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Fertiliser requirements of luceme cut for hay in northern Southland

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Abstract

Three field trials were laid down, on established luceme (*Medicago sativa* L.) stands and continued for 2, 3 or 4 years. On two sites fertilisers applied were potassium chloride (0 and 200 kg/ha) and single superphosphate (0, 200, 400 and 800 kg/ha), while on the third site potassium chloride (0, 100 and 200 kg/ha), sulphur (0, 25, 50 and 100 kg S/ha as gypsum) and phosphorus (0, 18, 36 and 72 kg P/ ha as monocalcium phosphate) were applied. Lucerne was harvested at the hay stage with 2 or 3 cuts per year. Consistent annual yield responses to 200 kg/ ha of potassium chloride application occurred at all sites. At the site where 100 kg/ha was applied it produced about 95% of maximum yield but nil K gave 8594% of maximum yield. Responses to superphosphate treatments were recorded at two sites with the major response considered to be due to phosphorus. 200 - 400 kg/ha of superphosphate was sufficient for near maximum response. Response to both phosphorus and sulphur occurred at site 3 with 18 kg/ha phosphorus and 25 kg/ha sulphur being sufficient for near maximum response. Results indicate that a soil P test of 13 and K test of 6 should support approximately 95% of maximum yield. Herbage P and S concentrations associated with near maximum yields were slightly higher than indicated in current standards for plant analysis interpretations, but K concentrations agreed with current standards. Maintenance fertiliser requirements derived from this trial series are similar to those predicted from AgResearch's fertiliser recommendation models.

Keywords *Medicago sativa*, potassium, phosphorus, soil test, plant analyses, sulphur, fertiliser

Introduction

In northern Southland, luceme is grown on the drier stony alluvial soils and is mainly used as a specialist crop for hay production over the spring and summer. then grazed in the autumn. Most farms growing luceme (*Medicago sativa* L.) have one or two paddocks, with hay from these fed over the other areas of the farm. This practice results in the removal of considerable quantities of nutrients from the luceme area which need to be replaced if optimum luceme production is to be maintained. Nutrient requirements are therefore likely to be greater than those of pasture.

In other South Island regions. phosphate, sulphur and potassium fertilisers are recommended for luceme with rates and frequency of application varying between regions (Dale 1967; Ludecke 1967; Stephens 1970). Overall there is a general requirement for phosphate with sulphur required on drier inland soils and potassium in wetter high producing districts.

Maintenance fertiliser requirements of luceme have been defined by Cornforth & Sinclair (1984) but recommendations are general and have not been evaluated in northern Southland.

This paper reports on the response of luceme to potassium (K), phosphorus (P) and sulphur (S) and relates these *results* to the recommendation scheme.

Methods

Three small-plot field trials were established on 2- or 3-year-old luceme stands on the Waikaia Plains (sites 1 and 2) and at Lumsden (site 3) in northern Southland. Treatments applied at sites 1 and 2 were potassium chloride (0 and 200 kg/ha) and superphosphate (0,200, 400 and 800 kg / ha) in a factorial randomised block design with 3 replicates. At site 3. treatments were potassium chloride (0, 100. 200 kg/ha), phosphate (0, 18.36 and 72 kgP/ha as monocalcium phosphate) and sulphur (0, 25, 50 and 100 kgS/ha as gypsum). Trial design was a factorial confounded into 3 randomised blocks of 16 plots (Cochran & Cox 1957). This loses the interaction between potassium chloride and the quadratic contrasts in phosphate and sulphur treatments. Treatments were applied to all 3 trials annually in early spring, with basal borax (5.5 kg/ha) and sodium molybdate (350 g/ha) applied at the start of each trial.

The soil at each site was Oreti stony silt loam which is classified as an intergrade yellow-grey/yellow-brown earth (NZ Soil Bureau 1968). Over the 2 years prior to starting the trials. site 1 had received a total of 250 kg/ ha superphosphate, site 2 1500 kg/ha 30% potassic superphosphate and site 3 (1000 kg/ha 25% potassic superphosphate). Initial soil test results are given in Table 1.

