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DYNAMICS AND ECONOMICS OF PASTURE PRODUCTION RESPONSES TO A REPRESENTATIVE RANGE OF PHOSPHORUS AND SULPHUR FERTILISERS

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Abstract

Two trials in the Nelson province with 6 alternative phosphate(P) fertilisers and 4 sulphur (S) fertilisers measured initial and residual responses over 3 seasons and used the results to determine appropriate topdressing frequencies, from which economic implications could be determined.

P and S treatments were applied at 50 kg total element/ha for all alternatives in a randomised block desing with 4 replicates Appropriate basal fertilisers were applied, and plots were mown at intervals for 2½ years.

Superphosphate was an effective P fertiliser at both sites, but at the lower rainfall yellow-brown earth site at Dovedale the intermediate solubility P fertilisers Longlife Super and Phospar PARPR and the low solubility P fertilisers Sechura and North Carolina RPR caught up with Superphosphate by years 2 and 3. At the high rainfall Collingwood site on a pakihi soil Superphosphate and Longlife super responded significantly in year 1 only while there were no significant responses to the other 4 P fertilisers at any stage.

Gypsum S was an effective source of S at both sites, but tended to be exceeded by elemental S forms at Collingwood. There were however, no significant differences between the four S fertilisers at either site.

The economic analysis of all products, assuming a P:S requirement of 1 :1 and appropriate spreading frequencies, shows Superphosphate to be the most cost effective at the time of analysis.

Keywords: yellow-brown earth, pakihi. cost effectiveness, phosphorus, sulphur, fertilisers, economics

INTRODUCTION

Stresses in the agricultural economy and doubts about the continuity of supply of some raw materials and the solubility and effectiveness of P in locally manufactured Superphosphate (SSP; see Table for abbreviations) during the early 1980s has focused attention on P and S fertilisers other than SSP. Cost savings have been implied or promoted. By the mid 1980s much confusion had developed in farmers' minds. The objective was to establish in the field the response characteristics over time so that the alternatives could be evaluated in economic terms.

TRIAL SITES

Two sites were chosen within the Nelson province with site characteristics as follows:

Dovedale

Soil type: Stanley hill; silt loam; yellow-brown earth (YBE) hygrous; typical of much of the rolling and steeper terrace and hill country in Nelson with this level of rainfall; approx. 60% of 115 000 ha grazed. Rainfall: 1000 mm average. Pasture type: white clover, ryegrass, crested dogstail and cat's ear and plaintain flatweeds. **Initial** soil test: pH 5.7; P 8; *K* 4; S 5; Mg 11; Ca 9; PR 17; TBK 0.4. Topdressing history: very infrequent.

Collingwood

Soil type: Onahau: Sandy loam; podzolised YBE; a pakihi typical of developed terraces and rolling hills, making up approx 25% of Golden Bay's grazed area of 35 000 ha Rainfall: 2000 mm average. Pasture type: white clover, ryegrass, cocksfoot, Yorkshire fog and minimal flatweeds Initial soil test: pH 5.7; P 9; K 3; S 5; Mg 16; Ca 9; PR 4; TBK 0.3. Topdressing history: Lime and fertiliser at typical maintenance levels last 15 years.

MATERIALS AND METHODS

Each site had the same experimental design. The S trial was adjacent to the P trial with each a randomised block design with 4 replicates. Date of establishment was 15 Oct. 1985 at Dovedale and 5 Nov. at Collingwood. Each treatment for both P and S comparative effects was applied, at 50 kg total element/ha, once only at the time of establishment. (See Table 1 for rates).

Basal fertiliser applications were applied so that any deficiencies of elements other than the one under test were eliminated. At establishment 10 kg/ha of sodium borate and 200 g/ha of sodium molybdate were applied. Potassium at 50 kg/ha was applied each spring at Dovedale (3 in total) and at 50 kg/ha each spring and autumn at Collingwood (5 in total). Both P trials had gypsum (50 kg S/ha) at establishment followed by SB 90 prills (50 kg S/ha) in Oct. 1986 and gypsum (30 kg S/ha) in Dec. 1987. Both S trials has TSP at establishment (50 kg/ total/ha) and an additional 30, kg total/ha in March 1987. N was applied to both sites throughout, at 30 kg N/ha in spring and/or autumn. (ammonium nitrate or urea).

Plot size was 5 m^2 and sites were fenced. Mowings were carried out with half clippings returned. Dry matter was calculated from a common sample from the whole trial at each mowing.

Trials were harvested for 2½ years. Analysis of variance was carried out on untransformed data, and differences identified using LSD at 5%.

