silt loam (lowland podzolised yellow-brown earth). Fifteen breeding ewes that had previously received a pre-lamb drench and, 3 months later, 15 lambs, were grazed for over 2 years on 3 paddocks of about 2 ha each, treated with Selcote granules in September 1985.

Wairakei Trial

A second trial was run at the MAFTech Wairakei Research Station on Waipahihi gravelly sand (yellow-brown pumice soil, very free draining). Selcote granules were applied on 21 March 1986, and 10 ewes and 10 lambs grazed the treated paddocks continuously for 2 years from 24 March 1986. Only 1 ewe and 7 lambs had not previously been treated with Se.

Samples and analysis

Two pasture samples were taken monthly, pasture growth permitting, dried and then ground for analysis. The Wairakei trial area was intensively sampled twice to give duplicate samples, while the Awarua trial area was sampled from only 1 or 2 caged areas until February 1987 when it was also sampled intensively. Whole blood samples, using heparin as an anticoagulant, were taken every 2 months for analysis. Pasture and blood were analysed for total Se by the method of Watkinson (1979).

RESULTS AND DISCUSSION

Se concentrations in pasture and blood for the two trials are shown in Fig. 1.

Pasture Se

Topdressing granules at 1 kg/ha gave a very low density of particles per unit area and the less intensive sampling in the Awarua trial (Fig. la) picked up only some effect of the standard granules, in the October and November 1985 samples. Pasture Se in the samples taken more intensively from February 1987 were low and showed no clear pattern. Comparison of the 2 years shows that low values were consistently obtained over December-February, a period of high plant growth rate.

The effects of both standard and slow-release granules can be seen in the

Wairakei trial (Fig. 1 b), partly because of the intensive sampling and partly because the natural pasture Se levels were very low at about 10 μg/kg Se.

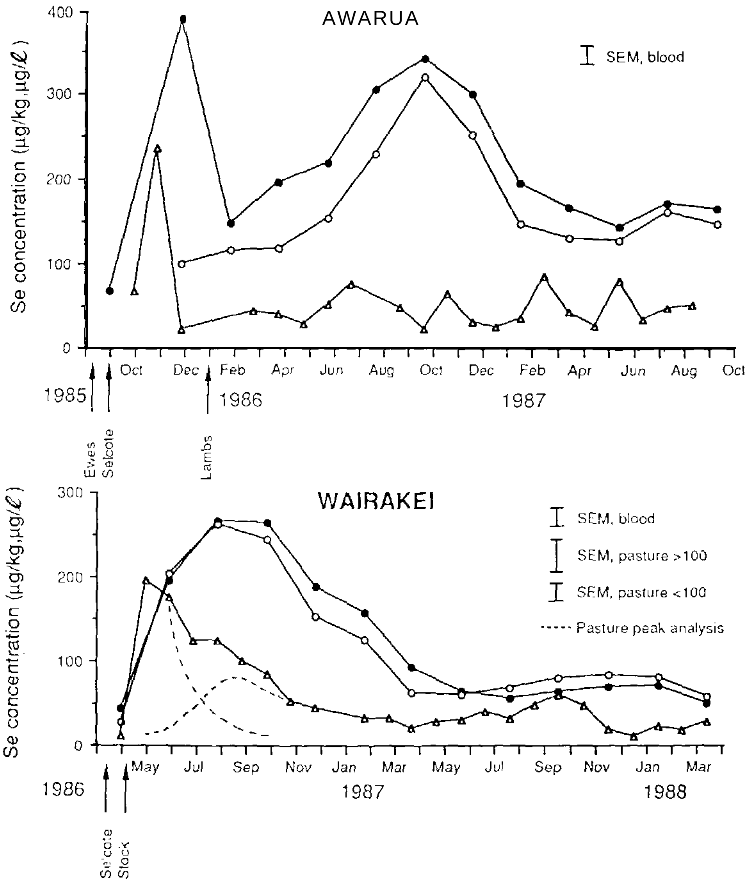

Figure 1: Selenium in pasture (Δ) and blood of ewes (●) and lambs (o) grazing pasture topdressed with standard Selcote (0.5 kg/ha) and controlled-release Selcote granules (0.5 kg/ha) in trials at Awarua (a) and Wairakei (b). The long- tailed pasture peak at Wairakei is analysed into 2 peaks (see text).