Table 1 Initial sail teat value at trial establishment (Data are MAF quick test units)

Site	pH	Ca	P	K	Mg	SO_4-S	P retention (%)
1	6.6	14	10	3	5	6[1]	46
2	6.0	10	14	4.5	7	25	26
3	6.1	11	24	9	19	6	24

[1] SO_4-S test for site 1 from control plots 1 year after initial treatment applications.

The luceme was cut at the hay growth stage (early flowering) with a sickle bar mower. Three harvests (in late spring, mid summer and early autumn) were made each year, except for year 2 at site 2 when no autumn cut was taken and at site 3 when no spring cut was taken in year 1. Trials were never grazed. Measurements included dry matter yields at all harvests, herbage chemical analysis for selected harvests and soil quick test analysis in early spring of each year before fertiliser application. Soil sampling depth was O-75 mm.

Results

At site 1. significant yield increases with potassium chloride and superphosphate applications occurred each year and for all years combined (Table 2). Responses to potassium chloride were recorded at all harvests except the initial spring cut after trial establishment. Superphosphate responses were more variable and occurred in autumn and spring rather than summer.

Over the first year at site 2 no significant yield responses were recorded but in the second year and for total production significant yield increases to both potassium chloride and superphosphate occurred (Table 2).

At site 3, potassium chloride treatments had significantly higher annual yields and total production than control treatments with responses recorded at most harvests (Table 3). S application was associated with significantly higher annual production in years 2 and 3 and in total production. P treatments had significantly higher production than controls in year 3 only (Table 3).

Dry conditions reduced production in year 4 at site 1 and in year 3 at site 3.

There was a general tendency for P, K and S soil test values (O-75 mm) in control treatments to decline over the course of the experiments (Tables 4 and 5). Fertiliser treatments consistently raised the respective soil test values above those in control treatments. Annual fertiliser application of 30-40 kg P/ha appeared to prevent decline of soil P tests at all sites. Table 4 reports that at site 1, soil K showed little change with nil K and perhaps increased with200 kg K/ha. Conversely, at site 3,200 kg K/ha did appear to maintain soil K. At site 3.25 kg S/ha appeared sufficient to maintain the initial low soil S test level but at site 2 which was initially very high in soil S, levels declined in all treatments. Initial soil S levels were not measured at site 1 and results were variable over time.

Table 2 Main effects of potassium chloride and superphosphate on dry matter yield of lucerne at sites 1 and 2 (Kg DM/ha), with SED's and significance levels (sig).

	Site 1					site 2		
	Yr 1	Yr 2	Yr 3	Yr 4	4 years	Yr 1	Yr 2	2 years
Potassium Chloride (kg/ha/yr)								
0	5940	5546	4277	1719	17464	7336	7074	14412
200	6796	7472	6494	2906	23670	7206	6341	15547
SED	235	199	166	126	515	166	156	227
sig	..	**	..	*	#	ns	**	*
Superphosphate (kg/ha/yr)								
0	5740	5776	4756	1996	16266	7066	7103	14171
200	6200	6465	5564	2265	20464	7059	7701	14760
400	6607	6925	5524	2259	21315	7572	7923	15495
600	6929	6674	5706	2730	22241	7390	6103	15493
SED	333	261	235	178	726	234	220	321
sig	.	..	**	*	#	ns	**	*

Table 3 Main **effects** of potassium chloride. **phosporus and sulphur ondry matter** yield of **lucerne** at **site 3** (kg **DM/ha)** with **SED's and significance levels (sig).**

