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DAP slurry evaluations in Hawke's Bay

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Abstract

Three experiments were conducted in Hawke's Bay to evaluate the agronomic effectiveness of DAP slurry fertilisers containing finely ground diammonium phosphate (DAP). The experiments also compared the effectiveness of sulphur (S) applied as sulphate and as elemental S. Experimental sites, all on dryland yellow-grey earth soils on permanent sheep pasture which had not received fertiliser for several years, covered a range of soil fertility, pasture species and chemical composition. Trials were open to grazing, and exclusion cages were used to measure herbage production over 1 or 2 years. No difference in yield ($P \leq 0.05$) was recorded for DAP applied at low rates either as a slurry or as a conventional solid fertiliser. It was concluded that grinding of DAP into small particles and its application as a slurry had no effect on the agronomic performance of the applied nutrients when compared with solid fertiliser. DAP slurry fertilisers had no statistically significant effect on herbage dry matter production, dry matter digestibility, protein content, or trace element content relative to unfertilised control pasture. Application of DAP slurry twice at annual intervals had no significant ($P \leq 0.05$) effect on soil test measurements. Sulphate S was more effective than elemental S in overcoming S deficiency in these experiments.

Keywords: diammonium phosphate, fertilisers, fertiliser forms, Hawke's Bay, slurry fertilisers, sulphur

Introduction

Ground diammonium phosphate (DAP), mixed with small quantities of other nutrients and trace elements, is sometimes applied to pasture as a slurry by helicopter. The research reported in this paper was conducted because of requests for information on the agronomic effectiveness of DAP slurry. As part of the experiments the agronomic effectiveness of sulphate sulphur and elemental sulphur was evaluated.

Fetyeret *al.* (1 989) concluded from their experiments and a review of fertiliser research that the agronomic effectiveness of liquid and proprietary solid fertilisers can be predicted from their nutrient content. Our experiments compared DAP applied as a slurry and as manufactured, but did not evaluate any differences in application accuracy due to helicopter spreading systems (slurry) compared with fixed-wing aircraft application (DAP solid).

Sulphur (S) can be applied as plant-available sulphate or as elemental S. Elemental S must be oxidised in the soil to the sulphate form before becoming available to plants, the rate of oxidation being influenced by several factors including particle size, soil moisture and temperature (Ghani et *al.* 1993). The most effective form of S fertiliser depends on time of application and sulphate leaching index, SLI (Cornforth & Sinclair 1984). It would be expected that on Hawke's Bay yellow-grey earth soils of low SLI that the efficiency of sulphate and elemental S would be similar for pasture maintenance, but with sulphate S providing faster availability where S deficiency occurred.

Methods

One experiment was conducted on a farm at Waipawa and two at the AgResearch Poukawa Research Station (Hastings). Experimental sites, all on dryland yellow-grey earth soils on permanent sheep pasture which had not received fertiliser for several years, covered a range of soil fertility and pasture composition (Table 1). At Waipawa fertilisers were applied in May 1992 and measurements were made for 1 year. At Poukawa fertilisers were applied in September 1992 and October 1993, and measurements were made over 2 years.

Experiments had up to 10 treatments, but only treatments 1-5 designed to investigate DAP slurry and treatments 6 and 7 comparing elemental and sulphate S are reported in this paper.

1. *Control:* no fertiliser applied.
2. ***Trace elements***: trace element mixture applied (3.8 kg/ha of Cu as cupric sulphate, 3.5 kg/ha of Zn as zinc sulphate, 1.7 kg/ha of B as sodium tetraborate, and 140 g/ha of Mo as sodium molybdate).
3. ***DAP Slurry:*** DAP applied as slurry at rates specified by the commercial applicator (Cost $32 to $74 per ha treated).
4. ***DAP*** Solid: DAP applied as a solid, at a rate with equivalent P and N to treatment 3 (Cost $13 to $23 per ha).

