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Development of sunny-facing high country using different forms of sulphur fertiliser

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Abstract

Different forms and rates of sulphur (S) fertiliser were examined for developing oversown tussock in sunny-lying South Island high country. Sulphur significantly increased dry matter (DM) production (p = 0.0001). Soluble forms of S were most effective in the first year, and lasted 15-18 months. Sulphur bentonite prills took 6 months to be effective, but over time the higher rate (56 kg S/ha) was one of the better treatments. Elemental S on its own was ineffective even after 3 years. The combination of soluble sulphate and finely divided elemental S (56 kg S/ha as sulphur super extra) was the most effective treatment. In the first 2 years alsike clover was the most dominant pasture species. Native grasses became dominant in the third year. After retopdressing at the beginning of year 4, pasture production again improved, particularly in those treatments containing only soluble forms of S. White clover was the dominant pasture species. in. the fourth year. Sulphur significantly increased soil-available nitrogen levels (p = 0.0001).

Keywords development, sunny hill country, sulphate sulphur, elemental sulphur, sulphur super extra, sulphur bentonite prills, available nitrogen

Introduction

Sulphur deficiency is widespread in New Zealand, particularly in the South Island high country. Work by Ludecke (1965) and McIntosh et al. (1985) has identified the best forms of sulphur (S) to use in this type of country.

Recent fertiliser research has centred primarily on alternative forms of phosphate fertiliser, forms that contain little or no S. As a consequence the market place is now looking at forms of S to complement these fertilisers. This, coupled with the fluctuating economics of developing and maintaining hill country pastures, has encouraged Ravensdown to explore the potential of different S fertilisers.

This work is of particular relevance to those drier yellow-brown earths and yellow-grey earths that seasonally suffer moisture deficit.

This paper reports on one of a wider series of trials looking at a range of domestic and imported S fertilisers.

Methods

The study was carried out near the Lindis Pass, North Otago. The trial site was located on a previously untopdressed block at an altitude of 800 m, with an annual rainfall of 600-800 mm. The soil type is a Nevis yellow-brown earth, typical of sunny-facing fans, rolling and steepland soils in the South Island high country. The soil test was pH 5.7, P 19, P retention 27, S 3, K 7, Ca 7, Mg 28 (MAF Quick-test units).

Native vegetation is dominated by the low fertility annual grasses, some mouse-ear hawkweed, and fescue tussock, with some sweet briar also present. The site was oversown in autumn 1986 with a mixture of alsike clover (*Trifolium hybridum*), 'Grasslands Huia' white clover (*T. repens*), 'Grasslands Nui' ryegrass (*Lolium perenne*) and 'Grasslands Wana' cocksfoot (*Dactylis glomerata*).

The treatments (Table 1) were applied in spring 1986. Where required triple super was applied to ensure each treatment except the Control received 14 kg P/ha. Annual maintenance had been calculated at 4.5 kg P and 15 kg S/ha by the MAF Fertiliser Model (Cornforth & Sinclair 1984), and treatments received the equivalent of 3 years' maintenance P.

Fertilisers were reapplied in early spring 1989 at the same rates.

Plots, 10 m by 2 m, replicated 4 times, were harvested as required under a mowing and clippings return technique in which approximately 50% of the clippings were returned to each plot. Measurements included pasture dry matter (DM) production, soil available nitrogen (N) levels and bulked herbage P and S. Soil-available N (0-8 cm) was determined from year 2 onwards by the anaerobic incubation techique of Keeney & Bremner (1966).

Table 1 Summary of treatments.

Treatment	Abbrev.	P	SO4 (kg/ha)	S°	Comments
Control	CTRL	0	0	0	
Triple super	TSP	14	0	0	
Screened elemental	S°	14	0	56	1st application: 70%<1 mm 31%<0.5, 6%<0.25, 3%<0.15 2nd application: 98%<1 mm 61%<0.5, 25%<0.25, 9%<0.15
Sulphur bentonite	SB28	14	0	28	'Tiger 90' prills
Sulphur bentonite	SB56	14	0	56	'Tiger 90' prills
Superphosphate	SSP	14	19	0	
Super/gypsum	SSP/GYP	14	28	0	
Sulphur super extra	SSX	14	19	37	1st application: a dry blend of SSP and S°. 2nd application: wet mix sulphur super.

Details of these products can be found in *Technical Bulletin 5/90 (Ravensdown Fertiliser Co-op Ltd 1990).*

Results

Dry matter

Dry matter production from all S treatments was significantly above control ($p = 0.001$), and varied significantly between years ($p = 0.0001$). With the exception of SB28 all S treatments gave different overall trends with time ($p<0.01$).

In the first year, SSP, SSP/GYP, SSX and SB56 produced the largest responses (Figure 1).

In the second year production was higher, but SSP and SSP/GYP fell relative to SSX and SB56.

In the third season production declined. Relatively the performance of the SB56 improved, and the relative decrease in production from SSP, SSP/GYP and SSX was greater than for the other treatments.