RESULTS AND DISCUSSION

Comparison of phosphate fertilisers

Dovedale (Table 2) The site was very P responsive. The RPRs both showed significant responses above control in year 1, but NC.RPR was less effective than all other P treatments. The slower P release characteristic of NC.RPR relative to Sec.RPR was presumably related to the coarseness of the 'as received' NC.RPR. Screen testing showed that 47% passed a 250 µm screen (cf. 95% for Sec.RPR). The slowness of NC.RPR tended to prevail throughout,

The much lower yields of year 2 were due to severe summer and autumn drought combined with an inherent site P deficiency. Soil Olsen P was still similar to control, irrespective of P treatments, at end of year 1 and at end of year 2 (September 1987). For herbage tests taken at the end of year 2 SSP and NC.RPR showed P levels at 0.25%, no better than control (only treatments tested). Of the year 2 responses, LLSP, PARPR and the RPRs were statistically significantly greater than control.

Growing conditions were good in year 3 but the prevailing P deficiency for all treatments severely limited growth. Despite this residual responses to all P sources were significant, but P treatmentds did not differ except Sec.RPR > TSP. From the MAF 'National Series' forms of P fertiliser trials, 3 sites have local climate, soil type, pH and P fertility features similar to those of Dovedale. R.G. Smith (Sinclair & Dyson 1988) reported significant residual responses in year 4 when treatments were withheld, for both acidulated fertilisers (TSP, SSP) and RPR at the Wanganui and Apiti sites. The difference between residual responses of the two groups of fertilisers was significant only in favour of the RPRs at Wanganui. Apiti had no

Table 1: Products tested (with abbreviation) and

Product tested	Abbrev.	Assumed total P	Ravensdown total P	Nelson Lab. CSP	May'88 WSP	Applic (kg/ha) for trials
Superphosphate	SSP	9.3	9.4	8.5	8.0	540
Triple Super	TSP	20.4	20.1	18.0	18.4	245
Longlife Super[1]	LLSP	10.6	10.4	6.8	4.8	470
Phospar PARPR[2]	PARPR	17.0	17.0	10.4	7.8	295
Sechura RPR 'as received	Sec.RPR	13.0	13.1	4.4	0.2	385
North Carolina RPR 'as received	NC.RPR	13.0	13.2	4.3	-	385
		Assumed Total S	Sample test s			
Gypsum	GYP	17	15.5			295
Elemental S (screened 10 mesh)	El.S	100				50
Sulphur Bentonite prill 85/15%[3]	SB85	85	81.4			59
Sulphur Bentonite prill 90/10%[4]	SB 90	90	89.9			56

[1] LLSP is SSP (70%) co-granulated with as received NC.RPR (30%)
[2] PARPR is finely ground NC.RPR scidulated with phosphoric acid to 30% of maximum.
[3] Ravensdown Fert. Co-op pilot plant development sample.
[4] Imported Canadian 'Tiger 90'.

Table 2: Dovedale P and S trials

Product	Kg DM/ha Year 1	Year 2	Year 3 (part)	Total	Relative 1	2	3	T	1	2	3	T	% of total response above control by year 1	2	3	T
Control	9780	4920	2780	17480	100	100	100	100	a	a	a	a				
SSP	11750	5540	3560	20850	120	113	128	119	c	ab	bc	b	58	18	24	100
TSP	11500	5440	3470	20410	118	110	125	117	c	ab	b	b	47	27	26	100
LLSP	11480	5880	3730	21090	117	120	134	121	c	b	bc	b	47	27	28	100
PARPR	11610	5980	3710	21300	119	122	133	122	c	b	bc	b	48	28	24	100
Sec.RPR	11130	6410	4010	21550	114	130	144	123	bc	b	c	b	33	36	31	100
NC.RPR	10700	5990	3800	20490	109	122	136	117	b	b	bc	b	31	35	34	100
SE.	480	660	320	1250												
LSD 5%	720	930	480	1860												
Control	11440	6130	3550	21120	100	100	100	100	a	a	a	a				
GYP	12560	8430	3990	22980	110	105	112	109	b	a	a	b	60	16	24	100
El.S	12110	6430	3990	22980	110	105	112	109	b	a	a	b	57	27	16	100
SB 85	12070	6280	3960	22290	106	102	112	105	ab	a	a	ab	54	11	35	100
SB 90	12290	7180	4000	23470	107	117	113	110	b	b	a	b	36	45	19	100
S E	490	340	320	980												
LSD 5%	750	520	500	1470												

Like letters = no significant difference at $P<0.05$

convincing difference between these groups which is similar to the Dovedale trial for year 3. At the Pongaroa site, responses in the first 2 years showed an advantage in favour of acidulated fertilisers. RPR improved in year 3 but still did not exceed TSP and SSP. A higher pH at this site may have accounted for this difference.