5. *DAP* Cost: DAP applied as a solid, at a similar applied cost per ha to treatment 3.
6. Crop Mix: A crop mix (N.P.K.S 20.10.0.13) applied at 200 kg/ha. The Crop Mix used was a proprietary mixture of DAP and ammonium sulphate ($98/ha).
7. *DAP+S+Urea*: 100 kg/ha DAP + 20 kg/ha sulphur bentonite prills + 48 kg/ha Urea. Sulphur bentonite prills had a range of elemental S particle sizes, typically with 97% less than 2 mm and 11% less than 150 microns ($121/ha).

Amounts of P, N and S applied in treatments 3, 4 and 5 are listed in Table 2.

DAP slurry is a proprietary formulation that contains DAP, elemental S and a mixture of trace elements (Co, Cu, B, Zn, Mg, Mn, I, Se). Trace elements in slurry were intended to alleviate animal health problems associated with any trace element deficiency. The rate of fertiliser application in slurry was based on soil tests conducted by the slurry applicator, and was different for each of the three experimental sites (Table 2).

At Waipawa the farm owner contracted a company to treat designated paddocks with DAP slurry. The company sent a representative to soil test the area and subsequently applied their product by helicopter using their usual procedure. Two tarpaulins were used to prevent DAP slurry being applied to part of the treated area, and this provided areas for other treatments. Treatments 1, 2, 4 and 5 were located in areas covered with tarpaulins during DAP application. Treatment 3 was located adjacent to and outside the covered area. Plots were 2 m x 5 m, and laid out in 4 block replicates (2 replicates per tarpaulin). Treatments 1, 2, 4 and 5 were randomised within blocks.

At Poukawa 2 experimental areas were soil tested separately by a DAP slurry application company representative, and DAP slurry recommendations (including cost) were provided. DAP slurry (dry ingredients) was supplied by the application company, mixed with water in the usual ratio of solids:water, then applied by small plot sprayer to treatment plots.

Experiments were open to grazing and exclusion cages were used to measure herbage production. At Waipawa 7 production cuts were taken for the period 9 May 1992 to 9 July 1993. At Poukawa 12 cuts were taken for the period 14 September 1992 to 27 September 1994, 8 cuts in the first year and 4 cuts in the second year.

Other measurements included hcrbage quality (protein, DM digestibility) measurements at the first cut of each experiment using a near infrared spectrophotometer, soil quick tests at the end of the Poukawa experiments, and herbage chemical measurements.

Table 1 Botanical composition of control plots in spring 1992, soil quick test results at the start of experiments, and chemical analysis of dried mixed species herbage samples from the control plots at the first harvest.

	Waipawa	Poukawa 1	Poukawa 2
Botanical composition (% DM)			
Perennial ryegrass	36	36	24
Other grasses	36	33	51
Clovers	24	30	23
Weeds	4	1	2
Soil quick tests			
pH	6.0	5.7	5.0
Olsen P	4	28	10
K	3	28	4
Sulphate S	5	7	4
Herbage chemicals			
N (%)	2.92	3.66	2.93
P (%)	0.21	0.50	0.35
S (%)	0.27	0.28	0.18
Mg (%)	0.22	0.19	0.17
Mn (ppm)	472	172	279
Zn (ppm)	322	83	108
B (ppm)		13	10
Cu (ppm)	12	10	9
Co (ppm)	0.87	0.34	0.65
Mo (ppm)	1.63	2.07	1.33

Table 2 Rates of nutrient application (kg/ha) in Treatments 3, 4, and 5.

	Waipawa			Poukawa 1			Poukawa 2		
Treatment	N	P	S	N	P	S	N	P	S
DAP Slurry	2	2	6	3	3	6	5	5	4
DAP Solid	3	3	0.3	3	3	0.3	5	5	0.5
DAP Cost	6.5	7	0.7	20	22	2	22	24	2

Data were analysed as a randomised complete block design, and treatment means were compared using Fisher's protected LSD ($P \leq 0.05$).

