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Long term effects of withholding phosphate application on North Island hill country: Te Kuiti

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ABSTRACT A farmlet grazing trial at the Te Kuiti Research Area (20 km south of Te Kuiti) began in April 1983 to study the effects on production of reducing or withholding fertiliser over a 6-year period. The effects of withholding fertiliser are considered in this paper. The soils on which the trial was conducted are Mahoenui or Mangatea silt loams typical of 1.3 million ha of North Island hill country. Applications of 250 kg/ha/annum of superphosphate had been applied for 10 years before the trial began, leading to Olsen P tests of 14. In spite of moderate soil test levels, declines in both animal and pasture production where fertiliser was withheld were evident from year 2. By years 3-4 onwards, production declines of some 20-30% were evident. Effects on pasture composition where fertiliser was withheld were evident, with less white clover and more moss and weeds. No noticeable increase in scrub weeds or brush weeds occurred. Maintaining a high stocking rate (or stock pressure) was considered a dominant factor in this regard.

Keywords grazing trial, fertiliser, hill country, phosphate, animal production, pasture production

INTRODUCTION

New Zealand agriculture, with its reliance on legume based pastures to supply nitrogen (N), has a major requirement for fertiliser inputs of phosphorus (P) and sulphur (S). With the economic downturn in New Zealand farming in recent years, fertiliser inputs have declined dramatically, particularly on hill country properties. Fertiliser use since 1984/85 (Figure 1) has been some 5060% below that of the late 1970s (Taylor 1989).

In order to study the effects of reducing or withholding fertiliser on production, a farmlet grazing trial began at the Te Kuiti Research Area (20 km south of Te Kuiti) in April 1983. This paper reports on 6 years of the trial and will highlight the effect of withholding fertiliser on pasture and animal production.

SITE CHARACTERISTICS

Soils

The trial was conducted on hill soils of the Mahoenui and Mangatea soil mapping units (O'Connor et al. 1973). These are yellow-brown earths formed on siltstone and sandstone. At Te Kuiti they have an average slope of 25” (range 15-40”) and a dominant south to south-east aspect. A thin veneer of volcanic ash is present in the surface layer on the easier slopes. These soils are typical of some 1.3 million ha of North Island hill country.

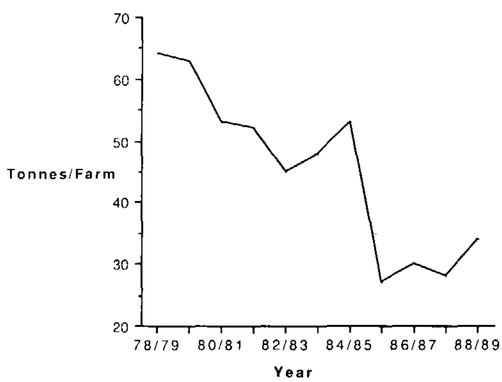

Figure 1 Fertiliser use on sheep and beef farms (Taylor 1989).

Climate

Air temperature over the duration of the trial was average to above average in all seasons (Figure 2a). Rainfall was approximately 12% below average except for 1983 which was 30% below average (Figure 2b). Apart form 1983 then, all seasons could be considered excellent growing ones.

Fertiliser history

The trial area had received an average of 250 kg/ha/annum of superphosphate for 10 years. In 1983 before the trial began, the average MAF soil test (Cornforth 1982) was pH 5.6, Ca 5, K 7, Olsen P 14, med-high P retention value. Marginal molybdenum deficiency was overcome by applications of sodium molybdate as required. Paddocks in a previous lime trial on the site (O'Connor *et al.* 198 1) were re-randomised to give similar soil pH across treatments in the current trial.

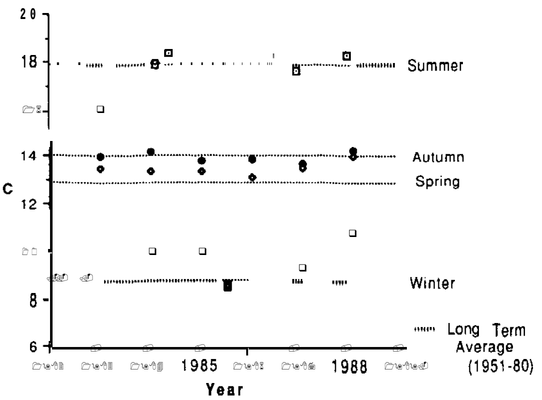

Figure 2a Mean air temperature, Te Kuiti Research Area.

