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ALTERNATIVE PHOSPHATIC FERTILISERS FOR HILL COUNTRY

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Abstract

The role of alternative phosphorus sources to single superphosphate as a maintenance fertiliser for hill country was evaluated in five experiments between 1980-1982. The experiments were located at Gisborne, Rotorua and Te Kuiti. Reactive rock phosphate-sulphur granules (previously known as biosuper) were as effective as superphosphate in the year of application, but the reactive rock phosphates applied alone were as effective on only two of the sites. Superphosphate/reactive rock mixtures were less effective than superphosphate. While most fertilisers had substantial residual effects in the second year after application there was no clear pattern between materials. When taken over two years, a single biennial application of all fertilisers was at least as effective as two annual dressings at half the rate. The role of alternative phosphorus fertilisers is discussed in terms of their cost and agronomic effectiveness, the requirements for other elements, and the structure of the present fertiliser industry.

Keywords: superphosphate, phosphorus, phosphatic fertilisers, biosuper, hill country, Sechura, North Carolina, Jordan.

INTRODUCTION

The development and maintenance of New Zealand hill country pastures is closely related to their phosphorus (P) status. Given the low P status of much hill country, there are important questions to be answered on the most cost effective P fertiliser for these situations. Traditionally, single superphosphate has been the major source available to New Zealand farmers, supplying not only P but also sulphur in a readily available form. Fertiliser, of which most is single superphosphate (hereafter referred to as super) is the largest single on-farm cost on hill country, In recent years the costs of super have escalated much faster than returns from sheep and cattle production (Table 1). Recently, some high-analysis phosphatic fertilisers have been competitively priced, and reactive rock phosphate products with utility for direct pasture application without further processing have become available. Given these factors, a series of experiments were initiated to compare alternative P sources as maintenance fertilisers.

EXPERIMENTAL PROCEDURES

Field trials were run on five sites from the King Country to the East Coast, representing a range of soils and climates (Table 2). On all the fertilisers were applied at a number of rates, on an equivalent total P basis, covering levels from below to double maintenance rates. Control plots received no P fertiliser. To minimise the risk of mineral deficienciesconfounding the results, blanket dressings of sulphur, potassium, magnesium and trace elements were applied to each site as appropriate.

The treatments were applied in November or December 1980 and 1981. Provision was made to study the residual effects of each fertiliser during the 12-24 month period by either splitting each plot in 1981 and only reapplying fertiliser to one half, or by withholding fertiliser on an extra treatment which had been initially topdressed at around the maintenance level.

Plots were generally 6 X 1.5m, with three replicates of each treatment. 'fields were measured on an as required basis (generally when herbage was 7-10 cm long), by cutting with a reel mower 8-12 times per year. For comparison between sites, yields from individual cuts have been pooled into similar periods. When comparing fertilisers, data is only given where there was a significant yield response to P. As the effects of the fertilisers and rates were similar at both Rotorua sites, no data from Rotorua/2 is presented.

RESULTS

Responsiveness of Individual Sites to Phosphorus

Pastures at all five sites were responsive to P except for both Gisborne sites in 1980/81. At Rotorua/1 and Te Kuiti the responses were large, the overall yield increases on these being 28 and 38% respectively.

Comparison of Superphosphate with Alternative Phosphatic Fertilisers (Table 3)

To compare fertiliser materials, the rate immediately above the maintenance level was used as at the lower rates interplot variation tended to obscure differences between materials. In no instance was any phosphatic fertiliser agronomically more effective than super on an annual basis. At both Gisborne/2 and Te Kuiti, the reactive rock phosphates and the reactive rock-sulphur granules were as effective on a 12 month basis as super, irrespective of the source of the reactive rocks. On Rotorua/1 and Gisborne/1 while the reactive rock – sulphur granules were as effective as super, the reactive rock phosphates applied alone were less effective. The super/Jordan rock mixtures were less effective than super on both sites at which they were evaluated.