	Year 1	Year 2	Year 3	**Total**
Potassium Chloride **(kg/ha/yr)**				
0	**5973**	8981	3908	18862
100	6151	9929	4330	20410
200	6352	10211	4608	21171
SED	106	165	106	262
sig	**	**	**	**
Phosphorus **(kg/ha/yr)**				
0	6201	**9700**	4040	19941
18	6136	9419	4305	19920
36	6168	9780	4474	20422
72	6130	9868	4311	20309
SED	106	165	106	262
sig	ns	ns	*	ns
Sulphur (kg/ha/yr)				
0	6032	9263	4072	19361
25	6210	9710	4444	20364
50	6264	9661	4318	20243
100	6129	10193	4295	20617
SED	106	165	**106**	262
sig	ns	**	**	**

Table 4: Main effects of fertiliser treatments on soil potassium, sulphate-S and Olsen P status over duration of trials at site 1 and 2. (Data are MAF quick test units)

		Sampling time since Laying Down (months)							
		Site 1					site 2		
Treatment		0	11	23	35	42	0	11	23
Potassium **(mg/g K)**									
Potassium **Chloride**	**0**	3.3	2.9	3.3	3.2	3.0	4.8	3.6	2.1
(kg/ha/yr)	**200**	3.3	2.9	3.9	4.0	6.3	4.8	4.3	3.2
	SED	0.27	0.21	0.22	0.18	0.37	0.34	0.22	0.21
	Sig	ns	ns	**	**	**	ns	**	*
Phosphorus (mg/g P)									
Superphosphate	0	10.0	9.0	7.8	1.8	7.0	13.3	10.2	8.2
(kg/ha/yr	**200**	9.1	9.3	8.8	9.1	8.1	13.8	11.2	9.5
	400	10.0	10.3	11.0	12.5	11.2	14.0	13.3	11.0
	800	10.3	11.0	14.3	11.1	16.8	13.5	14.2	14.3
	SED	0.76	0.45	0.72	0.93	0.81	0.63	0.90	0.87
	Sig	ns	**	**	**	**	ns	**	**
Sulphur (mg/g SO_4-S)									
Superphosphate	0	**nd#**	6.2	**1.8**	3.0	5.5	24.8	12.0	10.3
(kg/ha/yr)	**200**	nd	10.7	**5.2**	5.3	16.0	26.0	13.0	13.3
	400	nd	10.0	6.8	6.1	26.0	25.5	14.8	15.3
	800	nd	15.0	10.5	6.5	45.5	25.8	16.2	16.8
	SED		0.99	0.59	0.53	2.2	1.65	0.89	0.84
	Sig		**	**	**	**	ns	**	**

not done

Table 5 Effect of fertiliser treatments on soil potassium Olsen P and Sulphate-S status over duration of trial at site 3 (Data are MAF quick test units)

		Sampling Time since Laying Down (months)			
Treatment		0	10	22	34
		Potassium (mg/g K)			
Potassium chloride (kg/ha/yr)	0	9.3	5.7	5.0	4.5
	100	8.6	6.9	6.1	6.5
	200	9.7	7.2	7.6	10.9
	SED	0.60	0.46	0.54	0.56
	Sig	ns	** •	[illegible]	[illegible]
		Phosphorus (me/g P)			
P (kg/ha/yr)	0	22.5	22.2	11.3	11.6
	18	22.6	24.5	14.3	16.9
	36	25.4	30.7	20.5	24.0
	72	26.1	43.2	32.7	46.9
	SED	2.6	3.3	3.6	4.2
	Sig	ns	. *	. *	[illegible]
		Sulphur (mg/g SO,-S)			
S (kg/ha/yr)	0	6.3	6.3	4.3	4.6
	25	5.9	7.9	5.6	9.6
	50	6.3	9.1	7.2	12.9
	100	5.6	9.4	6.3	14.3
	SED	0.4	0.5	0.6	1.6
	Sig	ns	[illegible]	[illegible]	[illegible]

In Figures 1 and 2 results for each year from each site are presented with the fitted Mitscherlich curve with an asymptote equal to 100. These results indicate that soil P tests of 13 and K tests of 6 should support approximately 95% of maximum yield.