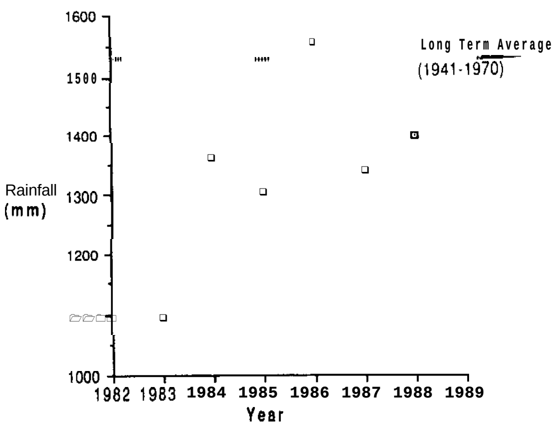

Figure 2b Annual rainfall, Te Kuiti Research Area.

METHODS

The trial consisted of 3 farmlets each comprising 6 (0.5 ha) paddocks. Treatments were:

(1) No fertiliser
(2) 125 kg/ha/annum superphosphate
(3) 250 kg/ha/annum superphosphate

Fertiliser was applied by helicopter in the autumn commencing April 1983. All treatments were stocked at 14 ewes/ha from 1983-87. In 1988 a differential stocking rate of 11, 13 and 15 ewes/ha was applied to treatments 1, 2 and 3 respectively. In this paper, data from treatments 1 and 3 only will be described; treatment 2 was intermediate in its effects. Each treatment had a separate mixed-age flock of Coopworth ewes and there was a 25% annual replacement rate (6 year olds with 3 year olds). Farmlets were rotationally grazed, except over lambing when they were set stocked.

Measurements included monthly ewe and lamb liveweights (lamb liveweights from birth to weaning), wool weights at shearing in May and November (November only in 1983), wool quality measurements, weekly pasture cover assessments on all paddocks (Baars & Dyson 1981), pasture production measurements over set stocking and from an associated small-plot trial (using a cage cut method) and annual pasture composition measurements on 5 fixed transect lines in each paddock. Soil tests were done annually and fertiliser quality monitored before application.

Statistical analyses

Animal liveweights were analysed by least squares analysis to obtain means and adjusted for any imbalance in age distribution between the flocks.

Table 1 Effect of withholding fertiliser on animal production

YEAR	EWE							
	LWT[1]				FWT[2]			
	0	250	SED	%	0	250	SED	%
1983	50.3	53.1	0.92	-1	3.14	3.19	0.10	-2
1984	45.9	54.9	1.19	-16	3.97	4.40	NA	-10
1985	52.4	56.8	0.99	-8	4.19	4.71	NA	-11
1986	46.1	51.6	1.30	-20	4.22	4.60		-8
1987	45.9	55.7	1.10	-18	3.87	4.54	NA	-15
1988[4]	44.2	44.0			4.63	4.27		
YEAR	**LAMB**							
	WWT[3]				FWT			
	0	250	SED	%	0	250	SED	%
1983	16.3	18.8	0.64	-15	0.59	0.67	0.02	-12
1984	17.5	20.4	0.71	-16	0.61	0.78	0.02	-22
1985	20.0	22.1	0.74	-11	0.76	0.81	0.04	-6
1986	17.4	21.4	0.70	-23	0.56	0.74	0.03	-24
1987	17.9	21.1	0.77	-18	0.62	0.76	0.04	-19
1988[4]	17.9	17.3			0.62	0.57		

[1]November liveweight (kg)
[2]Fleeceweight (kg/animal/yr)
[3]Weaning weight (kg)
[4]Differential stocking rate
NA Not available

RESULTS AND DISCUSSION

Effect of withholding fertiliser on animal production

Ewe liveweight and fleeceweight data indicate little effect on production in the first year without fertiliser but thereafter a marked decline of approximately 20% by years 4 and 5 (Table 1). Lamb data indicate a more immediate effect on production (Table I), and although this information has limitations (varying numbers between treatments according to lambing %), we nevertheless believe it to be a true indication of what would happen in practice.

Withholding fertiliser at Te Kuiti has had its greatest effect in the winter-spring period when pasture growth is at its lowest. Late spring-summer growth was more than sufficient for animal needs and led to surplus growth. Table 2 shows the decline in ewe wool production in these two periods and the effect of the winter-spring period. Lamb production is likely to suffer similarly over this period. There were also increased metabolic disorders (sleepy sickness) in the nil fertiliser treatment ewes as the trial progressed. These disorders and the very low ewe liveweight in this treatment necessitated the change in stocking rate in 1988.

Table 2 Percentage decline in ewe wool production when fertiliser is withheld

Period of wool growth		Year 1984	1985	1986	1987
December-May	(summer/autumn)	4	7	3	6
June-November	(winter/spring)	20	16	17	28

Wool quality

Wool quality measurements made in either November or May (Table 3) show no significant effect from withholding fertiliser on yield, fibre diameter or colour. This suggests that total wool weight is more important than wool quality in assessing the effects of withholding fertiliser on wool production.

Table 3 Ewe wool quality measurements for November and May (in brackets). Mean of 3 years' data.