The increase in pasture Se concentration resulting from either applying sodium selenate mixedwith fertiliser or in standard granules peaked within 1 month and, on pumice soil, returned to the initial level within 6-9 months (Watkinson 1987). In the Wairakei trial, the pasture Se peaked after 1 month and then declined slowly. This long-tailed peak can be regarded as the sum of two overlapping peaks: a large peak after 1 month from the standard granules and a smaller one immediately after the slow-release granules. Subtracting the exponential decay curve for the Se released by the standard granule from the observed data, gave a smaller peak, reflecting the Se contributed from the slow-release granules 5 or 6 months later in August-September (Fig. 1 b). This finding is consistent with earlier work showing a peak 6 months after application from similar slow-release granules (Watkinson, unpublished work). A small second peak in pasture Se was observed 12 months later in September 1987, while low pasture values associated with pumice soil, <20 µg/kg Se, were not seen until about 21 months after the application of the granules.

Blood Se

In both trials the blood Se levels in stock after 2 years on the Selcote-treated pasture was appreciably greater than levels that would have existed in stock not treated with Se.

Although all ewes in the Awarua trial had earlier received a pre-lamb Se drench giving an average blood Se before Se topdressing of 68±4 (SEM) µg/l Se, the levels of both ewes and 1985 lambs after 2 years on the Se treated area were well above this at 166±7 and 14817 µg/l, respectively. Similarly, the blood Se of lambs in the Wairakei trial increased from 27±5 µg/l to 60±15 µg/l Se after 2 years, while the Se concentration in ewes increased from 10±3 µg/l (undrenched animals) to 53±12 µg/ l Se.

The pattern of blood Se concentration versus time was quite different in the two trials. The Awarua trial showed a peak after about 3 months from the standard granules, followed by two broader peaks, the first much larger, after 12 and nearly 24 months from the slow-release granules. In the Wairakei trial, the first broad peak of blood Se concentration after about 5 months was evidently a combination of effects from the standard and slow-release granules, reflecting the slow tailing of the first pasture peak. A second broad, shallow peak was observed after about 21 months, lagging the small pasture peak by about 3 months, typical of the pattern observed in other studies (Watkinson 1983). In both trials, therefore, the slow-release granules had an effect for approximately 12 months after that expected from the standard granules. The Awarua trial showed a greater delayed response than the Wairakei.

As found previously (Watkinson 1983), lamb blood was lower in Se than ewe blood. This was accentuated in the Awarua trial because lambs from untreated ewes started grazing the treated area only 3 months after application and did not derive any Se from the ewes before weaning. The blood Se of lambs was always lower than that of the ewes, but concentrations in the two groups of animals began converging after 20 months. In the Wairakei trial lambs grazed the treated area from the start of the study and their blood Se was the same as that of ewes for 4 months until pasture Se concentrations began decreasing. The lamb blood Se decreased more rapidly than that of ewes, but then responded more rapidly to the second pasture peak so that values exceeded that of the ewes for the last 5 months. These changes in relative blood levels of lambs and ewes can be explained in terms of increasing body weight in the lambs but not the ewes, on first decreasing then on increasing levels of pasture Se.

The slower response in blood Se to the slow-release granules in the Awarua trial could have been due to the granules having a slower release, or to an interaction of the granule with the soil-pasture environment. These differences, however, did not affect the overall result so that even with a faster response on the severely deficient pumice soil, the blood Se concentration of grazing stock was appreciably above those of Se-deficient animals (20 µg/l) 2 years after application of the mixture of Selcote granules.

In order to enhance the pasture Se concentrations from 20 months onwards for the pumice soil and to give a more uniform blood Se level it could be advantageous to increase the proportion of slow-release granules from 50% to 75% or more. Under these conditions, stock of unknown low Se status would have their status maintained or improved when brought on to a Se-deficient property at any time within 2 years of applying the granules.

CONCLUSIONS

Controlled-release Selcote granules increased the usefulness of Se topdressing by extending the time of effectiveness from 1 to 2 years for deficient and retentive soils under a rainfall of up to at least 1000 mm. Use of the new granules would permit mixing with fertiliser where it was applied every 1 or 2 years, or the option of applying the Selcote granules every 2 years on their own (Watkinson 1983) if fertiliser were applied less frequently.

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