In Figures 3 and 4 results show that herbage concentrations of 0.26% P and 1.8% K should support about 95% of maximum yield. However, especially with the P comparison the Mitscherlich curve did not fit the data well.

Effects of S could be examined at site 3 only, and relationships between yields and soil and plant S tests cannot be well defined. The responses were associated with control treatment soil test levels of 4 and up to 6 in year 2 and herbage S levels of about 0.2%.

Discussion

Consistent yield responses to annual potassium chloride applications on sites which had a history of variable previous potassium chloride inputs indicates a regular K requirement of lucerne on these soils. The annual application of 200 kg/ha of potassium chloride generally

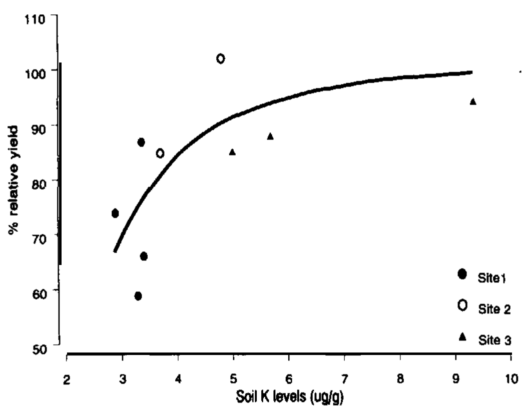

Figure 1 Relationship between control soil K test value and yields in control treatments relative to yields with maximum potassium chloride application.

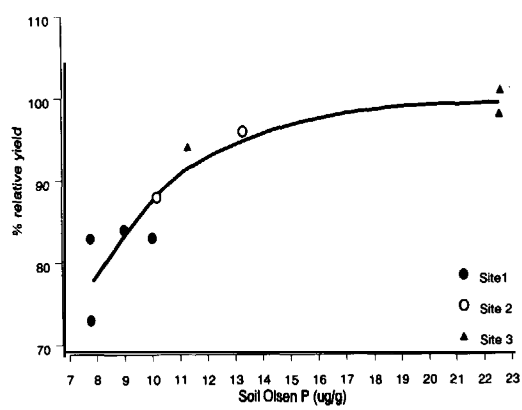

Figure 2 Relationship between control soil Olsen P test and yields in control treatments relative to yields with maximum phosphorus application.

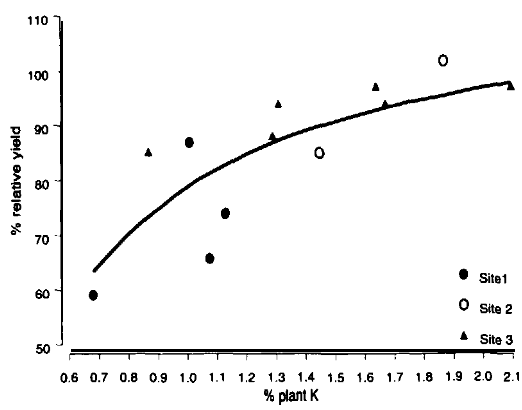

Figure 3 Relationship between weighted mean annual herbage K concentrations and relative yields with rates of potassium chloride.

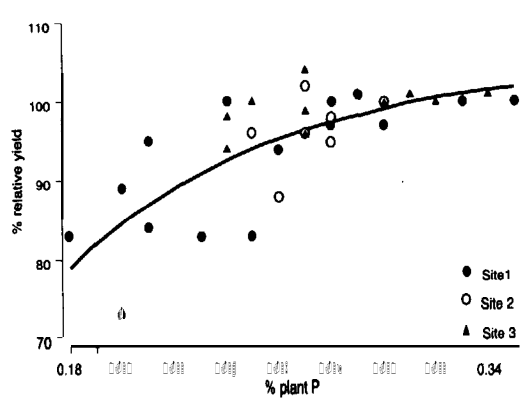

Figure 4 Relationship between weighted-annual herbage P concentrations and relative yields with rates of phosphorus fertiliser.