Table 1: CHANGES IN THE 'ON FARM' COST OF SUPERPHOSPHATE BETWEEN 1976 AND 1983 IN RELATION TO THE VALUE OF FARM PRODUCTION

Year	Net applied cost[1] of superphosphate ($/t)	Gross farm income[2] ($/livestock unit)	Superphosphate as % of gross income[3]
1976/77	53.68	13.68	7.5
1978179	79.49	13.61	11.1
1980/81	135.40	19.00	13.5
1982/83	172.58	19.50	16.8

[1] Based on the cost of superphosphate ex Gisborne plus transport (32 km) and aerial spreading.

[2] 60/40 sheep cattle ratio.

[3] 19 kg superphosphate per livestock unit.

Table 3: A COMPARISON OF ANNUAL PASTURE YIELDS FROM SEVERAL PHOSPHATIC FERTILISERS APPLIED AT 'ABOVE MAINTENANCE' LEVELS

Site	Rate phosphorus (kg P/ha)	Fertiliser Material	Annual yield (kg DM/ha) 1980/81	1981/82
Gisborne/1	30	Superphosphate	No P response	12350
		North Carolina rock phosphate		11490
		North Carolina-sulphur granules		12 130
		SE diff		430
Gisborne/2	30	Superphosphate	No P response	10 980
		Sechura rock phosphate		10 640
		Sechura-sulphur granules		10 970
		Superphosphate/Jordan rock		9 960
		SE diff		450
Rotorua/1	60	Superphosphate	9 620	12330
		Sechura rock phosphate	8 700	11 110
		Sechura-sulphur granules	10 130	11 720
		Superphosphate/Jordan-sulphur granules	9 100	10870
		SE diff	270	710
Te Kuiti	50	Superphosphate	8 980	9 400
		North Carolina rock phosphate	8 750	9 070
		North Carolina-sulphur granules	8 530	9 350
		SE diff	380	500

[1] Rate immediately above the 'normal maintenance' level

Table 2: SITE DETAILS AND THE FERTILISERS EVALUATED

Site	Soil Group	Fertilisers (superphosphate common to all sites)		
		Reactive rock[1] phosphates	Reactive rock phosphate -sulphur granules[2]	Superphosphate/Reactive rock phosphate mixtures (granulated)
Gisborne/1	Recent alluvium	North Carolina	North Carolina (2 types)	
Gisborne/2	Y.B. Pumice	Sechura	Sechura	45/55 Superphosphate/Jordan rock phosphate
Rotorua/1	Y.B. Pumice	Sechura	Sechura (2 types)	40/60 Superphosphate/Jordan rock phosphate-sulphur mixture
RotoruaJ2	Y.B. Pumice	North Carolina Chatham Rise	North Carolina	45/55 Superphosphate/North Carolina rock -phosphate[3] -sulphur mixture
Te Kuiti	Y.B. Loam	North Carolina	North Carolina (3 types)	

[1] All except Sechura ground to pass 3.3 mm sieve.

[2] Previously known as biosuper. P/S ratio 5.1/1.

[3] Phosphate rock unground.

Table 5: A COMPARISON OF THE RESIDUAL EFFECTS OF SEVERAL PHOSPHATIC FERTILISERS ON DRY MATTER YIELD (RELATIVE TO ZERO PHOSPHORUS= 100)

a Effect of deleting fertiliser for one year (measured in the second year, 1981/82)

b Effect of a single biennial fertiliser dressing compared with two annual dressings (measured over two years, 1980-1982)

