Comparing sulfur sources for pastures on light sandy soils

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Abstract

The performance of temperate pastures grown on light textured soils to applications of experimental and commercial fertilisers were evaluated. Fertilisers contained either elemental, sulfate or a combination of both forms of sulfur (S) and were evaluated at various rates of S and a basal rate of 15 kg phosphorus (P)/ha. The sites were located in the NE (Site 1) and SW (Site 2) regions of Victoria. Both sites had an average annual rainfall of 750 mm. Experiments were conducted between 1999 and 2001. Pasture composition was sub-clover based, with phalaris at site 1 and perennial ryegrass at site 2. At the commencement of both experiments, KCl_{40} extractable soil sulfur levels were 7.1 and 7.0 mg S/kg (0-10 cm) respectively.

In the absence of any fertiliser, pasture growth progressively declined at both sites. Significant responses to S were measured in the third year at Site 1 and from the second year at Site 2. At both sites, pasture yield responses to different S fertiliser sources were not significantly (P>0.1) different at comparable rates of S.

Extractable soil S levels in the soil surface (0-10 cm) in summer were higher where S was applied at 19 kg S compared to where S was applied at 9 kg of S. Soil S levels decreased at both sites when insufficient S was applied to replace S removed in herbage or potentially lost by leaching. This replacement rate differed between the two sites.

Key Words

Sulfur, elemental, sulfate, pasture, dry matter yield, extractable soil S.

Introduction

Sulfur (S) is an essential plant nutrient and important for legume-based pastures. It has been long recognised that sulfate S is effective in supplying S to pastures. The rate of microbial oxidation of elemental S is controlled by soil temperature, moisture and particle size (1, 2, 3, 4, 5). Elemental S applications to pastures can be at least as effective as sulfate S, provided particle sizings are < 250 micron. The microbes which are needed for the conversion of elemental S to sulfate S increase in activity as soil temperatures increase, as do plant growth rates. For example, trials conducted in 1997 in Scotland (6), using four different soils found the S oxidization rate was similar for all four soils. However, fine sulfur (53 micron) oxidised far quicker than the coarser sulfur (125 micron).

Compared to sulfate S products, incorporation of elemental S into fertiliser products has several potential advantages. Firstly, the products are capable of supplying sulfur over an extended period, thus reducing potentially large losses of S through leaching beyond the zone of plant roots; elemental S can be considered as a controlled release fertiliser (7). Secondly, it allows for better pasture production in the spring as the S oxidised allows soil sulfate levels to accumulate and be utilised more efficiently during the flush of pasture growth. Thirdly, because of its very high S content, there are cost savings in freight and handling.

This paper reports comparisons between fertilisers containing either sulfate, elemental S or a combination of S sources applied to pastures grown on light sandy soils in temperate regions of south eastern Australia.

Methods

Two pasture trials in Victoria were established in the autumn of 1999. Sites were selected on the basis of having good pasture composition (>30% sub-clover content) and having a sandy loam soil type that was likely to respond to applied S. Site 1, located near Corryong in NE Victoria, was a sub-clover/phalaris pasture with an annual rainfall of 750 mm, evenly spread through out the year. The surface soil texture was a light sandy loam with an organic carbon of 2.1 % and a CEC of 3.24 meq/100gm. Site 2, near Casterton in SW Victoria, was a sub-clover/perennial ryegrass pasture, and had an annual rainfall of 750mm, which was strongly winter dominant. Its surface soil texture was a sandy soil with an organic carbon of 3.4 % and a CEC of 4.32 meq/100gm.

The fertiliser treatments were combinations of P and S applied annually in autumn at a rate of 15 kg P/ha. The rates of S applied were 1, 8, 9, 12, 18 or 19 kg/ha, with a basal application of potassium (K) at 100 kg/ha. For simplicity, the 8 and 9 rates are jointly referred to henceforth as '9', and 18 and 19 jointly as '19'. The elemental S used in these trials had a range of particle sizes, with 34 % less than 50 micron, 51 % between 50 and 150 micron, 11 % between 150 and 250 micron, and 4% greater than 250 micron. Single superphosphate (SSP) at 15 kg P/ha supplied 19 kg S/ha, but some fertiliser products were compared at lower rates of applied S (Table 1). Each treatment was replicated four times in a randomised block and plot size measured 5m x 2m. Two-tailed significance levels are used throughout.

Dry matter (DM) production was measured by harvesting the whole plot (10 m^2), using a rotary mower with catcher, several times per year throughout 1999, 2000 and 2001. A residual pasture height of 5 cm remained after each cut. All harvested pasture was removed from each plot and weighed. A sub sample (200 gms fresh weight) from each plot was taken and oven-dried at 70?C, and weighed to determine DM content. The relative dry matter response to sulphur for each year and in total, was calculated as :annual DM production of all S treatments at the same S rate/annual DM production of MAP (1 kg S treatment).

Soil samples were collected at establishment and determined KCl_{40} extractable soil sulfur levels to be 7.1 and 7.0 mg S/kg (0-10 cm) respectively at Site 1 and Site 2.Whole tops of sub-clover were sampled in the early spring of 2000 and 2001 at Site 2 to compare the ability of each fertiliser product to supply adequate S for maximum plant growth. Soil samples (0-10 cm) were collected for analysis in December 2000 and December 2001 at Site 2, and in December 2001 at Site 1 and analysed for KCl_{40} extractable S.

Results and Discussion

Pasture yield responses

Total DM production (average of all treatments), over the three years was 20.1 t/ha at Site 1 and 16.3 t/ha at Site 2. DM yields are presented (Table 1) by year and in total for each product in order of increasing S content. The nil fertiliser treatment (no P or S applied) is presented for reference only.