After 2% years total DM yield was similar in all treatments. The response characteristic of each P source is shown by expressing the annual responses above control as a percentage of its respective total yield above control for the 3 years (Table 2). The similarity of SSP and TSP as highly soluble P sources contrasts with the less soluble LLSP and PARPR and the low solubility RPRs.

Collingwood: (Table 3) This site was less P responsive, a characteristic indicated more by the fertiliser history than the initial site P test. In year 1 SSP and LLSP showed significant responses above control and the two RPRs. The same order of treatment responses occurred in years 2 and 3, but differences were not significant for the best treatments. There is no good explanation for the poorer performance of Sec. RPR than of NC.RPR, apart from the greater variance in this trial compared with Dovedale.

On actual yield data the RPRs can be regarded as no better than control. Herbage P levels in Dec. 1987 showed control 0.31%, SSP 0.3596, Sec.RPR 0.35% and NC.RPR 0.37% (only treatments tested). Soil Olsen P did not differ between treatments at the end of years 1 and 2.

Unsatisfactory results are possible from RPR on poorer podzolised northern YBE soils (During & Malden 1985). The Collingwood trial indicates results may also be unsatisfactory on poorer Nelson soils such as the pakihis. For South Island pakihi soils conclusive comparative trial work on RPR performance is lacking.

Table 3: Collingwood P and S trials

	Kg DM/ha				Relative								% of total response above control by year			
Product	Year 1	Year 2 (part)	Year 3	Total	1	2	3	T	1	2	3	T	1	2	3	T
Control	11720	12840	6250	30810	100	100	100	100	ab	a	a	a				
SSP	13100	13850	6590	33340	112	106	105	108	c	a	a	a	55	32	13	100
TSP	12260	13430	8530	32220	105	105	105	105	abc	a	a	a	38	42	20	100
LLSP	13010	13510	6710	33230	110	105	107	108	c	a	a	a	53	28	19	100
PARPR	12560	13340	8310	32210	107	104	101	105	bc	a	a	a	60	38	4	100
Sec.RPR	11270	12470	8480	30220	98	97	104	98	a	a	a	a	–	–	–	–
NC.RPR	11860	13170	8320	31350	101	103	101	102	ab	a	a	a	–	–	–	–
SE.	790	1190	330	1780												
LSD 5%	1170	1770	485	2650												
Control	11990	10650	5000	27840	100	100	100	100	a	a	a	a				
GYP	13340	11560	4900	29800	111	109	98	108	b	ab	a	ab	62	38	–	100
El.S	12930	12190	5830	30950	106	114	117	112	b	b	a	b	26	46	26	100
SB 85	13710	11560	4930	30200	114	109	99	109	b	ab	a	b	67	33	–	100
SB 90	13840	12180	5410	31230	114	114	108	113	b	b	a	b	46	43	11	100
SE.	510	770	650	1500												
LSD 5%	790	1180	1030	2310												

Like letters = no significant different at $P<0.05$.

Comparison of S fertilisers

Dovedale: (Table 1) GYP was responsive in year 1 compared with control and with SB 90 was the only S source to show a significant response after 3 seasons. However the four S types did not differ at any stage except SB 90 in year 2 (Table 2). Sulphate-S levels in Oct. 1986 and Sept. 1987 were similar to control (4 ppm), but this does not indicate the effectivenss of residual elemental S in the soil. Herbage sampled Nov. 1987 after 2 years was very deficient in S (0.13% for both control and SB 90% only treatments sampled. El.S and SB 85 performed poorly because of coursness of the E l.S screen sample (see comment under Collingwood) and the lower than assumed S concentration of SB 85 (Table 1). S concentration of SB 90 did not allow this sourse to suffer the same disadvantage.

Collingwood: (Table 3). This site was more S responsive than Dovedale. For the most productive S sources at each site the DM response/kg S applied was 69 at Collingwood and 42 at Dovedale (cf. 50 and 70 for P, respectively). All S sources gave significant responses in year 1. El.S and SB 90 continued to respond significantly in Year 2, although as in year 1 the four S types did not differ. Year 3 showed no significant differences between treatments Over the 3 seasons El.S, SB

85 and SB 90 gave significant responses above control but there was no significant difference among any of these and GYP.

On the DM figures however, GYP and SB85 became S depleted by the end of year 2 as implied by the significance of responses for this year. Sulphate-S soil tests (ppm) were: oct. 1986, SB 90 (5), El.S and SB 85 (3), GYP (2) and control (1); Sept. 1987, no treatment differences (3-5). Herbage S tests of Dec. 1987 for GYP and SB 90 showed no treatment differences above control at 0.25%.