Site	Fertiliser Material	a) No. of annual applications		b) Annual vs. Biennial	
		2 yr X 30 Kg P/ha	1 x 30	2x 15	1 x 30
Gisborne/2	Superphosphate	119	106	105	106
	Sechura rock phosphate	115	107	107	103
	Sechura-sulphur granules	119	111	105	105
	Superphosphate-Jordan rock	108	106	105	107
	SE diff	5		4	
Rotorua/1		2X 60	1 X 60	2 x 30	1 X 60
	Superphosphate	127	122	112	117
	Sechura rock phosphate	114	111	110	106
	Sechura-sulphur granules	121	120	112	118
	SE diff	3		5[1]	
Te Kuiti		2x 50	1 x 50	2X 25	1 x 50
	Superphosphate	136	129	119	121
	North Carolina rock phosphate	131	133	118	122
	North Carolina-sulphur granules	135	138	123	124
	SE diff	7		5	

[1] Applies only to rate comparisons within fertilisers

Speed of Reaction of Alternative Phosphatic Fertilisers (Table 4)

The rate at which yield responses developed from the fertilisers was determined by comparing the yields of all rates of each material with the control (no P) for the periods O-5 and 8-12 months after application. In each instance the responses to super were substantially higher than for all other materials in the O-5 month period. At Gisborne/2 and Rotorua/1, the O-5 month response from the reactive rock phosphate was slower than for the reactive rock-sulphur granules, but at Te Kuiti the early responses from these two were similar. At Gisborne/2 the early response of the super/Jordan mixture was similar to the Sechura rock phosphate.

In the 8-12 month period at Gisborne/2 and Rotorua/1, the reactive rock-sulphur granules gave larger responses than super. Responses to the rock phosphate tended to be less than the same materials combined with sulphur, and in two of the three sites they performed better than super for this period. The super/Jordan mixture was poorer than super in the 8-12 month period.

Table4: A COMPARISON OF THE RATE AT WHICH YIELD RESPONSES DEVELOP WITH SEVERAL PHOSPHATIC FERTILISERS (YIELD RELATIVE TO ZERO PHOSPHORUS = 100)

Site	Fertiliser Material	Period after application O-5 months	8-12 months
Gisborne/2	Superphosphate	121	112
	Sechura rock phosphate	110	115
	Sechura-sulphur granules	114	118
	Superphosphate/Jordan rock	111	107
	SE diff	2	3
Rotorua/1	Superphosphate	108	116
	Sechura rock phosphate	101	107
	Sechura-sulphur granules	104	124
	SE diff		2
Te Kuiti	Superphosphate	112	114
	North Carolina rock phosphate	106	115
	North Carolina-sulphur granules	105	118
	SE diff	4	3

Residual Effects of Alternative Phosphatic Fertilisers (Table 5)

In comparing the residual effects of phosphatic fertilisers there are two major questions, (a) the effects of depleting fertiliser entirely for one year; and (b) the effects of a single biennial dressing compared with two annual dressings.

a) Deleting fertiliser entirely for one year after an above maintenance application the previous year showed that all materials tested had quite large residual effects. In making comparisons between materials there was no consistent pattern be-

Table 6: A COMPARISON OF 'ON GROUND' COSTS OF SEVERAL PHOSPHATIC FERTILISERS 32 km FROM GISBORNE.

Fertiliser[6]	Material cost ($/t ex-Gisborne	Effective P (%)	'On ground cost' ($/kg effective P)		
			P only basis	P + S[1] basis	P + N[2] basis
Superphosphate	122.05[3]	8.3[5]	2.07	1.71	
Sechura rock phosphate	139.77[3]	6.5[4]	2.92		
		11[4]	1.73		
		12.5[4]	1.52		
Diammonium phosphate	425.95	20[5]	2.43		1.55
Triple superphosphate	326.95	19[5]	2.04		

[1] 1 kgS = $0.28

[2] 1 kgN = $0.93

[3] Super ex East Coast Fertiliser Co. Napier (in 1983), Sechura ex Gisborne in 1981

[4] Effective P representing 50, 85, 96% availability of total P

[5] Effective P ex Quin (1983)