Pasture yield responses to applied S occurred in the second and third years (2000 and 2001) at site 2 and at site 1 in 2001 (Table 1). In these responsive years, higher pasture yields were measured at 19 kg S/ha compared to lower application rates of S. Annual pasture DM yields were not found to be affected by the form of S applied ($p > 0.10$) at comparable rates of applied S.

The MAP based products used in these trials have applied 5 to 7 kg of nitrogen per hectare. However, in a clover based pasture this rate of nitrogen applied in early autumn would not have a significant effect on dry matter production. Experimental work undertaken on dairy pastures in SW Victoria showed that early autumn applications of up to 50 kg of nitrogen per hectare had no significant effect on drymatter production of a grass-clover pasture when moisture was limiting (9). For this reason, the comparative basis for the performance of all products should be on their sulphur content.

Site 2 appears to be more responsive to applied S than Site 1. This may be linked to the sandier soil type and the site having a winter dominant rainfall, since waterlogging at this site was observed during two of the three winters. Even so, S fertilizers applied at either 12 or 19 kg S/ha at site 2 had adequate concentrations of S (8) in subterranean clover tissue samples taken in September 2000.

Table 1: Annual and total pasture DM production and relative responsiveness from different fertiliser products, by site

Product	**N rate (kg/ha)**	**S Form**	**S rate (kg/ha)**	**Site 1**				**Site 2**			
				1999	2000	2001	**Total**	1999	2000	2001	**Total**
Nil P	0		0	3.88	6.33	7.38	17.59	5.42	5.18	3.58	14.18
MAP	7	SO_4	1	4.40	6.83	8.14	19.36	5.52	5.25	3.81	14.58
GoldPhos 10?	0	Elem	8	3.77	6.73	8.73	19.22	5.78	5.84	4.63	16.24
MAP-S95	7	Elem	8	4.11	7.05	8.65	19.82	5.46	5.92	4.23	15.61
Super M?	7	Elem	9	4.24	6.94	9.79	20.97	5.73	6.03	4.66	16.42
Super M Extra?	5	Comb	12	4.19	7.25	9.82	21.25	5.81	6.09	4.60	16.50
MAP-S95	7	Elem	18	4.08	6.94	9.32	20.34	5.80	6.55	4.69	17.03
GoldPhos 20?	0	Elem	19	4.07	7.20	9.66	20.93	5.87	6.51	4.94	17.32
Pasture Gold?	0	Comb	19	4.24	7.24	9.29	20.77	5.94	5.51	4.87	16.32
SSP	0	SO_4	19	4.24	7.11	9.18	20.53	5.68	6.09	5.05	16.82
Lsd (P<0.05)				0.45	0.59	1.02	1.75	1.06	0.68	0.67	1.60
* RP9: Relative production @ 9			9	92	101	111	103	102	113	118	110
* RP19: Relative production @ 19			19	94	104	115	107	105	117	128	116
Lsd (P < 0.05) for RP9 cf RP19				5.5	4.7	6.8	4.9	10.4	7.0	9.5	5.9

* 100 x (Yield of all treatments at the same S rate)/(Yield of MAP treatment)

Extractable soil S

The initial extractable soil S values in the surface 10 cm layer at both sites (~ 7 mg S/kg) suggested both soils were approaching marginal S status, being slightly above the critical value for this soil test of 6.5 mg S/kg (10). The lack of pasture response in the first year at both sites supports the published critical value. However, under the harvesting regime used, soil extractable S concentrations measured in the 0 –10 cm layer by the second and third years progressively decreased to sub-optimal levels of around 4 to 5 mg S/kg where no S fertiliser was applied (Table 2). Corresponding to each analysis shown in Table 2, significant yield responses ($P < 0.05$) to applied S were obtained (Table 1).

Under grazing conditions, the recycling of S voided in excreta may maintain higher levels of extractable soil S in contrast to the nutrient depleting regimes used here, where pasture growth was being regularly removed.

Table 2: Effects of S fertiliser products on KCl_{40} extractable soil sulfur concentrations (mg S/Kg) in the surface 10 cm at Site 1 and Site 2 at 15 kg of P per Ha.

Product	S Form	S rate (kg S/ha)	Site 1 Dec 2001	Site 2 Dec 2000	Site 2 Dec 2001
			mg S/kg KCL_{40}	mg S/kg KCL_{40}	mg S/kg KCL_{40}
Nil P		(0; nil P)	4.6	4.2	3.6
MAP	SO_4	1	4.6	4.5	3.9
GoldPhos 10?	Elem	8	5.8	5.3	4.0
Super M?	Elem	9	5.4	5.4	4.4
GoldPhos 20?	Elem	19	7.4	6.1	5.5
Pasture Gold?	Comb	19	7.3	5.9	5.9
SSP	SO_4	19	8.2	6.5	4.4
5% lsd			1.5	2.2	1.5

Conclusion

Elemental sulfur products, used on light soils under moderate rainfall, produce similar amounts of pasture dry matter to sulfate sulfur products. Better matching of fertiliser inputs with plant demand and propensity to leach could lead to more sustainable pasture systems, with smaller nutrient losses. Only small DM responses were recorded at these sites 1 and 2 in year 1 with initial soil S levels of 7.1 mg S/kg and 7.0 mg S/kg respectively, indicating that the adequate range of soil S in these soils is most likely near 6.5 mg S/kg (10). Although the critical target KCl_{40} was derived from experimental work in northern NSW in a summer rainfall environment, the critical value was found to be appropriate in Victoria under quite a different rainfall regime.

We conclude that on these sandier soil types in south eastern Australia, applications of S enriched fertiliser are required. Application rates of at least 19 kg S/ha can be necessary to maintain DM production and soil and plant S status, under a heavy herbage removal regime and moderately high rainfall over the long term.

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