maintained soil K test levels. However. at site 3 where K soil status was low the response to 100 kg was two-thirds of that from 200 kg/ha. Calculations using the AgResearch 'fertiliser recommendations scheme' (Cornforth & Sinclair 1984) give estimates of annual potassium chloride requirement for sites 1 and 2 of respectively 120 and 70 kg/ha and for site 3 nil in year 1 and 90 kg/ha in years 2 and 3. These results are perhaps too low but this can only be determined by further field trials.

Although superphosphate treatments containing both P and S were applied to sites 1 and 2 most of the responses can be attributed to P. At site 2. soil and herbage S levels in controls were much in excess of requirements (Cornforth & Sinclair 1984) while at site 1, although soil S levels *were* low-medium, S/P ratios in herbage in control treatments ranged from 0.9 -1.4 strongly suggesting that P was the more deficient element. The 200 and 400 kg/ha superphosphate rates generally maintained soil P soil test values. A small response to P at site 3 developed only in year 3 when soil test levels had fallen from initial high levels in control treatments. At site 1 where initial P test values were in the deficient range ie Olsen Pof below 13 approximately (Figure 2). responses occurred each year, while at site 2 responses developed in year 2 when soil P tes t values had also declined to deficient levels. At sites 1 and2 approximately 95% of maximum yield would be obtained with 200-400 kg of superphosphate. Phosphorus requirements calculated from the AgResearch recommendation scheme for sites 1 and 2 are equivalent to 370 and 340 kg/ha respectively of single superphosphate initially, with maintenance rates being 206 and 231 kg/ha of single super-phosphate.

Only site 3 provides data for S requirements where applications of 25 kg S/ha maintained soil S levels and provided virtually all the yield response obtained to S at this site. Calculated maintenance using AgResearch recommendations is 20 kg S/ha.

The herbage K concentrations for 95% relative yield of about 1.8% (Figure 3) is within the optimum range of 1.51.8% reported by Comforth & Sinclair (1984) for New Zealand conditions. However, herbage P concentrations for 95% relative yield *were* about 0.26% (Figure 4) which is higher than the reported optimum range of 0.2-0.25%. Sulphur herbage concentrations associated with a yield response to sulphur at site 3 were 0.20% whereas the reported optimum range is 0.18-0.22. These results suggest that optimum herbage P and S concentration ranges should be. reviewed.

The responses to K, P and S recorded in this trial series are in good agreement with the AgResearch fertiliserrecommendationscheme estimates, thus supporting the use of this scheme for calculating the maintenance fertiliser requirements of lucerne in Northern Southland.

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REFERENCES

Cochran and *Cox* 1957. ***Experimental Designs (2nd edition).*** John Wiley and Sons Inc., New York, p234.

Comforth. I.S., Sinclair, A.G. 1984. ***In Fertiliser Recommendations for Pastures and Crops in New Zea***land, Second Revised Edition. Ministry of Agriculture and Fisheries, Wellington. New Zealand.

Dale, W.R. 1967. In *The Lucerne Crop*, R.H.M. Langer (Ed); A.H. and A.W. Reed, Wellington, New Zealand.

Ludecke, T.E. 1967. In ***The Lucerne Crop,*** R.H.M. Langer (Ed); A.H. and A.W. Reed, Wellington, New Zealand

New Zealand Soil Bureau 1968. General Survey of the Soils of South Island, New Zealand. New ***Zealand Soil Bureau Bulletin 27;*** 404pp

Stephen, R.C. 1970. Responses by Lucerne and Associated Volunteer Species to Applied Fertilisers in ***North Canterbury. Proceedings of the New Zealand Grassland Association 32:*** 117-126