Fettiliser	Yield (%)	Diameter (μm)	Colour (Y-Z)'
0	76.3 (77.6)	34.2 (40.6)	3.9 (3.9)
250	79.6 (79.2)	34.7 (40.9)	4.3 (3.7)

[1]Tristimulus colour measurement. Y-Z: 0 = no yellowness: 1-2 = slight yellowing: >6 severe yellowing.

Pasture production

Priority at Te Kuiti was given to animal production measurements. Pasture production measurements were limited to small paired plots (0 vs 250 kg/ha super-phosphate) within two of the nil P paddocks (pers. comm. K.W. Perrott & S.U. Sarathchandra) and to trial paddock measurements in the August-November set-stocking period (Table 4). Results follow a similar pattern to those for animal production, namely, little effect in the first year of withholding fertiliser, a marked reduction in year 2 and a levelling out thereafter at approximately 20% less production. Another approach to assessing pasture production was to visually assess pasture cover weekly on the three farmlets and by using previous calibration information (Baars & Dyson 1981) convert this to total dry matter (Table 5). The marked decline in the average feed available on the nil P farmlet is apparent.

Table 4 Pasture production measurements (kg DM/ha) in: (1) an associated small-plot trial and; (2) the main trial during set stocking (August-November).

Year	No. of cuts	Fertiliser -(kg/ha/an) 0	250	SED	%
(1) Small Plot Trial					
1984	4	7360	1950	NA	-7
1985	4	7210	9140	NA	-21
1986	3	7890	10540	NA	-25
1987	3	7230	8780	NA	-18
1988	4	91 IO	11200	NA	-19
(2) Main Trial					
1983		2230	2210	196	-1
IY84		4010	4760	335	-16
1985		2140	2810	NA	-24
1986		2160	2560	202	-19
1987		2570	3210	357	-20
1988		1510	3030	280	-50'

'inter-track areas only NA not available

Pasture composition

The dominant effect of withholding fertiliser at Te Kuiti has been a decline in white clover content and an increase in moss and weeds (Table 6). There has been no consistent effect on ryegrass content. Neither has there been any ingress of scrub or brushweeds. The dominant effect of stocking rate, or stock pressure in this regard, cannot be under-estimated.

Table 5 Visual assessments of pasture dry matter cover (kg DM/ha) (mean of weekly assessments)

Treatment	Year 1983	1984	1985	1986	1987	1988'
0	1120	1160	1080	1120	1240	1365
250	1280	1480	1520	1560	1840	1445
SED	40	78	52	54	NA	

[1]Differential stocking rate

Soil analyses

Soil Olsen P analyses were done annually in September-October. Test levels varied little between treatments until 5 years after commencement (Table 7). This is not surprising given the large

Table 6 Pasture composition changes over 5 years where fertiliser is withheld (% total hits).

Species	Fertiliser (kg/ha)	Year 1984	1985	1986	1987	1988
Ryegrass	0	31	32	39	42	40
	250	39	48	45	43	42
	SED	5	6	4	6	5
White clover	0	23	27	28	27	19
	250	24	41	42	38	32
	SED	3 19	4	4	4	3
Browntop	0	28	26	32	34	39
	250		25	21	27	15
	SED	2 44	6	7	6	11
Weeds	0	26	43	44	54	54
	250		33	28	34	43
	SED	4	4	4	6	6
Moss	0	0.6	47	41	47	55
	250	0	18	20	28	36
	SED		7	6	9	6

Table 7 Soil Olsen P analyses at Te Kuiti over 6 years (O-7.5 cm)

Fertiliser rate (kg/ha/yr)	Year 1983	1984	1985	1986	1987	1988	Mean
0	14.3	13.7	13.8	13.3	7.3	8.5	11.8
250	14.0	17.5	16.2	19.0	13.3	13.2	15.5
SED	2.3	3.3	2.6	3.3	I.5	2.9	
CV%	27	36	29	34	25	44	

variation expected when sampling hill country (CVs average 33% at Te Kuiti), which indicates that soil testing alone will not give a good indication of when a production loss will occur, or of its magnitude. It will, however, indicate a trend in nutrient levels providing testing is done regularly, e.g. every 2-3 years.

Soil sulphate-sulphur tests indicate a trend towards lower levels in the no fertiliser treatments. An associated trial (S.F. Ledgard, unpublished), however, has shown no significant response to sulphur applications after 6 years of withholding fertiliser. We are confident that the main effect of withholding fertiliser on these soils is due to a deficiency of phosphorus.

CONCLUSIONS

A 6-year grazing trial at the Te Kuiti Research Area has indicated that production declines in the first year of withholding fertiliser will be minimal (less than 5%), but thereafter decline will be rapid, reaching 20% after 3 years and remaining at 20-30% thereafter. Current stocking rate (ewes/ha) in year 7 to maintain equivalent production is 15 (250 kg/ha superphosphate) and 11 (no fertiliser), a difference of 27%. The importance of maintaining a high stocking pressure to control surplus feed and prevent ingress of brush and scrub weeds is emphasised.

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