[6] Transport/spreading charges $50/t for superphosphate and Sechura rock phosphate, and $60/t for DAP and TSP

tween the sites. At Te Kuiti both the North Carolina reactive rock and the reactive rock-sulphur granules performed as well as those plots to which treatments had been reapplied. The carryover effect of super was slightly poorer, but the differences between the three fertilisers were not significant. At Rotorua/1, super and the Sechura-sulphur granules had similar residual effects, with the Sechura rock applied alone being poorer, but still substantially better than the zero P control. At Gisborne/2, all materials except the super-Jordan rock mixture were poorer than plots to which treatments were reapplied. However, there were no significant differences between the four materials in their residual effect.

b) The effects of applying fertiliser biennially instead of two annual dressings (same total quantity applied) were much clearer. In nearly all instances over two years the single biennial dressing gave dry matter yields equal to or slightly greater (generally not significant) than the two annual dressings. This applied to nearly all fertilisers irrespective of their overall effectiveness. The only exception was with Sechura rock phosphate at Gisborne/2, where the single application was poorer. This is explained from the yield in this treatment being unexpectedly high at the 15 kg/ha P rate in 1980/81, which appeared to reflect inherent plot variation rather than a treatment effect.

DISCUSSION

If the alternative phosphatic fertilisers are to find a niche they must be cost effective. Besides those fertilisers evaluated there are also a number of high analysis P materials available. The main examples of these are triple superphosphate (TSP) and diammonium phosphate (DAP). In comparing various fertilisers the 'on ground costs' are affected by a number of factors. These include the manufacturing, transport and spreading charges, their agronomic effectiveness, and the value placed on other elements such as sulphur and nitrogen.

Where there is a requirement only for P the 'on ground' cost for Sechura rock phosphate is substantially lower than that for super, provided its agronomic effectiveness is high (Table 6). In three of the five trials this was not so, which effectively raised its 'on ground' cost substantially above that of super. The 'effective P' cost of DAP is higher than super, with TSP being slightly lower. In another recent study, Butler (pers comm) showed that when compared on a citric acid solubility basis, TSP was cheaper than super in most circumstances, though the breakeven point varies from month to month depending on relative product prices.

Some of the fertilisers also have appreciable quantities of other nutrients. When the value of these is considered the cost of 'effective P' can be substantially reduced. Super has 11% sulphur, which when taken into account lowers its 'effective P' cost below that of TSP (Table 6). There is a large change in the 'effective P' cost of DAP when the value of its nitrogen content is considered. This changes it from one of the dearer phosphatic fertilisers to the cheapest. All of the above findings apply only to one situation. The conclusions could be quite different using other values for spreading and transport charges. If an additional element such as sulphur has to be added, the cost of the 'effective P' tends to rise substantially (Butler 1982).

When determining which fertiliser to use the individual farmer must take all the above factors into account. It is possible to put an accurate.value on most items. One of the more difficult aspects is assessing the likely agronomic effectiveness of the reactive rock phosphates. In other experiments in the southern North

Island these were generally as effective as super over a three year period (Syers *et al* 1982). Their agronomic effectiveness is related to soil acidity (Quin 1982). Below a soil pH of 5.5 most of their P is readily available and hence they are agronomically effective. If pH is above 6.0 (applied to both Rotorua sites) the availability of their P is greatly reduced. Between pH 5.5 and 6.0 there is an intermediate but difficult to predict effectiveness. Reactive rock phosphates should only be used where it can be predicted that their 'effective P' cost is lower than that of super.

The reactive rock phosphate-sulphur granules and super/reactive rock mixtures are not commercially available at present, which makes it difficult to assess their future role. Since the reactive rock-sulphur granules are agronomically as effective as super they may find a niche if their 'effective P' cost was lower, The super/reactive rock mixtures were generally poorer than super, which makes it unlikely they will be used.

The availability of alternative phosphatic fertilisers has a number of implications for the superphosphate manufacturing industry. If the present trends in the relative prices of super and various alternatives continue there is likely to be a gradual shift away from super to either high analysis forms or products based on reactive rocks. Farmers must use their lowest cost option.

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