Results

Adequate summer and autumn rainfall in 1992193 resulted in rapid pasture growth in the first year. Herbage production was markedly reduced in 1993194 compared with 1992193 at Poukawa (Table 4) as a result of dry summer and autumn conditions.

DAP slurry

Herbage production from treatments l-5 during the first year were used in a combined analysis across sites to increase precision of statistical tests. This provided 14 replicates of each treatment (Table 3). The treatment by site interaction was not significant ($P \leq 0.05$).

Early cuts (Table 3) included cuts l-3 for Waipawa (May-November) and cuts l-2 for Poukawa

(September-November 1992). Production from the DAP Solid and DAP Cost treatments were significantly greater than from the Control (P≤0.05). Herbage production from the Trace Element treatment and the DAP Slurry treatment were not different (P≤0.05) from Control. The difference between DAP Slurry and DAP Solid was not significant (P≤0.05). Differences in herbage production from treatments l-5 for the remainder of the year (Late cuts) and for the whole year (Total) were not significant (Table 3).

In the Poukawa experiments, pasture production averaged for the two years was: Control 13 570 kg DM/ha, DAP Slurry 13 825 kg DM/ha, DAP Solid 13 750 kg DM/ha (LSD 1225). For all comparisons, herbage yield from DAP Slurry (treatment 3) was not different from either the Control (treatment 1) or DAP Solid (treatment 4).

At all three sites there was no significant (P≤0.05) effect of treatments l-5 on forage digestible DM content or protein level. Means were 73% DDM and 17% protein at Waipawa and 77% DDM and 19% protein at Poukawa.

Soil test results for samples from selected treatments taken at the end of the Poukawa experiments showed that 2 years of DAP slurry application had not significantly (P≤0.05) changed soil tests compared with Control. Mean tests for the two treatments were respectively: pH 5.5 and 5.8, Olsen P 14 and 13, sulphate S 4 and 3.

Herbage chemical analysis data could not be statistically analysed because herbage was bulked across replicates. Four to six weeks after fertiliser application, DAP slurry formulations had no apparent effect on the trace element level of pasture compared with Control. The Trace Element treatment increased the level of copper and molybdenum in herbage at Waipawa, and the levels of boron and molybdenum at Poukawa.

Form of sulphur

Results (Table 4) are presented separately for Poukawa 1 and Poukawa 2 because a significant site by treatment interaction was measured (P≤0.05)

There was a consistent trend for herbage production to be higher from application of Crop Mix than from DAP+S+Urea. On Poukawa 1 the difference of 4% over the two years of measurement was not statistically significant (P≤0.05). On Poukawa 2 the difference of 13% was statistically significant (P≤0.05).

Chemical analysis of cut 1 herbage 4 weeks after fertiliser application had the following S levels-(% DM) for Control, Crop Mix and DAP+S+Urea respectively. On Poukawa 1: 0.28, 0.39, 0.25. On Poukawa 2: 0.20, 0.36, 0.20. These results indicate that the oxidation rate of elemental S was insufficient to lift plant S levels in the weeks after application.

Table 3 Herbage production (kg DM/ha) combined over three experiments.

Treatments	Early cuts	Late cuts	Total
1 Control	4220	9880	13980
2 Trace elements	4200	9590	13660
3 DAP slurry	4350	10200	14410
4 DAP solid	4520	10030	14430
5 DAP cost	4740	9980	14570
LSD (*P*≤*0.05*)	260	780	830
F test significance	***	ns	ns
Coefficient of variation	8%	10%	7%

Table 4 Effect of form of sulphur on herbage production (kg DM/ha) at Poukawa. Annual N.P.K.S. applications in treatments 6 and 7 were 40.20.0.26 kg/ha. LSD and F ratio from analysis of 10 treatments.