A sample of the lo-mesh El.S used in the Nelson trials had a screen analysis identical to that reported for agricultural S by Boswell and Swanney (1985). Williams et al. (1986) have suggested from a preliminary report of several S trials in Nelson, Marlborough and the West Coast that fine fractions of elemental S are effective under low rainfall conditions, while large fractions are less useful in the short term at least. This parallels experience at Dovedale but larger fractions become important sooner under the warmer, high rainfall conditions as at Collingwood.

Without detailed analysis of particle size fractions of the sulphur bentonite prills used, we cannot explain the apparent good performance of SB 90 at both sites, which occurred despite the different soil and rainfall characteristics.

ECONOMIC ANALYSIS

The cost effectiveness of the alternative phosphate products was determined as follows:

1. Mean treatment responses were used. Statistical analysis showed that all products tended to respond similarly. The mean treatment responses generally reflected better early responses from products with higher P or S solubility, and the converse.

2. Elemental S was costed into low or nil S-bearing P products in order to achieve a 1:1 S:P ratio in each product. Likewise the mean response to S was included for costing purposes. This was the response to GYP for SSP and LLSP, and El.S for low or nil S-bearing products.

3. The relative cost of producting a kg of pasture DM was calculated by:

$$CP = (CT + CF + CS + CI) \times \frac{AR}{1000} \times \frac{1}{(RP+RS)}$$

Where CP = Cost per kg of DM

CT = Cost per bulk t of product ex works

CF = Cost pert of freight from works to costing location

CS = Cost pert of spreading at costing location

CI = Cost pert of the interest component

AR = Application rate of product (kg/ha)

RP = Phosphate response in (kg DM/ha)

RS = Sulphur response in kg DM/ha

4. Costings were made on the basis of annual application for SSP and TSP (16.7 kg/ha TP), biennial application for LLSP and PARPR (33.4 kg/ha TP), and triennial application for NC RPR (50 kg/ha TP). P responses for the respective trial period were used. The application rates represent maintenance at a stocking rate of approximately 13 su/ha. These frequency of topdressing strategies were adopted because of the positive correlation between the CSP% of the P fertilisers and total response% occuring in year 1 at Dovedale together with the greater residual responses to the lower CSP% products (Table 4). The costing method also rationalises the response cost mechanisms operating in the event of annual applications of slower-release products.

5. The costings were carried out on a total P basis.

6. Costs used for the analysis were based on product, freight, and spreading costs effective as at 31 May 1988. Sec. RPR was excluded because it was unavailable commercially.

7. The cost of farm working capital was taken into account. Interest charges were costed in for all products, and interest charges were compounded in the cost of the products which were applied biennially and triennially. An interest rate of 20% was used, recognising seasonal overdraft rates of 24% but term deposit rates of 16%.

8. Six costings were produced to demonstrate the cost implications of the trials under 6 representative circumstances (Table 5).

Table 4: Dovedal P trial - Percentage of total response in each of 3 years

Product	CSP%	Percentage of total response Year 1	Year 2	Year 3
SSP	90.4	58	16	24
TSP	69.5	59	18	23
LLSP	65.4	47	27	26
PARPR	61.2	46	27	24
Sec.RPR	33.6	33	36	31
NC.RPR	32.5	31	35	34

Table 5: Cost of producting 1 kg of pasture OM (cents)

Soil	works	Distance	Spread	SSP	TSP	LLSP	PARPR	NC.RPR
YBE	Nelson	120 km	Aerial	3.1	4.2	3.5	4.3	4.3
YBE	Nelson	60 km	Ground	2.9	4.0	3.2	4.0	3.6
YBE	Homby	120 km	Aerial	2.8	4.2	3.2	3.6	3.4
YBE	Homby	60 km	Ground	2.6	4.0	2.9	3.3	3.7
Pakihi	Nelson	120 km	Ground	3.3	-	3.4	-	-
Pakihi	Homby	120 km	Ground	3.0	-	3.1	-	-

CONCLUSIONS

The cumulative responses of the 6 phosphate alternatives at Dovedale were similar after 3 seasons, which allowed time for the lower-solubility products to respond. At Collingwood SSP and LLSP produced significant responses in the first year only. There were no significant responses to the other four products.

The cumulative responses of the 4 sulphur alternatives showed that GYP and SB 90 performed best at Dovedale. The three elemental sulphurs gave superior responses at Collingwood but there were no significant differences between these and GYP in spite of high leaching.

These trials at two sites with widely different characteristics demonstrated the consistent performance and versatility of SSP because of its effective combination of P and S.

The economic analysis with the chosen method clearly demonstrated the superior economic performance of SSP at current costs, and where there was a common deficiency of P and S.

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