After retopdressing, DM production increased dramatically, although the rate of response from SB28 was not as significant as for the other S treatments.

Total production for the six S treatments fell into three categories:

High — SSX, SSP/GYP
Medium — SSP, SB56
Low — SB28, S°

The trial was not responsive to triple superphosphate applied in the absence of S fertiliser, and the soil P test indicated an adequate P status.

Soil-available nitrogen

Mean soil-available N levels significantly increased in all S treatments ($p = 0.001$). As S fertility declined before retopdressing, a significant drop was noted in the soil N status of the two soluble S treatments, SSP and SSP/GYP ($p = 0.01$) (Figure 2). Retopdressing in early spring 1989 in general restored soil-available N status in S treatments during the following season.

The pattern of treatment effects on soil N status was very similar to that for DM production.

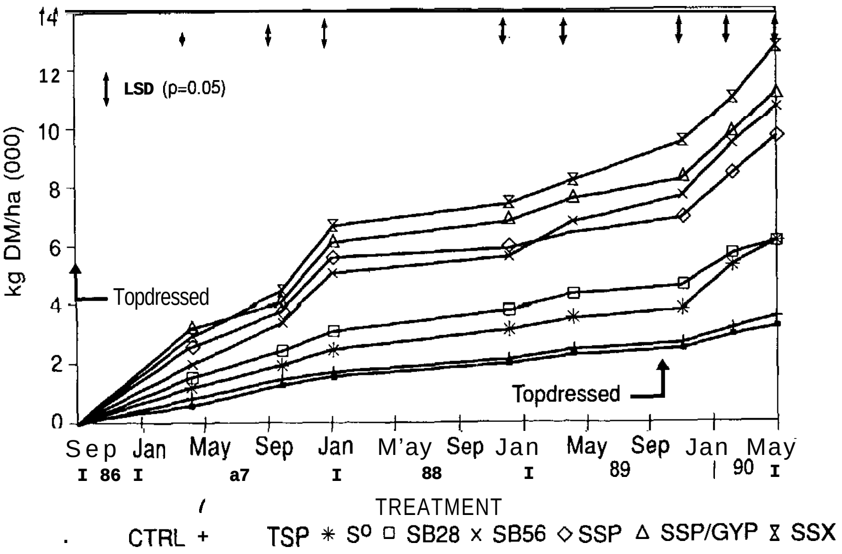

Figure 1 Mount Thomas sulphur trial: cumulative dry matter yield 1986-1990 (kg DM/ha).

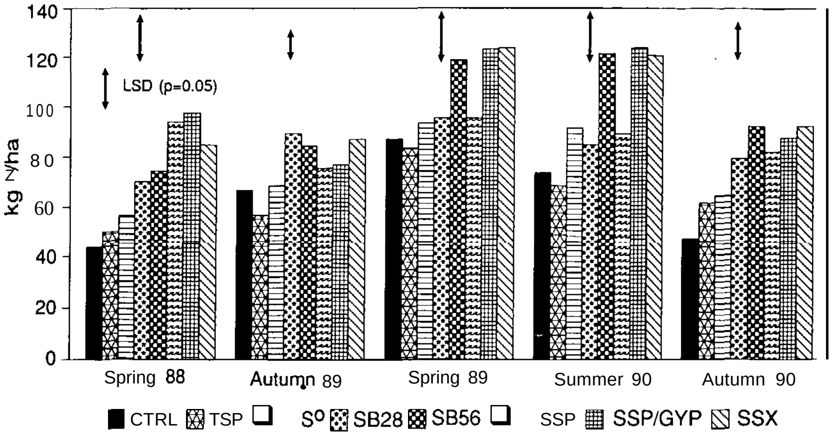

Figure 2 Mount Thomas sulphur trial: soil available nitrogen 1988-1990 (kg/ha).

Herbage

All herbage N, P and S levels peaked in the spring of the second year and declined thereafter. Herbage would have been considered S deficient before the end of the second season (S<0.15%).

After retopdressing, the spring 1989 herbage nutrient values partially improved.

Plant N and S uptake (Figure 3) followed a similar though slightly delayed trend to DM production. SSP produced the highest S uptake/kg S applied.

Pasture composition

The results are not reported. Initially the dominant species in the most responsive plots was alsike clover. As S fertility declined it was replaced in dominance by native grasses. On retopdressing clover reappeared, but was less dominant than initially. The main species was white clover.

Discussion

Sulphate sulphur

Of the S forms used, sulphate S is the most readily available to plants. Therefore the fertilisers containing this form i.e. super, super/gypsum and sulphur super extra gave the best initial responses.

Sulphate S leaches. Providing all S in this form leads to unnecessary losses. For this reason the lower rate, 19 kg S as super, was more efficient (on a kg DM/kg S basis) than the higher rate, 28 kg S as super/gypsum. Despite this, the higher rate maintained more adequate production through to retopdressing. These results differ from those of Ludecke (1965) who obtained greater residual effects from sulphate S. However, he used higher rates of sulphate S, in a lower rainfall area where less leaching occurs.