	1992/93	1993194
Poukawa 1		
1 Control	19590	10650
6 Crop Mix	20600	12580
7 DAPcS+Urea	20210	11840
LSD (*P*≤*0.05*)	1706	1195
F test significance	ns	
Poukawa 2		
1 Control	14520	9520
6 Crop Mix	17230	13230
7 DAP+S+Urea	15830	11120
LSD (*P*≤*0.05*)	1637	1346
F test significance	**	***

Discussion

DAP slurry

DAP slurry was applied commercially (Waipawa), and experimentally (Poukawa) using product formulated and supplied by a commercial applicator. The suppliers used their normal methods of soil sampling and laboratory analysis before they decided on product rates and formulations. It was considered that slurry applications were typical of commercial practice at the time the experiments were established, and that evaluations covered the range of situations that could be expected on typical East Coast sheep and beef farms.

Neither herbage production nor nutritive value was statistically different for DAP slurry and solid DAP. There was no evidence that trace elements included in the slurry formulation had any influence on herbage production or herbage chemical composition. It was concluded that grinding of DAP into small particles and application as a slurry had no effect on the agronomic performance of the applied nutrients when compared with conventional solid DAP applied by hand.

This conclusion would not be expected to change with a higher slurry application rate. Results of these experiments are consistent with the established scientific practice (Feyter et al. 1989) of evaluating the agronomic efficiency of different fertilisers based on chemically analysed major nutrient content (N, P, S, K).

No significant ($P \leq 0.05$) increase in herbage production over the unfertilised control treatment was measured in any of the three experiments where DAP slurry was applied. The lack of a significant difference was not because the experimental sites were unresponsive to fertiliser. Other treatments with higher nutrient rates resulted in significant responses (e.g., Crop Mix treatment). The DAP slurry treatment contained only 2-5 kg/ha of N and P, insufficient to produce a measurable increase in herbage production. With considerably increased replication, a significant difference in herbage production between slurry and control treatments could have been detected (Johnstone & Sinclair 1991). However, any production increase would still only be in a similar magnitude to that measured in the current experiments.

If DAP application rate in slurry was increased (e.g., to 15 kg/ha of N and P) above the levels evaluated in these experiments (2-5 kg/ha of N and P), as is sometimes the practice of applicators at present, significant pasture production responses to slurry relative to unfertilised pasture would be expected. The magnitude of any such increase could be predicted on the basis of the agronomic value of the applied rates of N, P, S and any other nutrients of agronomic benefit.

The application of trace elements in DAP slurry at the experimental sites was considered unnecessary. Initial trace element levels (Table 1) *were* adequate for pasture and sheep growth at Waipawa and Poukawa 2 (Grace 1983; Comforth & Sinclair 1984). At other sites, where deficiencies occur, trace element application could be of benefit.

Form of sulphur

Application of sulphate S in Crop Mix increased pasture S uptake compared with elemental S applied in prills. Sulphate S increased herbage S levels on both Poukawa trials, and herbage production 13% in Poukawa 2 (Table 4). Poukawa 2 had a lower S status than Poukawa l (Table 1). Fine elemental S can take up to 4 months to release sufficient S for pasture requirements; coarser materials can take longer (Ghani et al. 1993). The advantage of sulphate S over elemental S was maintained into the second year for Poukawa 2.

It was concluded that where S deficiency occurs, as it did at Poukawa 2, sulphate S is more effective than elemental S in overcoming the deficiency. Under these conditions the superiority of sulphate over elemental S can continue beyond the first few months after application. Where S levels are adequate for pasture growth, as on Poukawa 1, the release of elemental S by microbiological oxidation is adequate to maintain pasture growth (During 1984).

It is recommended that S status is monitored on farms, so that the appropriate form of S is applied in fertiliser. The experimental results confirm the observation of East Coast farm advisers that Crop Mix can give a better pasture response than DAP/eIemental S fertilisers.

Conclusion

The cost efficiency of DAP slurry fertilisers can be evaluated from (I) the applied cost (fertiliser, transport, spreading), (2) the nutrient content of the slurry (N.P.K.S), (3) the rate of application, and (4) the nutrient status of the land under consideration.

Ammonium sulphate (results not presented) and Crop Mix (20.10.0.13) were the two most cost-efficient fertilisers at the experimental sites, reflecting the deficiency of both N and S.

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