The residual effect of super could be predicted from the annual requirement of 15 kg S as calculated by CFAS (Cornforth & Sinclair 1984).

Sulphur bentonite prills

Sulphur-bentonite-prills-rely-on-water-absorption -by the bentonite clay component to physically break down the fertiliser granule. 'Tiger 90' granules are relatively hard and this leads to a delay in release of S

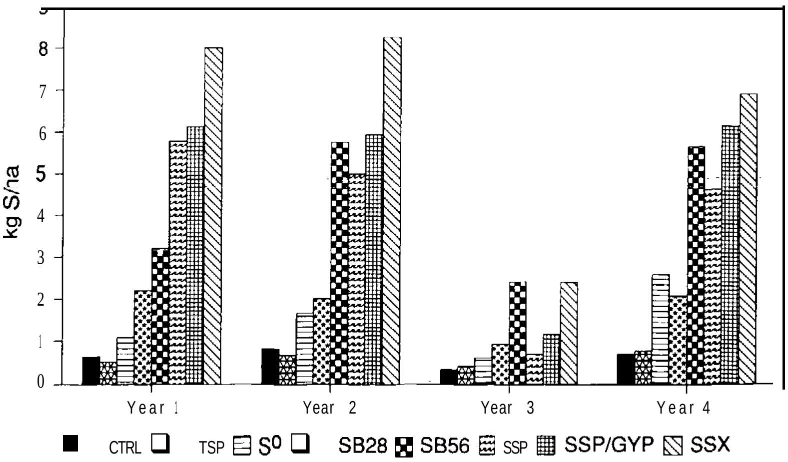

Figure 3 Mount Thomas sulphur trial: sulphur uptake by herbage (kg/ha).

from the product. Hence responses were better in the second year.

Sulphur bentonite prills' consist of elemental S grades of a narrow, intermediate particle size (Ravensdown 1990). The higher rate (56 kg S) could supply more available (but not excessive) S at any given time. Therefore, it not only preformed better, but it was more efficient (on a kg DM/kg S applied) than the lower rate (19 kg S).

Comparison of sulphate vs sulphur bentonite, 28 kg S

Super/gypsum was superior to sulphur bentonite as it provided more immediately available S, i.e. granule breakdown hindered the performance of sulphur bentonite. As increasing the application rate will not solve this problem, it is concluded that 'Tiger 90' sulphur bentonite prills do not suit development situations.

Elemental sulphur

The elemental S used for the first application was relatively ineffective due to the large particle size. Work by Boswell (Boswell & Sweeney 1988, Boswell pers. comm.) indicates about half of the first application of elemental S would have oxidised to sulphate S in 3-4 years. It provides only 40% (6.3 kg) of the first year's requirement.

The second application of elemental S would provide about 15 kg S. The marked response to this application would be the result of the higher oxidation of the finer particles plus any residual effect from the first application. Three quarters of this grade might be expected to be released in 3-4 years.

Application rate, 56 kg S

Sulphur super extra, sulphur bentonite and elemental S all supplied 56 kg S/ha.

Sulphur super extra outperformed the other two because it was the only product containing immediately available sulphate S. This is highlighted by the total production of sulphur super extra being at least equivalent to the sum of the performance of its individual components, i.e. super and elemental S.

Work by Ludecke (1965) and McIntosh *et al.* (1985) has previously shown the superiority of sulphate S to elemental forms in this region.

In sulphur super extra the elemental component complements the sulphate S in giving the product a residual effect, even though this was limited by the relatively coarse particle size. The use of wet mix S super at the second application will provide an earlier and higher rate of elemental S release due to its finer particle size. Wet mix has previously proven superior to dry mix sulphur supers (Sinclair & Enright 1983).

The rate of sulphur super extra used (205 kg/ha of product) is similar to the 200 kg/ha recommended by McIntosh *et al.* 1985 to be the minimum initial (two year) dressing on yellow-grey earths. Sulphur super extra is a much cheaper source of S than superphosphate, so it was the most cost effective treatment.

Nitrogen build-up

Soil N fertility improved as S deficiency was corrected. Levels fluctuated as a result of winter leaching, seasonal plant uptake, and the influences of soil temperature and moisture on soil microbial activity. The dominance of the higher fertility white clover in the fourth year reflects this improved fertility (Scott et *al.* 1989).

Conclusions

Sulphur super extra containing a combination of soluble and slow release forms of S gave the best results in terms of total DM production, pasture composition and herbage S uptake. It was the most cost effective fertiliser in the trial.

Superphosphate is the most efficient S source based on the DM produced per kg of S supplied.

The delay in release of S from 'Tiger 90' sulphur bentonite prills suggests that they suit maintenance rather than development situations.

Soil available N levels indicate that fertility is now at a stage where improved grass species could be successfully introduced.

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